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12TH EDITION

SYSTEMS ANALYSIS AND DESIGN



SCOTT TILLEY

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DEDICATION

To all of my students – past, present, and future

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PREFACE

The Shelly Cashman Series® offers the finest texts in computer education. We are proud that our previous editions of *Systems Analysis and Design* have been so well received by instructors and students. *Systems Analysis and Design, 12th edition* continues with the innovation, quality, and reliability you have come to expect.

The Shelly Cashman Series development team carefully reviewed our pedagogy and analyzed its effectiveness in teaching today's student. Contemporary students read less but need to retain more. As they develop and perform skills, students must know how to apply the skills to different settings. Today's students need to be continually engaged and challenged to retain what they're learning. With this book, we continue our commitment to focusing on the user and how they learn best.

Facing a challenging global marketplace, companies need strong IT resources to survive and compete effectively. Many of today's students will become the systems analysts, managers, and IT professionals of tomorrow. This text will help prepare them for those roles.

Overview

Systems Analysis and Design, 12th edition offers a practical, streamlined, and updated approach to information systems development. Systems analysis and design is a disciplined process for creating high-quality enterprise information systems. An information system is an amalgam of people, data, and technology to provide support for business functions. As technology evolves, so does systems analysis. The book emphasizes the role of the systems analyst in a dynamic, business-related environment. A systems analyst is a valued team member who helps plan, develop, and maintain information systems. Analysts must be excellent communicators with strong analytical and critical thinking skills. They must also be business savvy, technically competent, and be equally comfortable working with managers and programmers. Throughout the book, real-world examples emphasize critical thinking and IT skills.

Many two- and four-year colleges and schools use this book in information systems and computer science curriculums. The 12th edition includes expanded coverage of emerging technologies, such as agile methods, cloud computing, and mobile applications. This new material complements the updated treatment of traditional approaches to systems analysis and design.

Using this book, students learn how to translate business requirements into information systems that support a company's strategic objectives. Case studies and assignments teach analytical reasoning, critical thinking, and problem-solving skills. Numerous projects, assignments, and end-of-chapter exercises are provided, along with detailed instructor support material.

Objectives of This Text

Systems Analysis and Design, 12th edition is intended for a three credit-hour introductory systems analysis and design course. This text is designed to:

- explain systems analysis and design using an appealing full-color format, numerous screenshots and illustrations, and an easy-to-read style that invites students to learn.
- introduce project management concepts early in the systems development process.
- challenge students with a Question of Ethics mini-case in each chapter that asks them to respond to real-life ethical issues in an IT environment.

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- provide multi-method coverage, including a comparison of structured, object-oriented, and agile systems development methods.
- explain how IT supports business requirements in today's intensely competitive environment, and
- describe major IT developments and trends.

New and Updated Features in This Edition

Systems Analysis and Design, 12th edition offers these exciting new and updated features:

- Reexamined structure and subject coverage to ensure students can identify and focus on the main content readily. Confirmed that related content has been aligned under comprehensive section headings to maintain a clear flow of topics and reduce distraction.
- A renewed emphasis on aligning learning objectives with chapter content and assessments. The learning objectives have been updated and carefully reworded so that instructors know what to focus on, and students know what is expected of them. The questions, discussion topics, and projects have all been updated to better assess student mastery of the material.
- Updated or replaced many *Case in Point* mini-cases to ensure learners are exposed to relevant and current examples of real-world business applications of key concepts.
- Updated examples of CASE tools reflecting web-based and/or open source offerings. These tools are often free and are representative of modern systems analysis solutions.
- Updated screenshots to Microsoft Office 2019 products and Visible Analyst 2016.

Organization of This Text

Systems Analysis and Design, 12th edition contains 12 chapters that teach valuable cross-functional skills. The chapters are organized into five phases: planning, analysis, design, implementation, and support and security. A four-part Systems Analyst's Toolkit, now available as an online appendix, reflects the most recent changes in today's systems analysis tools and also includes invaluable resources. Cross-functional toolkits provide students with the basic skills sought after by organizations hiring systems analysts.

Phase 1: Systems Planning

- **Chapter 1 – Introduction to Systems Analysis and Design:** Chapter 1 provides an introduction to systems analysis and design by describing the role of information technology in today's dynamic business environment.
- **Chapter 2 – Analyzing the Business Case:** Chapter 2 explains how systems projects get started and how to evaluate a project proposal to determine its feasibility.
- **Chapter 3 – Managing Systems Projects:** Chapter 3 describes how to use project management tools and techniques, and how to plan, schedule, monitor, and report on IT projects.

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Phase 2: Systems Analysis

- **Chapter 4 – Requirements Engineering:** Chapter 4 describes the requirements engineering process: gathering facts about a systems project, preparing documentation, and creating models that will be used to design and develop the system.
- **Chapter 5 – Data and Process Modeling:** Chapter 5 discusses data and process modeling techniques that analysts use to show how the system transforms data into useful information.
- **Chapter 6 – Object Modeling:** Chapter 6 discusses object modeling techniques that analysts use to create a logical model.
- **Chapter 7 – Development Strategies:** Chapter 7 considers various development strategies for the new system and plans for the transition to the systems design phase.

Phase 3: Systems Design

- **Chapter 8 – User Interface Design:** Chapter 8 explains how to design an effective user interface and how to handle data security and control issues.
- **Chapter 9 – Data Design:** Chapter 9 focuses on the data design skills that are necessary for a systems analyst to construct the physical model of the information system.
- **Chapter 10 – System Architecture:** Chapter 10 describes system architecture, which translates the logical design of an information system into a physical blueprint.

Phase 4: Systems Implementation

- **Chapter 11 – Managing Systems Implementation:** Chapter 11 describes application development, documentation, testing, training, data conversion, and system changeover.

Phase 5: Systems Support and Security

- **Chapter 12 – Managing Systems Support and Security:** Chapter 12 describes systems support and security tasks that continue throughout the useful life of the system, including maintenance, security, backup and disaster recovery, performance measurement, and system retirement.

Online Appendix: The Systems Analyst's Toolkit

- **Toolkit Part A – Communication Tools:** Part A of the toolkit discusses communication tools that can help the analyst write clearly, speak effectively, and deliver powerful presentations.
- **Toolkit Part B – CASE Tools:** Part B describes CASE tools that be can used to design, construct, and document an information system.
- **Toolkit Part C – Financial Analysis Tools:** Part C demonstrates financial analysis tools that can used to measure project feasibility, develop accurate cost-benefit estimates, and make sound decisions.
- **Toolkit Part D – Internet Resource Tools:** Part D describes Internet resource tools that can be used to locate information, obtain reference material, and monitor IT trends and developments.

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FEATURES

CHAPTER LEARNING TOOLS AND HOW THEY WILL HELP YOU

Case In Point: Each chapter includes three brief cases that provide a contextual business example for students focused on the key issues covered in the chapter.

A Question of Ethics: A realistic ethical issue is presented at the end of each chapter. These examples force you to examine your reactions and how you would respond to common workplace situations.

Chapter Exercises: The chapter exercises are directly related to the learning objectives. Your answers to the 10 questions will show that you understand the key points. Five discussion topics and five projects offer opportunities to dig deeper and learn even more.

MINDTAP FOR SYSTEMS ANALYSIS AND DESIGN

MindTap for *Systems Analysis and Design, 12th edition* is a personalized, fully online, digital learning platform of content, assignments, and services that engages students and encourages them to think critically while allowing instructors to easily set their course through simple customization options.

MindTap is designed to help students master the skills they need in today's workforce. Research shows employers need critical thinkers, troubleshooters, and creative problem-solvers to stay relevant in our fast paced, technology-driven world. MindTap helps students achieve this with assignments and activities that provide hands-on practice and real-life relevance. They are guided through assignments that help them master basic knowledge and understanding before moving on to more challenging problems.

MindTap is designed around learning objectives and provides the analytics and reporting to easily see where the class stands in terms of progress, engagement, and completion rates. Students can access eBook content in the MindTap Reader, which offers highlighting, note-taking, search and audio, and mobile access. Learn more at www.cengage.com/mindtap.

ConceptClips: ConceptClip videos focus learners on a key concept in each chapter and are designed to deepen their understanding of the topic.

Running Case: Based on feedback from readers and instructors, we've created a new running case to replace the SCR Case from previous editions. The case challenges learners to apply key systems analysis and design concepts and skills to a realistic scenario they would encounter in the workplace. The case brings the key concepts and skills of the chapter together in an authentic assignment. The look and feel of the case tool has also been updated to be an authentic, immersive experience for students.

INSTRUCTOR RESOURCES

We are dedicated to providing you all the tools you need to make your class a success. Information on all supplementary materials can be found on the password-protected website at *login.cengage.com*. If you need help accessing this page, please contact your Cengage representative.

The Instructor Resources include the following:

- **Online Appendix: The Systems Analyst's Toolkit:** A 4-part online appendix reflects the most recent changes in today's systems analysis tools.

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- **Instructor's Manual:** Contains lecture notes summarizing the chapter sections, figures and boxed elements found in every chapter, teacher tips, classroom activities, and quick quizzes in Microsoft Word files.
- **PowerPoint Presentations:** A multimedia lecture presentation system provides slides for each chapter, based on chapter objectives.
- **Figure Files:** Illustrations for every figure in the text in electronic form.
- **Solutions to Exercises:** Includes solutions for end-of-chapter exercises.
- **Test Bank and Test Engine:** Test banks include questions for every chapter, featuring objective-based and critical thinking question types, page number references, and figure references when appropriate. Cengage Learning Testing powered by Cognero is a flexible, online system that allows you to:
  - author, edit, and manage test bank content from multiple Cengage Learning solutions.
  - create multiple test versions in an instant.
  - deliver tests from your LMS, your classroom, or wherever you want.

ABOUT THE AUTHOR

With the 12th edition, Scott Tilley becomes the sole author of *Systems Analysis and Design* in the Shelly Cashman Series. Dr. Tilley is an emeritus professor at the Florida Institute of Technology, president and founder of the Center for Technology & Society, president and co-founder of Big Data Florida, president of the Space Coast chapter of the International Council of Systems Engineering (INCOSE), and a Space Coast Writers' Guild Fellow. In addition to this book, he is the author or editor of numerous other publications, including *Software Testing in the Cloud: Migration & Execution* (Springer, 2012), *Testing iOS Apps with Hadoop Unit: Rapid Distributed GUI Testing* (Morgan & Claypool, 2014), *The Vicious Swans (And Other Tall Tales)* (Precious Publishing, 2017), *Dreams* (Anthology Alliance, 2018), and *Technical Justice* (CTS Press, 2019). He wrote the weekly "Technology Today" column for Florida Today (Gannett) from 2010 to 2018. He holds a Ph.D. in computer science from the University of Victoria.

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Textbooks these days are much more than just printed books; they are educational platforms that have many moving parts. This means putting together an updated edition of a book like this, particularly on an aggressive schedule, is a challenge. I'm pleased to say that the entire production team rose to the occasion. Thanks to Jaymie Falconi, Michele Stulga, Emily Pope, and Maria Garguilo at Cengage for all of their help. Thanks to John Freitas for providing new screenshots of programs and applications. Any errors or omissions in this edition of the text are purely my responsibility.

Finally, sincere thanks to the instructors and students who offered feedback and comments. We have tried to address your concerns and incorporate your suggestions. As this field is constantly evolving, we strongly encourage your participation in helping us provide the freshest, most relevant information possible. We will certainly continue to listen carefully. If you have any questions or comments, please contact us through your local representative.

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PHASE I SYSTEMS PLANNING

DELIVERABLE
Preliminary investigation report

Systems planning is the first of five phases in the systems development life cycle. It's always a good idea to know whether a project fits the company's overall strategy. A systems project that does not align with corporate strategies should not be approved. The role of an information system is to support business goals.

Chapter 1 focuses on an introduction to systems analysis and design by describing the role of information technology in today's dynamic business environment. This includes information systems, Internet business strategies, modeling business operations, business information systems, organizational information models, systems development, the information technology department, and the role of the systems analyst.

Chapter 2 focuses on analyzing the business case, explains how systems projects get started, and describes how to evaluate a project proposal to determine its feasibility. This includes strategic planning and strategic planning tools, the business case, systems requests, factors affecting systems projects, processing systems requests, assessing request feasibility, setting priorities, and the preliminary investigation.

Chapter 3 focuses on managing systems projects. This includes an overview of project management, creating a work breakdown structure, task patterns, the critical path, project monitoring and control, reporting, project management software, risk management, and managing for success.

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CHAPTER 1

Introduction to Systems Analysis and Design

Chapter 1 is the first of three chapters in the systems planning phase. This chapter explains the role of information technology in today's dynamic business environment. This chapter describes the development of information systems, systems analysis and design concepts, and various systems development methods. This chapter also summarizes the role of the information technology department and its people in the enterprise.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" invites examination of the ACM's code of ethics and those of a developing systems analyst.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Describe the impact of information technology on society
2. Describe the five main components of an information system
3. Explain Internet business strategies and relationships, including B2C and B2B
4. Explain how to use business profiles and models
5. Understand the seven types of information systems used in business
6. Describe the types of information the four classes of users need
7. Distinguish among structured analysis, object-oriented analysis, and agile systems development methods
8. List the tools that enable the systems analyst to develop, manage, and maintain large-scale information systems
9. Explain the seven main functions of the information technology department
10. Describe the roles and responsibilities of a systems analyst within the enterprise

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1.1 Information Technology

Information technology (IT) refers to the combination of hardware, software, and services that people use to manage, communicate, and share information. Companies use information as a way to increase productivity, deliver quality products and services, maintain customer loyalty, and make sound decisions. In a global economy with intense competition, information technology can mean the difference between success and failure.

More than ever, business success depends on information technology. IT is driving a new digital economy, where advances in hardware, software, and connectivity can provide enormous benefits to businesses and individuals. Although economic trends affect IT spending levels, most companies give IT budgets a high priority, in good times or bad. The reason is simple: during periods of growth, companies cannot afford to lag behind the IT curve. Conversely, when the economy slows down, firms often use IT to reduce operating costs and improve efficiency.



FIGURE 1-1 These headlines illustrate the enormous impact of information technology on our lives.

Information technology also has profound influence on modern life. Although fictitious, the headlines in Figure 1-1 offer dramatic examples of how information technology issues such as data privacy, mobile devices, and social media affects our society. We live in a world where we can be traced, analyzed, and surveilled without our knowledge. This raises many important questions, such as how to secure personal data while still providing useful functionality and business value.

The following sections provide a sense of IT history, an overview of systems analysis and design, and a description of the systems analyst's role.

1.1.1 The Changing Nature of Information Technology

The history of IT is a fascinating study of human progress and achievement. We are dazzled by the latest and greatest technology, just as our parents and grandparents were astonished by the arrival of television, space flight, and personal computing. It is important for IT professionals, who live and work in this exciting world, to realize that each technology advance is part of a long-term process that often brings dramatic change but never really ends. The story of IBM is a good example.

As its name suggests, International Business Machines was a major supplier of office equipment and typewriters long before the modern computer era. Herman Hollerith, who invented a card that identified characters by the location of punched holes, founded IBM's predecessor company in 1896. A deck of hundreds or even thousands of these cards could store data that was easily sorted, queried, and printed by machines. This system sounds archaic now, but punch card technology was a huge advance that revolutionized the business world and was in use into the 1960s and beyond.

Today, IBM is a globe-spanning company with several hundred thousand employees. It has succeeded in part by constantly adapting to its changing business environment. For example, while it was once known primarily as a hardware company, today IBM makes a significant part of its revenue from software and services. It also invests in its people and tries to hire the best talent available. The result is that IBM has more patents and more Noble Prize winners than any other IT company in history.

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1.1.2 Systems Analysis and Design

Systems analysis and design is a step-by-step process for developing high-quality information systems. An **information system** combines technology, people, and data to provide support for business functions such as order processing, inventory control, human resources, accounting, and many more. Some information systems handle routine day-to-day tasks, while others can help managers make better decisions, spot marketplace trends, and reveal patterns that might be hidden in stored data.

Talented people, including a mix of managers, users, network administrators, web designers, programmers, and systems analysts, typically develop information systems. Capable IT professionals like these are always in demand, even in a slow economy. For example, notice how many positions related to information technology and information systems are available in the Melbourne, Florida area, as shown on Monster.com's job search website in Figure 1-2.

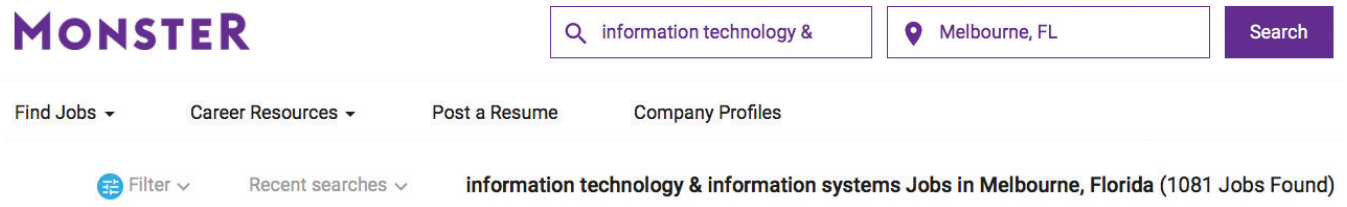


FIGURE 1-2 Monster.com is an example of an online job search website that IT professionals can use.
Source: Monster.com

1.1.3 What Does a Systems Analyst Do?

A **systems analyst** is a valued member of the IT department team who helps plan, develop, and maintain information systems. Analysts must be excellent communicators with strong analytical and critical thinking skills. Because systems analysts transform business requirements into IT projects, they must be business-savvy as well as technically competent and be equally comfortable with managers and programmers, who sometimes have different points of view.

Most companies assign systems analysts to the IT department, but analysts can also report to a specific user area such as marketing, sales, or accounting. As a member of a functional team, an analyst is better able to understand the needs of that group and how IT supports the department's mission. Smaller companies often use consultants to perform systems analysis work on an as-needed basis.

On any given day, an analyst might be asked to document business processes, test hardware and software packages, design input screens, train users, and plan e-commerce websites. A systems analyst may occasionally manage IT projects, including tasks, resources, schedules, and costs. To keep managers and users informed, the analyst conducts meetings, delivers presentations, and writes memos, reports, and documentation.

Section 1.9 lists typical skills and education requirements, certifications, career opportunities, and the possible impact of future IT trends for systems analysts.

1.2 Information Systems

A **system** is a set of related components that produces specific results. For example, specialized systems route Internet traffic, manufacture microchips, and control complex entities like the Hubble telescope, which took the amazing image shown in

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Figure 1-3. A **mission-critical system** is one that is vital to a company's operations. An order processing system, for example, is mission-critical because the company cannot do business without it.

Every system requires input data. For example, a computer receives data when a key is pressed or when a menu command is selected. In an information system, **data** consists of basic facts that are the system's raw material. **Information** is data that has been transformed into output that is valuable to users.

An information system has five key components, as shown in Figure 1-4: hardware, software, data, processes, and people.



FIGURE 1-3 Consider the amazing technology that enabled the Hubble telescope to capture this image.

Source: Courtesy of the Hubble Heritage Team (AURA/STScI/NASA)

1.2.1 Hardware

Hardware consists of everything in the physical layer of the information system. For example, hardware can include servers, workstations, networks, telecommunications equipment, fiber-optic cables, mobile devices, scanners, digital capture devices, and other technology-based infrastructure. A large concentration of networked computers working together is called a **data center**. As new technologies emerge, manufacturers race to market the innovations and reap the rewards.

Hardware purchasers today face a wide array of technology choices and decisions. In 1965, Gordon Moore, a cofounder of Intel, predicted that the number of transistors on an integrated circuit chip would double about every 24 months. His concept, called **Moore's law**, has remained valid for over 50 years. Fortunately, as hardware became more powerful, it also became much less expensive. Large businesses with thousands or millions of sales transactions require company-wide information systems and powerful servers, which are often now in the cloud, such as those shown in Figure 1-5.

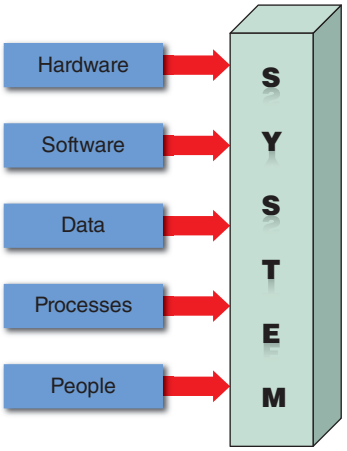


FIGURE 1-4 An information system needs these components.

1.2.2 Software

Software refers to the programs that control the hardware and produce the desired information or results. Software consists of system software and application software.

System software manages the hardware components, which can include a single computer or a global network with many thousands of clients. Either the hardware manufacturer supplies the system software or a company purchases it from a vendor. Examples of system software include the operating system, security software that protects the computer from intrusion, device drivers that communicate with hardware such as printers, and utility programs that handle specific tasks such as data backup and disk management. System software also controls the flow of data, provides data security, and manages network operations. In today's interconnected business world, network software is vitally important.

Application software consists of programs that support day-to-day business functions and provide users with the information they need. Examples of company-wide applications, called **enterprise applications**, include order processing systems, payroll systems, and company communications networks. On a smaller scale, individual users can boost productivity with tools such as spreadsheets, presentation software, and database management systems.

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FIGURE 1-5 Cloud computing provides the enormous storage and speed that modern IT systems need.
Oleksiy Mark/Shutterstock.com

Application software includes horizontal and vertical systems. A **horizontal system** is a system, such as an inventory or payroll application, that can be adapted for use in many different types of companies. A **vertical system** is designed to meet the unique requirements of a specific business or industry, such as an online retailer, a medical practice, or an auto dealership.

Most companies use a mix of software that is acquired at various times. When planning an information system, a company must consider how a new system will interface with older systems, which are called **legacy systems**. For example, a new human resources system might need to exchange data with a legacy payroll application.

1.2.3 Data

Data is the raw material that an information system transforms into useful information. For example, an information system using a relational database can store data in various locations, called tables. By linking the tables, the system can display the specific information that the user needs—no more and no less. Figure 1-6 shows a payroll system that stores data in four separate tables. Notice that the linked tables work together to supply 19 different data items. A user can display any or all data items and filter the data to fit defined limits. In this example, the user requested a list of employees who live in a certain city and worked more than 40 hours in the last pay period. Jane Doe's name was the first to display.

The growth of **big data** has given rise to new ways of storing, searching, and managing data. Traditional relational models are still used, but so-called **NoSQL databases** are gaining in popularity due to their ability to scale to extremely large and unstructured datasets.

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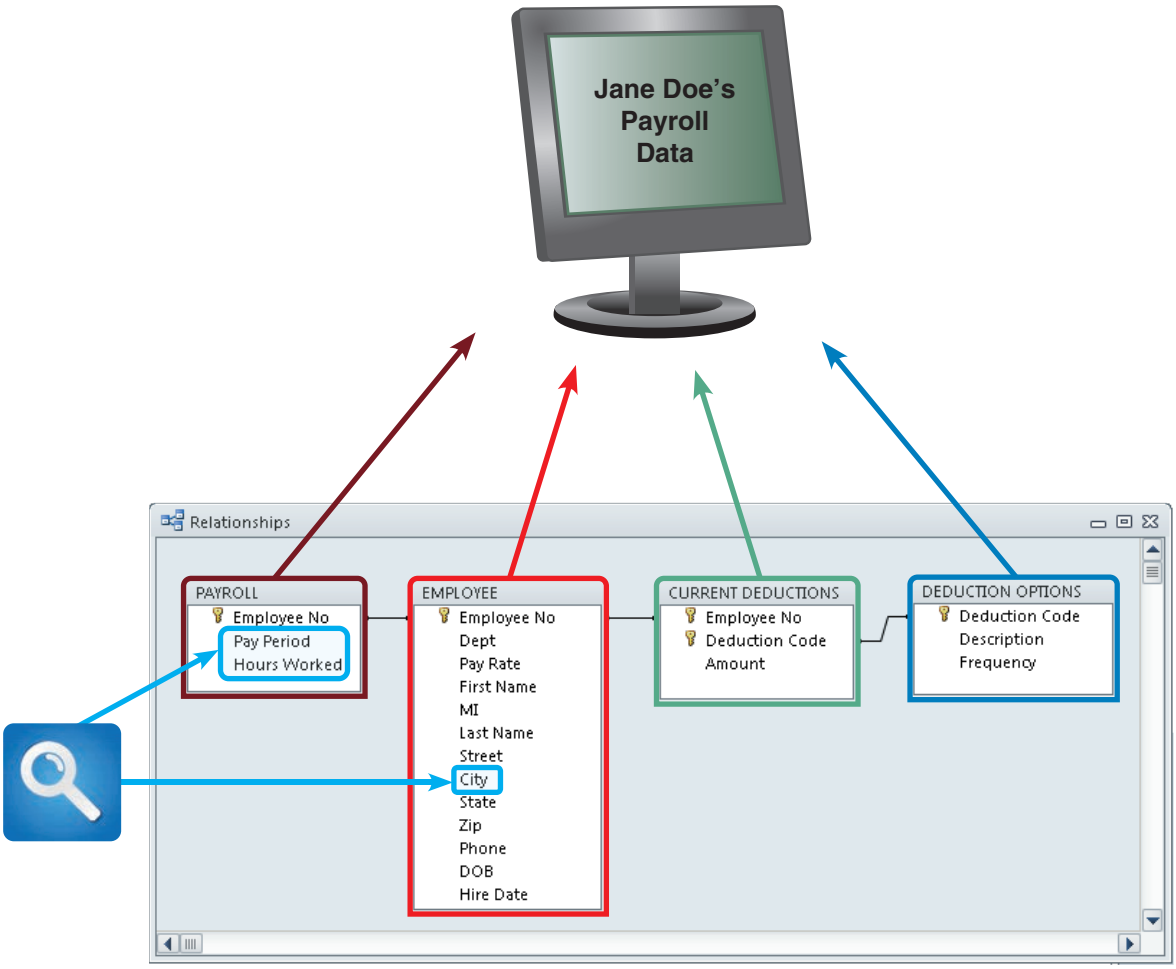


FIGURE 1-6 In a typical payroll system using a relational model, data is stored in separate tables that are linked to form an overall database.

1.2.4 Processes

Processes describe the tasks and business functions that users, managers, and IT staff members perform to achieve specific results. Processes are the building blocks of an information system because they represent actual day-to-day business operations. To build a successful information system, analysts must understand business processes and document them carefully.

1.2.5 People

People who have an interest in an information system are called **stakeholders**. Stakeholders include the management group responsible for the system, the **users** (sometimes called end users) inside and outside the company who will interact with the system, and IT staff members, such as systems analysts, programmers, and network administrators, who develop and support the system.

Each stakeholder group has a vital interest in the information system, but most experienced IT professionals agree that the success or failure of a system usually depends on whether it meets the needs of its users. For that reason, it is essential to understand user requirements and expectations throughout the development process.

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CASE IN POINT 1.1: Data Breaches

A data breach occurs when a hacker gains illegal access to a system and steals personal data, such as credit card numbers or home addresses. With more of our information stored in the cloud, data breaches are becoming increasingly common. Research recent news articles about large-scale data breaches, summarize why they occurred, and suggest how they might be prevented in the future.

1.3 Internet Business Strategies

To design successful systems, systems analysts must understand a company's business operations. Each situation is different. For example, a retail store, a medical practice, and a hotel chain all have unique information systems requirements. As the business world changes, systems analysts can expect to work in new kinds of companies that will require innovative IT solutions.

Business today is being shaped by three major trends: rapidly increasing globalization, technology integration for seamless information access across a wide variety of devices such as laptops and smartphones, and the rapid growth of cloud-based computing and software services. These trends are being driven by the immense power of the Internet.

1.3.1 The Internet Model

Internet-based commerce is called **e-commerce (electronic commerce)**. Internet-based systems involve various hardware and software designs, but a typical model is a series of web pages that provides a user interface, which communicates with database management software and a web-based data server. On mobile devices, the user interacts with the system with an **app**, but the same back-end services are accessed. As Internet-based commerce continues to grow, career opportunities will expand significantly for IT professionals such as web designers, database developers, and systems analysts.

1.3.2 B2C (Business-to-Consumer)

Using the Internet, consumers can go online to purchase an enormous variety of products and services. This new shopping environment allows customers to do research, compare prices and features, check availability, arrange delivery, and choose payment methods in a single convenient session. Many companies, such as airlines, offer incentives for online transactions because web-based processing costs are lower than traditional methods. By making flight information available online to last-minute travelers, some airlines also offer special discounts on seats that might otherwise go unfilled.

B2C (business-to-consumer) is changing traditional business models and creating new ones. For example, a common business model is a retail store that sells a product to a customer. To carry out that same transaction on the Internet, the company must develop an online store and deal with a totally different set of marketing, advertising, and profitability issues.

Some companies have found new ways to use established business models. For example, Airbnb and VRBO have transformed the traditional hospitality service industry into a popular and successful way for individuals to rent their properties. Other retailers seek to enhance the online shopping experience by offering gift advisors, buying guides, how-to clinics, and similar features. In the e-commerce battles, the real winners are online consumers, who have more information, better choices, and the convenience of shopping at home.

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1.3.3 B2B (Business-to-Business)

Although the business-to-consumer (B2C) sector is more familiar to retail customers, the volume of **B2B (business-to-business)** transactions is many times greater. Industry observers predict that B2B sales will increase sharply as more firms seek to improve efficiency and reduce costs.

Initially, electronic commerce between two companies used a data sharing arrangement called **electronic data interchange (EDI)**. EDI enabled computer-to-computer data transfer, usually over private telecommunications lines. Firms used EDI to plan production, adjust inventory levels, or stock up on raw materials using data from another company's information system. As B2B volume soared, company-to-company transactions migrated to the Internet, which offered standard protocols, universal availability, and low communication costs. The main advantage of the web is that it offers seamless communication between different hardware and software environments, anywhere and anytime.

Because it allows companies to reach the global marketplace, B2B is especially important to smaller suppliers and customers who need instant information about prices and availability. In an approach that resembles an open marketplace, some B2B sites invite buyers, sellers, distributors, and manufacturers to offer products, submit specifications, and transact business.

Most large firms and government agencies use **supply chain management (SCM)** software. A **supply chain** refers to all the companies who provide materials, services, and functions needed to provide a product to a customer. For example, a Sherwin-Williams customer who buys a gallon of paint is at the end of a chain that includes the raw material sources, packaging suppliers, manufacturers, transporters, warehouses, and retail stores. Because SCM is complex and dynamic, specialized software helps businesses manage inventory levels, costs, alternate suppliers, and much more.

1.4 Modeling Business Operations

Systems analysts use modeling to represent company operations and information needs. **Modeling** produces a graphical representation of a concept or process that systems developers can analyze, test, and modify. A systems analyst can describe and simplify an information system by using a set of business, data, object, network, and process models.

A **business profile** is an overview of a company's mission, functions, organization, products, services, customers, suppliers, competitors, constraints, and future direction. Although much of this information is readily available, a systems analyst usually needs to do additional research and fact-finding to fill out missing or incomplete information. A business profile is the starting point for the modeling process, and a systems analyst can describe and simplify an information system by using a set of business models and business process models.

A **business model** describes the information that a system must provide. Analysts also create models to represent data, objects, networks, and other system components. Although the models might appear to overlap, they actually work together to describe the same environment from different points of view.

Business process modeling involves a business profile and a set of models that document business operations. **Model-based systems engineering (MBSE)** is one of the leading methods used by systems analysts to develop information systems.

A **business process** is a specific set of transactions, events, and results that can be described and documented. A **business process model (BPM)** graphically displays one or more business processes, such as handling an airline reservation, filling a product order, or updating a customer account. The sales order example in Figure 1-7 shows a simple model that includes an event, three processes, and a result.

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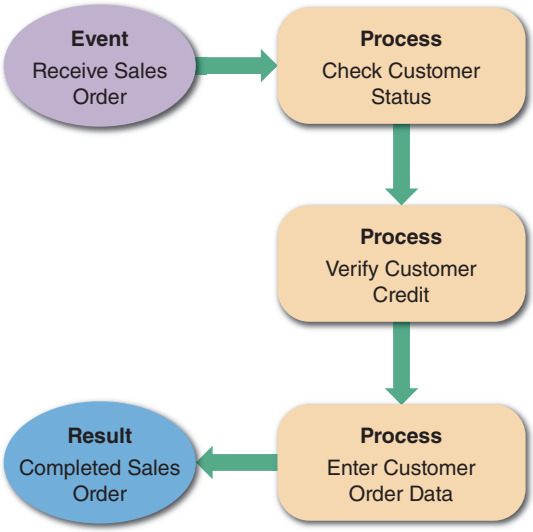


FIGURE 1-7 A simple business model might consist of an event, three processes, and a result.

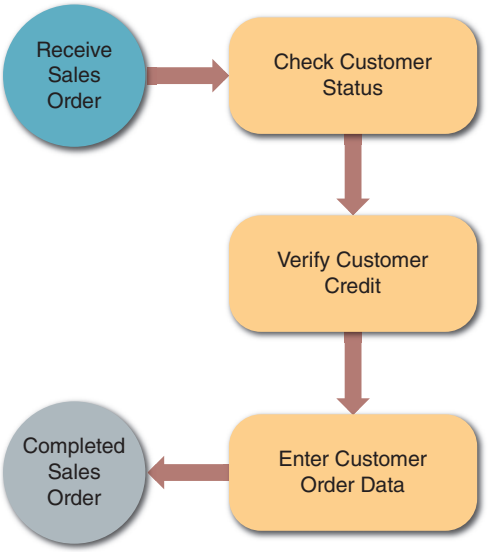


FIGURE 1-8 This sample uses business process modeling notation (BPMN) to represent the same events, processes, and workflow shown in Figure 1-7.
Source: Drawio.com

A rough sketch might be sufficient to document a simple business process. For complex models, analysts can choose computer-based tools that use **business process modeling notation (BPMN)**. BPMN includes standard shapes and symbols to represent events, processes, workflows, and more. Multipurpose application such as Microsoft Visio or online diagramming tools such as draw.io can be used to create BPMN models. Notice that the draw.io model in Figure 1-8 uses BPMN symbols to represent the same sales order process shown in Figure 1-7.

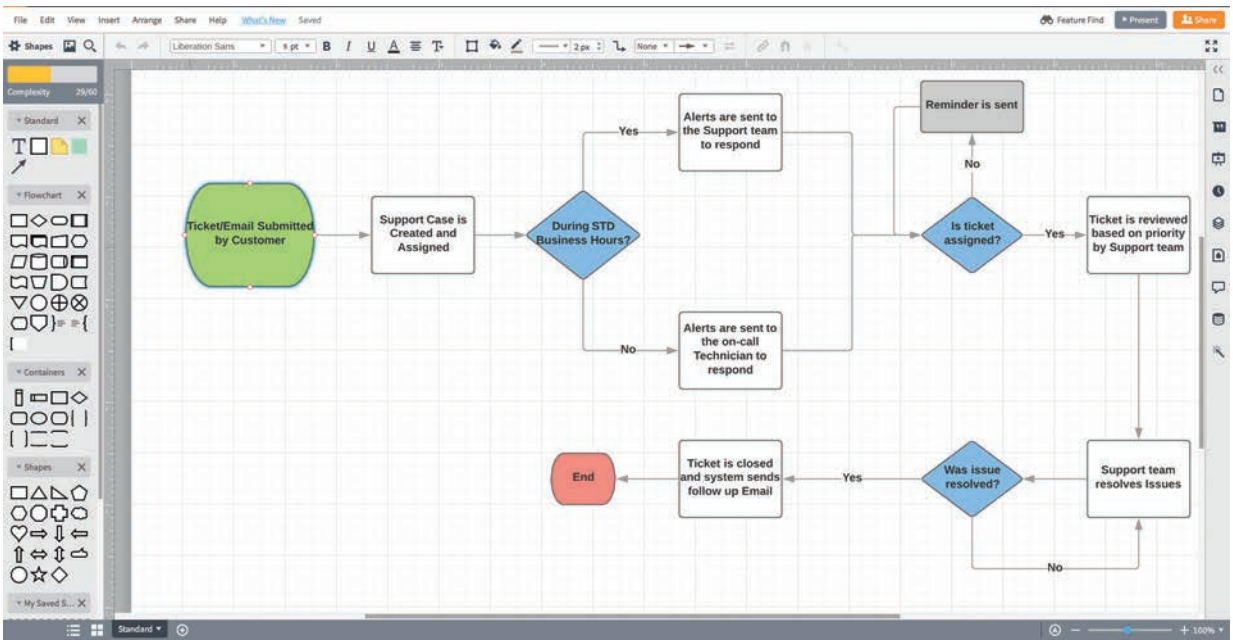


FIGURE 1-9 Lucidchart allows you to drag and drop various symbols and connect them to model a business process.
Source: Lucid Software Inc.

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Systems developers often use multipurpose charting tools such as Lucidchart to display business-related models. Lucidchart is a popular tool that systems analysts can use to create business process diagrams, flowcharts, organization charts, network diagrams, floor plans, project timelines, and workflow diagrams, among others. Figure 1-9 shows how to drag and drop various symbols from the left pane into the drawing on the right and connect them to show a business process.

1.5 Business Information Systems

In the past, IT managers identified an information system based on its primary users. For example, administrative staff used *office systems*, operational people used *operational systems*, middle managers used *decision support systems*, and top managers used *executive information systems*.

Today, those traditional labels no longer apply. For example, all employees, including top managers, use office productivity systems to do their jobs. Similarly, operational users often require decision support systems to do their jobs. As business changes, information use also changes, and now it makes more sense to identify a system by its functions and features, rather than by its users. A new set of system definitions includes enterprise computing systems, transaction processing systems, business support systems, knowledge management systems, user productivity systems, digital assistants, and systems integration.

1.5.1 Enterprise Computing

Enterprise computing refers to information systems that support company-wide operations and data management requirements. Walmart's inventory control system, Boeing's production control system, and Hilton Hotels' reservation system are examples of enterprise computing systems. The main objective of enterprise computing is to integrate a company's primary functions (such as production, sales, services, inventory control, and accounting) to improve efficiency, reduce costs, and help managers make key decisions. Enterprise computing also improves data security and reliability by imposing a company-wide framework for data access and storage.

In many large companies, applications called **enterprise resource planning (ERP)** systems provide cost-effective support for users and managers throughout the company. For example, a car rental company can use ERP to forecast customer demand for rental cars at hundreds of locations. Because of its growth and potential, many hardware and software vendors target the enterprise computing market and offer a wide array of products and services. For example, Figure 1-10 highlights SAP's leading ERP solutions. SAP is a Germany company that is a market leader in enterprise application software.

By providing a company-wide computing environment, many firms have been able to achieve dramatic cost reductions. Other companies have been disappointed in the time, money, and commitment necessary to implement ERP successfully. A potential disadvantage is that ERP systems generally impose an overall structure that might or might not match the way a company operates. ERP is described in more detail in Chapter 7, which discusses development strategies.

1.5.2 Transaction Processing

Transaction processing (TP) systems process data generated by day-to-day business operations. Examples of TP systems include customer order processing, accounts receivable, and warranty claim processing.

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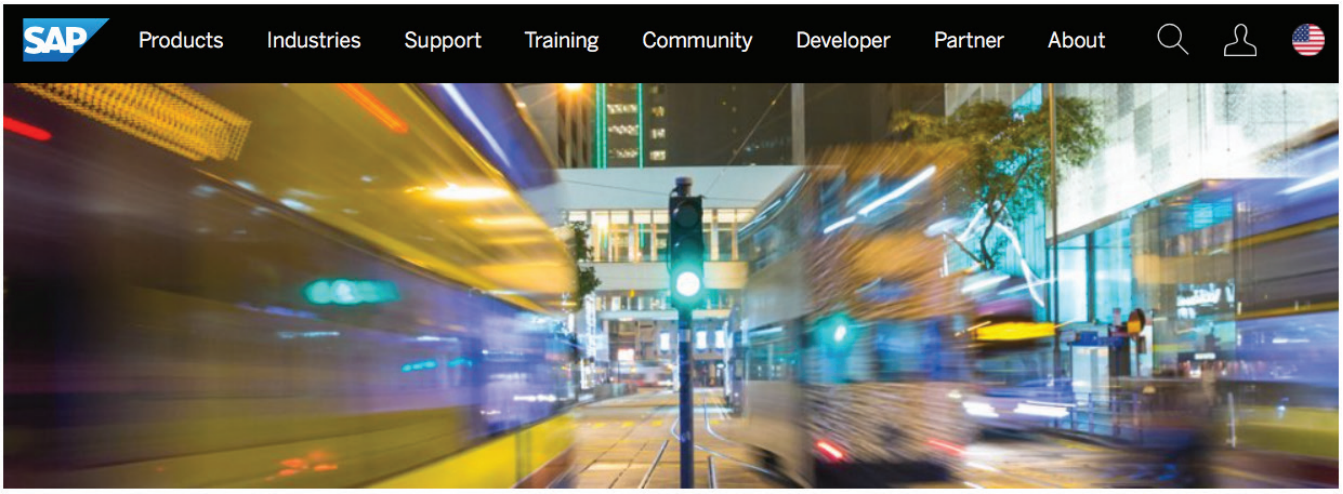


FIGURE 1-10 SAP is a leading vendor of ERP solutions that can boost productivity.
Source: SAP

TP systems perform a series of tasks whenever a specific transaction occurs. In the example shown in Figure 1-11, a TP system verifies the customer's data, checks the customer's credit status, checks the stock status, posts to accounts receivable, adjusts the inventory level, and updates the sales file. TP systems typically involve large amounts of data and are mission-critical systems because the enterprise cannot function without them.

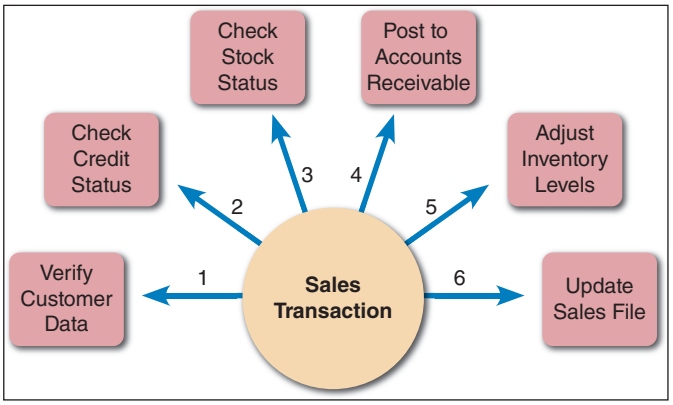


FIGURE 1-11 A single sales transaction consists of six separate tasks, which the TP system processes as a group.

TP systems are efficient because they process a set of transaction-related commands as a group rather than individually. To protect data integrity, however, TP systems ensure that if any single element of a transaction fails, the system does not process the rest of the transaction.

1.5.3 Business Support

Business support systems provide job-related information support to users at all levels of a company. These systems can analyze transactional data, generate information needed to manage and control business processes, and provide information that leads to better decision making.

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The earliest business computer systems replaced manual tasks, such as payroll processing. Companies soon realized that computers also could produce valuable information. The new systems were called **management information systems (MIS)** because managers were the primary users. Today, employees at all levels need information to perform their jobs, and they rely on information systems for that support.

A business support system can work hand in hand with a TP system. For example, when a company sells merchandise to a customer, a TP system records the sale, updates the customer's balance, and makes a deduction from inventory. A related business support system highlights slow- or fast-moving items, customers with past-due balances, and inventory levels that need adjustment.

To compete effectively, firms must collect production, sales, and shipping data and update the company-wide business support system immediately. Automated data acquisition is possible using technology such as **radio frequency identification (RFID)**, which uses high-frequency radio waves to track physical objects, such as the shirt shown in Figure 1-12. Major retailers such as Walmart, which requires its suppliers to add RFID tags to all items, have fueled RFID's dramatic growth by tracking products throughout the retail process.



FIGURE 1-12 With an RFID tag, items can be tracked and monitored throughout the retail process.
Tatchaphol/Shutterstock.com

An important feature of a business support system is decision support capability. Decision support helps users make decisions by creating a computer model and applying a set of variables. For example, a truck fleet dispatcher might run a series of what-if scenarios to determine the impact of increased shipments or bad weather. Alternatively, a retailer might use what-if analysis to determine the price it must charge to increase profits by a specific amount while volume and costs remain unchanged.

1.5.4 Knowledge Management

Knowledge management systems use a large database called a **knowledge base** that allows users to find information by entering keywords or questions in normal English phrases. A knowledge management system uses **inference rules**, which are logical rules that identify data patterns and relationships.

The WolframAlpha website, shown in Figure 1-13, describes itself as a "computational knowledge engine." It has a sophisticated natural language front end that understands user queries in several domains. As shown in the figure, these domains include mathematics, science and technology, society and culture, and everyday life. WolframAlpha relies upon a large knowledge base spanning multiple websites and its own proprietary algorithms to provide users with detailed answers to their questions on many different topics. The results are displayed using a mix of multimedia, including mathematical equations if appropriate.

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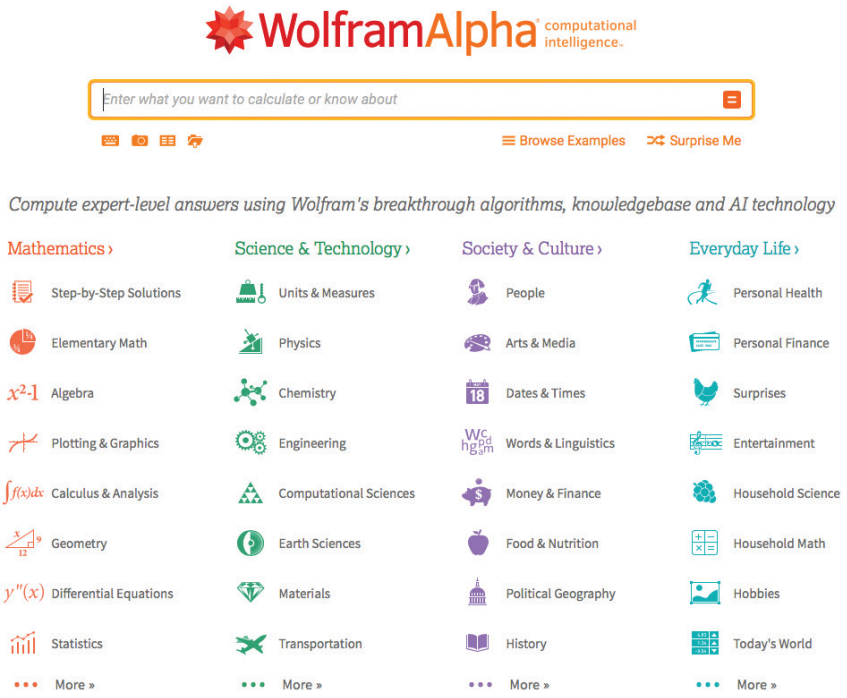


FIGURE 1-13 WolframAlpha describes itself as a "computational knowledge engine."
Source: Wolfram Alpha LLC

1.5.5 User Productivity

Companies provide employees at all levels with technology that improves productivity. Examples of **user productivity systems** include email, voice mail, video and web conferencing, word processing, automated calendars, database management, spreadsheets, desktop publishing, presentation graphics, company intranets, and integrated mobile computing systems. User productivity systems also include **groupware**, which enables users to share data, collaborate on projects, and work in teams. One popular groupware product is Slack, shown in Figure 1-14. Slack provides common app integration and unified communication channels for distributed teams.

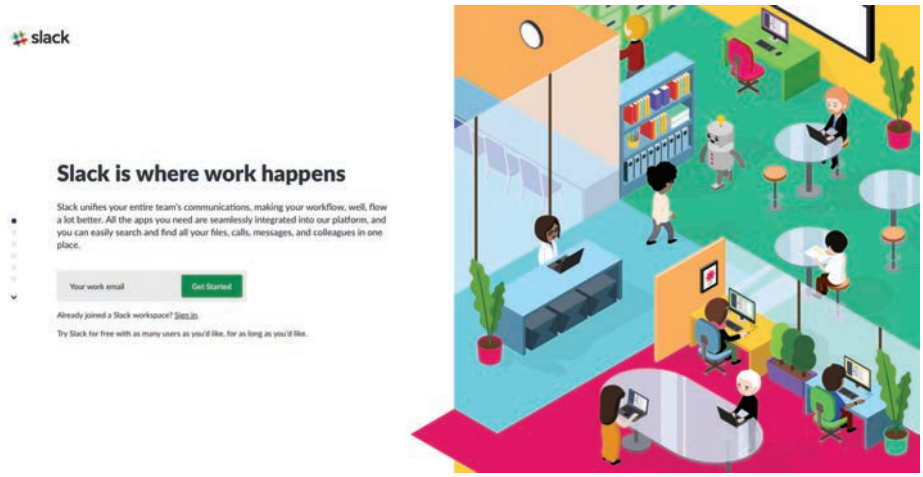


FIGURE 1-14 Slack is a popular groupware application that provides common app integration and unified communication channels for distributed teams.
Source: Slack.com

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When companies first installed word processing systems, managers expected to reduce the number of employees as office efficiency increased. That did not happen, primarily because the basic nature of clerical work changed. With computers performing the repetitive work, office personnel were able to handle tasks that required more judgment, decision making, and access to information.

Computer-based office work expanded rapidly as companies assigned more responsibility to employees at lower organizational levels. Relatively inexpensive hardware, powerful networks, corporate downsizing, and a move toward employee empowerment also contributed to this trend. Today, administrative assistants and company presidents alike are networked, use computer workstations, and share corporate data to perform their jobs.

1.5.6 Digital Assistants

Rapid advances in natural language processing have made a new type of business information system possible: the **personal digital assistant**. These systems are combinations of knowledge management systems and user productivity systems, enhanced with **artificial intelligence** and **machine learning** capabilities. They are typically cloud based and can be embedded in hardware devices of various sizes and types.

Digital assistants are exemplified by products such as Amazon.com's Alexa, Apple's Siri, and Google Assistant. Users speak to these applications just as they would speak to a real person. The device replies in a human-sounding voice. These services increase their capabilities over time. They can integrate with other software applications and actual hardware, such as controlling lights at home or the temperature at the office. An image of the Amazon Echo Dot, which is a smart speaker powered by Alexa, is shown in Figure 1-15.



FIGURE 1-15 Amazon.com's Echo Dot, a digital assistant embedded in a smart speaker powered by Alexa.
Source: Amazon.com, Inc.

1.5.7 Systems Integration

Most large companies require systems that combine transaction processing, business support, knowledge management, and user productivity features. For example, suppose an international customer makes a warranty claim. A customer service representative enters the claim into a TP system, which updates two other systems: a knowledge management system that tracks product problems and warranty activity and a quality control system with decision support capabilities. A quality control engineer uses what-if analysis to determine if the firm should make product design changes to reduce warranty claims. In this example, a TP system is integrated with a knowledge management system and a business support system with decision support features.

CASE IN POINT 1.2: Autonomous Vehicles

Imagine you work for a large automotive company. Your manager asks you to look into integrating a digital assistant into a new vehicle for the next production year. How would understanding your company's business profile help you complete this task?

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1.6 Organizational Information Models

Corporate organizational structure has changed considerably in recent years. In an effort to increase productivity, many companies reduced the number of management levels and delegated responsibility to operational personnel. Although modern organization charts tend to be flatter, an organizational hierarchy still exists in most firms.

1.6.1 Functions and Organizational Levels

A typical organizational model identifies business functions and organizational levels, as shown in Figure 1-16. Within the functional areas, operational personnel report to supervisors and team leaders. The next level includes middle managers and knowledge workers, who, in turn, report to top managers. In a corporate structure, the top managers report to a board of directors elected by the company's shareholders.

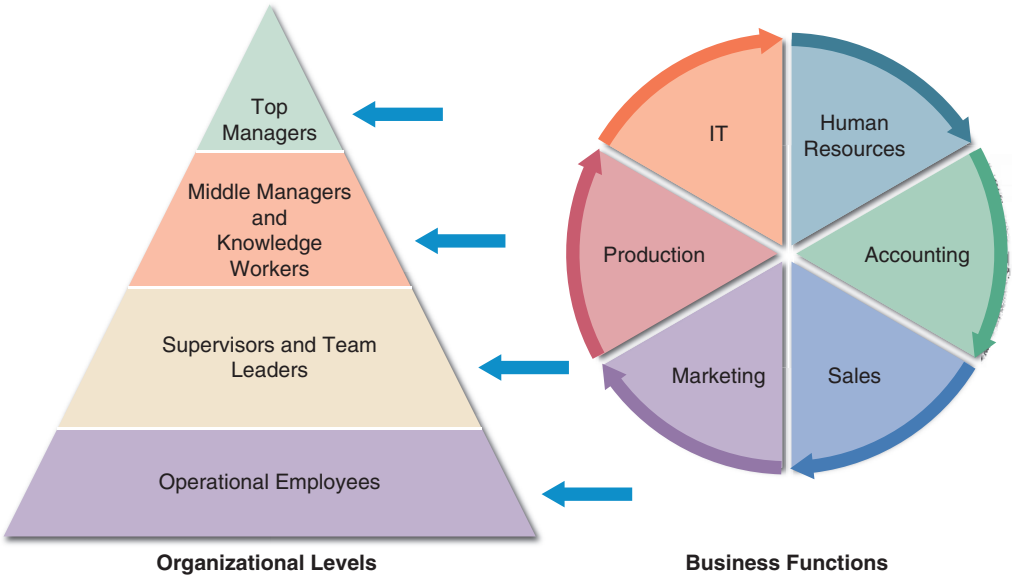


FIGURE 1-16 A typical organizational model identifies business functions and organizational levels.

A systems analyst must understand the company's organizational model to recognize who is responsible for specific processes and decisions and to be aware of what information is required by whom.

1.6.2 Top Managers

Top managers develop long-range plans, called **strategic plans**, which define the company's overall mission and goals. To plot a future course, top managers ask questions such as "How much should the company invest in information technology?", "How much will Internet sales grow in the next five years?", or "Should the company build new factories or contract out production functions?"

Strategic planning affects the company's future survival and growth, including long-term IT plans. Top managers focus on the overall business enterprise and use IT to set the company's course and direction. To develop a strategic plan, top managers also need information from outside the company, such as economic forecasts, technology trends, competitive threats, and governmental issues.

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1.6.3 Middle Managers and Knowledge Workers

Just below the top management level, most companies have a layer of middle managers and knowledge workers. Middle managers provide direction, necessary resources, and performance feedback to supervisors and team leaders. Because they focus on a somewhat shorter time frame, middle managers need more detailed information than top managers but somewhat less than supervisors who oversee day-to-day operations. For example, a middle manager might review a weekly sales summary for a three-state area, whereas a local sales team leader would need a daily report on customer sales at a single location.

In addition to middle managers, every company has people called knowledge workers. Knowledge workers include systems analysts, programmers, accountants, researchers, trainers, human resource specialists, and other professionals. Knowledge workers also use business support systems, knowledge management systems, and user productivity systems. Knowledge workers provide support for the organization's basic functions. Just as a military unit requires logistical support, a successful company needs knowledge workers to carry out its mission.

1.6.4 Supervisors and Team Leaders

Supervisors, often called team leaders, oversee operational employees and carry out day-to-day functions. They coordinate operational tasks and people, make necessary decisions, and ensure that the right tools, materials, and training are available. Like other managers, supervisors and team leaders need decision support information, knowledge management systems, and user productivity systems to carry out their responsibilities.

1.6.5 Operational Employees

Operational employees include users who rely on transaction processing systems to enter and receive data they need to perform their jobs. In many companies, operational users also need information to handle tasks and make decisions that were assigned previously to supervisors. This trend, called **empowerment**, gives employees more responsibility and accountability. Many companies find that empowerment improves employee motivation and increases customer satisfaction.

1.7 Systems Development

Many options exist for developing information systems, but the most popular alternatives are **structured analysis**, which is a traditional method that still is widely used, **object-oriented (O-O) analysis**, which is a more recent approach that many analysts prefer, and **agile methods**, which include the latest trends in software development. Figure 1-17 provides an overview of the three methods, which are discussed in the following sections.

Although most projects utilize one approach, it is not unusual for systems developers to mix and match methods to gain a better perspective. In addition to these three main development methods, some organizations choose to develop their own in-house approaches or use techniques offered by software suppliers, tool vendors, or consultants. Many alternatives exist, and IT experts agree that no single development method is best in all cases. An approach that works well for one project might have disadvantages or risks in another situation. The important thing is to understand the various methods and the strengths and weaknesses of each approach.

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	STRUCTURED ANALYSIS	OBJECT-ORIENTED ANALYSIS	AGILE METHODS
Description	Represents the system in terms of data and the processes that act upon that data. System development is organized into phases, with deliverables and milestones to measure progress. The waterfall model typically consists of five phases: requirements, design, construction, testing, and maintenance & evolution. Iteration is possible among the phases.	Views the system in terms of objects that combine data and processes. The objects represent actual people, things, transactions, and events. Compared to structural analysis, O-O phases tend to be more interactive. Can use the waterfall model or a model that stresses greater iteration.	Stresses intense team-based effort. Breaks development into cycles, or iterations, that add functionality. Each cycle is designed, built, and tested in an ongoing process. Attempts to reduce major risks by incremental steps in short time intervals.
Modeling Tools	Data flow diagrams (DFDs) and process descriptions, which are described in Chapter 5. Also, business process modeling.	Various object-oriented diagrams depict system actors, methods, and messages, which are described in Chapter 6. Also, business process modeling.	Tools that enhance communication, such as collaborative software, brainstorming, and whiteborads. Business process modeling works well with agile methods.
Pros	Traditional method that has been very popular over time. Relies heavily on written documentation. Frequent phase iteration can provide flexibility comparable to other methods. Well-suited to traditional project management tools and techniques.	Integrates easily with object-oriented programming languages. Code is modular and reusable, which can reduce cost and development time. Easy to maintain and expand because new objects can be created using inherited properties.	Very flexible and efficient in dealing with change. Stresses team interaction and reflects a set of community-based values. Frequent deliverables constantly validate the project and reduce risk.
Cons	Changes can be costly, especially in later phases. Requirements are defined early, and can change during development. Users might not be able to describe their needs until they can see examples of features and functions.	Somewhat newer method might be less familiar to development team members. Interaction of objects and classes can be complex in larger systems.	Team members need a high level of technical and communications skills. Lack of structure and documentation can introduce risk factors. Overall project might be subject to scope change as user requirements change.

FIGURE 1-17 Comparison of structured, object-oriented, and agile development methods.

Regardless of the development strategy, people, tasks, timetables, and costs must be managed effectively. Complex projects can involve dozens of people, hundreds of tasks, and many thousands of dollars. **Project management** is the process of planning, scheduling, monitoring, controlling, and reporting upon the development of an information system. Chapter 3 describes project management tools and techniques in detail.

1.7.1 Structured Analysis

Structured analysis is a traditional systems development technique that is time tested and easy to understand. Structured analysis uses a series of phases, called the

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systems development life cycle (SDLC), to plan, analyze, design, implement, and support an information system. Although structured analysis evolved many years ago, it remains a popular systems development method. Structured analysis is based on an overall plan, similar to a blueprint for constructing a building, so it is called a predictive approach.

Structured analysis uses a set of process models to describe a system graphically. Because it focuses on processes that transform data into useful information, structured analysis is called a process-centered technique. In addition to modeling the processes, structured analysis also addresses data organization and structure, relational database design, and user interface issues.

A process model shows the data that flows in and out of system processes. Inside each process, input data is transformed by business rules that generate the output. Figure 1-18 shows a process model that was created with the Visible Analyst CASE tool. The model, which represents a school registration system, is a called a data flow diagram (DFD) because it uses various symbols and shapes to represent data flow, processing, and storage. DFDs are discussed in more detail in Chapter 5.

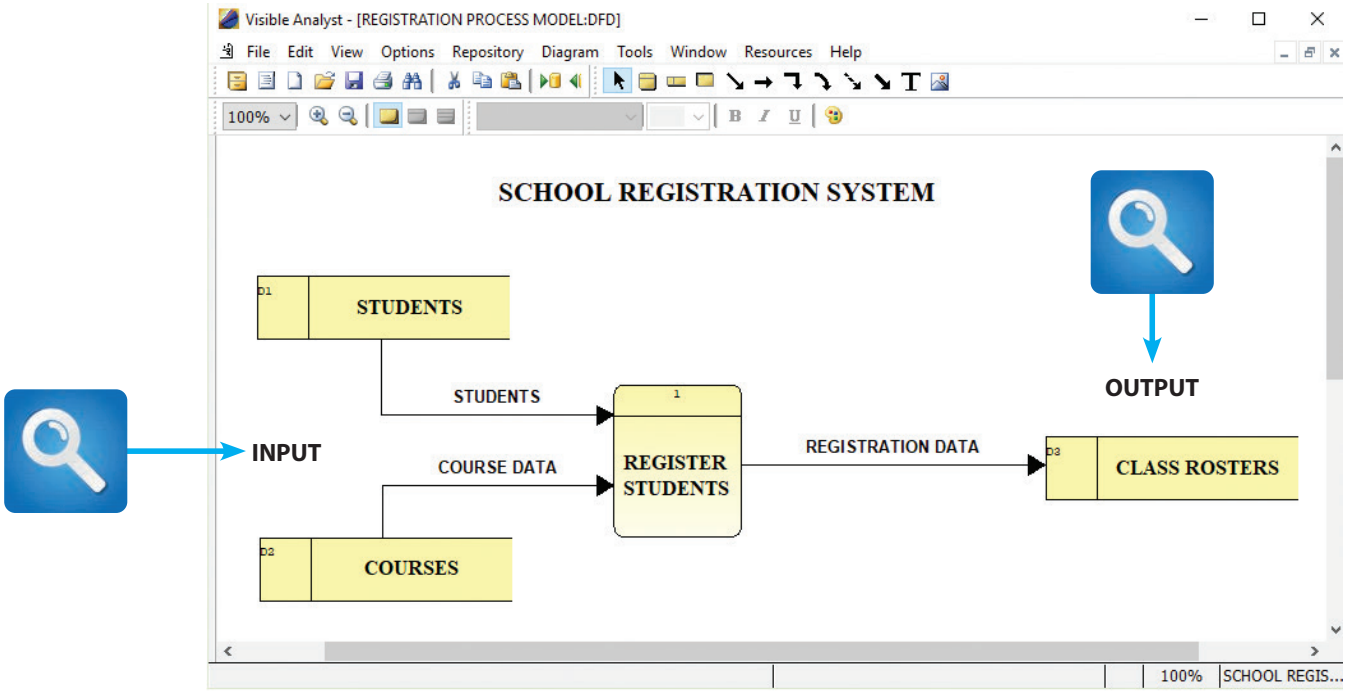


FIGURE 1-18 This Visible Analyst screen shows a process model for a school registration system. The REGISTER STUDENTS process accepts input data from two sources and transforms it into output data.

Source: Visible Systems Corporation

Structured analysis uses the SDLC to plan and manage the systems development process. The SDLC describes activities and functions that all systems developers perform, regardless of which approach they use. In the waterfall model, the result of each phase is called a deliverable, which flows into the next phase.

Some analysts see a disadvantage in the built-in structure of the SDLC because the waterfall model does not emphasize interactivity among the phases. This criticism can be valid if the SDLC phases are followed too rigidly. However, adjacent phases can and do interact, as shown by the circular arrows in Figure 1-19, and interaction among several phases is not uncommon. Used in this manner, the traditional model is not as different from agile methods as it might appear to be.

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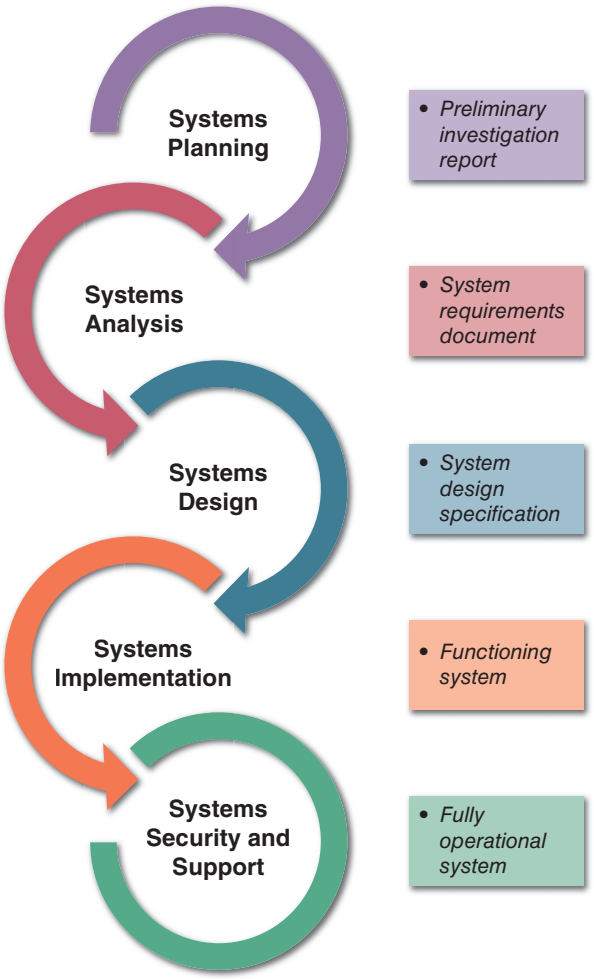


FIGURE 1-19 Development phases and deliverables are shown in the waterfall model. The circular symbols indicate interaction among the phases.

The SDLC model usually includes five steps, which are described in the following sections: systems planning, systems analysis, systems design, systems implementation, and systems support and security.

SYSTEMS PLANNING: The **systems planning phase** usually begins with a formal request to the IT department, called a **systems request**, which describes problems or desired changes in an information system or a business process. In many companies, IT systems planning is an integral part of overall business planning. When managers and users develop their business plans, they usually include IT requirements that generate systems requests. A systems request can come from a top manager, a planning team, a department head, or the IT department itself. The request can be very significant or relatively minor. A major request might involve a new information system or the upgrading of an existing system. In contrast, a minor request might ask for a new feature or a change to the user interface.

The purpose of this phase is to perform a **preliminary investigation** to evaluate an IT-related business opportunity or problem. The preliminary investigation is a critical step because the outcome will affect the entire development process. A key part of the preliminary investigation is a **feasibility study** that reviews anticipated costs and benefits and recommends a course of action based on operational, technical, economic, and time factors.

Suppose a systems analyst receives a request for a system change or improvement. The first step is to determine whether it makes sense to launch a preliminary investigation at all. Before a conclusion can be reached, more information about the business operations may be needed. After an investigation, the systems analyst might determine that the information system functions properly, but users need more training. In some situations, a business process review may be recommended rather than an IT solution. In other cases, a full-scale systems review may be necessary. If the development process continues, the next step is the systems analysis phase.

SYSTEMS ANALYSIS: The purpose of the **systems analysis phase** is to build a logical model of the new system. The first step is **requirements engineering**, where the analyst investigates business processes and documents what the new system must do to satisfy users. Requirements engineering continues the investigation that began during the systems planning phase. To understand the system, fact-finding using techniques such as interviews, surveys, document review, observation, and sampling is performed. The fact-finding results are used to build business models, data and process models, and object models.

The deliverable for the systems analysis phase is the **system requirements document**. The system requirements document describes management and user requirements, costs, and benefits and outlines alternative development strategies.

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SYSTEMS DESIGN: The purpose of the **systems design phase** is to create a physical model that will satisfy all documented requirements for the system. At this stage, the user interface is designed, and necessary outputs, inputs, and processes are identified. In addition, internal and external controls are designed, including computer-based and manual features, to guarantee that the system will be reliable, accurate, maintainable, and secure. During the systems design phase, the application architecture is also determined, which programmers will use to transform the logical design into program modules and code.

The deliverable for this phase is the **system design specification**, which is presented to management and users for review and approval. Management and user involvement are critical to avoid any misunderstanding about what the new system will do, how it will do it, and what it will cost.

SYSTEMS IMPLEMENTATION: During the **systems implementation phase**, the new system is constructed. Whether the developers use structured analysis or O-O methods, the procedure is the same—programs are written, tested, and documented, and the system is installed. If the system was purchased as a package, systems analysts configure the software and perform any necessary modifications. The objective of the systems implementation phase is to deliver a completely functioning and documented information system. At the conclusion of this phase, the system is ready for use. Final preparations include converting data to the new system's files, training users, and performing the actual transition to the new system.

The systems implementation phase also includes an assessment, called a systems evaluation, to determine whether the system operates properly and if costs and benefits are within expectations.

SYSTEMS SUPPORT AND SECURITY: During the **systems support and security phase**, the IT staff maintains, enhances, and protects the system. Maintenance changes correct errors and adapt to changes in the environment, such as new tax rates. Enhancements provide new features and benefits. The objective during this phase is to maximize return on the IT investment. Security controls safeguard the system from both external and internal threats. A well-designed system must be secure, reliable, maintainable, and scalable. A **scalable** design can expand to meet new business requirements and volumes. Information systems development is always a work in progress. Business processes change rapidly, and most information systems need to be updated significantly or replaced after several years of operation. For example, a web-based system may need more servers added to cope with increased workload.

1.7.2 Object-Oriented Analysis

Whereas structured analysis treats processes and data as separate components, object-oriented analysis combines data and the processes that act on the data as **objects**. Systems analysts use O-O to model real-world business processes and operations. The result is a set of software objects that represent actual people, things, transactions, and events. Using an O-O programming language, a programmer then writes the code that creates the objects.

An object is a member of a **class**, which is a collection of similar objects. Objects possess characteristics called **properties**, which the object inherits from its class or possesses on its own. As shown in Figure 1-20, the class called PERSON includes INSTRUCTOR and STUDENT. Because the PERSON class has a property called Address, a STUDENT inherits the Address property. A STUDENT also has a property called Major that is not shared by other members of the PERSON class.

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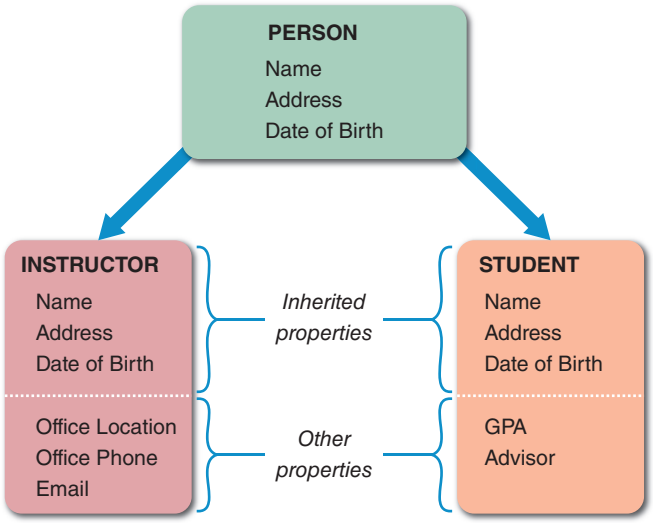


FIGURE 1-20 The PERSON class includes INSTRUCTOR and STUDENT objects, which have inherited properties and their own properties.

In O-O design, built-in processes called *methods* can change an object's properties. For example, in an online catalog store, an ORDER object might have a property called STATUS that changes when a CUSTOMER object clicks to place, confirm, or cancel the order.

One object can send information to another object by using a message. A *message* requests specific behavior or information from another object. For example, an ORDER object might send a message to a CUSTOMER object that requests a shipping address. When it receives the message, the CUSTOMER object supplies the information. The ORDER object has the capability to send the message, and the CUSTOMER object knows what actions to perform when it receives the message. O-O analysis uses object models to represent data and behavior and to show how objects affect other objects. By describing the objects and methods needed to support a business operation, a systems developer can design reusable components that speed up system implementation and reduce development cost.

Object-oriented methods usually follow a series of analysis and design phases that are similar to the SDLC, although there is less agreement on the number of phases and their names. In an O-O model, the phases tend to be more interactive. Figure 1-21 shows an O-O development model where planning, analysis, and design tasks interact to produce prototypes that can be tested and implemented. The result is an interactive model that can accurately depict real-world business processes.

O-O methodology is popular because it provides an easy transition to O-O programming languages such as C++, Java, and Swift. Chapter 6 covers O-O analysis and design, with a detailed description of O-O terms, concepts, tools, and techniques.

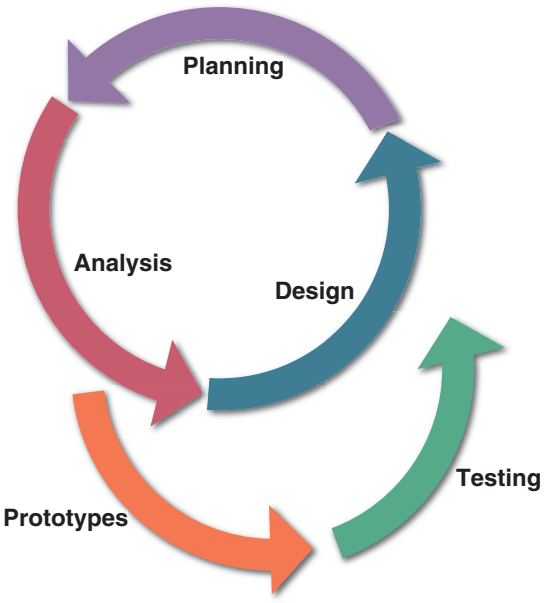


FIGURE 1-21 In a typical O-O development model, planning, analysis, and design tasks interact continuously to generate prototypes that can be tested.

1.7.3 Agile Methods

Development techniques change over time. For example, structured analysis is a traditional approach, and agile methods are the newest development. Structured analysis builds an overall plan for the information system, just as a contractor might use a blueprint for constructing a building. Agile methods, in contrast, attempt to develop a system incrementally by building a series of prototypes and constantly adjusting them to user requirements. As the agile process continues, developers revise, extend, and merge earlier versions into the final product. An agile approach emphasizes continuous feedback, and each incremental step is affected by what was learned in the prior steps.

Although relatively new to software development, the notion of **iterative** development can be traced back to Japanese auto firms that were able to boost productivity by using a flexible manufacturing system, where team-based effort and short-term milestones helped keep quality up and costs down. Agile methods have attracted a wide following and an entire community of users, as shown in Figure 1-22.

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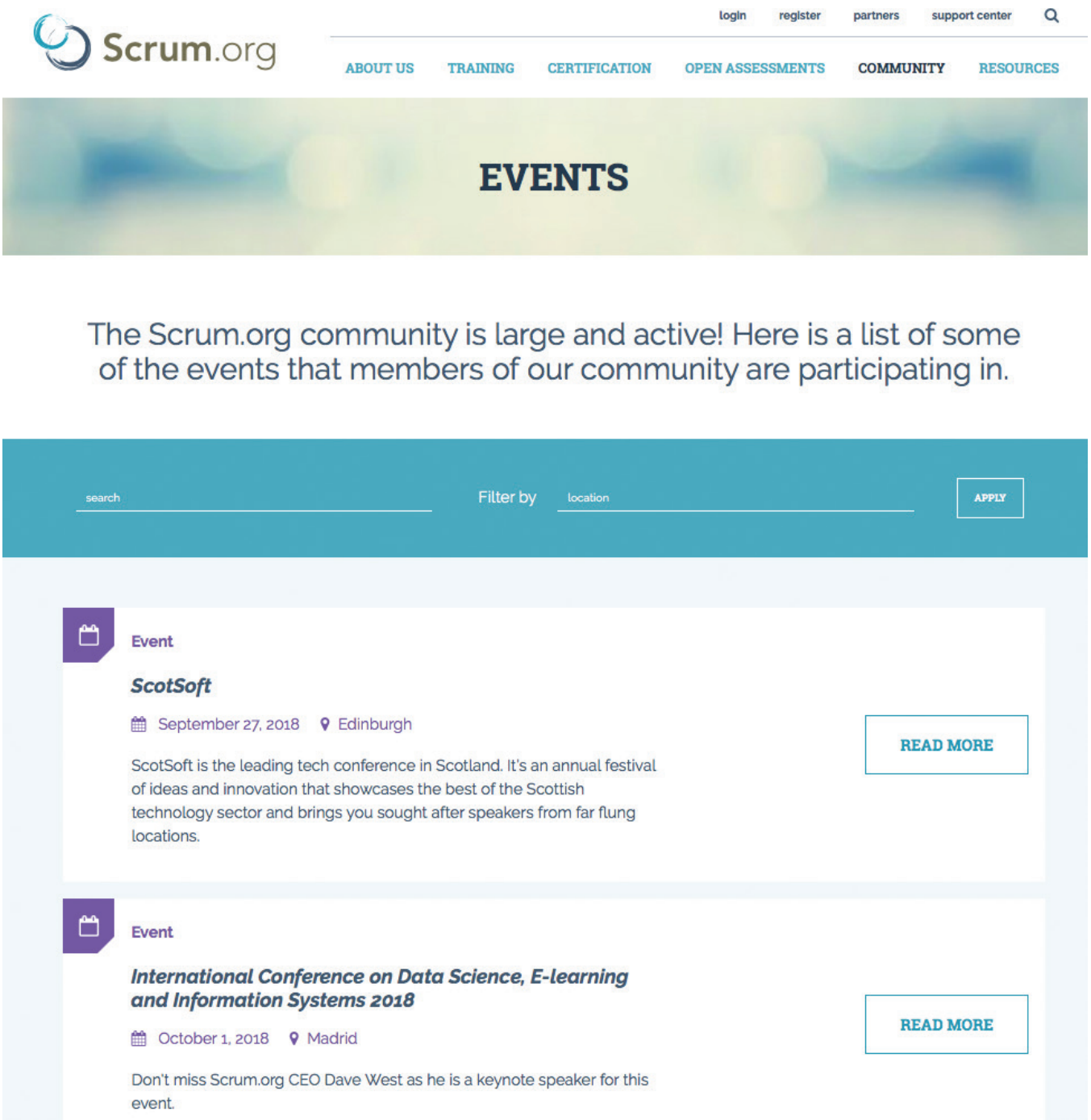


FIGURE 1-22 Scrum.org is a popular website supporting the agile community.
Source: Scrum.org

Agile methods typically use a **spiral model**, which represents a series of iterations, or revisions, based on user feedback. As the process continues, the final product gradually evolves. An agile approach requires intense interactivity between developers and individual users and does not begin with an overall objective. Instead, the agile process determines the end result. Proponents of the spiral model believe that this approach reduces risks and speeds up software development.

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Barry Boehm, a noted software engineering professor, initially suggested spiral models in the 1990s. He stated that each iteration, or phase, of the model must have a specific goal that is accepted, rejected, or changed by the user or client. Thus, each iteration produces feedback and enhancements, which enable the team to reach the overall project goal. Typically, each iteration in a spiral model includes planning, risk analysis, engineering, and evaluation. The repeated iterations produce a series of prototypes, which evolve into the finished system. Notice that these phases resemble SDLC tasks, which also can be iterative.

Numerous other adaptive variations and related methods exist, and most IT developers expect this trend to continue in the future. Two examples are Scrum, which is discussed in Chapter 4, and Extreme Programming (XP), which is discussed in Chapter 11.

Although agile methods are becoming popular, analysts should recognize that these approaches have advantages and disadvantages. By their nature, agile methods can allow developers to be much more flexible and responsive but can be riskier than more traditional methods. For example, without a detailed set of system requirements, certain features requested by some users might not be consistent with the company's larger game plan.

Other potential disadvantages of agile methods can include weak documentation, blurred lines of accountability, and too little emphasis on the larger business picture. Also, unless properly implemented, a long series of iterations might actually add to project cost and development time. The bottom line is that systems analysts should understand the pros and cons of any approach before selecting a development method for a specific project.

1.7.4 Prototyping

Structured analysis, object-oriented analysis, and agile methods can all employ prototyping as a supporting systems development method. Prototyping tests system concepts and provides an opportunity to examine input, output, and user interfaces before final decisions are made. A **prototype** is an early working version of an information system. Just as an aircraft manufacturer tests a new design in a wind tunnel, systems analysts construct and study information system prototypes. A prototype can serve as an initial model that is used as a benchmark to evaluate the finished system, or the prototype itself can develop into the final version of the system. Either way, prototyping speeds up the development process significantly.

A possible disadvantage of prototyping is that important decisions might be made too early, before business or IT issues are understood thoroughly. A prototype based on careful fact-finding and modeling techniques, however, can be an extremely valuable tool.

1.7.5 Tools

All systems development methods must be supported by tools to enable the systems analyst to develop, manage, and maintain large-scale information systems. These tools go by various names, including **application lifecycle management (ALM)**, also called **product lifecycle management (PLM)**; **integrated development environments (IDE)**; and **computer-aided systems engineering (CASE)**, also called **computer-aided software engineering**. **CASE tools** provide an overall framework for systems development and support a wide variety of design methodologies, including structured analysis and object-oriented analysis.

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Tools make it easier to build an information system, thereby boosting IT productivity and improving the quality of the finished product. After developing a model, many CASE tools can generate program code, which speeds the implementation process. Figure 1-23 shows the website for Polarion, an ALM solution from Siemens that is part of their larger suite of offerings. Figure 1-24 shows the website for Microsoft Visual Studio, a leading IDE. Figure 1-25 shows the website for Cameo Systems Modeler, a leading MBSE CASE tool.

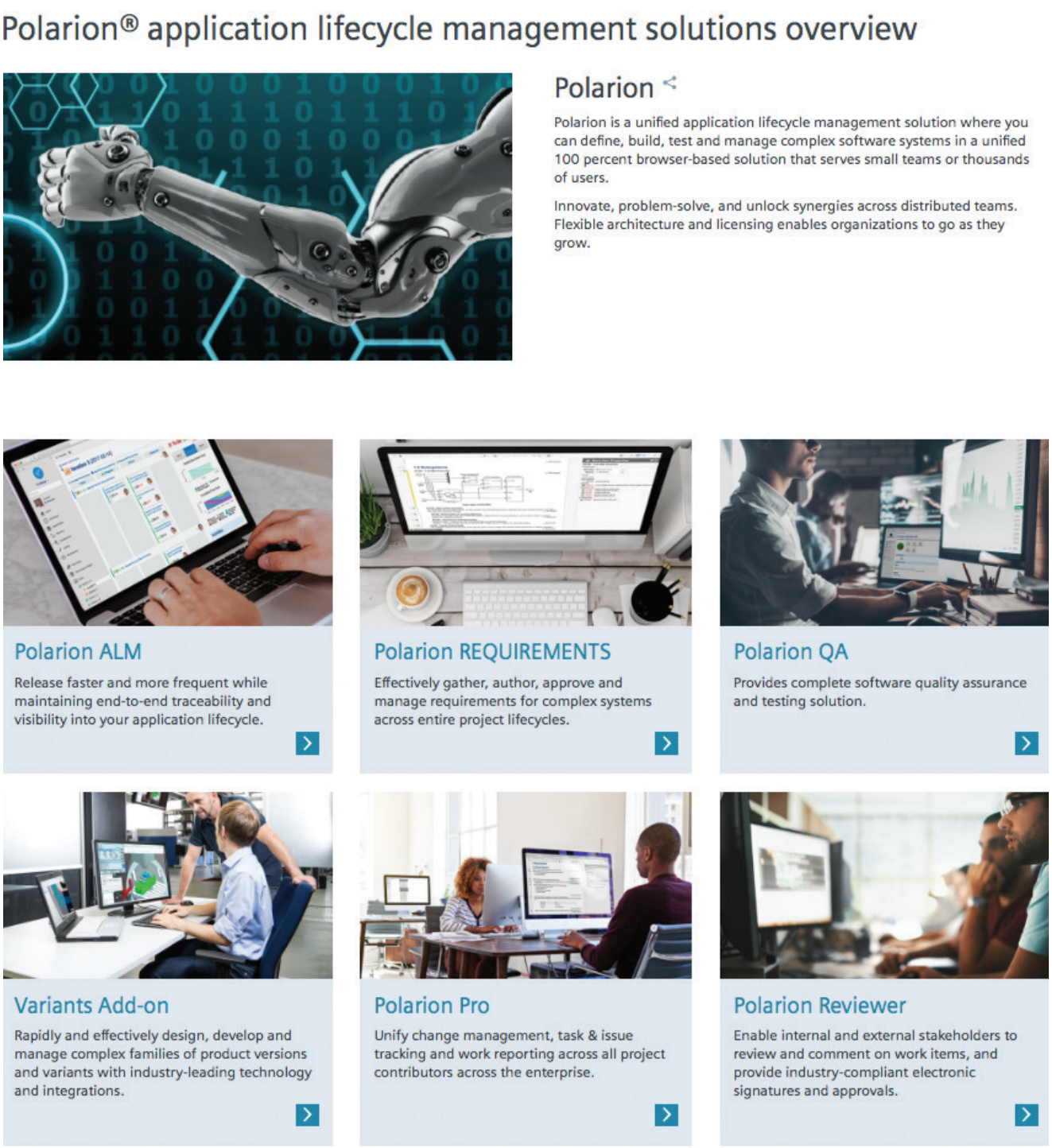


FIGURE 1-23 Polarion is a unified application lifecycle management (ALM) solution from Siemens.

Source: Siemens Product Lifecycle Management Software Inc.

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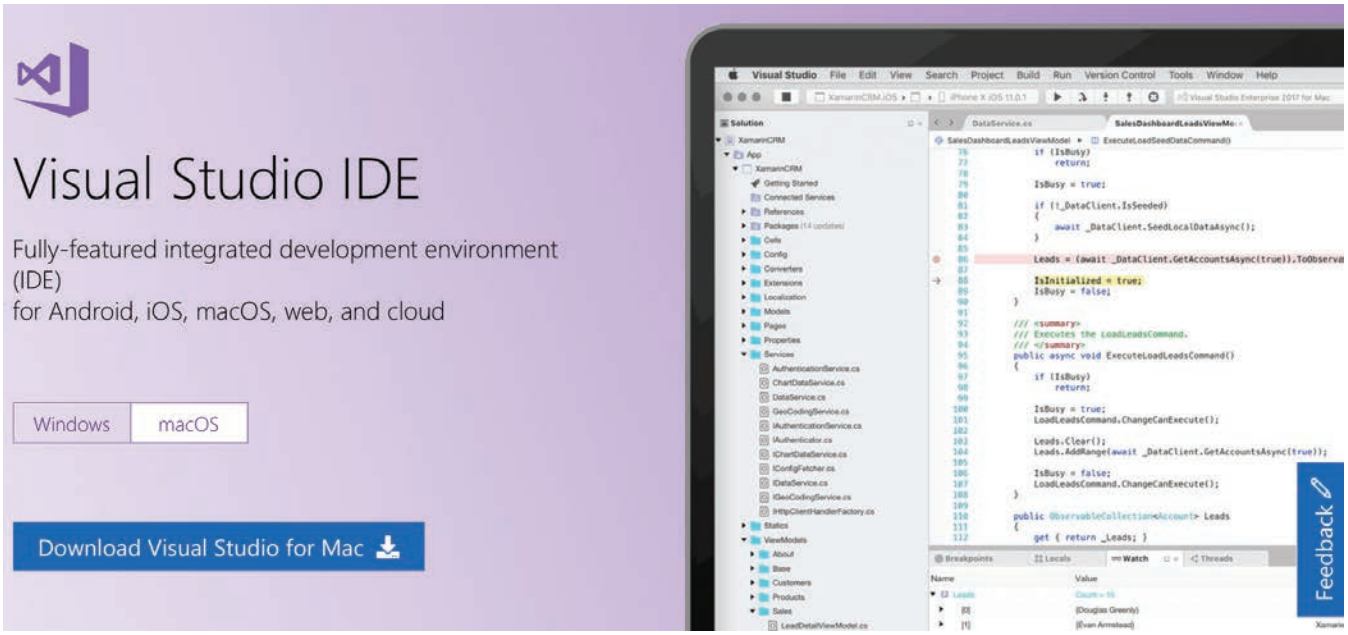


FIGURE 1-24 Microsoft Visual Studio is a fully-featured integrated development environment (IDE).
Source: Microsoft Corporation

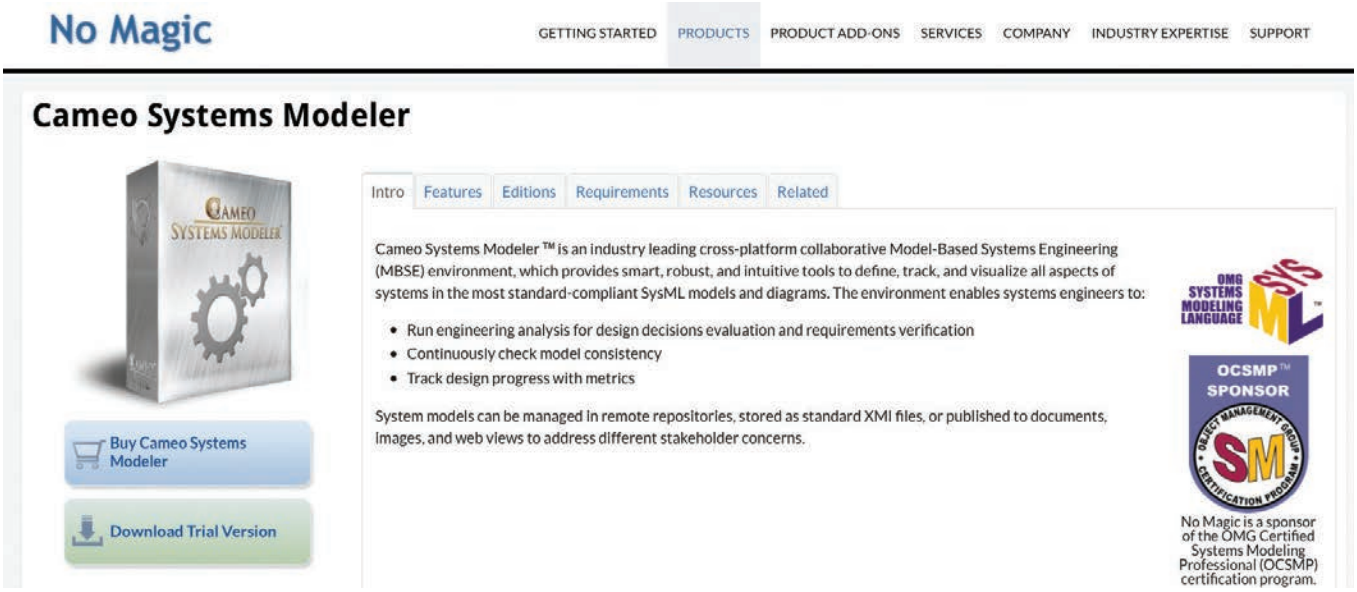


FIGURE 1-25 Cameo Systems Modeler is a cross-platform collaborative Model-Based Systems Engineering (MBSE) environment.
Source: No Magic, Inc.

1.8 The Information Technology Department

The IT department develops and maintains information systems. The IT group provides **technical support**, which includes seven main functions: application development, systems support and security, user support, database administration, network administration, web support, and quality assurance. These functions overlap considerably and often have different names in different companies.

The structure of the IT department varies among companies, as does its name and placement within the organization. In a small firm, one person might handle

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all computer support activities and services, whereas a large corporation might require many people with specialized skills to provide information systems support. Figure 1-26 shows a typical IT organization in a company that has networked PCs, enterprise-wide databases, centralized processing, and web-based operations.

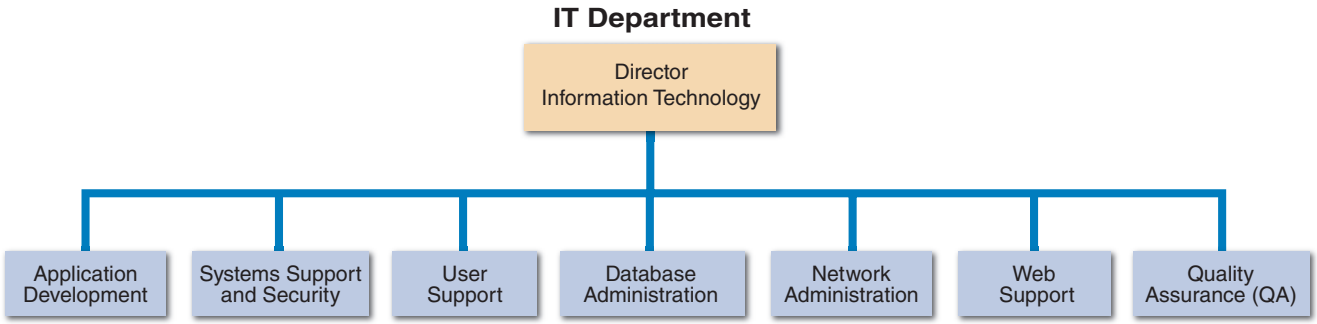


FIGURE 1-26 Depending on its size, an IT department might have separate organization units for these functions, or they might be combined into a smaller number of teams.

1.8.1 Application Development

The IT application development group typically provides leadership and overall guidance, but teams consisting of users, managers, and IT staff members develop the systems themselves. A popular model for information systems development is a project-oriented team with IT professionals providing overall coordination, guidance, and technical support.

CASE IN POINT 1.3: Global Hotels and Momma's Motels

Suppose you work in the IT department of Global Hotels, a multinational hotel chain. Global Hotels runs several specialized business support systems, including a guest reservations system that was developed in-house to meet the requirements of a large company with worldwide operations. Guests can make one-stop online reservations by visiting Global's website, which has links to all major travel industry sites.

Global Hotels just acquired Momma's, a regional chain of 20 motels. Momma's uses a vertical reservations package suitable for small- to medium-sized businesses and a generic accounting and finance package. Should Momma's use Global Hotels' information systems or continue with its own? In your answer, consider issues such as business profiles, business processes, system interactivity, and e-commerce. What additional information would be helpful to you in making a recommendation?

1.8.2 Systems Support and Security

Systems support and security provides vital protection and maintenance services for system hardware and software, including enterprise computing systems, networks, transaction processing systems, and corporate IT infrastructure. The systems support and security group implements and monitors physical and electronic security hardware, software, and procedures. This group also installs and supports operating systems, telecommunications software, and centralized database management systems. In addition, systems support and security technicians provide technical assistance to other groups in the IT department. If a site has a large number of remote clients, the systems support group often includes a deployment team that installs and configures the workstations.

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1.8.3 User Support

User support provides users with technical information, training, and productivity support. The user support function usually is called a **help desk**. A help desk's staff trains users and managers on application software such as email, word processing, spreadsheets, and graphics packages. User support specialists answer questions, troubleshoot problems, and serve as a clearinghouse for user problems and solutions.

1.8.4 Database Administration

Database administration involves data design, management, security, backup, and access. In small- and medium-sized companies, an IT support person performs those roles in addition to other duties. Regardless of company size, mission-critical database applications require continuous attention and technical support.

1.8.5 Network Administration

Business operations depend on networks that enable company-wide information systems. Network administration includes hardware and software maintenance, support, and security. In addition to controlling user access, network administrators install, configure, manage, monitor, and maintain network applications. Network administration is discussed in more detail in Chapter 10.

1.8.6 Web Support

Web support is a vital technical support function. Web support specialists design and construct web pages, monitor traffic, manage hardware and software, and link web-based applications to the company's information systems. Reliable, high-quality web support is especially critical for companies engaged in e-commerce.

1.8.7 Quality Assurance (QA)

Many large IT departments also use a quality assurance (QA) team that reviews and tests all applications and systems changes to verify specifications and software quality standards. The QA team usually is a separate unit that reports directly to IT management.

1.9 The Systems Analyst

A systems analyst investigates, analyzes, designs, develops, installs, evaluates, and maintains a company's information systems. To perform those tasks, a systems analyst constantly interacts with users and managers within and outside the company. The following sections describe a systems analyst's role, knowledge, skills, education, certifications, and career opportunities.

1.9.1 Role

A systems analyst helps develop IT systems that support business requirements. To succeed, analysts often must act as translators. For example, when they describe business processes to programmers, they must speak a language that programmers will understand clearly. Typically, the analyst builds a series of models, diagrams, and decision tables and uses other descriptive tools and techniques. Similarly, when

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communicating with managers, the analyst often must translate complex technical issues into words and images that nontechnical people can grasp. To do this, the analyst uses various presentation skills, models, and communication methods.

Analysts are often the company's best line of defense against an IT disaster—a system that is technically sound but fails because it does not meet the needs of users and managers. When this occurs, poor communication is usually to blame. For an analyst, the most valuable skill is the ability to listen. An effective analyst will involve users in every step of the development process and listen carefully to what they have to say. As the process continues, the analyst will seek feedback and comments from the users. This input can provide a valuable early warning system for projects that might otherwise go off the track.

1.9.2 Knowledge, Skills, and Education

A successful systems analyst needs technical knowledge, oral and written communication skills, an understanding of business operations, and critical thinking skills. Educational requirements vary widely depending on the company and the position. In a rapidly changing IT marketplace, a systems analyst must manage his or her own career and have a plan for professional development.

TECHNICAL KNOWLEDGE: State-of-the-art knowledge is extremely important in a rapidly changing business and technical environment. The Internet offers numerous opportunities to update technical knowledge and skills. Many IT professionals go online to learn about technical developments, exchange experiences, and get answers to questions. For example, the International Council on Systems Engineering (INCOSE), shown in Figure 1-27, is one of the leading organizations offering systems analysts a wealth of information, news, training, support communities, and more. Analysts also maintain their skills by attending training courses, both



FIGURE 1-27 INCOSE is one of the leading organizations offering systems analysts a wealth of information, news, training, communities, and more.

Source: INCOSE - International Council on Systems Engineering

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on-site and online. Networking with colleagues is another way to keep up with new developments, and membership in professional associations also is important.

COMMUNICATION SKILLS: A systems analyst needs strong oral and written communication skills and the ability to interact with people at all levels, from operational staff to senior executives. Often, the analyst must work with people outside the company, such as software and hardware vendors, customers, and government officials. Analysts often coordinate IT project teams, where they use communication skills to guide and motivate team members.

BUSINESS SKILLS: A systems analyst works closely with managers, supervisors, and operational employees. To be effective, he or she must understand business operations and processes, communicate clearly, and translate business needs into requirements that can be understood by programmers and systems developers. A successful analyst is business-oriented, curious, comfortable with financial tools, and able to see the big picture. Chapter 2 describes some basic concepts, including strategic planning, SWOT analysis, and feasibility tests.

CRITICAL THINKING SKILLS: Most educators agree that **critical thinking skills** include the ability to compare, classify, evaluate, recognize patterns, analyze cause and effect, and apply logic. Critical thinkers often use a *what-if* approach, and they have the ability to evaluate their own thinking and reasoning.

Critical thinking skills are valuable in the IT industry, where employers seek job candidates who can demonstrate these skills and bring them to the workplace. Figure 1-28 shows the website for Critical Thinking Community, a nonprofit organization that provides encouragement and resources for critical thinkers.

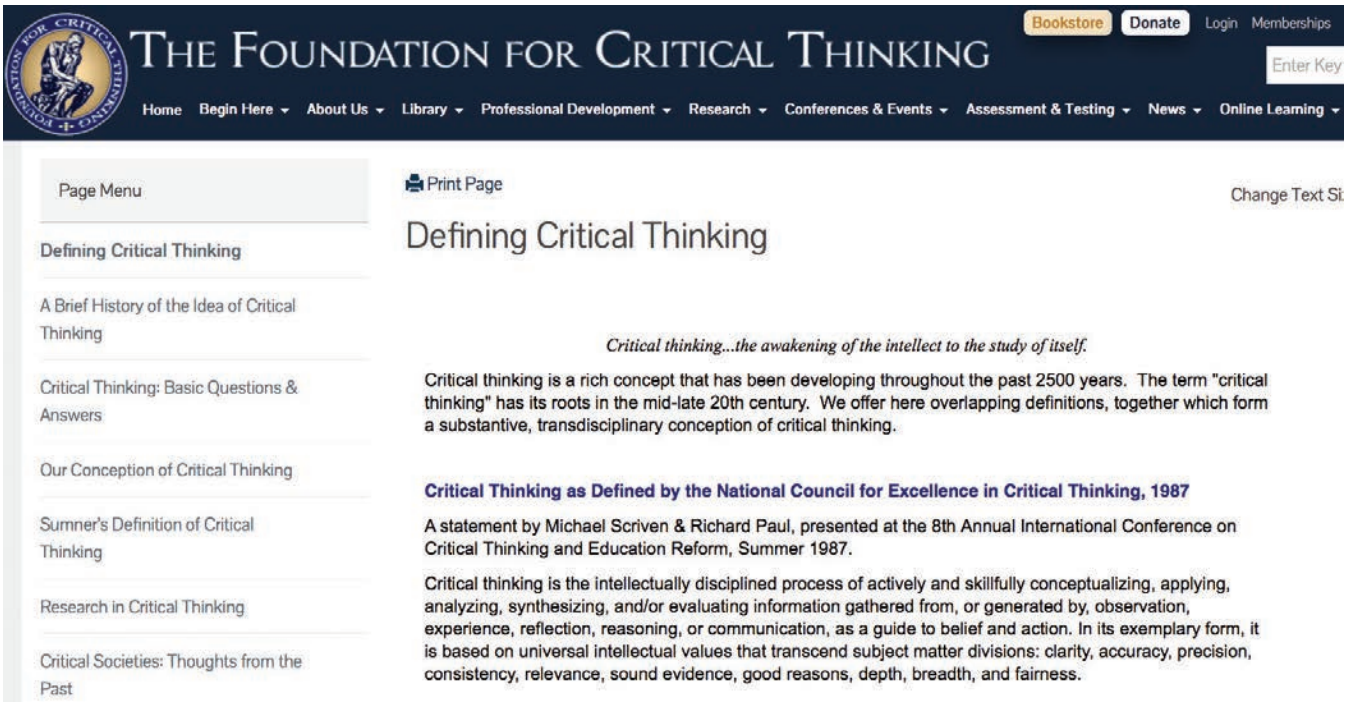


FIGURE 1-28 The Critical Thinking Community is a nonprofit organization that provides encouragement and resources for critical thinkers.
Source: Foundation for Critical Thinking

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EDUCATION: Companies typically require systems analysts to have a college degree in information systems, computer science, or business, and some IT experience usually is required. For higher-level positions, many companies require an advanced degree. Sometimes, educational requirements can be waived if a candidate has significant experience, skills, or professional certifications.

1.9.3 Certification

Many hardware and software companies offer certification for IT professionals. Certification verifies that an individual demonstrated a certain level of knowledge and skill on a standardized test. Certification is an excellent way for IT professionals to learn new skills and gain recognition for their efforts. Although certification does not guarantee competence or ability, many companies regard certification as an important credential for hiring or promotion. Certification is discussed in more detail in Chapter 12.

In addition to traditional hardware and software certifications, some firms are exploring ways to assess critical thinking skills, as shown in Figure 1-29. These skills include perception, organization, analysis, problem solving, and decision making. Whether or not formal certification is involved, these skills are extremely valuable to IT professionals and the employers who hire them.

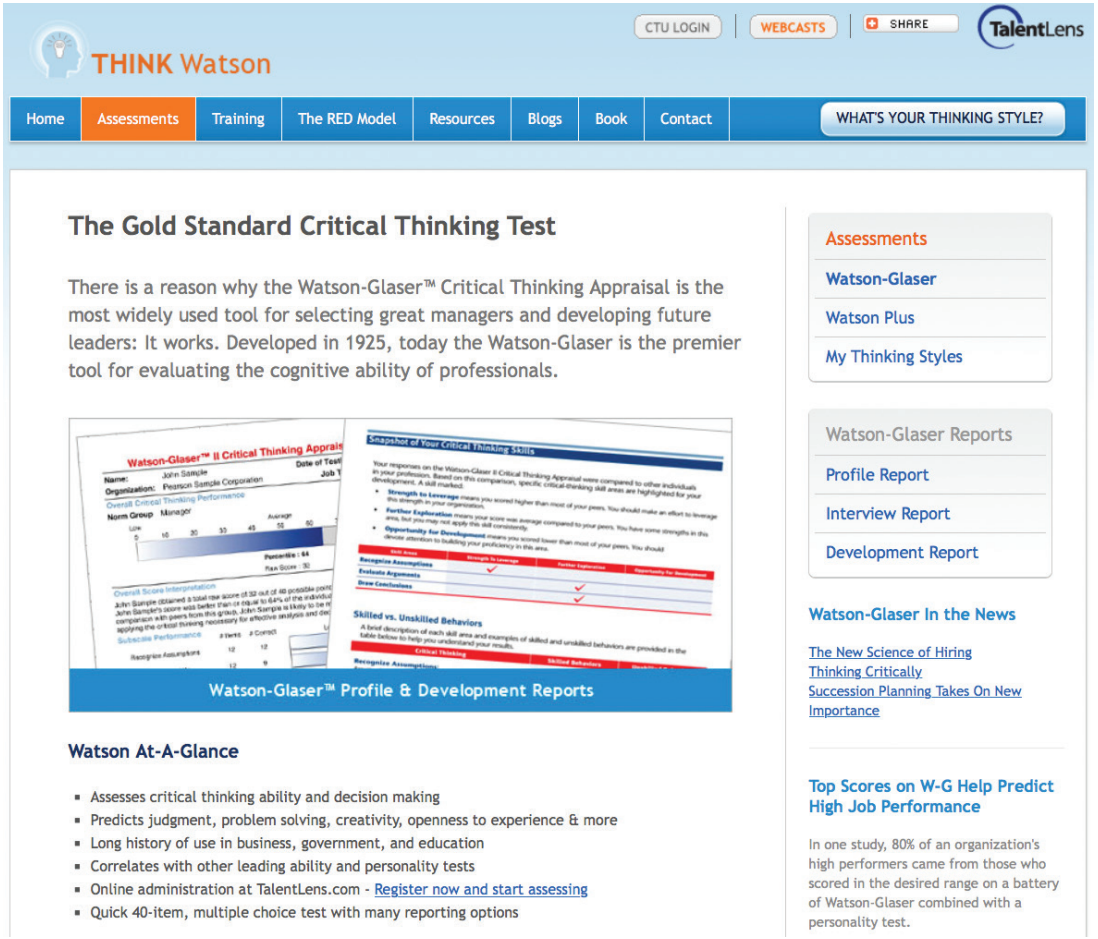


FIGURE 1-29 Employers like to hire people who can think logically and effectively.
Source: Pearson Education

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1.9.4 Career Opportunities

The demand for systems analysts is expected to remain strong. Companies will need systems analysts to apply new information technology, and the explosion in e-commerce will fuel IT job growth. The systems analyst position is a challenging and rewarding one that can lead to a top management position. With an understanding of technical and business issues, a systems analyst has an unlimited horizon. Many companies have presidents and senior managers who started in IT departments as systems analysts.

The responsibilities of a systems analyst at a small firm are different from those at a large corporation. Working at a small or large company is a matter of personal choice.

JOB TITLES: First, do not rely on job titles alone. Some positions are called systems analysts but involve only programming or technical support. In other cases, systems analyst responsibilities are found in positions titled computer specialist, programmer, programmer/analyst, systems designer, software engineer, and various others. Be sure the responsibilities of the job are stated clearly when considering a position.

COMPANY ORGANIZATION: Find out everything about the company and where the IT department fits in the organization chart: Where are IT functions performed, and by whom? A firm might have a central IT group but decentralize the systems development function. This situation sometimes occurs in large conglomerates, where the parent company consolidates information that actually is developed and managed at the subsidiary level.

COMPANY SIZE: A smaller firm might provide more variety. However, a larger company with state-of-the-art systems provides opportunities for specialization. Although there might be more responsibility in a smaller company, the promotional opportunities and financial rewards could be greater in larger companies. Working as an independent consultant is also an option. Many consulting firms have been successful in offering their services to smaller business enterprises that do not have the expertise to handle systems development on their own.

SALARY, LOCATION, AND FUTURE GROWTH: Finally, consider salary, location, and the company's prospects for future growth and success. Initial impressions from employment interviews with the company and its people are important. Most importantly, review short- and long-term goals very carefully before deciding which position is most suitable.

CORPORATE CULTURE: In addition to having goals, methods, and information systems requirements, every firm has an underlying **corporate culture**. A corporate culture is the set of beliefs, rules, traditions, values, and attitudes that define a company and influence its way of doing business. To be successful, a systems analyst must understand the corporate culture and how it affects the way information is managed. Companies sometimes include statements about corporate culture in their mission statements, which are explained in Chapter 2.

A systems analyst must understand the firm's culture and find it comfortable. If the company encourages personal growth and empowerment, work is much more enjoyable. For example, consider the Salesforce corporate culture described in Figure 1-30. A company like Salesforce is likely to attract, retain, and motivate the best and brightest people. In fact, Salesforce ranked #1 in Fortune's 21st annual list of the country's greatest places to work.

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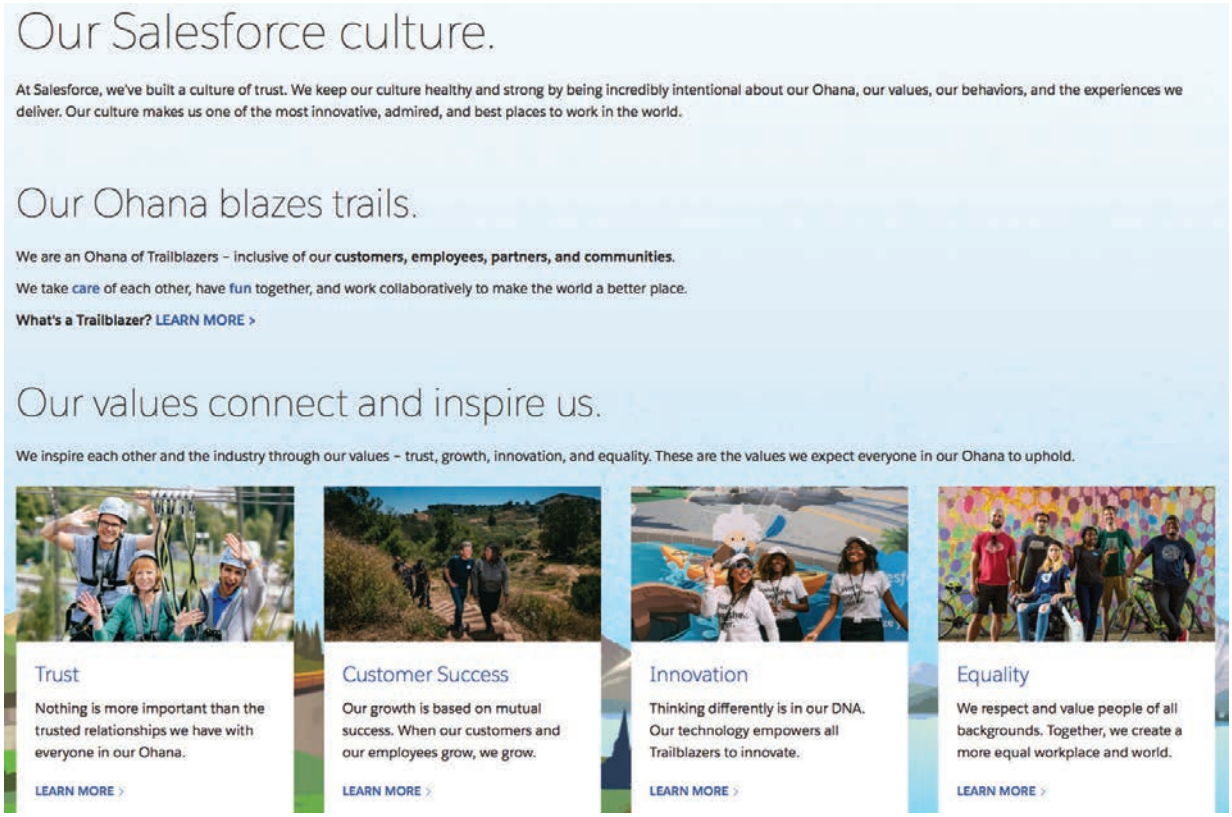


FIGURE 1-30 A corporate culture like Salesforce is likely to attract, retain, and motivate the best and brightest people.
Source: salesforce.com, inc.

1.9.5 Trends in Information Technology

Systems analysts need to track trends in information technology because technological changes affect business operations, career opportunities, and enterprise strategies. Very few areas evolve as fast as information technology. Each year sees evolutionary developments in current technology, such as faster processors, wider network bandwidth, and increased storage capabilities. Once in a while, a truly transformative change occurs, such as the injection of artificial intelligence applications across the enterprise or a revolution in the basic tenets of computation with the nascent introduction of quantum computing.

Some of the key trends that are disrupting information technology include agile methods, artificial cloud computing, data science, mobile devices, service orientation, and social media networks. These trends can affect education and training needs, give rise to new certifications, and open lucrative career opportunities.

Agile methods have already been discussed in this chapter and are covered in more detail later in the book. The agile movement is a significant trend in information technology that all systems analysts should follow. It started as a response to the heavyweight process models and was initially used for smaller teams, but interest in agile methods has grown to encompass almost all application areas and business organizations.

Cloud computing is in many ways a return to the past: a model of shared computing and data storage resources accessed from remote clients, rather like the mainframe era. However, cloud computing is different in that it offers virtualized resources that can grow to accommodate increased requirements as needed. It's also different in

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that buying capacity on demand from a thriving vendor marketplace can reduce the capital costs needed for in-house computing infrastructure. It also presents additional security needs to address.

If cloud computing represents the computational aspect of processing, **data science** represents the data aspect. The world is producing more and more data at an incredible rate. New tools and techniques are being developed to manage these large datasets. Areas such as machine learning and predictive analytics are experiencing tremendous growth as companies try to apply artificial intelligence techniques to the problem of big data. As depicted in Figure 1-31, many of the developments related to big data are driving trends in information technology—trends the systems analyst must follow to stay current.



FIGURE 1-31 Big data is driving many new developments in information technology.
Rafal Olechowski/Shutterstock.com

Mobile devices and the app ecosystem that goes with them are a revolutionary development in information technology. The shift of computing capabilities to "the edge" of the network has put unprecedented power in the hands of end users. Smartphones are the most common computing device on the planet, and systems analysts will need to know about the role of apps and the effect of the **bring your own device (BYOD)** movement in the enterprise.

Traditionally, IT companies were identified as product-oriented or service-oriented. **Product-oriented** firms manufactured computers, routers, or microchips, while **service-oriented** companies included consultants, vendors, software developers, and service providers. Today, those distinctions are gone. Most successful IT companies offer a mix of products, services, and support. Value-added services such as consulting, software, and technical support often are more profitable than hardware sales.

Social media rides on some of the trends mentioned earlier, such as cloud computing, data science, mobile devices, and service orientation. However, social media has had arguably the most profound influence on society. Witness the popularity of Facebook, with over 2 billion users worldwide. Companies tap into the power of social media, coupled with location-aware apps, to create truly innovative solutions that are changing the face of information technology.

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A QUESTION OF ETHICS



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You are enjoying your job as a summer intern in the IT department of a local company. At lunch yesterday, several people were discussing ethical issues. You learned that some of them belong to IT organizations that have ethical codes to guide members and set professional standards. For example, your supervisor belongs to the Association for Computing Machinery (ACM), which has over 100,000 members from more than 100 countries and a website at *acm.org*. Your supervisor said that the ACM code of ethics is important to her and would definitely influence her views. On the other hand, one of the senior programmers believes that his own personal standards would be sufficient to guide him if ethical questions were to arise.

Because you are excited about your career as an IT professional, you decide to visit ACM's website to examine the code of ethics and make up your own mind. After you do so, would you tend to agree more with your supervisor or with the senior programmer?

1.10 Summary

Information technology (IT) refers to the combination of hardware, software, and services that people use to manage, communicate, and share information. Technology is changing rapidly, and IT professionals must prepare for the future. IT supports business operations, improves productivity, and helps managers make decisions. Systems analysis and design is the process of developing information systems that transform data into useful information, and systems analysts are IT team members who help plan, develop, and maintain information systems.

The essential components of an information system are hardware, software, data, processes, and people. Hardware consists of everything in the physical layer of the information system. Software consists of system software, which manages the hardware components, and application software, which supports day-to-day business operations. Data is the raw material that an information system transforms into useful information. Processes describe the tasks and functions that users, managers, and IT staff members perform. People who interact with a system include users, from both within and outside the company.

Most successful companies offer a mix of products, technical and financial services, consulting, and customer support. A rapidly growing business category is the Internet-dependent firm, which relies solely on Internet-based operations. E-commerce includes business-to-consumer (B2C) sales, and business-to-business (B2B) transactions that use Internet-based digital marketplaces or private electronic data interchange (EDI) systems.

A systems analyst starts with a business profile, which is an overview of company functions, and then he or she creates a series of business models that represent business processes, which describe specific transactions, events, tasks, and results. Analysts use business process modeling tools to document complex operations. Systems analysts use modeling, prototyping, and computer-aided systems engineering (CASE) tools. Modeling produces a graphical representation of a concept or process, whereas prototyping involves the creation of an early working model of the information or its components.

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Based on their functions and features, business information systems are identified as enterprise computing systems, transaction processing systems, business support systems, knowledge management systems, user productivity systems, digital assistants, or systems integration. In most companies, significant overlap and integration exists among the various types of information systems.

A typical organization structure includes top managers, middle managers and knowledge workers, supervisors and team leaders, and operational employees. Top managers develop strategic plans, which define an overall mission and goals. Middle managers provide direction, resources, and feedback to supervisors and team leaders. Knowledge workers include various professionals who function as support staff. Supervisors and team leaders oversee operational employees. Each organizational level has a different set of responsibilities and information needs.

Three popular system development approaches are structured analysis, which is a traditional method that still is widely used, object-oriented analysis (O-O), which is a more recent approach that many analysts prefer, and agile methods, which include the latest trends in software development.

Structured analysis uses a series of phases, called the systems development life cycle (SDLC) that usually is shown as a waterfall model. Structured analysis uses an overall plan, similar to a blueprint for constructing a building, so it is called a predictive approach. This method uses a set of process models to describe a system graphically and also addresses data organization and structure, relational database design, and user interface issues.

Object-oriented analysis combines data and the processes that act on the data into things called objects that represent people, things, transactions, and events. Objects have characteristics, called properties, and built-in processes, called methods, and can send information to other objects by using messages. Using an O-O programming language, a programmer then writes the code that creates the objects. Object-oriented methods usually follow a series of analysis and design phases similar to the SDLC, but the phases are more interactive.

Agile methods are the newest development approach and attempt to develop a system incrementally by building a series of prototypes and constantly adjusting them to user requirements. Agile methods typically use a spiral model, which represents a series of iterations, or revisions, based on user feedback. The repeated iterations produce a series of prototypes, which evolve into the finished system.

Regardless of the development strategy, people, tasks, timetables, and costs must be managed effectively using project management tools and techniques, which are described in detail in Chapter 3.

The IT department develops, maintains, and operates a company's information systems. IT staff members provide technical support, including application development, systems support, user support, database administration, network administration, web support, and quality assurance. These functions overlap considerably and often have different names in different companies.

In addition to technical knowledge, a systems analyst must understand the business, think critically, and communicate effectively. Valuable credentials such as certifications are available to systems analysts. A systems analyst's responsibilities depend on a company's organization, size, and culture. Systems analysts need to consider salary, location, and future growth potential when making a career decision.

Some of the key trends in information technology include agile methods, artificial cloud computing, data science, mobile devices, service orientation, and social media networks.

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Key Terms

agile methods Systems development methods that attempt to develop a system incrementally by building a series of prototypes and constantly adjusting them to user requirements. Related to adaptive methods.

app A software application that runs on a mobile device, such as a smartphone or tablet.

application lifecycle management (ALM) Activities that cover the entire SDLC, including requirements, design, development, testing, and deployment and management of software applications.

application software Software programs, such as email, word processors, spreadsheets, and graphics packages, used by employees in typical office scenarios.

artificial intelligence The attempt to recreate natural intelligence through software in machines.

B2B (business-to-business) A commercial exchange (e.g., products or services) between businesses, typically enabled by the Internet or electronic means.

B2C (business-to-consumer) A commercial exchange (e.g., products or services) between businesses and consumers conducted over the Internet.

big data Extremely large datasets (e.g., petabytes) requiring nontraditional approaches to deal with them. Sometimes characterized by three terms: volume, variety, and velocity.

bring your own device (BYOD) An equipment management model where employees are in charge of their devices (e.g., computers, tablets, smartphones) at work, not the IT department. This includes device selection and setup, program installation and updating, and network connectivity (including security).

business model A graphical representation of business functions that consist of business processes, such as sales, accounting, and purchasing.

business process A description of specific events, tasks, and desired results.

business process model (BPM) A graphical representation of one or more business processes.

business process modeling notation (BPMN) A standard set of shapes and symbols used to represent events, processes, and workflows in computer-based modeling tools.

business profile A definition of a company's overall functions, processes, organization, products, services, customers, suppliers, competitors, constraints, and future direction.

business rules How a system handles data and produces useful information. Business rules, also called business logic, reflect the operational requirements of the business. Examples include adding the proper amount of sales tax to invoices, calculating customer balances and finance charges, and determining whether a customer is eligible for a volume-based discount.

business support systems Provide job-related information support to users at all levels of a company.

CASE tools Powerful software used in computer-aided systems engineering (CASE) to help systems analysts develop and maintain information systems.

certification A credential an individual earns by demonstrating a certain level of knowledge and skill on a standardized test.

class A term used in object-oriented modeling to indicate a collection of similar objects.

computer-aided software engineering (CASE) A technique that uses powerful programs called CASE tools to provide an overall framework for systems development. The tools support a wide variety of design methodologies, including structured analysis and object-oriented analysis. Also referred to as computer-aided systems engineering.

computer-aided systems engineering (CASE) *See* computer-aided software engineering (CASE).

corporate culture A set of beliefs, rules, traditions, values, and attitudes that define a company and influence its way of doing business.

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critical thinking skills The ability to compare, classify, evaluate, recognize patterns, analyze cause and effect, and apply logic. Such skills are valued in the IT industry.

data The raw material or basic facts used by information systems.

data center A large concentration of networked computers working together.

data flow diagram (DFD) Graphical representation of the system, showing it stores, processes, and transforms data into useful information.

data science Interdisciplinary field that blends computer science, math and statistics, and business methods to analyze large datasets. Involves artificial intelligence, machine learning and predictive analytics, and visualization techniques.

deliverable A polished, final product, suitable for its intended use. End products or deliverables often coincide with the completion of each SDLC phase.

e-commerce (electronic commerce) Transactions (e.g., buying and selling of goods and information) that occur on the Internet. Includes both business-to-consumer and business-to-business.

electronic data interchange (EDI) A process that involves computer-to-computer transfer of data between companies.

empowerment A business practice that places more responsibility and accountability throughout all levels of an organization.

enterprise applications Company-wide applications, such as order processing systems, payroll systems, and company communications networks.

enterprise computing Information systems that support company-wide data management requirements, such as airline reservations or credit card billing systems.

enterprise resource planning (ERP) A process that establishes an enterprise-wide strategy for IT resources. ERP defines a specific architecture, including standards for data, processing, network, and user interface design.

feasibility study An initial investigation to clearly identify the nature and scope of the business opportunity or problem. Also called preliminary investigation.

groupware Programs that run on a network that enable users to share data, collaborate on projects, and work in teams. Also called workgroup software.

hardware The physical layer of the information system, to include computers, networks, communications equipment, and other technology-based infrastructure.

help desk A centralized resource staffed by IT professionals that provides users with the support they need to do their jobs. A help desk has three main objectives: to show people how to use system resources more effectively, to provide answers to technical or operational questions, and to make users more productive by teaching them how to meet their own information needs.

horizontal system A basic system, such as an inventory or payroll package, that is commonly used by a variety of companies.

inference rules Instructions that direct a knowledge management system to identify data patterns and relationships.

information Data that has been changed into a useful form of output.

information system A combination of information technology, people, and data to support business requirements. The five key components are hardware, software, data, processes, and people.

information technology (IT) A combination of hardware, software, and telecommunications systems that support business operations, improve productivity, and help managers make decisions.

integrated development environments (IDE) An application for building other software applications. Typically includes a visual code editor, an integrated compiler, a debugger, a configuration management system, and a test framework.

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iterative An adaptive method typically uses a spiral development model, which builds on a series of iterations.

knowledge base A popular systems development technique that uses a group of users, managers, and IT professionals who work together to gather information, discuss business needs, and define the new system requirements.

legacy system An older system that is typically less technologically advanced than currently available systems.

machine learning An application of computer science and artificial intelligence that uses automated approaches to pattern recognition and predictive analytics based on large datasets.

management information system (MIS) A computer-based information system used in business planning, control, decision making, and problem solving.

mission-critical system An information system that is vital to a company's operations.

model-based systems engineering (MBSE) An approach to systems engineering that relies on domain models, rather than traditional documents, to design large-scale systems and convey information between engineers.

modeling A process that produces a graphical representation of a concept or process that systems developers can analyze, test, and modify.

Moore's law A prediction that computing power would double every 18 to 24 months due to increased miniaturization of electronic components.

NoSQL databases Database systems that use a flat, nontabular (nonrelational) structure to store and process large-scale datasets.

object In object-oriented analysis or programming, an object represents a real person, place, event, or transaction.

object-oriented (O-O) analysis The act of understanding an information system by identifying things called objects. An object represents a real person, place, event, or transaction. Object-oriented analysis is a popular approach that sees a system from the viewpoint of the objects themselves as they function and interact with the system.

personal digital assistant A program that responds to user requests through a natural interface, such as regular speech, to provide assistance to general-purpose queries. Often embedded in devices such as Internet-connected speakers and smartphones.

preliminary investigation An initial analysis to clearly identify the nature and scope of the business opportunity or problem. Also called feasibility study.

process Procedure or task that users, managers, and IT staff members perform. Also, the logical rules of a system that are applied to transform data into meaningful information. In data flow diagrams, a process receives input data and produces output that has a different content, form, or both.

product lifecycle management (PLM) *See* application lifecycle management (ALM).

product-oriented Companies that manufacture computers, routers, or microchips.

project management The process of planning, scheduling, monitoring, controlling, and reporting upon the development of an information system.

properties In object-oriented (O-O) analysis, characteristics that objects inherit from their class or possess on their own.

prototype An early, rapidly constructed working version of the proposed information system.

radio frequency identification (RFID) Technology that uses high-frequency radio waves to track physical objects.

requirements engineering Used in the systems planning phase of the SDLC. It involves using various fact-finding techniques, such as interviews, surveys, observation, and sampling, to describe the current system and identify the requirements for the new system.

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scalable The ability of a system to expand to meet new business requirements and volumes.

service-oriented A company that primarily offers information or services or sells goods produced by others.

software A program run by computers for a specific function or task.

spiral model A development model with a series of iterations, or revisions, based on user feedback.

stakeholder Anyone who is affected by the company's performance, such as customers, employees, suppliers, stockholders, and members of the community.

strategic plans The long-range plans that define the corporate mission and goals. Typically defined by top management, with input from all levels.

structured analysis A traditional systems development technique that uses phases to plan, analyze, design, implement, and support an information system. Processes and data are treated as separate components.

supply chain A traditional systems development technique that uses phases to plan, analyze, design, implement, and support an information system. Processes and data are treated as separate components.

supply chain management (SCM) The coordination, integration, and management of materials, information, and finances as they move from suppliers to customers, both within and between companies. In a totally integrated supply chain, a customer order could cause a production planning system to schedule a work order, which in turn could trigger a call for certain parts from one or more suppliers.

system A set of related components that produces specific results.

system design specification A document that presents the complete design for the new information system, along with detailed costs, staffing, and scheduling for completing the next SDLC phase, systems implementation. Also called the technical design specification or the detailed design specification.

system requirements document A document that contains the requirements for the new system, describes the alternatives that were considered, and makes a specific recommendation to management. It is the end product of the systems analysis phase.

system software Programs that control the computer, including the operating system, device drivers that communicate with hardware, and low-level utilities.

systems analysis and design The process of developing information systems that effectively use hardware, software, data, processes, and people to support the company's business objectives.

systems analysis phase The second SDLC phase. The purpose of this phase is to build a logical model of the new system.

systems analyst A person who plans, analyzes, and implements information systems. They may work internally within a company's IT department or be hired by a company as an independent consultant.

systems design phase The third SDLC phase. The purpose of systems design is to create a blueprint for the new system that will satisfy all documented requirements, whether the system is being developed in-house or purchased as a package.

systems development life cycle (SDLC) Activities and functions that systems developers typically perform, regardless of how those activities and functions fit into a particular methodology. The SDLC model includes five phases: (1) systems planning, (2) systems analysis, (3) systems design, (4) systems implementation, and (5) systems support and security.

systems implementation phase The fourth phase of the SDLC. During this phase, the new system is constructed—programs are written, tested, and documented, and the system is installed.

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systems planning phase The first phase of the SDLC. During this phase, the systems project gets started. The project proposal is evaluated to determine its feasibility. The project management plan is formulated, with the help of CASE tools where appropriate.

systems request A formal request to the IT department that describes problems or desired changes in an information system or business process. It might propose enhancements for an existing system, the correction of problems, or the development of an entirely new system.

systems support and security phase During the systems support and security phase of the SDLC, the IT staff maintains, enhances, and protects the system.

technical support Technical support is necessary to support the wide variety of IT systems and users. It includes six main functions: application development, systems support, user support, database administration, network administration, and web support. These functions overlap considerably and often have different names in different companies.

transaction processing (TP) systems Operational systems used to process day-to-day recurring business transactions, such as customer billing.

user productivity systems Applications that provide employees of all levels a wide array of tools to improve job performance. Examples include email, word processing, graphics, and company intranets.

users Stakeholders inside and outside the company who will interact with the system.

vertical system A system designed to meet the unique requirements of a specific business or industry, such as a web-based retailer or auto-supply store.

waterfall model The traditional model of software development. A graph that depicts the result of each SDLC phase flowing down into the next phase.

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Exercises

Questions

1. What is information technology, and why is it important to society?
2. What are the five main components of an information system?
3. Explain how ridesharing services such as Uber and Lyft are disrupting traditional taxicab business models.
4. Describe the business profile of a home improvement store like Home Depot or Lowe's and how it is used.
5. What are the seven types of information systems used in business?
6. What types of information do the four organizational levels common to many businesses need?
7. Compare three systems development methods.
8. Name the tools that enable the systems analyst to develop, manage, and maintain large-scale information systems.
9. Summarize the seven main functions of the IT department.
10. What are the roles and responsibilities of a systems analyst in a modern business?

Discussion Topics

1. Some experts believe that the growth in e-commerce will cause states and local governments to lose tax revenue, unless Internet transactions are subject to sales tax. What is one argument that supports this view and one that opposes it?
2. When team members are geographically dispersed, communication becomes more challenging. Explain how groupware can increase user productivity in this context.
3. Under what circumstances should a systems analyst recommend an agile methodology over structured development or object-oriented analysis?
4. Should the IT director report to the company president or somewhere else? Does it matter?
5. Rapid advancements in areas such as machine learning and predictive analytics in data science are affecting the daily operations of many IT departments. What should a systems analyst do to stay current?

Projects

1. Contact three people at your school who use information systems. List their positions, the information they need, the systems they use, and the business functions they perform.
2. Visit three websites to learn more about agile system development. Prepare a list of the sites you visited and a summary of the results.
3. Model-based systems engineering (MBSE) is one of the leading methods used by systems analysts to develop information systems. Cameo Systems Modeler is one of the leading tools supporting MBSE. Research magazine articles and the web to learn more about this tool's capabilities. Identify three of its strengths in terms of improving the quality of the finished product.
4. Explore the *Critical Thinking Community* website at *criticalthinking.org*. Identify three important topics currently being discussed and describe your findings.
5. Compare the corporate culture of three leading IT companies and show how their statement of values could attract (or repel) systems analysts from joining their organization.

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CHAPTER 2 Analyzing the Business Case

Chapter 2 explains how to analyze a business case. This chapter also explains why it is important to understand business operations and requirements, how IT projects support a company's overall strategic plan, how systems projects get started, and how systems analysts conduct a feasibility study and perform preliminary investigations, which concludes with a report to management. Fact-finding techniques that begin at this point and carry over into later development phases are also described.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" asks the systems analyst to consider the implications of granting preferential treatment to a system enhancement request when the request originates with a friend of the project's manager.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Describe the strategic planning process.
2. Conduct a SWOT analysis.
3. Explain how tools can support strategic planning.
4. Explain the concept of a business case.
5. Summarize the six main reasons for systems requests.
6. Describe the two factors affecting systems projects.
7. Explain how systems requests are processed.
8. Explain how systems request feasibility is assessed.
9. Explain how systems requests are prioritized.
10. Conduct a preliminary investigation.

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2.1 Strategic Planning

Strategic planning is the process of identifying long-term organizational goals, strategies, and resources. A strategic plan looks beyond day-to-day activities and focuses on a horizon that is three, five, ten, or more years in the future. The IT team must deliver IT resources to support the firm's long-term strategic goals. Therefore, IT managers and systems analysts must understand and participate in strategic planning activities.

IT managers have to prepare for long-range needs, such as a new data warehouse, even as they handle immediate problems, such as a logic bug in the payroll system. In most companies, the IT team reviews each IT-related proposal, project, and systems request to determine if it presents a strong business case, or justification.

The following sections provide an overview of strategic planning, a description of SWOT analysis, and a look at the role of the IT department.

2.1.1 Strategic Planning Overview

Strategic planning starts with a **mission statement** that reflects the firm's vision, purpose, and values. Mission statements usually focus on long-term challenges and goals, the importance of the firm's stakeholders, and a commitment to the firm's role as a corporate citizen. For example, Google's mission statement posted on their website is stated succinctly as, "… to organize the world's information and make it universally accessible and useful."

With the mission statement as a backdrop, a firm develops short-term goals and objectives. For example, the company might establish one-year, three-year, and five-year goals for expanding market share. To achieve those goals, the company might develop a list of shorter-term objectives. If it wants to increase online orders by 30% next year, a company might set quarterly objectives with monthly milestones. High-priority objectives are called critical success factors. A **critical success factor** is one that must be achieved to fulfill the company's mission.

Objectives also might include tactical plans, such as creating a new website and training a special customer support group to answer email inquiries. Finally, the objectives translate into day-to-day business operations, supported by IT and other corporate resources. The outcome is a set of business results that affect company stakeholders.

CASE IN POINT 2.1: Pets for Rent

Pets for Rent is an innovative company that brings puppies to corporate meetings. The company's CEO says that having puppies in a room with employees in an informal setting helps break down communication barriers and fosters a greater sense of teamwork and comradery. Since this is a new company, the CEO has asked you if a mission statement is necessary. After you review the chapter material, write a brief memo with your views. Be sure to include good (and not-so-good) examples of actual mission statements that you find on the web.

2.1.2 SWOT Analysis

The letters SWOT stand for strengths, weaknesses, opportunities, and threats. A **SWOT analysis** can focus on a specific product or project, an operating division, the entire company, or the mission statement itself. The overall aim is to avoid seeking goals that are unrealistic, unprofitable, or unachievable.

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An enterprise SWOT analysis usually begins with these questions:

- What are our strengths, and how can we use them to achieve our business goals?
- What are our weaknesses, and how can we reduce or eliminate them?
- What are our opportunities, and how do we plan to take advantage of them?
- What are our threats, and how can we assess, manage, and respond to the possible risks?

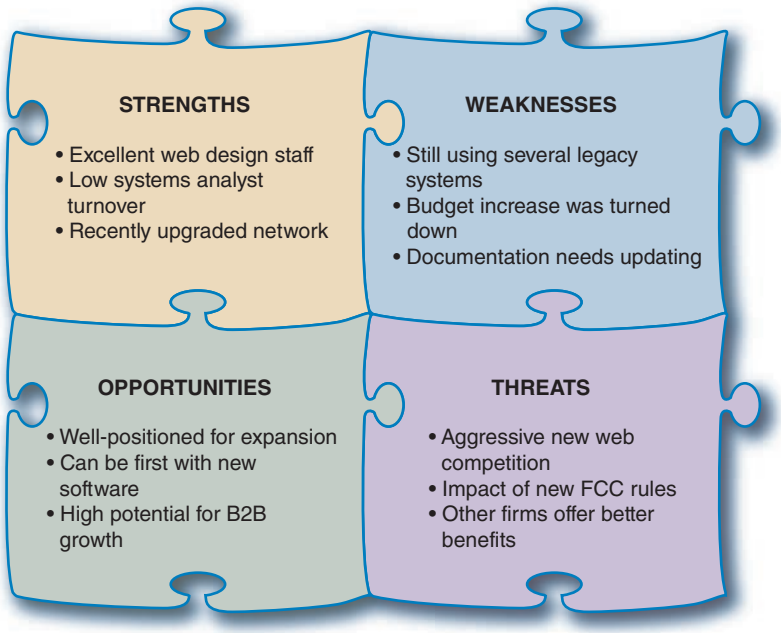


FIGURE 2-1 A SWOT analysis might produce results similar to those shown here.

A SWOT analysis examines a firm's technical, human, and financial resources. In Figure 2-1, the bulleted lists show samples of typical strengths, weaknesses, opportunities, and threats for an organization considering expanding their web-based online operations.

As the SWOT process continues, management reviews specific resources, business operations, and valuable assets. For example, suppose that the company owns an important patent. A SWOT review for the patent might resemble Figure 2-2.

There is no standard approach to strategic planning. Some managers believe that a firm's mission statement should contain an inspirational message to its stakeholders. Others feel that unless a firm starts with a realistic SWOT assessment, it might develop a mission statement that is unachievable. Most companies view the strategic planning process as a dynamic interaction, where the company's mission statement reflects a long-term horizon, but sets forth goals that are achievable and consistent with real-world conditions.

2.1.3 The Role of the IT Department

A systems analyst should be interested in strategic planning because it reflects a higher level of involvement in supporting the direction of the project. For example, while working on the same project, one analyst might say, "I am using a CASE tool," while another might say, "I am helping the company succeed in a major new business venture." Systems analysts should focus on the larger, strategic role of the IT department even as they carry out their day-to-day technical tasks.

Experienced analysts know that planning is essential for IT project success, and it must start as early as possible. Careful planning can help assure that:

- The project supports overall business strategy and operational needs.
- The project scope is well defined and clearly stated.
- The project goals are realistic, achievable, and tied to specific statements, assumptions, constraints, factors, and other inputs.

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During the planning process, management and IT should be closely linked. In the past, a typical IT department handled all aspects of systems development and consulted users only when, and if, the department wanted user input. Today, systems development is much more team-oriented. New approaches to systems development, such as agile methods, typically involve groups of users, managers, and IT staff working together right from the start of the project.

Although team-oriented development is the norm, some companies still see the role of the IT department as a gatekeeper, responsible for screening and evaluating systems requests. Should the IT department perform the initial evaluation, or should a cross-functional team do it? The answer probably depends on the company's size, the nature of the system request, and the scale of the project. For example, in smaller companies or firms where only one person has IT skills, that person acts as a coordinator and consults closely with users and managers to evaluate systems requests. Larger firms are more likely to use an evaluation team or a systems review committee.

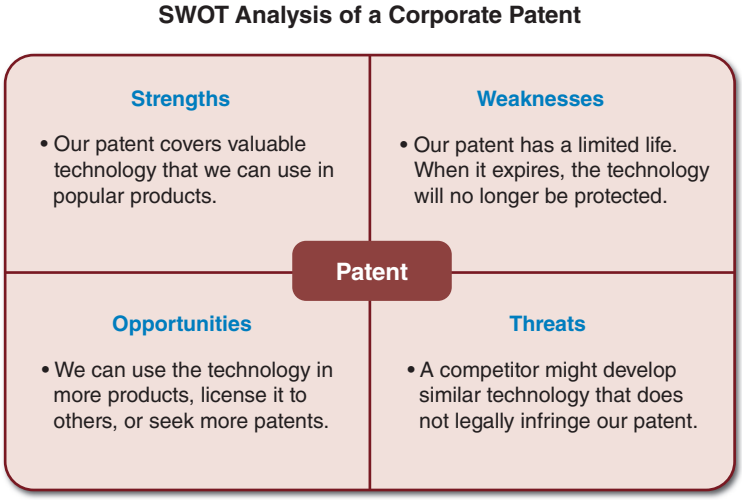


FIGURE 2-2 This SWOT analysis example focuses on a specific asset: a company patent.

2.2 Strategic Planning Tools

Irrespective of the development strategy used, many organizations still rely on the IT group to provide guidance when it comes to selecting tools to support strategic planning activities. Some analysts stick to traditional text-based methods, using Microsoft Word tables, to provide structure and clarity. Others prefer a spreadsheet, such as Microsoft Excel, because it is easy to display priorities and the relative importance of planning assumptions.

A more sophisticated approach is to use a CASE tool to define and document the overall environment. Such tools can integrate various statements, entities, data elements, and graphical models into an overall structure. The result is more consistency, better quality, and much less effort for the system analyst. Figure 2-3 shows a cloud-based road mapping software product from Aha! that provides integrated support for product strategy visioning and strategy development.

There are other strategic planning "tools" that are not CASE tools, but more techniques that are sometimes supported by software programs. For example, mind maps, balanced scorecards, and gap analysis are all valuable techniques that can be part of strategic planning in an organization. An important role for the systems analyst is to know when each of these tools and techniques can best be used in particular project contexts.

2.3 The Business Case

During the systems planning phase, the IT team reviews a request to determine if it presents a strong business case. The term **business case** refers to the reasons, or

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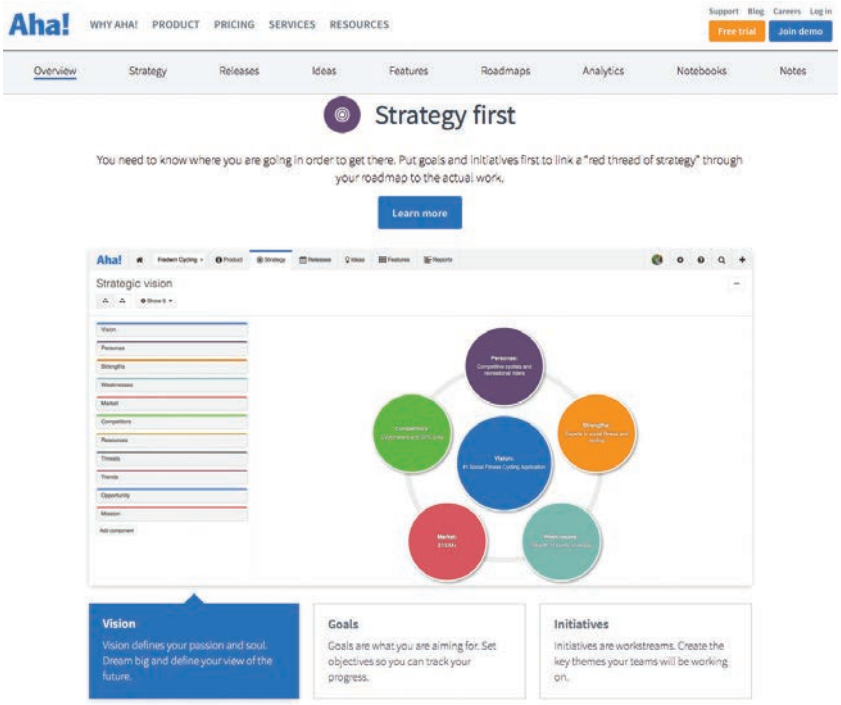


FIGURE 2-3 Aha! provides integrated support for product strategy visioning.
Source: Aha! Labs Inc.

justification, for a proposal. To perform the review, the analyst must consider the company's overall mission, objectives, and IT needs.

A business case should be comprehensive yet easy to understand. It should describe the project clearly, provide the justification to proceed, and estimate the project's financial impact. Specifically, the business case should answer questions such as the following:

- Why are we doing this project?
- What is the project about?
- How does this solution address key business issues?
- How much will it cost and how long will it take?
- Will we suffer a productivity loss during the transition?
- What is the return on investment and payback period?
- What are the risks of doing the project? What are the risks of not doing the project?
- How will we measure success?
- What alternatives exist?

Examples of business cases, both good and bad, can be found online. Just search for "sample business case" and examine the structure and content of some of the samples available. It is particularly instructive to compare and contrast business cases for different areas, such as those for government contracts versus private enterprises.

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2.4 Systems Requests

The starting point for most information systems projects is called a **systems request**, which is a formal way of asking for IT support. A systems request might propose enhancements for an existing system, the correction of problems, the replacement of an older system, or the development of an entirely new information system that is needed to support a company's current and future business needs.

As Figure 2-4 shows, the six main reasons for systems requests are stronger controls, reduced cost, more information, better performance, improved service to customers, and more support for new products and services.

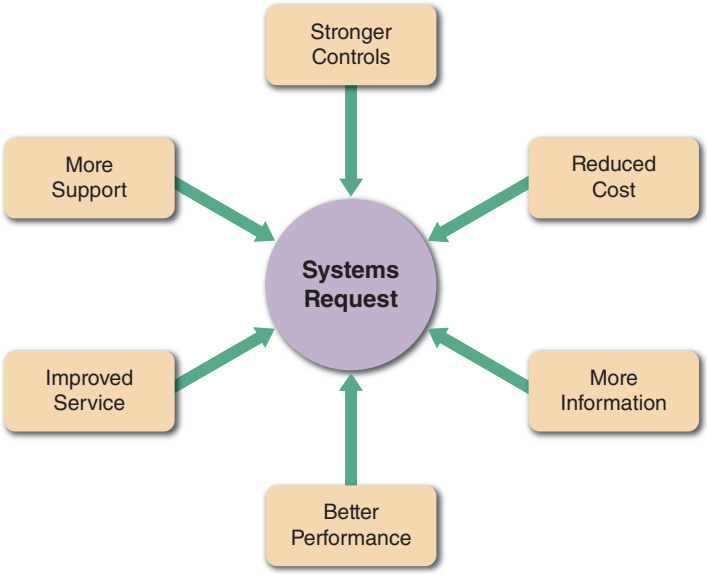


FIGURE 2-4 Six main reasons for systems requests.

STRONGER CONTROLS: A system must have effective controls to ensure that data is secure and accurate. This is becoming increasingly important given the number of data breaches that seem to occur on a daily basis. Some common security controls include passwords, various levels of user access, and **encryption**, or coding data to keep it safe from unauthorized users. Hardware-based security controls include **biometric devices** that can identify a person by a retina scan or by mapping a fingerprint pattern. The technology uses infrared scanners that create images with thousands of measurements of personal physical characteristics, as shown in Figure 2-5, which displays Apple's Face ID security mechanism on the iPhone.

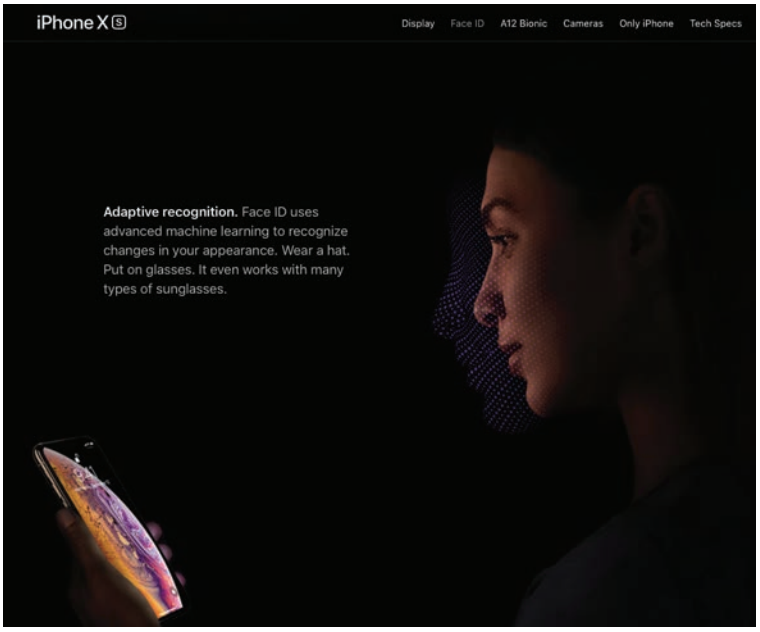


FIGURE 2-5 Apple Face ID uses advanced machine learning to recognize users.
Source: Apple Inc.

In addition to being secure, data also must be accurate. Controls should minimize data entry errors whenever possible. For example, if a user enters an invalid customer number, the order processing system should reject the entry immediately and prompt the user to enter a valid number. Data entry controls must be effective without being excessive. If a system requires users to confirm every item with an "Are you sure? Y/N" message, internal users and customers might complain that the system is not user-friendly.

REDUCED COST: The current system could be expensive to operate or maintain as a result of technical problems, design weaknesses, or the changing demands of the business. It might be possible to adapt the system to newer technology or upgrade it. On the other hand, cost-benefit analysis might show that a new system would be more cost effective and provide better support for long-term objectives.

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MORE INFORMATION: The system might produce information that is insufficient, incomplete, or unable to support the company's changing information needs. For example, a system that tracks customer orders might not be capable of analyzing and predicting marketing trends. In the face of intense competition and rapid product development cycles, managers need the best possible information to make major decisions on planning, designing, and marketing new products and services.

BETTER PERFORMANCE: The current system might not meet performance requirements. For example, it might respond slowly to data inquiries at certain times, or it might be unable to support company growth. Performance limitations also result when a system that was designed for a specific hardware configuration becomes obsolete when new hardware is introduced.

IMPROVED SERVICE: Systems requests often are aimed at improving service to customers or users within the company. For instance, allowing mutual fund investors to check their account balances on a website, storing data on rental car customer preferences, or creating an online college registration system are all examples of providing valuable services and increased customer satisfaction.

MORE SUPPORT FOR NEW PRODUCTS AND SERVICES: New products and services often require new types or levels of IT support. For example, a software vendor might offer an automatic upgrade service for subscribers; or a package delivery company might add a special service for RFID-tagged shipments. In situations like these, it is most likely that additional IT support will be required. At the other end of the spectrum, product obsolescence can also be an important factor in IT planning. As new products enter the marketplace, vendors often announce that they will no longer provide support for older versions. A lack of vendor support would be an important consideration in deciding whether or not to upgrade.

2.5 Factors Affecting Systems Projects

Internal and external factors affect every business decision that a company makes, and IT projects are no exception. Figure 2-6 shows internal and external factors that shape corporate IT choices.

2.5.1 Internal Factors

Internal factors include the strategic plan, top managers, user requests, information technology department, existing systems and data, and company finances.

STRATEGIC PLAN: A company's strategic plan sets the overall direction for the firm and has an important impact on IT projects. Company goals and objectives that need IT support will generate systems requests and influence IT priorities. A strategic plan that stresses technology tends to create a favorable climate for IT projects that extends throughout the organization.

TOP MANAGERS: Because significant resources are required, top management usually initiates large-scale projects. Those decisions often result from strategic business goals that require new IT systems, more information for decision making processes, or better support for mission-critical information systems.

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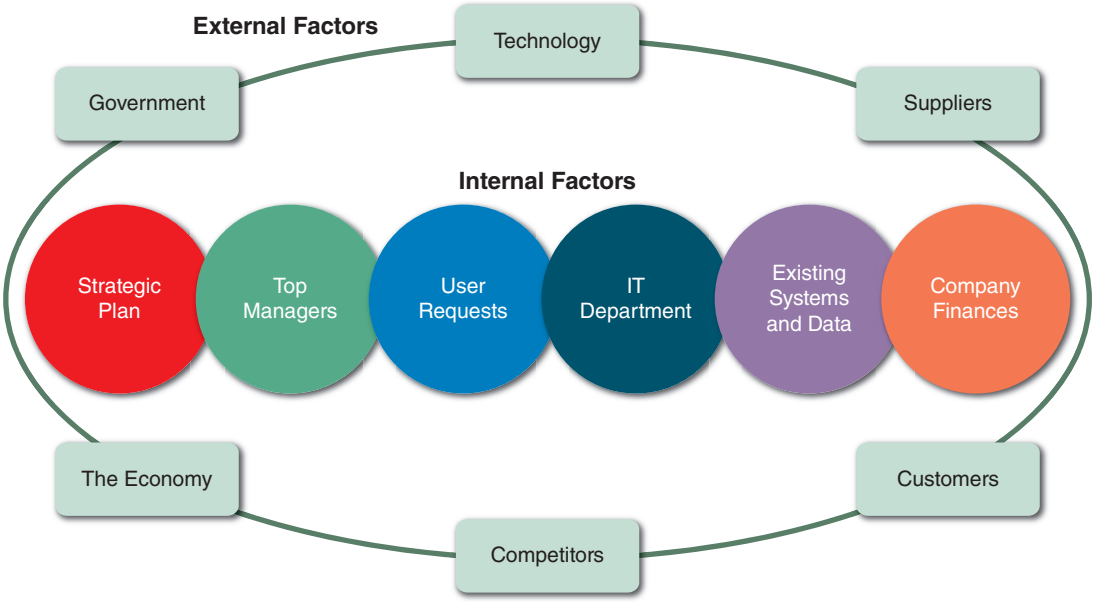


FIGURE 2-6 Internal and external factors that affect IT projects.

USER REQUESTS: As users rely more heavily on information systems to perform their jobs, they are likely to request even more IT services and support. For example, sales reps might request improvements to the company's website, a more powerful sales analysis report, a network to link all sales locations, or an online system that allows customers to obtain the status of their orders instantly. Or, users might not be satisfied with the current system because it is difficult to learn or lacks flexibility. They might want information systems support for business requirements that did not even exist when the system was first developed.

INFORMATION TECHNOLOGY DEPARTMENT: Systems project requests come also from the IT department itself. IT staff members often make recommendations based on their knowledge of business operations and technology trends. IT proposals might be strictly technical matters, such as replacement of certain network components, or suggestions might be more business oriented, such as proposing a new reporting or data collection system.

EXISTING SYSTEMS AND DATA: Errors or problems in existing systems can trigger requests for systems projects. When dealing with older systems, analysts sometimes spend too much time reacting to day-to-day problems without looking at underlying causes. This approach can turn an information system into a patchwork of corrections and changes that cannot support the company's overall business needs. This problem typically occurs with legacy systems, which are older systems that are less technologically advanced. When migrating to a new system, IT planners must plan the conversion of existing data, which is described in detail in Chapter 11.

COMPANY FINANCES: A company's financial status can affect systems projects. If the company is going through a difficult time, the project may be postponed until there is more cash available to finance the effort. On the other hand, if the company is enjoying financial success, the decision to embark on a new project may be easier to make.

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2.5.2 External Factors

External factors include technology, suppliers, customers, competitors, the economy, and government.

TECHNOLOGY: Changing technology is a major force affecting business and society in general. For example, the rapid growth of telecommunications, coupled with increased computing power and continuous miniaturization of electronic components, has created entire new industries and technologies, including the proliferation of smartphones and the app ecosystem.

Technology also dramatically reshapes existing business operations. The success of scanner technology resulted in universal bar coding that now affects virtually all products. Some industry experts predict that bar code technology, which is over 40 years old, will be overshadowed in the future by **electronic product code (EPC)** technology that uses RFID tags to identify and monitor the movement of each individual product, from the factory floor to the retail checkout counter.

Quick Response codes (QR Codes), as shown in Figure 2-7, are like bar codes but square in shape. They contain more information than traditional bar codes, but less than RFID tags. They do have the advantage of being less expensive to use than RFID tags, and they can be printed on almost anything—including online advertisements.

FIGURE 2-7 QR Code.
Source: http://www.qrstuff.com using URL http://amazon.com/author/stilley

The **Internet-of-Things (IOT)** is a newer development that involves almost all electronic devices communicating with one another over a computer network. The communication can use radio signals, as with RFID tags, digital messages, or other means. IoT devices can act as sensors, sending important information to centralized data storage and processing nodes. IoT devices also raise new security and privacy concerns that the systems analyst must consider.

SUPPLIERS: With the growth of **electronic data interchange (EDI)**, relationships with suppliers are critically important. For example, an automobile company might require that suppliers code their parts in a certain manner to match the auto company's inventory control system. EDI also enables **just-in-time (JIT)** inventory systems that rely on computer-to-computer data exchange to minimize unnecessary inventory. The purpose of a JIT system is to provide the right products at the right place at the right time.

Blockchain technology is a promising mechanism for managing supply chains more powerfully than before. Blockchain provides a distributed ledger system that is efficient, secure, transparent. Large companies such as IBM are already using blockchain to improve operations for their customers, such as the Food Trust product shown in Figure 2-8 that Walmart uses for tracking food safety from grower to consumer.

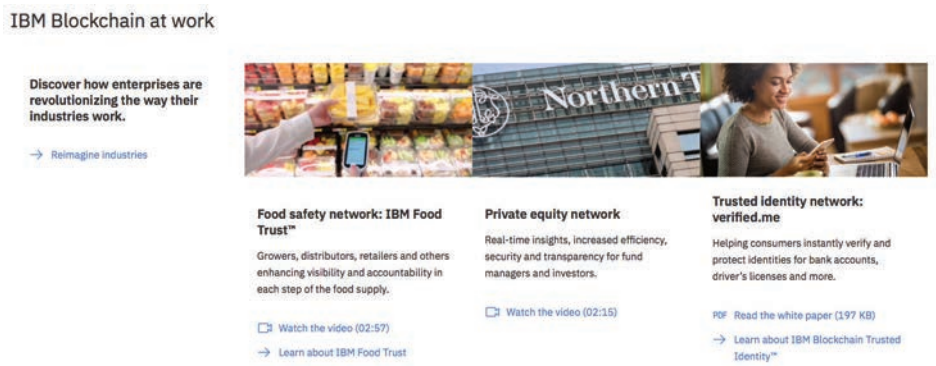


FIGURE 2-8 IBM Blockchain.
Source: IBM Corporation

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CUSTOMERS: Customers are vitally important to any business. Information systems that interact with customers usually receive top priority. Many companies implement **customer relationship management (CRM)** systems that integrate all customer-related events and transactions, including marketing, sales, and customer service activities. Vendor-oriented CRM systems often interconnect with supply chain management (SCM) systems, which were discussed in Chapter 1. CRM components can provide automated responses to sales inquiries, online order processing, and inventory tracking. Some suppliers use robots for order fulfillment, such as the Kiva robots shown in Figure 2-9 that Amazon.com uses in their warehouses.

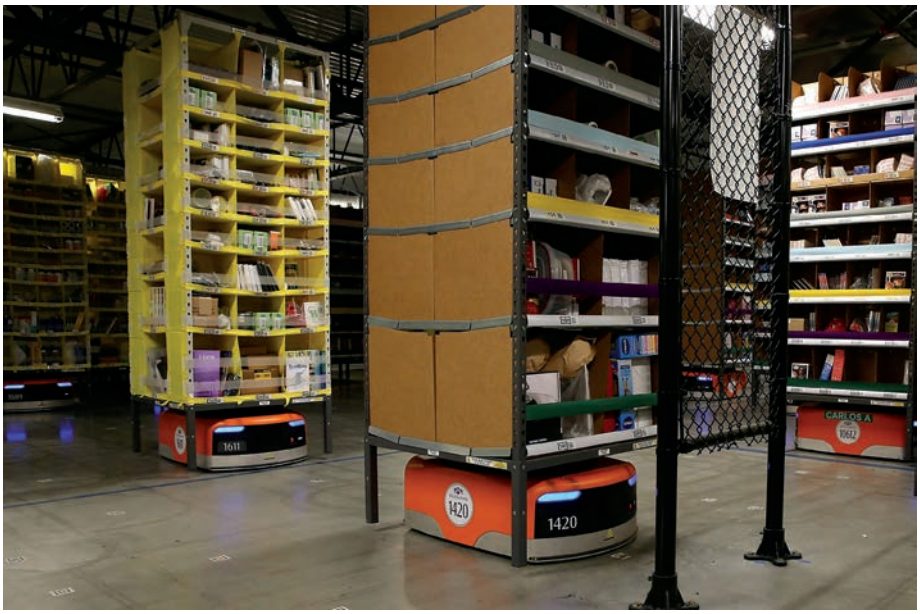


FIGURE 2-9 Amazon Robotics' Kiva robots.
Justin Sullivan/Staff/Getty Images News/Getty Images

Another RFID application is called **electronic proof of delivery (EPOD)**. Using EPOD, a supplier uses RFID tags on each crate, case, or shipping unit to create a digital shipping list. The customer receives the list and scans the incoming shipment. If a discrepancy is detected, it is reported and adjusted automatically. Because they would be expensive to investigate manually, small shipping inconsistencies might not otherwise be traced. This is an example of technology-related cost control.

COMPETITORS: Competition drives many information systems decisions. For example, if one cellular telephone provider offers a new type of digital service, other firms must match the plan in order to remain competitive. New product research and development, marketing, sales, and service all require IT support.

THE ECONOMY: Economic activity has a powerful influence on corporate information management. In a period of economic expansion, firms need to be ready with scalable systems that can handle additional volume and growth. Predicting the business cycle is not an exact science, and careful research and planning are important.

GOVERNMENT: Federal, state, and local government regulations directly affect the design of corporate information systems. For example, up-to-date IRS reporting requirements must be designed into a payroll package.

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2.6 Processing Systems Requests

In most organizations, the IT department receives more systems requests than it can handle. Many organizations assign responsibility for evaluating systems requests to a group of key managers and users. Many companies call this group a **systems review committee** or a **computer resources committee**. Regardless of the name, the objective is to use the combined judgment and experience of several analysts to evaluate project requests.

2.6.1 Systems Request Forms

Many organizations use a special form for systems requests, similar to the online sample shown in Figure 2-10. A properly designed form streamlines the request process and ensures consistency. The form must be easy to understand and include clear instructions. It should include enough space for all required information and should indicate what supporting documents are needed. Most companies use online systems request forms that users submit electronically because the form can be processed automatically.

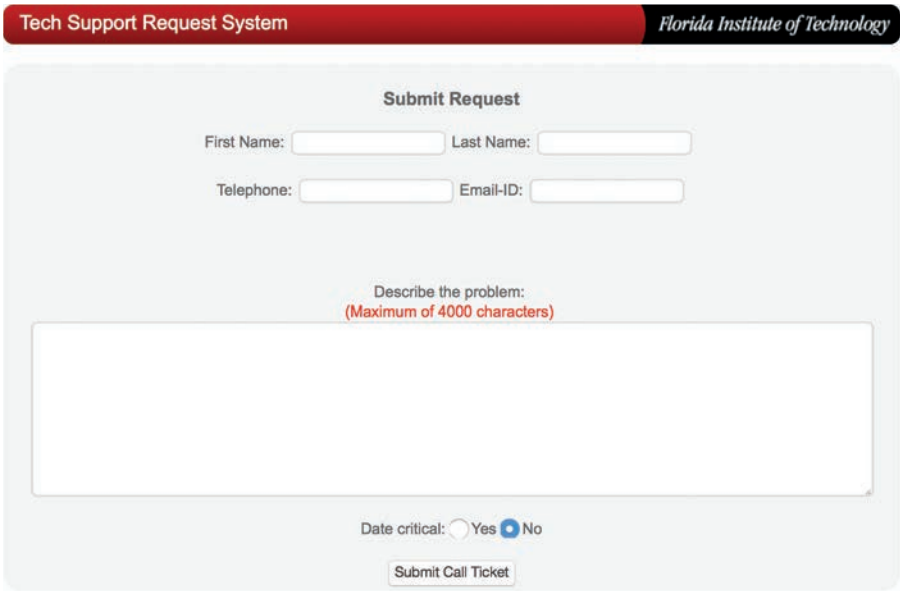


FIGURE 2-10 Example of an online systems request form.
Source: Florida Institute of Technology

When a systems request form is received, a systems analyst or IT manager examines it to determine what IT resources are required for the preliminary investigation. A designated person or a committee then decides whether to proceed with a preliminary investigation. Sometimes, a situation requires an immediate response. For example, if the problem involves a mission-critical system, an IT maintenance team must restore normal operations immediately. When the system is functioning properly, the team conducts a review and prepares a systems request to document the work that was performed.

2.6.2 Systems Request Tools

When the number of requests submitted through automated forms becomes significant, or if the requests can originate from internal sources as well as external customers, special-purpose systems request tools can be used to help manage the workflow. For example, Figure 2-11 illustrates the service request capabilities from Integrify that captures, manages, and routes requests to systems analysts based on definable business rules. In this way, requests are tracked and analyzed for improved performance.

2.6.3 Systems Review Committee

Most large companies use a systems review committee to evaluate systems requests. Instead of relying on a single individual, a committee approach provides a variety of experience and knowledge. With a broader viewpoint, a committee can establish priorities more effectively than an individual, and one person's bias is less likely to affect the decisions.

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A typical committee consists of the IT director and several managers or representatives from other departments. The IT director usually serves as a technical consultant to ensure that committee members are aware of crucial issues, problems, and opportunities.

Although a committee offers many advantages, some disadvantages exist. For example, action on requests must wait until the committee meets. Another potential disadvantage of a committee is that members might favor projects requested by their own departments, and internal political differences could delay important decisions.

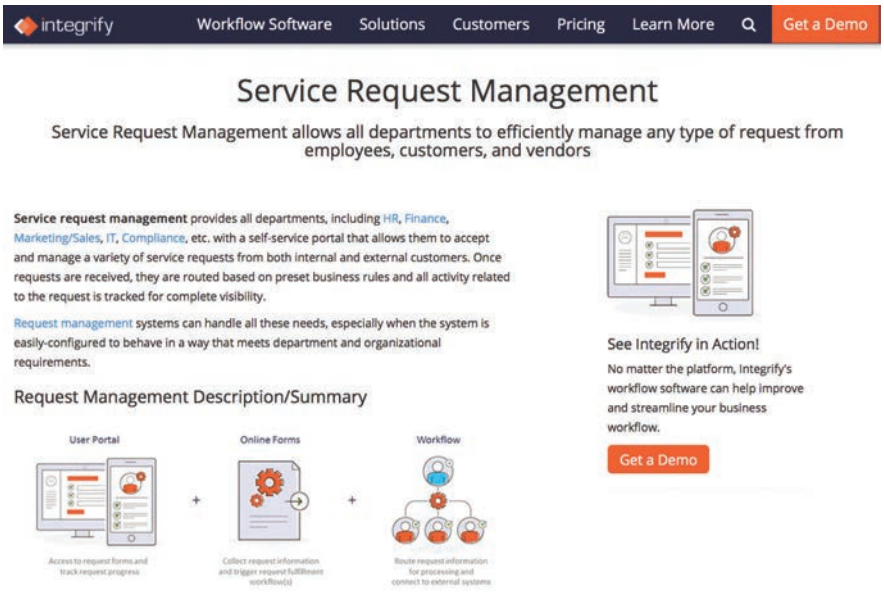


FIGURE 2-11 A service request management system from Integrify.
Source: Integrify

Many smaller companies rely on one person to evaluate system requests instead of a committee. If only one person has the necessary IT skills and experience, that person must consult closely with users and managers throughout the company to ensure that business and operational needs are considered carefully.

Whether one person or a committee is responsible, the goal is to evaluate the requests and set priorities. Suppose four requests must be reviewed:

1. The marketing group wants to analyze current customer spending habits and forecast future trends.
2. The technical support group wants a cellular link, so service representatives can download technical data instantly.
3. The accounting department wants to redesign customer statements and allow Internet access.
4. The production staff wants an inventory control system that can exchange data with major suppliers.

Which projects should the firm pursue? What criteria should be applied? How should priorities be determined? To answer those questions, the individual or the committee must assess the feasibility of each request.

CASE IN POINT 2.2: Attaway Airlines, Part One

You are the IT director at Attaway Airlines, a small regional air carrier. You chair the company's systems review committee, and you currently are dealing with strong disagreements about two key projects. The marketing manager says it is vital to have a new computerized reservation system that can provide better customer service and reduce operational costs. The vice president of finance is equally adamant that a new accounting system is needed immediately because it will be very expensive to adjust the current system to new federal reporting requirements. The VP outranks the marketing manager, and the VP is your boss. The next meeting, which promises to be a real showdown, is set for 9:00 a.m. tomorrow. How will you prepare for the meeting? What questions and issues should be discussed?

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2.7 Assessing Request Feasibility

As described in Chapter 1, a systems request must pass several tests to see whether it is worthwhile to proceed further. The first step is to identify and weed out systems requests that are not feasible. For example, a request would not be feasible if it required hardware or software that the company already had rejected.

Even if the request is feasible, it might not be necessary. For example, a request for multiple versions of a report could require considerable design and programming effort. A better alternative might be to download the server data to a personal computer-based software package and show users how to produce their own reports. In this case, training users would be a better investment than producing reports for them.

Sometimes assessing request feasibility is quite simple and can be done in a few hours. If the request involves a new system or a major change, however, extensive fact-finding and investigation in the form of feasibility studies are required.

2.7.1 Feasibility Studies

As shown in Figure 2-12, a feasibility study uses four main yardsticks to measure a proposal: operational feasibility, economic feasibility, technical feasibility, and schedule feasibility.

How much effort should go into a feasibility study depends on nature of the request. For example, if a department wants an existing report sorted in a different order, the analyst can decide quickly whether the request is feasible. On the other hand, a proposal by the marketing department for a new market research system to predict sales trends would require much more effort. In either case, the systems analyst should ask these important questions:

- Is the proposal desirable in an operational sense? Is it a practical approach that will solve a problem or take advantage of an opportunity to achieve company goals?
- Is the proposal technically feasible? Are the necessary technical resources and people available for the project?
- Is the proposal economically desirable? What are the projected savings and costs? Are other intangible factors involved, such as customer satisfaction or company image? Is the problem worth solving, and will the request result in a sound business investment?
- Can the proposal be accomplished within an acceptable time frame?

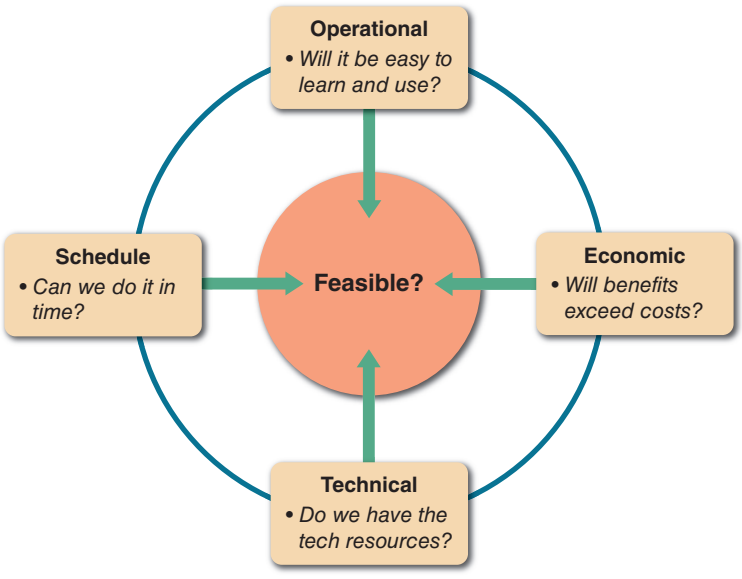


FIGURE 2-12 A feasibility study examines operational, technical, economic, and schedule factors.

To obtain more information about a systems request, initial fact-finding might be accomplished by studying organization charts, performing interviews, reviewing current documentation, observing operations, and surveying users. Sometimes, developing prototypes can provide additional insight into the feasibility of the request. If the systems request is approved, more intensive fact-finding will continue during the systems analysis phase.

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2.7.2 Operational Feasibility

Operational feasibility means that a proposed system will be used effectively after it has been developed. If users have difficulty with a new system, it will not produce the expected benefits. Organizational culture can also affect operational feasibility. For instance, a system that works well in a highly structured workplace might be very unpopular in a more relaxed corporate culture. Operational feasibility is difficult to measure with precision but must be studied very carefully. The following questions would help predict a system's operational feasibility:

- Does management support the project? Do users support the project? Is the current system well liked and effectively used? Do users see the need for change?
- Will the new system result in a workforce reduction? If so, what will happen to the affected employees?
- Will the new system require training for users? If so, is the company prepared to provide the necessary resources for training current employees?
- Will users be involved in planning the new system right from the start?
- Will the new system place any new demands on users or require any operating changes? For example, will any information be less accessible or produced less frequently? Will performance decline in any way? If so, will an overall gain to the organization outweigh individual losses?
- Will customers experience adverse effects in any way, either temporarily or permanently?
- Will any risk to the company's image or goodwill result?
- Does the development schedule conflict with other company priorities?
- Do legal or ethical issues need to be considered?

2.7.3 Economic Feasibility

Economic feasibility means that the projected benefits of the proposed system outweigh the estimated costs usually considered the **total cost of ownership (TCO)**, which includes ongoing support and maintenance costs, as well as acquisition costs. To determine TCO, the analyst must estimate costs in each of the following areas:

- People, including IT staff and users
- Hardware and equipment
- Software, including in-house development as well as purchases from vendors
- Formal and informal training, including peer-to-peer support
- Licenses and fees
- Consulting expenses
- Facility costs
- The estimated cost of not developing the system or postponing the project

Tangible costs, such as those listed above, usually can be measured in dollars. But **intangible costs** also must be considered. For example, low employee morale might not have an immediate dollar impact, but certainly will affect the company's performance.

In addition to costs, tangible and intangible benefits to the company must be assessed. The systems review committee will use those figures, along with the cost estimates, to decide whether to pursue the project beyond the preliminary investigation phase.

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Tangible benefits are benefits that can be measured in dollars. Tangible benefits result from a decrease in expenses, an increase in revenues, or both. Examples of tangible benefits include the following:

- A new scheduling system that reduces overtime
- An online package tracking system that improves service and decreases the need for clerical staff
- A sophisticated inventory control system that cuts excess inventory and eliminates production delays

Intangible benefits are advantages that are difficult to measure in dollars but are important to the company. Examples of intangible benefits include the following:

- A user-friendly system that improves employee job satisfaction
- A sales tracking system that supplies better information for marketing decisions
- A new website that enhances the company's image

The development timetable must also be considered, because some benefits might occur as soon as the system is operational, but others might not take place until later.

2.7.4 Technical Feasibility

Technical feasibility refers to the technical resources needed to develop, purchase, install, or operate the system. When assessing technical feasibility, an analyst should consider the following points:

- Does the company have the necessary hardware, software, and network resources? If not, can those resources be acquired without difficulty?
- Does the company have the needed technical expertise? If not, can it be acquired?
- Does the proposed platform have sufficient capacity for future needs? If not, can it be expanded?
- Will a prototype be required?
- Will the hardware and software environment be reliable? Will it integrate with other company information systems, both now and in the future? Will it interface properly with external systems operated by customers and suppliers?
- Will the combination of hardware and software supply adequate performance? Do clear expectations and performance specifications exist?
- Will the system be able to handle future transaction volume and company growth?

Keep in mind that systems requests that are not currently technically feasible can be resubmitted as new hardware, software, or expertise becomes available. Development costs might decrease, or the value of benefits might increase enough that a systems request eventually becomes feasible. Conversely, an initially feasible project can be rejected later.

2.7.5 Schedule Feasibility

Schedule feasibility means that a project can be implemented in an acceptable time frame. When assessing schedule feasibility, a systems analyst must consider the interaction between time and costs. For example, speeding up a project schedule might make a project feasible, but much more expensive.

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Other issues that relate to schedule feasibility include the following:

- Can the company or the IT team control the factors that affect schedule feasibility?
- Has management established a firm timetable for the project?
- What conditions must be satisfied during the development of the system?
- Will an accelerated schedule pose any risks? If so, are the risks acceptable?
- Will project management techniques be available to coordinate and control the project?
- Will a project manager be appointed?

Chapter 3 describes various project management tools and techniques.

2.8 Setting Priorities

After rejecting systems requests that are not feasible, the systems review committee must establish priorities for the remaining items. If tools are used as part of the review process, the requests may already be in a partially or fully sorted order. The highest priority goes to project requests that provide the greatest benefit, at the lowest cost, in the shortest period of time. Many factors, however, influence project evaluation.

2.8.1 Dynamic Priorities

It's important to note that many projects are dynamic in nature. For example, projects that have adopted an agile methodology are prone to rapid changes throughout the system development lifecycle. These changes can cause request priorities to change as well.

For example, acquisition costs might increase over time, making the project more expensive than anticipated. This can affect the economic feasibility of a number of requests. In addition, managers and users sometimes lose confidence in a project. For all those reasons, feasibility analysis and priority setting are ongoing task that must be performed throughout the systems development process.

2.8.2 Factors That Affect Priority

When assessing a project's priority, a systems analyst should consider the following:

- Will the proposed system reduce costs? Where? When? How? By how much?
- Will the system increase revenue for the company? Where? When? How? By how much?
- Will the systems project result in more information or produce better results? How? Are the results measurable?
- Will the system serve customers better?
- Will the system serve the organization better?
- Can the project be implemented in a reasonable time period? How long will the results last?
- Are the necessary financial, human, and technical resources available?

Few projects will score high in all areas. Some proposals might not reduce costs but will provide important new features. Other systems might reduce operating costs

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substantially but require the purchase or lease of additional hardware. Some systems might be very desirable but require several years of development before producing significant benefits.

Whenever possible, the analyst should use tangible costs and benefits that can be measured in dollars. However, the proposal might involve intangible benefits, such as enhancing the organization's image, raising employee morale, or improving customer service. These examples are harder to measure but should also be considered.

2.8.3 Discretionary and Nondiscretionary Projects

Projects where management has a choice in implementing them are called **discretionary projects**. Projects where no choice exists are called **nondiscretionary projects**. Creating a new report for a user is an example of a discretionary project; adding a report required by a new federal law is an example of a nondiscretionary project.

If a particular project is not discretionary, the systems analyst should ask if it is really necessary for the systems review committee to evaluate it. Some people believe that waiting for committee approval delays critical nondiscretionary projects unnecessarily. Others believe that submitting all requests to the systems review keeps the committee aware of all projects that compete for IT resources. As a result, the committee can review priorities and create realistic schedules.

Many nondiscretionary projects are predictable. Examples include annual updates to payroll, tax percentages, or quarterly changes in reporting requirements for an insurance processing system. By planning ahead for predictable projects, the IT department manages its resources better and keeps the systems review committee fully informed without needing prior approval in every case.

CASE IN POINT 2.3: Attaway Airlines, Part Two

Back at Attaway Airlines, the morning meeting ended with no agreement between the VP of finance and the marketing manager. In fact, a new issue arose. The VP now says that the new accounting system is entitled to the highest priority because the federal government soon will require the reporting of certain types of company-paid health insurance premiums. Because the current system will not handle this report, the VP insists that the entire accounting system is a nondiscretionary project. As you might expect, the marketing manager is upset. Can part of a project be nondiscretionary? What issues need to be discussed? The committee meets again tomorrow, and the members will look to you, as the IT director, for guidance.

2.9 The Preliminary Investigation

A systems analyst conducts a **preliminary investigation** to study the systems request and recommend specific action. After obtaining an authorization to proceed, the analyst interacts with managers, users, and other stakeholders, as shown in the model in Figure 2-13. The analyst gathers facts about the problem or opportunity, project scope and constraints, project benefits, and estimated development time and costs. The end product of the preliminary investigation is a report to management.

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2.9.1 Planning the Preliminary Investigation

Before starting a preliminary investigation, it is important to let people know about the investigation and explain the role of the system analyst. Meetings with key managers, users, and other stakeholders such as the IT staff should be scheduled, to describe the project, explain roles and responsibilities, answer questions, and invite comments. Interactive communication with users starts at this point and continues throughout the development process.

A systems project often produces significant changes in company operations. Employees may be curious, concerned, or even opposed to those changes. It is not surprising to encounter some user resistance during a preliminary investigation. Employee attitudes and reactions are important and must be considered.

When interacting with users, use the word *problem* carefully, because it has a negative meaning. When users are asked about *problems*, some will stress current system limitations rather than desirable new features or enhancements. Instead of focusing on difficulties, question users about additional capability they would like to have. This approach highlights ways to improve the user's job, provides a better understanding of operations, and builds better, more positive relationships with users.

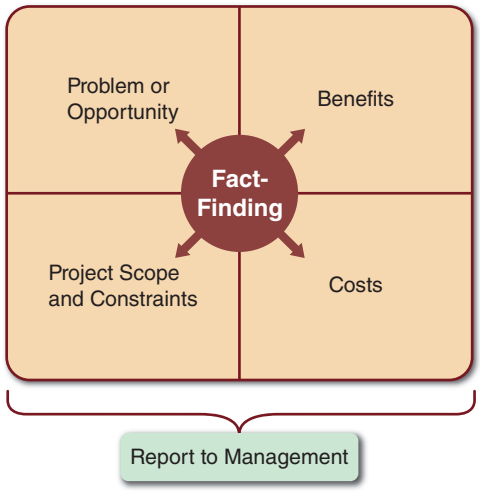


FIGURE 2-13 Model of a preliminary investigation. Note the importance of fact-finding in each of the four areas.

2.9.2 Performing the Preliminary Investigation

During a preliminary investigation, a systems analyst typically follows a series of steps, as shown in Figure 2-14. The exact procedure depends on the nature of the request, the size of the project, and the degree of urgency.

Step 1: Understand the Problem or Opportunity

If the systems request involves a new information system or a substantial change in an existing system, systems analysts might need to develop a business profile that describes current business processes and functions, as explained in Chapter 1. Even where the request involves relatively minor changes or enhancements, how those modifications will affect business operations and other information systems must be understood. Often a change in one system has an unexpected ripple effect on another system. When a systems request is analyzed, which departments, users, and business processes are involved must be determined.

In many cases, the systems request does not reveal the underlying problem, but only a symptom. For example, a request to investigate centralized processing delays might reveal improper scheduling practices rather than hardware problems. Similarly, a request for analysis of customer complaints might disclose a lack of sales representative training, rather than problems with the product.

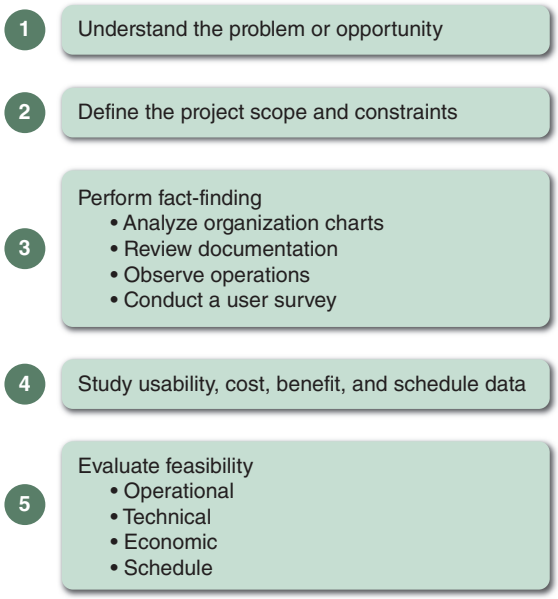


FIGURE 2-14 Five main steps in a typical preliminary investigation.

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A popular technique for investigating causes and effects is called a **fishbone diagram**, as shown in Figure 2-15. A fishbone diagram is an analysis tool that represents the possible causes of a problem as a graphical outline. When using a fishbone diagram, an analyst first states the problem and draws a main bone with sub-bones that represent possible causes of the problem. In the example shown in Figure 2-15, the problem is *Low Morale*, and the analyst has identified four areas to investigate: *Environment*, *People*, *Management*, and *Machines*. In each area, the analyst identifies possible causes and draws them as horizontal sub-bones. For example, *Temp too hot or cold* is a possible cause in the *Environment* bone. For each cause, the analyst must dig deeper and ask the question: What could be causing *this* symptom to occur? For example, *why* is it too hot? If the answer is a *Faulty thermostat*, the analyst indicates this as a sub-bone to the *Temp too hot or cold* cause. In this manner, the analyst adds additional sub-bones to the diagram, until he or she uncovers root causes of a problem, rather than just the symptoms.

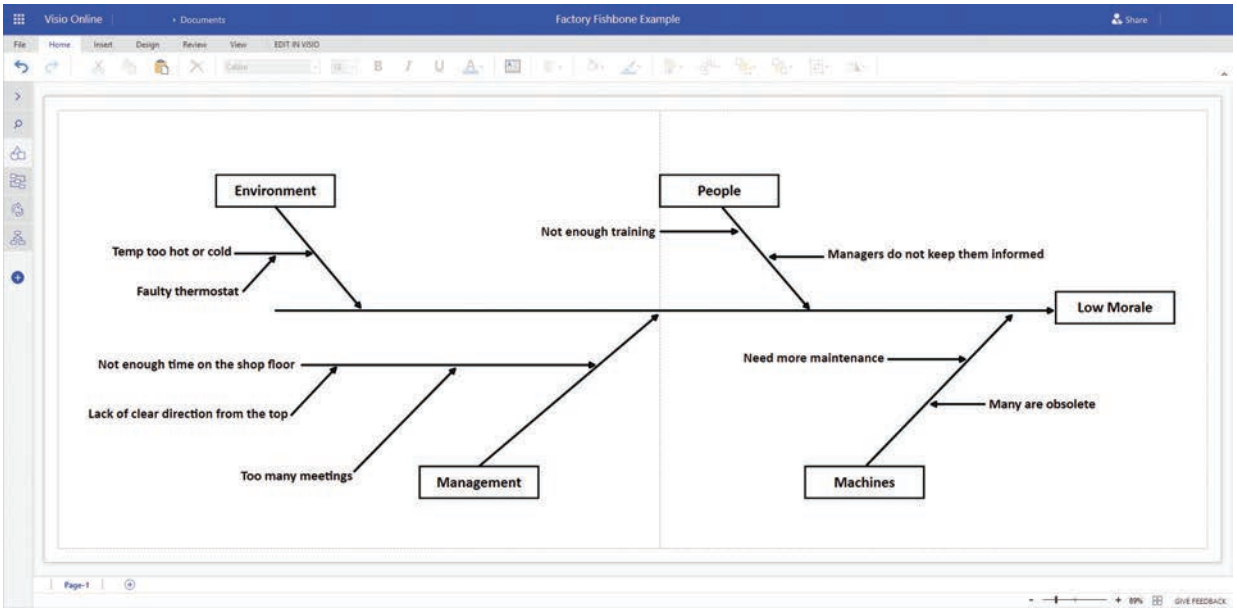


FIGURE 2-15 A fishbone diagram displays the causes of a problem. Typically, you must dig deeper to identify actual causes rather than just symptoms

Step 2: Define the Project Scope and Constraints

Determining the **project scope** means defining the specific boundaries, or extent, of the project. For example, a statement that, *payroll is not being produced accurately* is very general, compared with the statement, *overtime pay is not being calculated correctly for production workers on the second shift at the Yorktown plant*. Similarly, the statement, *the project scope is to modify the accounts receivable system*, is not as specific as the statement, *the project scope is to allow customers to inquire online about account balances and recent transactions*.

Some analysts find it helpful to define project scope by creating a list with sections called *Must Do*, *Should Do*, *Could Do,* and *Won't Do*. This list can be reviewed later, during the systems analysis phase, when the systems requirements document is developed.

Projects with very general scope definitions are at risk of expanding gradually, without specific authorization, in a process called **project creep**. To avoid this problem, project scope should be defined as clearly as possible. A graphical model

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that shows the systems, people, and business processes that will be affected is sometimes useful. The scope of the project also establishes the boundaries of the preliminary investigation itself. A systems analyst should limit the focus to the problem at hand and avoid unnecessary expenditure of time and money.

Along with defining the scope of the project, any constraints on the system must be identified. A **constraint** is a requirement or condition that the system must satisfy or an outcome that the system must achieve. A constraint can involve hardware, software, time, policy, law, or cost. System constraints also define project scope. For example, if the system must operate with existing hardware, that is a constraint that affects potential solutions. Other examples of constraints are:

- The order entry system must accept input from 15 remote sites.
- The human resources information system must produce statistics on hiring practices.
- The new website must be operational by March 1.

When examining constraints, their characteristics should be identified, as follows.

PRESENT VERSUS FUTURE: Is the constraint something that must be met as soon as the system is developed or modified, or is the constraint necessary at some future time?

INTERNAL VERSUS EXTERNAL: Is the constraint due to a requirement within the organization, or does some external force, such as government regulation, impose it?

MANDATORY VERSUS DESIRABLE: Is the constraint mandatory? Is it absolutely essential to meet the constraint, or is it merely desirable?

Figure 2-16 shows five examples of constraints. Notice that each constraint has three characteristics, which are indicated by its position in the figure and by the symbol that represents the constraint, as follows:

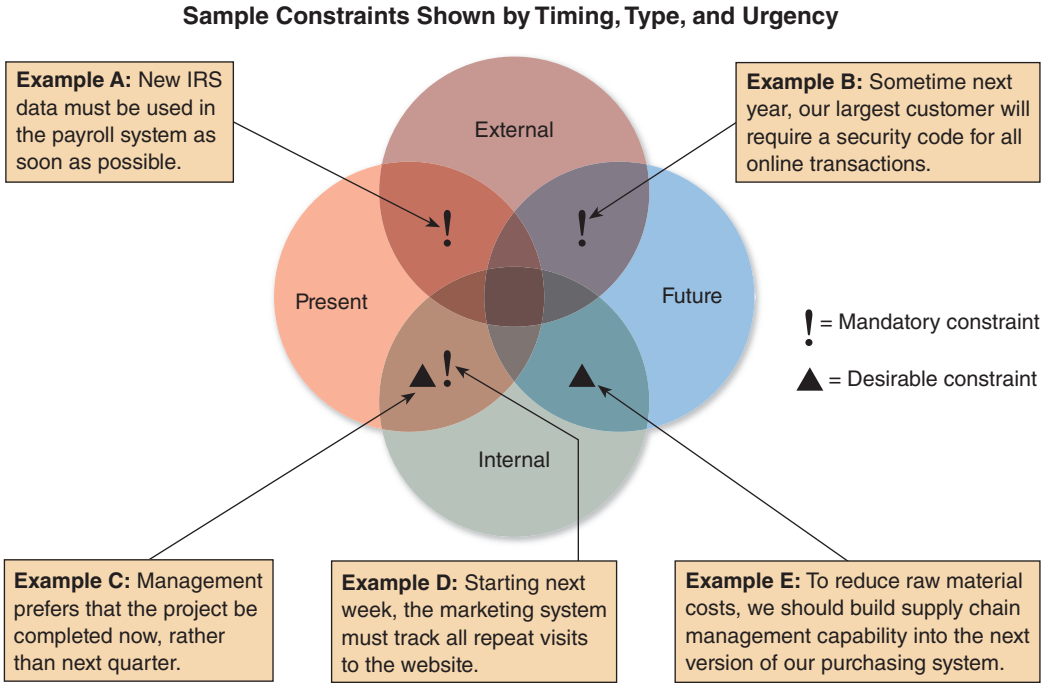


FIGURE 2-16 Examples of various types of constraints.

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- The constraint in Example A is present, external, and mandatory.
- The constraint in Example B is future, external, and mandatory.
- The constraint in Example C is present, internal, and desirable.
- The constraint in Example D is present, internal, and mandatory.
- The constraint in Example E is future, internal, and desirable.

Regardless of the type, all constraints should be identified as early as possible to avoid future problems and surprises. A clear definition of project scope and constraints avoids misunderstandings that arise when managers assume that the system will have a certain feature or support for a project, but later find that the feature is not included.

Step 3: Perform Fact-Finding

The objective of fact-finding is to gather data about project usability, costs, benefits, and schedules. Fact-finding involves various techniques, which are described below. Depending on what information is needed to investigate the systems request, fact-finding might consume several hours, days, or weeks. For example, a change in a report format or data entry screen might require a single telephone call or email message to a user, whereas a new inventory system would involve a series of interviews. During fact-finding, the analyst might analyze organization charts, conduct interviews, review current documentation, observe operations, and carry out a user survey.

ANALYZE ORGANIZATION CHARTS: An analyst will not always know the organizational structure of departments involved in the study. Organization charts should be obtained to understand the functions and identify people to interview.

If organization charts are not available, or are out-of-date, the necessary information should be obtained from department personnel and construct the charts, as shown in Figure 2-17.

Even when charts are available, their accuracy should be verified. Keep in mind that an organization chart shows formal reporting relationships but not the informal alignment of a group, which also is important.

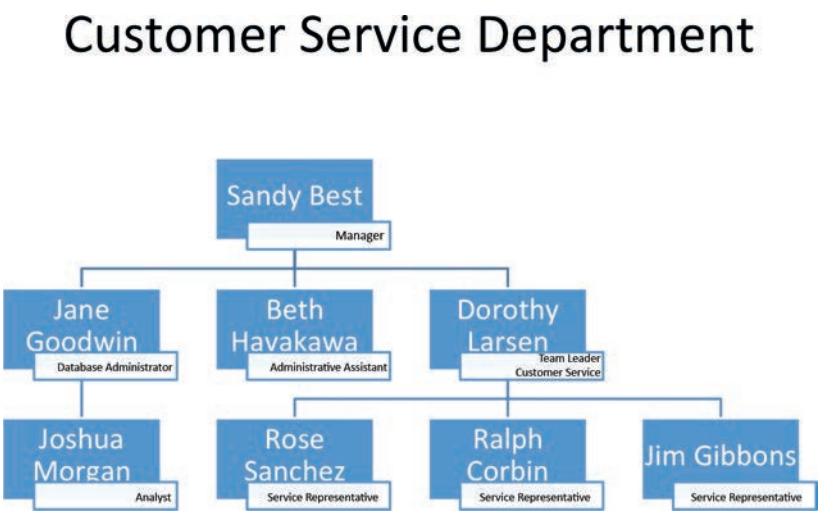


FIGURE 2-17 Specialized tools such as Microsoft Visio can be used to draw organizational charts, but general purpose presentation tools such as Microsoft PowerPoint shown here can also be used.

CONDUCT INTERVIEWS: The primary method of obtaining information during the preliminary investigation is the interview. The interviewing process involves a series of steps:

1. Determine the people to interview.
2. Establish objectives for the interview.
3. Develop interview questions.
4. Prepare for the interview.
5. Conduct the interview.
6. Document the interview.
7. Evaluate the interview.

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These seven steps are discussed in detail in Chapter 4, which describes fact-finding techniques that occur during the systems analysis phase of the SDLC.

Remember that the purpose of the interview, and of the preliminary investigation itself, is to uncover facts, not to convince others that the project is justified. The analyst's primary role in an interview is to ask effective questions and listen carefully. If several people will be asked about the same topic, a standard set of questions for all the interviews should be prepared. Also be sure to include open-ended questions, such as "What else do you think I should know about the system?" or "Is there any other relevant information that we have not discussed?"

When conducting interviews during the preliminary investigation, interview managers and supervisors who have a broad knowledge of the system and can provide an overview of the business processes involved. Depending on the situation, talking to operational personnel to learn how the system functions on a day-to-day basis may also be helpful.

REVIEW DOCUMENTATION: Although interviews are an extremely important method of obtaining information, investigating the current system documentation is also useful. The documentation might not be up to date, so check with users to confirm that the information is accurate and complete.

OBSERVE OPERATIONS: Another fact-finding method is to observe the current system in operation. Observe how workers carry out typical tasks. Trace or follow the actual paths taken by input source documents or output reports. In addition to observing operations, consider sampling the inputs or outputs of the system. Using sampling techniques described in Chapter 4, valuable information about the nature and frequency of the problem can be obtained.

CONDUCT A USER SURVEY: Interviews can be time consuming. Sometimes information from a larger group can be obtained by conducting a user survey. In this case, design a form that users complete and return for tabulation. A survey is not as flexible as a series of interviews, but it is less expensive, generally takes less time, and can involve a broad cross-section of people.

ANALYZE THE DATA: Systems analysts use many techniques to locate the source of a problem. For example, the **Pareto chart** is a widely used tool for visualizing issues that need attention. Named for a nineteenth century economist, a Pareto chart is drawn as a vertical bar graph, as shown in Figure 2-18. The bars, which represent various causes of a problem, are arranged in descending order, so the team can focus on the most important causes. In the example shown, a systems analyst might use a Pareto chart to learn more about the causes of inventory system problems, so that necessary improvements can be made.

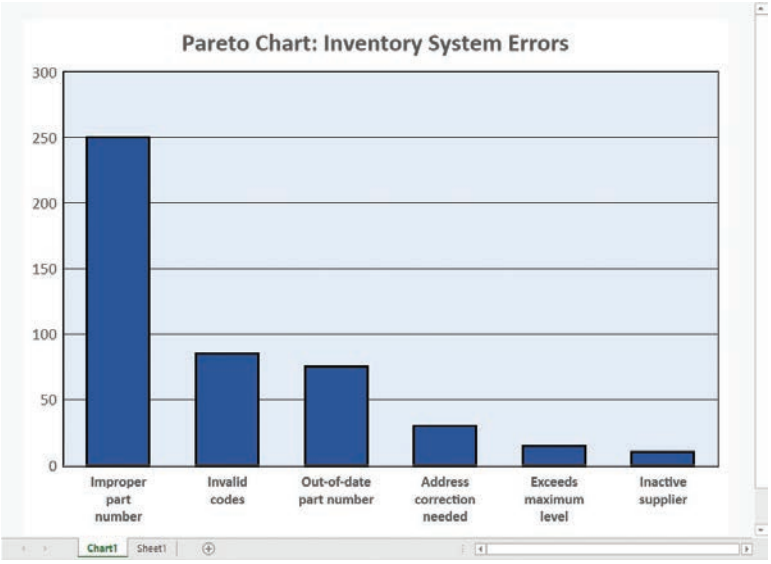


FIGURE 2-18 A Pareto chart displays the causes of a problem, in priority order, so an analyst can tackle the most important cases first. In this example, the part number issue would be the obvious starting point.

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The **XY chart**, sometimes called a **scatter diagram**, is another problem-solving tool. Often, an analyst looks for a correlation between two variables. For example, suppose complaints are received about network response time, and the cause needs to be determined. The analyst would try to identify variables, such as the number of users, to see whether there is a correlation, or pattern. Figure 2-19 shows two XY charts with data samples. The first chart sample would suggest that there is no correlation

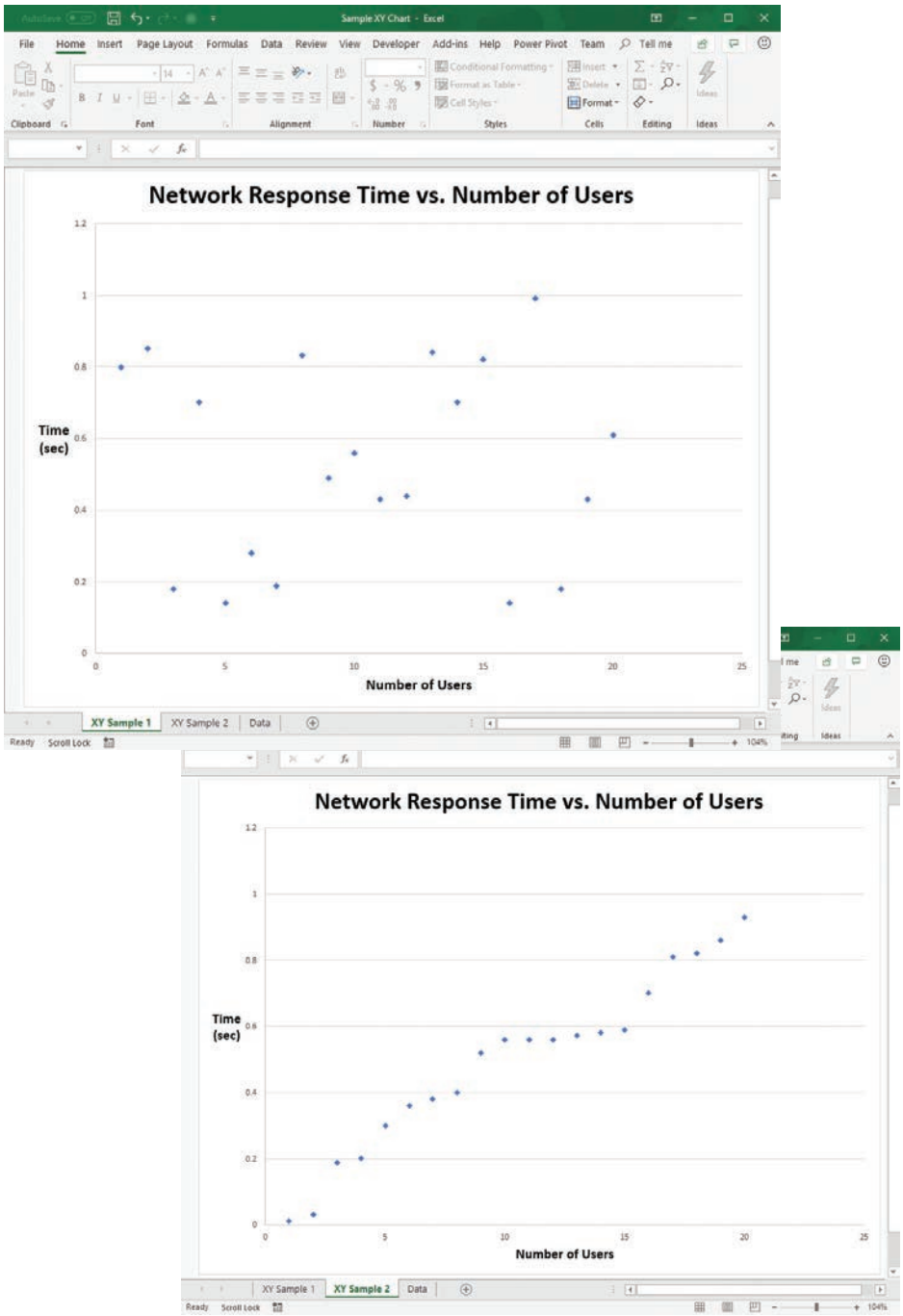


FIGURE 2-19 An XY chart shows correlation between variables, which is very important in problem solving. Conversely, a lack of correlation suggests that the variables are independent, and that you should look elsewhere for the cause.

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between the delays and the number of users, so the analyst would look elsewhere for the source of the problem. However, if the data resembles the second XY sample, it indicates a strong relationship between the number of users and the longer response times. That information would be extremely valuable in the problem-solving process.

Step 4: Analyze Project Usability, Cost, Benefit, and Schedule Data

During fact-finding, data is gathered about the project's predicted costs, anticipated benefits, and schedule issues that could affect implementation. Before feasibility can be evaluated, this data must be analyzed carefully. If interviews were conducted or surveys used, the data should be tabulated to make it easier to understand. If current operations were observed, the results should be reviewed and key facts that will be useful in the feasibility analysis highlighted. If cost and benefit data were gathered, financial analysis and impact statements can be prepared using spreadsheets and other decision-support tools.

Also, time and cost estimates should be developed for the requirements modeling tasks for the next SDLC phase, systems analysis. Specifically, the following should be considered:

- What information must be obtained, and how will it be gathered and analyzed?
- Who will conduct the interviews? How many people will be interviewed, and how much time will be needed to meet with the people and summarize their responses?
- Will a survey be conducted? Who will be involved? How much time will it take people to complete it? How much time will it take to tabulate the results?
- How much will it cost to analyze the information and prepare a report with findings and recommendations?

Step 5: Evaluate Feasibility

At this point, the problem or opportunity has been analyzed, the project scope and constraints have been defined, and fact-finding has been performed to evaluate project usability, costs, benefits, and time constraints. The next step is to assess the project's feasibility, beginning with reviewing the answers to the questions listed in Section 2.7. The following guidelines should also be considered:

OPERATIONAL FEASIBILITY: Fact-finding should have included a review of user needs, requirements, and expectations. When this data is analyzed, look for areas that might present problems for system users and how they might be resolved. Because operational feasibility means that a system will be used effectively, this is a vital area of concern.

ECONOMIC FEASIBILITY: Using the fact-finding data, financial analysis tools can be applied to assess feasibility. The cost-benefit data will be an important factor for management to consider. Also, a cost estimate for the project development team will be built into the project management plan.

TECHNICAL FEASIBILITY: The fact-finding data should identify the hardware, software, and network resources needed to develop, install, and operate the system. With this data, a checklist can be developed that will highlight technical costs and concerns, if any.

SCHEDULE FEASIBILITY: The fact-finding data should include stakeholder expectations regarding acceptable timing and completion dates. As mentioned previously,

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often a trade-off exists between a project's schedule and its costs. For example, compressing a project schedule might be possible, but only if the budget is increased accordingly to add extra personnel. The schedule data will be incorporated into the project plan in the form of task durations and milestones.

At this stage of the preliminary investigation, there are several alternatives. It might be that no action is necessary or that some other strategy, such as additional training, is needed. To solve a minor problem, a simple solution might be chosen without performing further analysis. In other situations, it will be recommended that the project proceed to the next phase, which is systems analysis.

2.9.3 Summarizing the Preliminary Investigation

The final task in the preliminary investigation is to summarize the results and recommendations, which can be conveying to management in a report and/or in a presentation. The written report and the oral presentation are examples of the need for systems analysts to develop strong communications skills. The report includes an evaluation of the systems request, an estimate of costs and benefits, and a **case for action**, which is a summary of the project request and a specific recommendation.

The specific format of a preliminary investigation report varies. A typical report might consist of the following sections:

- *Introduction*—the first section is an overview of the report. The introduction contains a brief description of the system, the name of the person or group who performed the investigation, and the name of the person or group who initiated the investigation.
- *Systems Request Summary*—the summary describes the basis of the systems request.
- *Findings*—the findings section contains the results of the preliminary investigation, including a description of the project's scope, constraints, and feasibility.
- *Recommendations*—a summary of the project request and a specific recommendation. Management will make the final decision, but the IT department's input is an important factor.
- *Project Roles*—this section lists the people who will participate in the project and describes each person's role.
- *Time and Cost Estimates*—this section describes the cost of acquiring and installing the system, and the total cost of ownership during the system's useful life. Intangible costs also should be noted.
- *Expected Benefits*—this section includes anticipated tangible and intangible benefits and a timetable that shows when they are to occur.
- *Appendix*—an appendix is included in the report if supporting information must be attached. For example, the interviews conducted might be listed, the documentation reviewed, and other sources for the information obtained. Detailed interview reports do not need to be included, but those documents that support the report's findings should be retained for future reference.

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A QUESTION OF ETHICS



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As a new systems analyst at Premier Financial Services, you are getting quite an education. You report to the IT manager, who also chairs the systems review committee. Several months ago, the committee rejected a request from the finance director for an expensive new accounts payable system because the benefits did not appear to outweigh the costs.

Yesterday, the IT manager's boss asked the IT manager to reconsider the finance director's request, and to persuade the other members to approve it. The IT manager wanted to discuss the merits of the request, but the discussion was cut off rather abruptly. It turns out the IT manager's boss and the finance director are longtime friends.

The IT manager is now very uncomfortable meeting with her boss. She believes the directive to reconsider the finance director's request would undermine the integrity of the systems review process. She feels it would be unethical to grant preferred treatment just because a friendship is involved. She is thinking of submitting a request to step down as review committee chair, even though that might harm her career at the company.

Is this an ethical question, or just a matter of office politics? What would you do if you were the IT manager?

2.10 Summary

Systems planning is the first phase of the systems development life cycle. Effective information systems help an organization support its business processes, carry out its mission, and serve its stakeholders. During strategic planning, a company examines its purpose, vision, and values and develops a mission statement, which leads to goals, objectives, day-to-day operations, and business results that affect company stakeholders. SWOT analysis examines strengths, weaknesses, opportunities, and threats. SWOT analysis can be used at the enterprise level and for individual projects.

During the systems planning phase, an analyst reviews the business case, which is the basis, or reason, for a proposed system. A business case should describe the project clearly, provide the justification to proceed, and estimate the project's financial impact.

Systems projects are initiated to improve performance, provide more information, reduce costs, strengthen controls, or provide better service. Various internal and external factors affect systems projects, such as user requests, top management directives, existing systems, the IT department, software and hardware vendors, technology, customers, competitors, the economy, and government.

During the preliminary investigation, the analyst evaluates the systems request and determines whether the project is feasible from an operational, technical, economic, and schedule standpoint. Analysts evaluate systems requests on the basis of their expected costs and benefits, both tangible and intangible.

The steps in the preliminary investigation are to understand the problem or opportunity; define the project scope and constraints; perform fact-finding; analyze project usability, cost, benefit, and schedule data; evaluate feasibility; and present results and recommendations to management. During the preliminary investigation, analysts often use investigative tools such as fishbone diagrams, Pareto charts, and XY charts. The last task in a preliminary investigation is to prepare a report to management. The report must include an estimate of time, staffing requirements, costs, benefits, and expected results for the next phase of the SDLC.

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Key Terms

biometric devices A mechanism used to uniquely identify a person by a retina scan or by mapping a facial pattern.

blockchain A distributed ledger system. The technology underlying Bitcoin.

business case Refers to the reasons, or justification, for a proposal.

case for action A part of the preliminary investigation report to management that summarizes project requests and makes specific recommendations.

computer resources committee A group of key managers and users responsible for evaluating systems requests. The term "systems review committee" is also used.

constraint A requirement or a condition that the system must satisfy or an outcome that the system must achieve.

critical success factors Vital objectives that must be achieved for the enterprise to fulfill its mission.

customer relationship management (CRM) Many companies implement systems to integrate all customer-related events and transactions including marketing, sales, and customer service activities.

discretionary projects Where management has a choice in implementing a project, they are called discretionary. For example, creating a new report for a user is an example of a discretionary project.

economic feasibility Achieved if the projected benefits of the proposed system outweigh the estimated costs involved in acquiring, installing, and operating it.

electronic data interchange (EDI) The exchange of business documents between computers using a standard electronic format.

electronic product code (EPC) Technology that uses RFID tags to identify and monitor the movement of each individual product, from the factory floor to the retail checkout counter.

electronic proof of delivery (EPOD) A supplier uses RFID tags on each crate, case, or shipping unit to create a digital shipping list to verify receipt of goods.

encryption A process where data is coded (converted into unreadable characters) so that only those with the required authorization can access the data.

fishbone diagram An analysis tool that represents the possible causes of a problem as a graphical outline. Also called an Ishikawa diagram.

intangible benefits Positive outcomes that are difficult to measure in dollars. However, intangible benefits can be very important in the calculation of economic feasibility. An example of an intangible benefit might be a new website that improves a company's image.

intangible costs Items that are difficult to measure in dollar terms, such as employee dissatisfaction.

Internet-of-Things (IOT) Devices connected to one another over a computer network.

just-in-time (JIT) The exchange or delivery of information when and where it is needed. For example, just-in-time inventory systems rely on computer-to-computer data exchange to minimize unnecessary inventory.

mission statement A document or statement that describes the company for its stakeholders and briefly states the company's overall purpose, products, services, and values.

nondiscretionary projects Where management has no choice in implementing a project, they are called nondiscretionary. For example, adding a report required by a new federal law.

operational feasibility A system that that will be used effectively after it has been developed.

Pareto chart A vertical bar graph named for a nineteenth century economist. The bars, which represent various causes of a problem, are arranged in descending order, so the team can focus on the most important causes.

preliminary investigation An initial analysis to clearly identify the nature and scope of the business opportunity or problem. Also called a feasibility study.

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project creep The process by which projects with very general scope definitions expand gradually, without specific authorization.

project scope A specific determination of a project's boundaries or extent.

scatter diagram A tool used by system analysts to graphically show the correlation between two variables. Also called an XY chart.

schedule feasibility A project can be implemented in an acceptable time frame.

strategic planning The process of identifying long-term organizational goals, strategies, and resource.

SWOT analysis An examination of a company's strengths (S), weaknesses (W), opportunities (O), and threats (T).

systems request A formal appeal to the IT department that describes problems or desired changes in an information system or business process. It might propose enhancements for an existing system, the correction of problems, or the development of an entirely new system.

systems review committee A group of key managers and users responsible for evaluating systems requests. The term computer resources committee is sometimes also used.

tangible benefits Positive outcomes that can be measured in dollars. They can result from a decrease in expenses, an increase in revenues, or both.

tangible costs Expenses that have a specific dollar value. Examples include employee salaries and hardware purchases.

technical feasibility When an organization has the resources to develop or purchase, install, and operate the system.

total cost of ownership (TCO) A number used in assessing costs, which includes ongoing support and maintenance costs, as well as acquisition costs.

XY chart A tool used by system analysts to graphically show the correlation between two variables. Also called a scatter diagram.

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Exercises

Questions

1. Why should a systems analyst be interested in strategic planning?
2. List the four factors involved in a SWOT analysis.
3. Describe how CASE tools can support strategic planning.
4. List five questions the business case should answer.
5. What are the six main reasons for systems requests?
6. Explain the two main factors affecting systems requests.
7. Describe the role of the systems review committee in processing systems requests.
8. Define operational, economic, technical, and schedule feasibility.
9. List seven questions the systems analyst should consider when assessing project priorities.
10. What are the five steps of a preliminary investigation?

Discussion Topics

1. One of your coworkers says, "Mission statements are nice, but they really don't change things down here where the work gets done." How would you reply?
2. Discuss how a company's financial status can affect systems projects.
3. The vice president of accounting says to you, the IT director, "This request procedure takes too long. My people know what they are doing, and their systems requests are necessary and important." She suggests that the IT department bypass the initial steps and immediately get to work on her requests. What would you say to her?
4. When setting priorities for system requests, the highest priority goes to projects that provide the greatest benefit, at the lowest cost, in the shortest period of time. How would you reconcile projects that can produce good results in the short term versus projects that can produce excellent results in the long term?
5. The final task in the preliminary investigation is to summarize the results and recommendations in a report and/or in a presentation. Which form of communication, written or oral, do you think is the most effective for conveying your findings to management?

Projects

1. Use the Internet to find three examples of corporate mission statements.
2. Prepare a SWOT analysis of your school or your employer.
3. A mind map is a diagram used to visually organize information. Identify a tool that supports the creation of mind maps and explain how they can be a valuable part of strategic planning.
4. Visit the website for an IT magazine and find an article that discusses business cases. Summarize the article and what you learned from it.
5. Think of a problem you have experienced at school or at work and draw a sample fishbone diagram with at least two levels.

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CHAPTER 3 Managing Systems Projects

Chapter 3 is the final chapter in the systems planning phase of the SDLC. This chapter describes project management and explains how to plan, schedule, monitor, and report on IT projects.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" considers the implications of raising awareness of a project going astray even when the project manager is reluctant to do so.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Illustrate project priorities in the form of a project triangle
2. Explain project planning, scheduling, monitoring, and reporting
3. Create a work breakdown structure
4. Identify task patterns
5. Calculate a project's critical path
6. Describe project monitoring and control techniques to keep a project on schedule
7. Explain how project status is reported
8. Describe project management software and how it can be of assistance
9. Create a risk management plan
10. Describe why projects sometimes fail

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3.1 Overview of Project Management
3.2 Creating a Work Breakdown Structure
Case in Point 3.1: Sunrise Software
3.3 Task Patterns
Case in Point 3.2: Parallel Services
3.4 The Critical Path
3.5 Project Monitoring and Control
3.6 Reporting
3.7 Project Management Software
3.8 Risk Management
3.9 Managing for Success
Case in Point 3.3: Just-in-Time Software
A Question of Ethics
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Exercises

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3.1 Overview of Project Management

Many professionals manage business and personal projects every day but do not always give it much thought. The management process for developing an information system or working on a construction project is much the same. The only difference is the nature of the project. To manage a large-scale IT project, specific tools and techniques are needed. A project manager is also needed, someone who is responsible for overseeing all relevant tasks. **Project management** for IT professionals includes planning, scheduling, monitoring and controlling, and reporting on information system development.

A project manager will break the project down into individual tasks, determine the order in which the tasks need to be performed, and figure out how long each task will take. With this information, Gantt charts or PERT/CPM charts can be used to schedule and manage the work. Microsoft Project is a popular project management tool that can help create and then monitor the project plan, report progress, and use risk management to make the whole process easier for everyone.

3.1.1 What Shapes a Project?

A successful project must be completed on time, be within budget, and deliver a quality product that satisfies users and meets requirements. Project management techniques can be used throughout the SDLC. Systems developers can initiate a formal project as early as the preliminary investigation stage, or later on, as analysis, design, and implementation activities occur.

Systems development projects tend to be dynamic and challenging. There is always a balance between constraints, which was discussed in Chapter 2, and interactive elements such as project cost, scope, and time.



FIGURE 3-1 You can't get everything you want; you have to make choices.

3.1.2 What Is a Project Triangle?

Figure 3-1 shows a very simple example of a project triangle. For each project, it must be decided what is most important, because the work cannot be good *and* fast *and* cheap.

When it comes to project management, things are not quite so simple. Decisions do not need to be all-or-nothing but recognize that any change in one leg of the triangle will affect the other two legs. Figure 3-2 represents a common view of a **project triangle**, where the three legs are cost, scope, and time. The challenge is to find the optimal balance among these factors. Most successful project managers rely on personal experience, communication ability, and resourcefulness. For example, if an extremely time-critical project starts to slip, the project manager might have to trim some features, seek approval for a budget increase, add new personnel, or a combination of all three actions.

On its website, Microsoft offers an interesting suggestion for project managers who have a project at risk: Find the "stuck side" of the triangle. Microsoft states that in most projects, at least one side of the triangle is fixed and unlikely to change. It might be a budget cast in stone, a scope that is inflexible, or a schedule driven by factors beyond the firm's control.

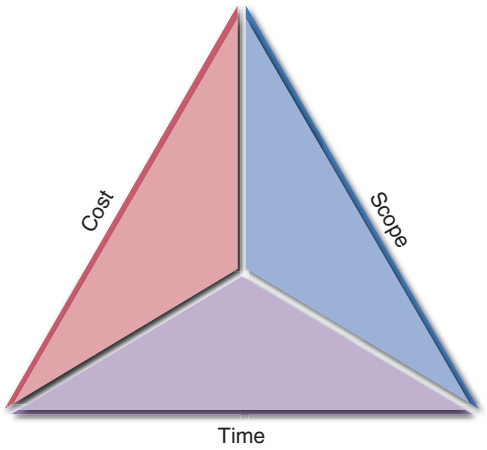


FIGURE 3-2 A typical project triangle includes cost, scope, and time.

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Whichever side is fixed is probably critical to the project's success. The leg where the problem resides must also be identified: cost, scope, or time.

3.1.3 What Does a Project Manager Do?

Whether a project involves a new office building or an information system, good leadership is essential. In a systems project, the **project manager**, or **project leader**, usually is a senior systems analyst or an IT department manager if the project is large. An analyst or a programmer/analyst might manage smaller projects. In addition to the project manager, most large projects have a project coordinator. A **project coordinator** handles administrative responsibilities for the team and negotiates with users who might have conflicting requirements or want changes that would require additional time or expense.

Project managers typically perform four activities or functions: planning, scheduling, monitoring, and reporting:

- **Project planning** includes identifying all project tasks and estimating the completion time and cost of each.
- **Project scheduling** involves the creation of a specific timetable, usually in the form of charts that show tasks, task dependencies, and critical tasks that might delay the project. Scheduling also involves selecting and staffing the project team and assigning specific tasks to team members. Project scheduling uses Gantt charts and PERT/CPM charts, which are explained in the following sections.
- **Project monitoring** requires guiding, supervising, and coordinating the project team's workload. The project manager must monitor the progress, evaluate the results, and take corrective action when necessary to control the project and stay on target.
- **Project reporting** includes regular progress reports to management, users, and the project team itself. Effective reporting requires strong communication skills and a sense of what others want and need to know about the project.

The following sections describe the project planning and scheduling steps: how to create a work breakdown structure, identify task patterns, and calculate the project's critical path.

3.2 Creating a Work Breakdown Structure

A **work breakdown structure (WBS)** involves breaking a project down into a series of smaller tasks. Before creating WBSs, the two primary chart types should be understood: Gantt charts and PERT/CPM charts.

3.2.1 Gantt Charts

Henry L. Gantt, a mechanical engineer and management consultant, developed Gantt charts almost 100 years ago. His goal was to design a chart that could show planned and actual progress on a project. A **Gantt chart** is a horizontal bar chart that represents a set of tasks. For example, the Gantt chart in Figure 3-3 displays five tasks in a vertical array, with time shown on the horizontal axis. The position of the bar shows the planned starting and ending time of each task, and the length of the bar indicates its duration. On the horizontal axis, time can be shown as elapsed time

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from a fixed starting point or as actual calendar dates. A Gantt chart also can simplify a complex project by combining several activities into a **task group** that contains subsidiary tasks. This allows a complex project to be viewed as a set of integrated modules.

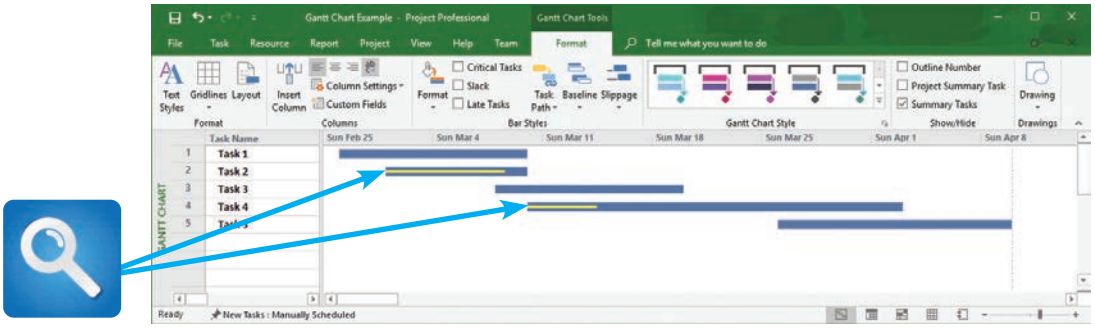


FIGURE 3-3 In this Gantt chart, note the yellow bars that show the percentage of task completion.

A Gantt chart can show task status by adding a contrasting color to the horizontal bars. For example, a vertical red arrow marks the current date in Figure 3-3. With a fixed reference point, it is easy to see that Task 1 is way behind schedule; Task 2 is only about 80% done and is running behind schedule; Task 3 should have started, but no work has been done; Task 4 actually is running ahead of schedule; and Task 5 will begin in several weeks.

Gantt charts can present an overview of the project's status, but they do not provide enough detailed information, which is necessary when managing a complex project. Some project managers may find that PERT/CPM charts, which are discussed in the following section, are better tools for managing large projects.

3.2.2 PERT/CPM Charts

The **Program Evaluation Review Technique (PERT)** was developed by the U.S. Navy to manage very complex projects, such as the construction of nuclear submarines. At approximately the same time, the **Critical Path Method (CPM)** was developed by private industry to meet similar project management needs. The distinction between the two methods has disappeared over time, and today the technique is called either PERT, CPM, or **PERT/CPM**. This text will use the term *PERT chart*.

PERT is a **bottom-up technique** because it analyzes a large, complex project as a series of individual tasks, just as a pyramid is built from the bottom up using individual blocks. To create a PERT chart, first identify all the project tasks and estimate how much time each task will take to perform. Next, determine the logical order in which the tasks must be performed. For example, some tasks cannot start until other tasks have been completed. In other situations, several tasks can be performed at the same time.

Once the tasks are known, their durations, and the order in which they must be performed, calculate the time that it will take to complete the project. The specific tasks that will be critical to the project's on-time completion can also be identified. An example of a PERT chart, which Microsoft calls a **network diagram**, is shown in the lower screen in Figure 3-4.

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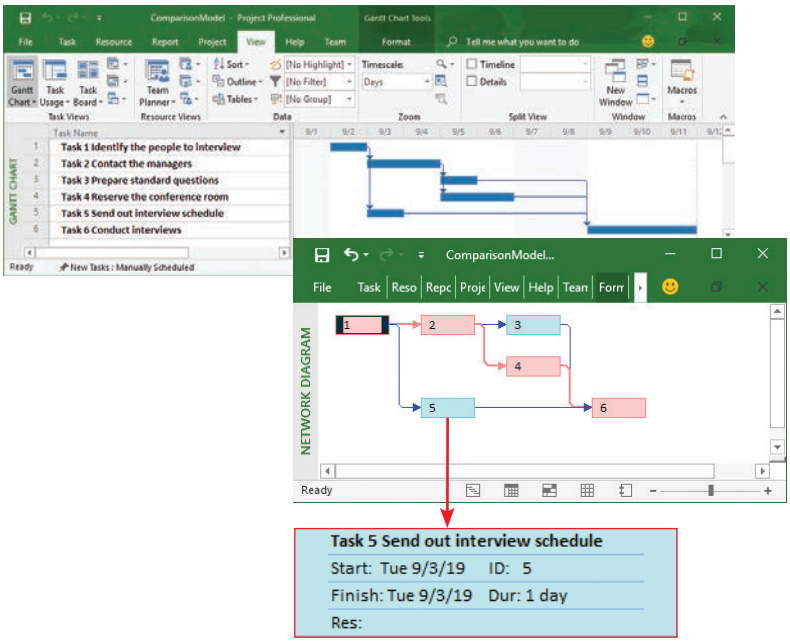


FIGURE 3-4 The top screen shows a Gantt chart with six tasks. The PERT chart in the bottom screen displays an easy-to-follow task pattern for the same project. When the user mouses over the summary box for Task 5, the details become visible.

Although a Gantt chart offers a valuable snapshot view of the project, PERT charts are more useful for scheduling, monitoring, and controlling the actual work. With a PERT chart, a project manager can convert task start and finish times to actual dates by laying out the entire project on a calendar. Then, on any given day, the manager can compare what should be happening with what is taking place and react accordingly. Also, a PERT chart displays complex task patterns and relationships. This information is valuable to a manager who is trying to address high priority issues. PERT and Gantt charts are not mutually exclusive techniques, and project managers often use both methods.

Figure 3-4 shows both chart types. The top screen is a Gantt chart with six tasks. The PERT chart below it shows the same project, using a separate box for each task instead of a horizontal bar. Although they both show the task patterns and flow, the PERT chart boxes can provide more information, such as task duration, start date, finish date, and the names of resources assigned to the task. The PERT chart in Figure 3-4 would be too small to view the actual details, which are shown in the expanded text box at the bottom of the figure. How to create PERT charts is explained in a later section.

3.2.3 Identifying Tasks in a Work Breakdown Structure

A WBS must clearly identify each task and include an estimated duration. A **task**, or an **activity**, is any work that has a beginning and an end and requires the use of company resources such as people, time, or money. Examples of tasks include conducting interviews, designing a report, selecting software, waiting for the delivery of equipment, or training users. Tasks are basic units of work that the project manager plans, schedules, and monitors—so they should be relatively small and manageable.

In addition to tasks, every project has **events**, or **milestones**. An event, or a milestone, is a recognizable reference point that can be used to monitor progress. For example, an event might be the start of user training, the conversion of system data, or the completion of interviews. A milestone such as "complete 50% of program testing" would not be useful information unless it could be determined exactly when that event will occur.

Figure 3-5 shows tasks and events that might be involved in the creation, distribution, and tabulation of a questionnaire. Note that the beginning and end of each task are marked by a recognizable event. It would be virtually impossible to manage a project as one large task. Instead, the project is broken down into smaller tasks, creating a WBS. The first step in creating a WBS is to list all the tasks.

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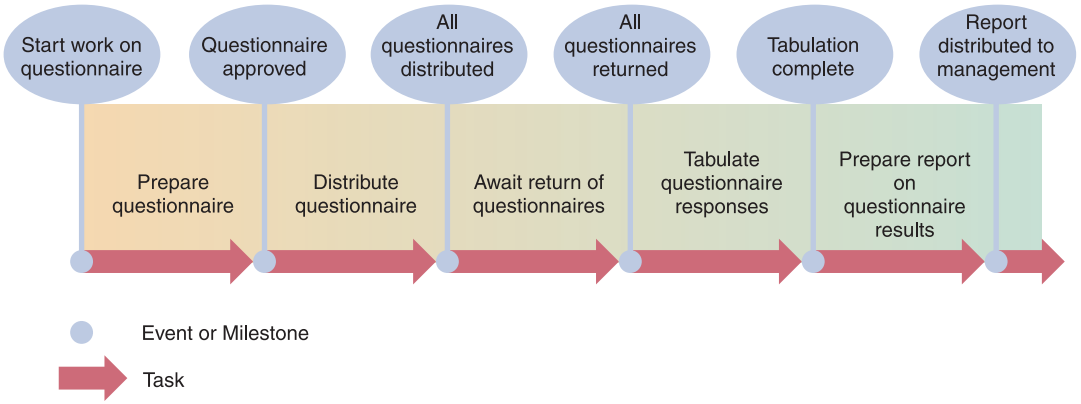


FIGURE 3-5 Using a questionnaire requires a series of tasks and events to track the progress. The illustration shows the relationship between the tasks and the events, or milestones, which mark the beginning and end of each task.

LISTING THE TASKS: While this step sounds simple, it can be challenging because the tasks might be embedded in a document, such as the one shown in the first version of Figure 3-6. One trick is to start by highlighting the individual tasks, as shown in the second version. Adding bullets makes the tasks stand out more clearly, as shown in the third version. The next step is to number the tasks and create a table, similar to the one shown in Figure 3-7, with columns for task number, description, duration, and **predecessor tasks**, which must be completed before another task can start.

ESTIMATING TASK DURATION: Task duration can be hours, days, or weeks—depending on the project. Because the following example uses days, the units of measurement are called person-days. A **person-day** represents the work that one person can complete in one day. This approach, however, can present some problems. For example, if it will take one person 20 days to perform a particular task, it might not be true that two people could complete the same task in 10 days or that 10 people could perform the task in two days. Some tasks can be divided evenly so it is possible to use different combinations of time and people—up to a point—but not all. In most systems analysis tasks, time and people are not interchangeable. If one analyst needs two hours to interview a user, two analysts also will need two hours to do the same interview.

Project managers often use a weighted formula for estimating the duration of each task. The project manager first makes three time estimates for each task: an optimistic, or **best-case estimate** (B), a **probable-case estimate** (P), and a pessimistic, or **worst-case estimate** (W). The manager then assigns a **weight**, which is an importance value, to each estimate. The weight can vary, but a common approach is to use a ratio of B = 1, P = 4, and W = 1. The expected task duration is calculated as follows:

$$\frac{(B + 4P + W)}{6}$$

First version

First, reserve the meeting room. Then order the marketing materials and brief the managers. After the briefings, send out customer emails and upload program to the app store. When the emails are sent and the program is available on the app store ready, load the new software. When the marketing materials have arrived and the software is ready, do a dress rehearsal.

Second version

First, *reserve the meeting room*. Then *order the marketing materials* and *brief the managers*. After the briefings, *send out customer emails* and *upload program to the app store*. When the emails are sent and the program is available on the app store ready, *load the new software*. When the marketing materials have arrived and the software is ready, *do a dress rehearsal*.

Third version

- First, *reserve the meeting room*.
- Then *order the marketing materials* and *brief the managers*.
- After the briefings, *send out customer emails* and *upload program to the app store*.
- When the emails are sent and the program is available on the app store ready, *load the new software*.
- When the marketing materials have arrived and the software is ready, *do a dress rehearsal*.

FIGURE 3-6 The three versions show how to transform a task statement into a list of specific tasks for a work breakdown structure.

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Task No.	Description	Duration (Days)	Predecessor Tasks
1	Reserve the meeting room		
2	Order the marketing materials		
3	Brief the managers		
4	Send out customer emails		
5	Upload program to the app store		
6	Load the new software		
7	Do a dress rehearsal		

FIGURE 3-7 In this table, columns have been added for task number, description, duration, and predecessor tasks, which must be completed before another task can start.

For example, a project manager might estimate that a file-conversion task could be completed in as few as 20 days or could take as many as 34 days, but most likely will require 24 days. Using the formula, the expected task duration is 25 days, calculated as follows:

$$\frac{(20 + (4*24) + 34)}{6} = 25$$

CASE IN POINT 3.1: SUNRISE SOFTWARE

A lively discussion is under way at Sunrise Software, where you are a project manager. The main question is whether the person-days concept has limitations. In other words, if a task will require 100 person-days, does it matter whether two people in 50 days, five people in 20 days, ten people in 10 days, or some other combination that adds up to 100 performs the work?

Two programmers on the project seem to think it doesn't matter. On the other hand, one of the project's systems analysts says it is ridiculous to think that any combination would work. To support his point, this extreme example was offered: Could 100 people accomplish a task estimated at 100 person-days in one day?

Is the systems analyst correct? If so, what are the limits in the "people versus days" equation? Taking the concept a step further, is there an optimum number of people to be assigned to a task? If so, how would that number be determined? You need to offer some guidance at the next project team meeting. What will you say?

3.2.4 Factors Affecting Duration

When developing duration estimates, project managers consider four factors:

1. Project size
2. Human resources
3. Experience with similar projects
4. Constraints

PROJECT SIZE: As described in Chapter 1, information systems have various characteristics that affect their complexity and cost. In addition to considering those factors, a project manager must estimate the time required to complete each project phase.

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To develop accurate estimates, a project manager must identify all project tasks, from initial fact-finding to system implementation. Regardless of the systems development methodology used, the project manager must determine how much time will be needed to perform each task. In developing an estimate, the project manager must allow time for meetings, project reviews, training, and any other factors (e.g., scheduled vacations or unscheduled medical leave) that could affect the productivity of the development team.

HUMAN RESOURCES: Companies must invest heavily in cutting-edge technology to remain competitive in a connected world. In many areas, skilled IT professionals are in great demand, and firms must work hard to attract and retain the talent they need. A project manager must assemble and guide a development team that has the skill and experience to handle the project. If necessary, additional systems analysts or programmers must be hired or trained, and this must be accomplished within a specific time frame. After a project gets under way, the project manager must deal with turnover, job vacancies, and escalating salaries in the technology sector—all of which can affect whether the project can be completed on time and within budget. The project manager also has to accommodate official holidays, family emergencies, and other events that may affect the schedule.

EXPERIENCE WITH SIMILAR PROJECTS: A project manager can develop time and cost estimates based on the resources used for similar, previously developed information systems. The experience method works best for small- or medium-sized projects where the two systems are similar in size, basic content, and operating environment. In large systems with more variables, the estimates are less reliable.

CONSTRAINTS: Chapter 2 explained that constraints are defined during the preliminary investigation. A constraint is a condition, restriction, or requirement that the system must satisfy. For example, a constraint might involve maximums for one or more resources, such as time, dollars, or people. A project manager must define system requirements that can be achieved realistically within the required constraints. In the absence of constraints, the project manager simply calculates the resources needed. However, if constraints are present, the project manager must adjust other resources or change the scope of the project. This approach is similar to the what-if analysis described in Chapter 12.

3.2.5 Displaying the Work Breakdown Structure

After the task durations are entered, the WBS will look like Figure 3-8. Task groups can be used to manage a complex project with many tasks, just as with a

Task No.	Description	Duration (Days)	Predecessor Tasks
1	Reserve the meeting room	1	
2	Order the marketing materials	9	
3	Brief the managers	2	
4	Send out customer emails	3	
5	Upload program to the app store	3	
6	Load the new software	2	
7	Do a dress rehearsal	1	

FIGURE 3-8 Task durations have been added, and the WBS is complete except for predecessor task information. The predecessor tasks will determine task patterns and sequence of performance.

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Gantt chart, to simplify the list. Note that the WBS shown in Figure 3-8 is still incomplete: It does not show fields such as Start Date, End Date, Task Name, Duration, and Predecessors—fields that can be key for project managers. With Microsoft Project, the WBS (including some of these missing fields) might resemble Figure 3-9.

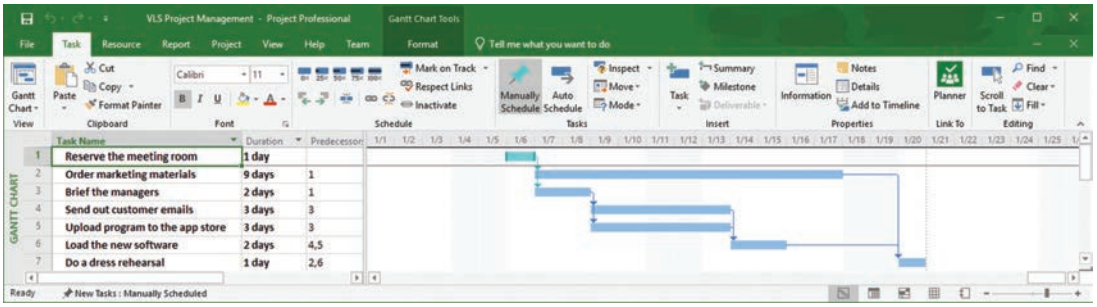


FIGURE 3-9 This Microsoft Project screen displays the same WBS, including task number, task name, duration, and predecessor tasks.

3.3 Task Patterns

Tasks in a WBS must be arranged in a logical sequence called a **task pattern**. In any project, large or small, tasks depend on each other and must be performed in a sequence, not unlike the commands in a software program. Task patterns can involve dependent tasks, multiple successor tasks, and multiple predecessor tasks. In larger projects, these patterns can be very complex, and an analyst must study the logical flow carefully. This section explains how to understand and create graphical models of these patterns.

3.3.1 Using Task Boxes to Create a Model

In a PERT/CPM chart, project tasks are shown as rectangular boxes, arranged in the sequence in which they must be performed. Each rectangular box, called a **task box**, has five sections, as shown in Figure 3-10. Each section of the task box contains important information about the task, including the Task Name, Task ID, Task Duration, Start Day/Date, and Finish Day/Date.

TASK BOX FORMAT

Task Name	
Start Day/Date	Task ID
Finish Day/Date	Task Duration

FIGURE 3-10 Each section of the task box contains important information about the task, including the Task Name, Task ID, Task Duration, Start Day/Date, and Finish Day/Date.

TASK NAME: The **task name** should be brief and descriptive, but it does not have to be unique in the project. For example, a task named Conduct Interviews might occur in several phases of the project.

TASK ID: The **task ID** can be a number or code that provides unique identification.

TASK DURATION: The **duration** is the amount of time it will take to complete a task, which is not necessarily the same as the elapsed time. For example, a task that takes eight hours of effort to complete would be done in one day by a person dedicated 100%, but if the person assigned this task is only working 50% on this project, the task would take two days elapsed time to complete. All tasks must use the same time units, which can be hours, days, weeks, or months, depending on the project. An actual project starts on a specific date but can also be measured from a point in time, such as Day 1.

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START DAY/DATE: The **start day/date** is the time that a task is scheduled to begin. For example, suppose that a simple project has two tasks: Task 1 and Task 2. Also suppose that Task 2 cannot begin until Task 1 is finished. An analogy might be that a program cannot run until the computer is turned on. If Task 1 begins on Day 1 and has duration of three days, it will finish on Day 3. Because Task 2 cannot begin until Task 1 is completed, the start time for Task 2 is Day 4, which is the day after Task 1 is finished.

FINISH DAY/DATE: The **finish day/date** is the time that a task is scheduled for completion. To calculate the finish day or date, add the duration to the start day or date. When doing this, be very careful not to add too many days. For example, if a task starts on Day 10 and has duration of five days, then the finish date would be on Day 14—not Day 15.

3.3.2 Task Pattern Types

A project is based on a pattern of tasks. In a large project, the overall pattern would be quite complex, but it can be broken down into three basic types of patterns: dependent tasks, multiple successor tasks, and multiple predecessor tasks.

DEPENDENT TASKS: When tasks must be completed one after another, like the relay race shown in Figure 3-11, they are called **dependent tasks** because one depends on the other. For example, Figure 3-12 shows that Task 2 depends on Task 1, because Task 2 cannot start until Task 1 is completed. In this example, the finish time of Task 1, Day 5, controls the start date of Task 2, which is Day 6.



FIGURE 3-11 In a relay race, each runner is dependent on the preceding runner and cannot start until the earlier finishes.
William Perugini/Shutterstock.com

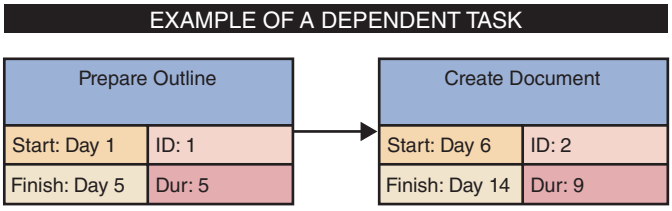


FIGURE 3-12 This example of a dependent task shows that the finish time of Task 1, Day 5, controls the start date of Task 2, which is Day 6.

MULTIPLE SUCCESSOR TASKS: When several tasks can start at the same time, each is called a **concurrent task**. Often, two or more concurrent tasks depend on a single prior task, which is called a predecessor task. In this situation, each concurrent task is called a **successor task**. In the example shown in Figure 3-13, successor Tasks 2 and 3 both can begin as soon as Task 1 is finished. Note that the finish time for Task 1 determines the start time for both Tasks 2 and 3. In other words, the earliest that Task 1 can finish is Day 30, so Day 31 is the earliest that Tasks 2 and 3 can start.

MULTIPLE PREDECESSOR TASKS: Suppose that a task requires two or more prior tasks to be completed before it can start. Figure 3-14 shows that example because Task 3 cannot begin until Tasks 1 and 2 are both completed. Since the two tasks might not finish at the same time, the longest (latest) predecessor task becomes the controlling factor. Note that the start for Task 3 is Day 16, not Day 6. Why is this so? Because Task 3 depends on two predecessor tasks, Tasks 1 and 2, Task 3 cannot begin until the later of those

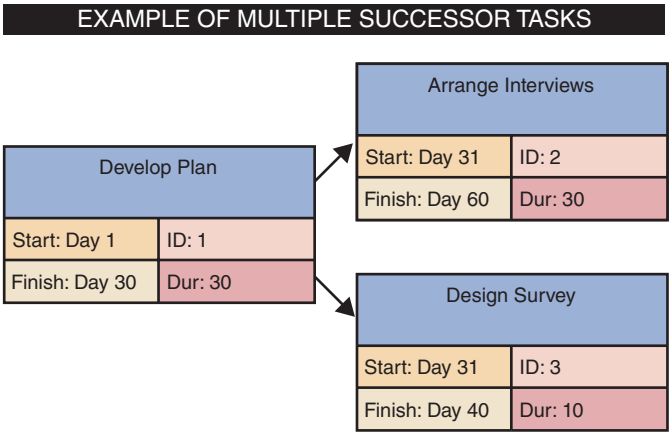


FIGURE 3-13 This example of multiple successor tasks shows that the finish time for Task 1 determines the start time for both Tasks 2 and 3.

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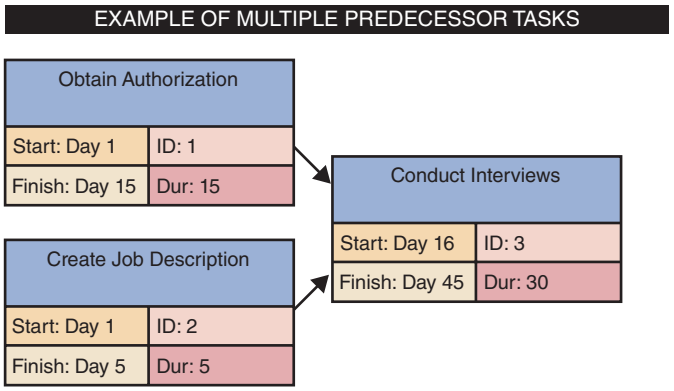


FIGURE 3-14 This example of multiple predecessor tasks shows that the start time for a successor task must be the latest (largest) finish time for any of its preceding tasks. In the example shown, Task 1 ends on Day 15, while Task 2 ends on Day 5, so Task 1 controls the start time for Task 3.

tasks is complete. Therefore, the start time for a successor task must be the latest (largest) finish time for any of its preceding tasks. In the example shown, Task 1 ends on Day 15, while Task 2 ends on Day 5, so Task 1 controls the start time for Task 3.

Task pattern types are identified by looking carefully at the wording of the task statement. Words like *then*, *when*, or *and* are action words that signal a sequence of events. Here are three simple examples:

- Do Task 1, *then* do Task 2 describes dependent tasks that must be completed one after the other.
- *When* Task 2 is finished, start two tasks: Task 3 *and* Task 4 describe multiple successor tasks that can both start as soon as Task 2 is finished.
- *When* Tasks 5 *and* 6 are done, start Task 7 indicates that Task 7 is a multiple predecessor task because it can't start until two or more previous tasks all are completed.

3.3.3 Working with Complex Task Patterns

When several task patterns combine, the facts must be studied very carefully to understand the logic and sequence. A project schedule will not be accurate if the underlying task pattern is incorrect. For example, consider the following three fact statements and the task patterns they represent. Examples of the task patterns are shown in Figures 3-15, 3-16, and 3-17.

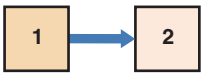


FIGURE 3-15 Dependent tasks.

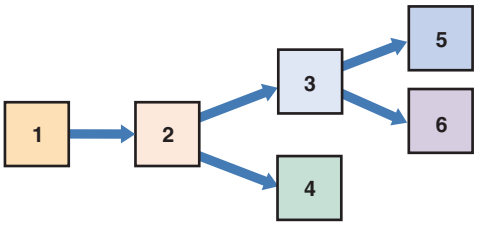


FIGURE 3-16 Dependent tasks and multiple successor tasks.

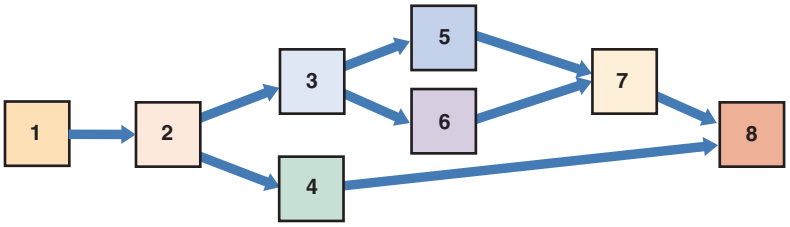


FIGURE 3-17 Dependent tasks, multiple successor tasks, and multiple predecessor tasks.

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DEPENDENT TASKS: Perform Task 1. When Task 1 is complete, perform Task 2.

DEPENDENT TASKS AND MULTIPLE SUCCESSOR TASKS: Perform Task 1. When Task 1 is complete, perform Task 2. When Task 2 is finished, start two tasks: Task 3 and Task 4. When Task 3 is complete, start two more tasks: Task 5 and Task 6.

DEPENDENT TASKS, MULTIPLE SUCCESSOR TASKS, AND MULTIPLE PREDECESSOR TASKS: Perform Task 1. When Task 1 is complete, perform Task 2. When Task 2 is finished, start two Tasks: Task 3 and Task 4. When Task 3 is complete, start two more tasks: Task 5 and Task 6. When Tasks 5 and 6 are done, start Task 7. Then, when Tasks 4 and 7 are finished, perform Task 8.

CASE IN POINT 3.2: Parallel Services

The project management team at Parallel Services is having a debate about how to define tasks in the WBS. The project manager wants to break tasks down into the smallest possible units. For example, she objected to a broad task statement called "Develop a training schedule." Instead, she suggested three subtasks: (1) "Determine availability of training room," (2) "Determine availability of attendees," and (3) "Select specific dates and training times."

Another project team member disagrees. He feels that the broader task statement is better because it allows more flexibility and will produce the same result. He says that if you break tasks into pieces that are too small, you risk overmanaging the work and spending more time on monitoring than actually performing the tasks. As a member of the team, which approach do you agree with more? What are the pros and cons of each?

3.4 The Critical Path

Task patterns determine the order in which the tasks are performed. Once the task sequence has been defined, a project manager can schedule the tasks and calculate the critical path. A **critical path** is a series of tasks that, if delayed, would affect the completion date of the overall project. If any task on the critical path falls behind schedule, the entire project will be delayed.

For example, suppose that Joan and Jim are invited to someone's home for dinner. Joan arrives on time, but Jim arrives 30 minutes late. Jim's arrival is part of the critical path because the host does not want to start without him, so the meal will be served 30 minutes later than originally planned.

Project managers always must be aware of the critical path, so they can respond quickly to keep the project on track. Microsoft Project and other project management software can highlight the series of tasks that form the critical path.

3.4.1 Calculating the Critical Path

Figure 3-18 shows a training project with five tasks. Note that the analyst has arranged the tasks and entered task names, IDs, and durations. The task patterns should be reviewed first. In this example, Task 1 is followed by Task 2, which is a dependent task. Task 2 has two successor tasks: Task 3 and Task 4. Tasks 3 and 4 are predecessor tasks for Task 5.

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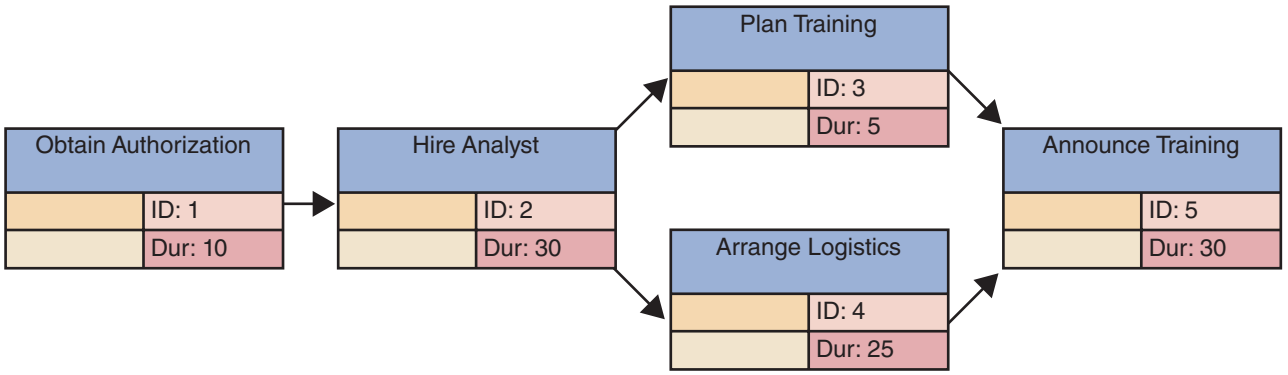


FIGURE 3-18 Example of a PERT/CPM chart with five tasks. Task 2 is a dependent task that has multiple successor tasks. Task 5 has multiple predecessor tasks. In this figure, the analyst has arranged the tasks and entered task names, IDs, and durations.

The next step is to determine start and finish dates, which will determine the critical path for the project. The following explanation outlines a step-by-step process. The result is shown in Figure 3-19.

- Task 1 starts on Day 1 and has duration of 10 days, so the finish date is Day 10.
- Task 2, which is dependent on Task 1, can start on Day 11—the day after Task 1 ends. With duration of 30 days, Task 2 will end on Day 40.
- Tasks 3 and 4 are multiple successor tasks that can start after Task 2 is done. Task 2 ends on Day 40, so Tasks 3 and 4 both can start on Day 41. Task 3 has duration of five days and will end on Day 45. Task 4 has duration of 25 days and will not end until Day 65.
- Task 5 depends on Tasks 3 and 4, which are multiple predecessors. Because Task 5 depends on both tasks, it cannot start until the later of the two tasks is complete. In this example, Task 3 ends earlier, but Task 4 will not be completed until Day 65, so Task 5 cannot start until Day 66.

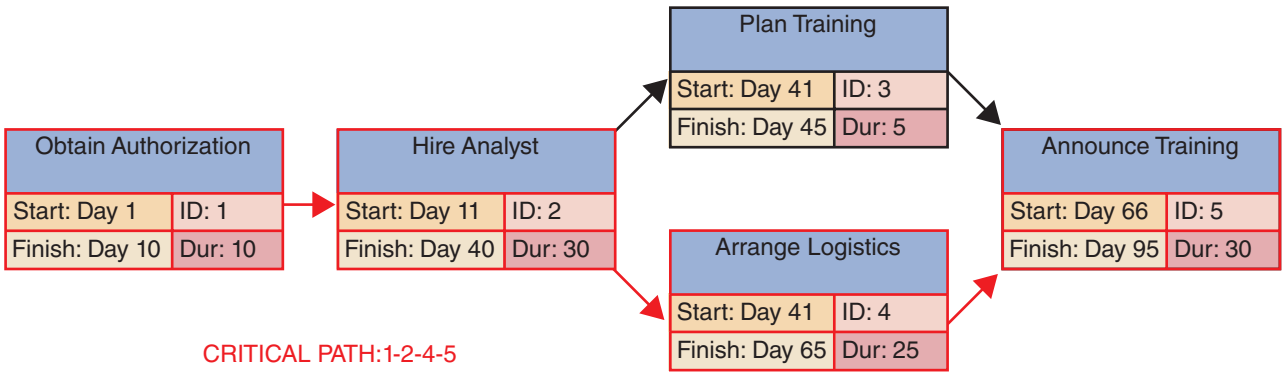


FIGURE 3-19 Now the analyst has entered the start and finish times, using the rules explained in this section. Note that the overall project has duration of 95 days.

Recall that the critical path is a series of tasks that, if delayed, would affect the final completion date of the overall project. In this example, Tasks 1 and 2 are the first tasks on the critical path. Now look at Task 5, which cannot start until both Tasks 3 and 4 are done. In this case, Task 4 is the controlling factor because Task 4 finishes on Day 65, which is 20 days later than Task 3, which is completed on Day 45. Therefore, the start date for Task 5 is determined by the finish date for Task 4.

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In contrast, Task 3 has slack time and could be delayed up to 20 days without affecting Task 5. **Slack time** is the amount of time that the task could be late without pushing back the completion date of the entire project. Tasks 1, 2, 4, and 5 represent the critical path, which is highlighted with red arrows in Figure 3-19.

3.5 Project Monitoring and Control

Regardless of whether the project was planned and scheduled with project management software or in some other manner, the project manager must keep track of the tasks and progress of team members, compare actual progress with the project plan, verify the completion of project milestones, and set standards and ensure that they are followed.

3.5.1 Monitoring and Control Techniques

To help ensure that quality standards are met, many project managers institute structured walk-throughs. A **structured walk-through** is a review of a project team member's work by other members of the team. Generally, systems analysts review the work of other systems analysts, and programmers review the work of other programmers, as a form of peer review. Structured walk-throughs take place throughout the SDLC and are called **design reviews**, **code reviews**, or **testing reviews**, depending on the phase in which they occur.

3.5.2 Maintaining a Schedule

Maintaining a project schedule can be challenging, and most projects run into at least some problems or delays. By monitoring and controlling the work, the project manager tries to anticipate problems, avoid them or minimize their impact, identify potential solutions, and select the best way to solve the problem.

The better the original plan, the easier it will be to control the project. If clear, verifiable milestones exist, it will be simple to determine if and when those targets are achieved. If enough milestones and frequent checkpoints exist, problems will be detected rapidly. A project that is planned and scheduled with PERT/CPM or in a WBS with Gantt chart can be tracked and controlled using these same techniques. As work continues, the project manager revises the plan to record actual times for completed tasks and revises times for tasks that are not yet finished.

3.5.3 Tasks and the Critical Path

Project managers spend most of their time tracking the tasks along the critical path because delays in those tasks have the greatest potential to delay or jeopardize the project. Other tasks cannot be ignored, however. For example, suppose that a task not on the critical path takes too long and depletes the allotted slack time. At that point, the task actually becomes part of the critical path, and any further delay will push back the overall project.

3.6 Reporting

Members of the project team regularly report their progress to the project manager, who in turn reports to management and users. The project manager collects, verifies, organizes, and evaluates the information he or she receives from the team. Then the manager decides which information needs to be passed along, prepares a summary

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that can be understood easily, adds comments and explanations if needed, and submits it to management and users.

3.6.1 Project Status Meetings

Project managers, like the one shown in Figure 3-20, schedule regular meetings to update the team and discuss project status, issues, problems, and opportunities. Although meetings can be time consuming, most project managers believe they are worth the effort. The sessions give team members an opportunity to share information, discuss common problems, and explain new techniques. The meetings also give the project manager an opportunity to seek input and conduct brainstorming sessions.



FIGURE 3-20 Project managers schedule regular meetings to update the project team and discuss project status, issues, problems, and opportunities.
Hero Images/Getty Images

3.6.2 Project Status Reports

A project manager must report regularly to his or her immediate supervisor, upper management, and users. Although a progress report might be given verbally to an immediate supervisor, reports to management and users usually are written. Gantt charts often are included in progress reports to show project status graphically.

3.6.3 Dealing with Problems

Deciding how to handle potential problems can be difficult. At what point should management be informed about the possibility of cost overruns, schedule delays, or technical problems? At one extreme is the overly cautious project manager who alerts management to every potential snag and slight delay. The danger here is that the manager loses credibility over a period of time, and management might ignore potentially serious situations. At the other extreme is the project manager who tries to handle all situations single-handedly and does not alert management until a problem is serious.

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By the time management learns of the problem, little time might remain in which to react or devise a solution.

A project manager's best course of action lies somewhere between the two extremes but is probably closer to the first. If the consequences are unclear, the analyst should err on the side of caution and warn management about the possibility of a problem.

When the situation is reported, explain what is being done to handle and monitor the problem. If the situation is beyond the analyst's control, suggest possible actions that management can take to resolve the situation. Most managers recognize that problems do occur on most projects; it is better to alert management sooner rather than later.

3.7 Project Management Software

Project managers use software applications to help plan, schedule, monitor, and report on a project. Most programs offer features such as PERT/CPM, Gantt charts, resource scheduling, project calendars, and cost tracking. As shown in Figure 3-21, Microsoft Project is a full-featured program that holds the dominant share of the market. It is available as a software product for Windows and as an add-on online service as part of Microsoft's Office 365.

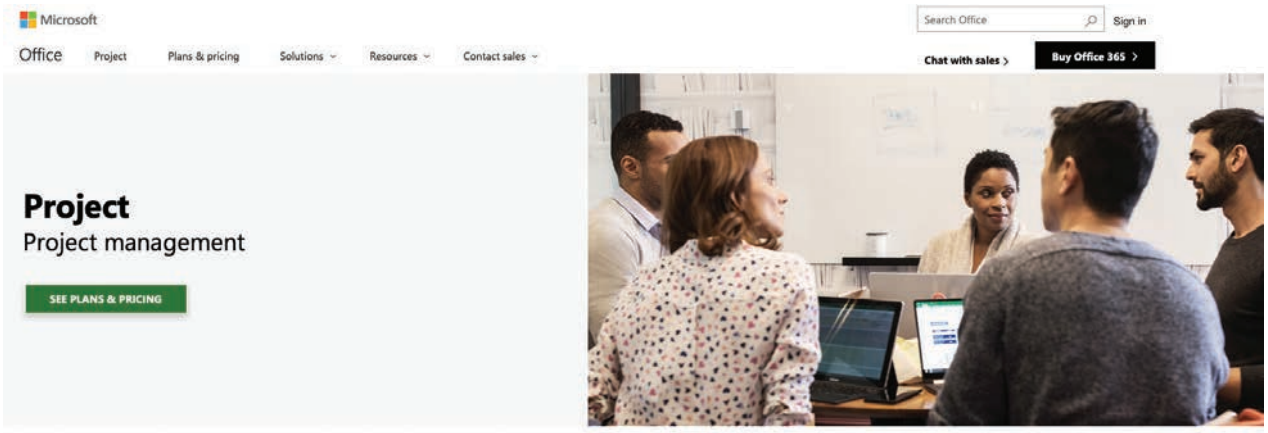


FIGURE 3-21 Microsoft Project.
Source: Microsoft Corporation

In addition to Microsoft Project, there are a number of other project management tools available. For example, *GanttProject* is a free **open-source** Java-based project management tool that is available on multiple platforms (Windows, Mac OS X, and Linux). It can produce Gantt and PERT/CPM charts, calculate the critical path automatically, and read/write Microsoft Project files.

Gantter is a free cloud-based project management tool. It runs in a browser window, so there's no software to install to use it. *Apptivo* and *smartsheet* are other examples of web-based project management tools offering similar capabilities but on a paid subscription model.

Monday is a project management tool that is tailored toward Mac users. As shown in Figure 3-22, it is a highly visual cloud-based tool that supports agile development. Trello, shown in Figure 3-23, is another project management tool that is tailored toward agile development.

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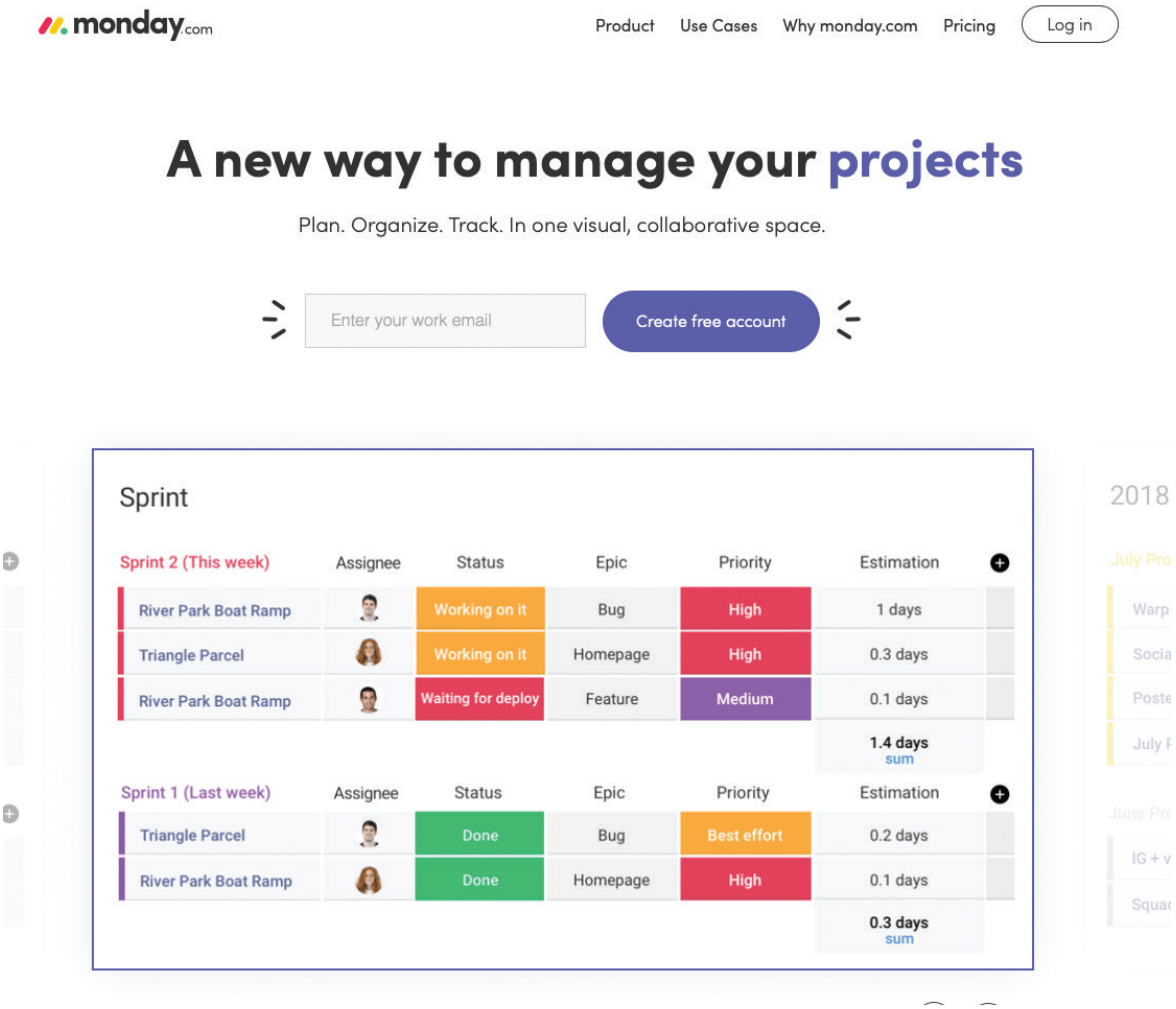


FIGURE 3-22 Monday is a project management tool that is tailored toward Mac users.
Source: monday.com

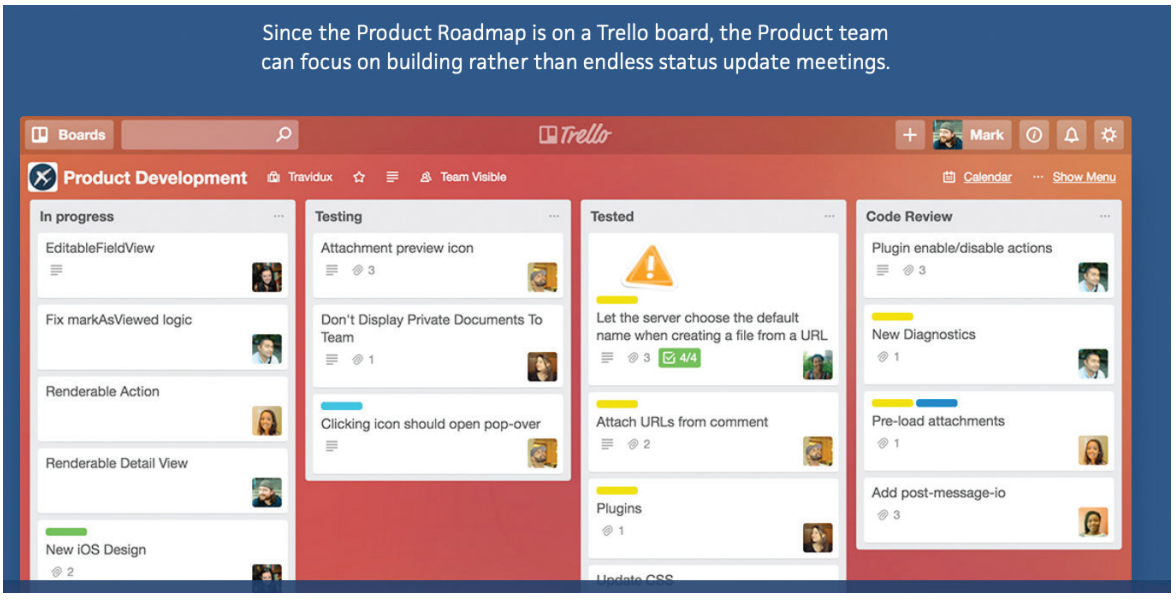


FIGURE 3-23 Trello is a project management tool that is tailored toward agile development.
Source: Atlassian

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The websites for all of these tools have more information about their capabilities, including demos, trial versions (where applicable), and training material.

Irrespective of which project management tool used, a step-by-step process is followed to develop a WBS, work with task patterns, and analyze the critical path. The main difference is that the software does most of the work automatically, which enables much more effective management.

The following sections explain how Microsoft Project could be used to handle the sample task summary for a preliminary investigation shown in Figure 3-24. This example illustrates that project management is dynamic and challenging. One significant advantage of integrated project management software is that it allows the project manager to adjust schedules, estimates, and resource assignments rapidly in response to real-world events.

Please study the following task summary:

- First, we need to spend one day studying potential problems or opportunities.
- Then, we will define the project scope and constraints. That will take two days.
- Next, we will analyze the organization charts. That will take one day.
- After we analyze the charts, four fact-finding tasks can start at once:
  - Observe operations (two days)
  - Conduct a user survey (three days)
  - Conduct interviews (two days)
  - Review documentation (one day)
- When all four fact-finding tasks are finished, we will spend one day evaluating feasibilty.
- Then we will spend one day presenting the results and recommendations to management.

FIGURE 3-24 A sample task summary for a preliminary investigation.

WORK BREAKDOWN STRUCTURE: Creating a WBS using Microsoft Project is much the same as creating it manually. The tasks, durations, and task patterns must still be identified. This information might have to be developed, or a task summary like the one in Figure 3-24 might be used. The goal is to document all tasks, dependencies, dates, and total project duration. The first step is to create a Gantt chart showing the necessary information. As the information for each task is entered into Microsoft Project, the duration and the predecessor tasks, if any, should also be noted.

GANTT CHART: As tasks are entered, the program automatically performs the calculations, detects the task patterns, and creates a Gantt chart. The chart consists of horizontal bars, connected with arrows that indicate task dependencies. If a typical workweek is selected, tasks will not be scheduled on Saturdays and Sundays. However, for a mission-critical project, a 24/7 calendar might be created. Whatever is specified, the program will handle the tasks accordingly. Microsoft Project offers numerous choices of display settings, formats, and calculation methods.

NETWORK DIAGRAM: After the Gantt chart is completed, the data can be viewed in the form of a Microsoft Project network diagram, which is similar to a PERT chart. When the Network Diagram option is selected, the project tasks, dependencies, and start and finish dates for each task are shown. A network diagram displays the same information as the Gantt chart, including task dependencies, but use task boxes

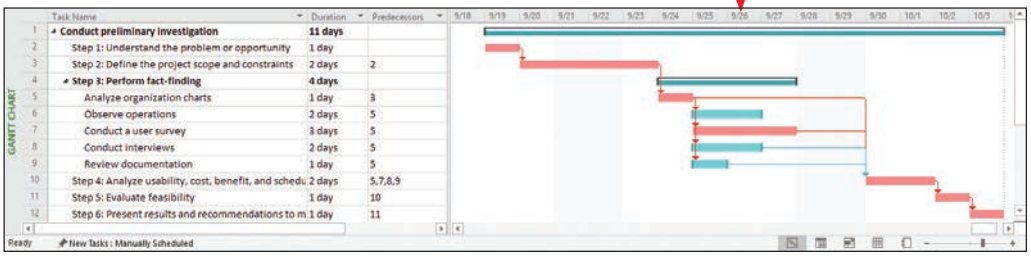
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to include much more detail. Using Microsoft Project, each task can be assigned to one or more people, budgets can be assigned targets, progress reports produced, and schedules and deadlines readjusted as necessary.

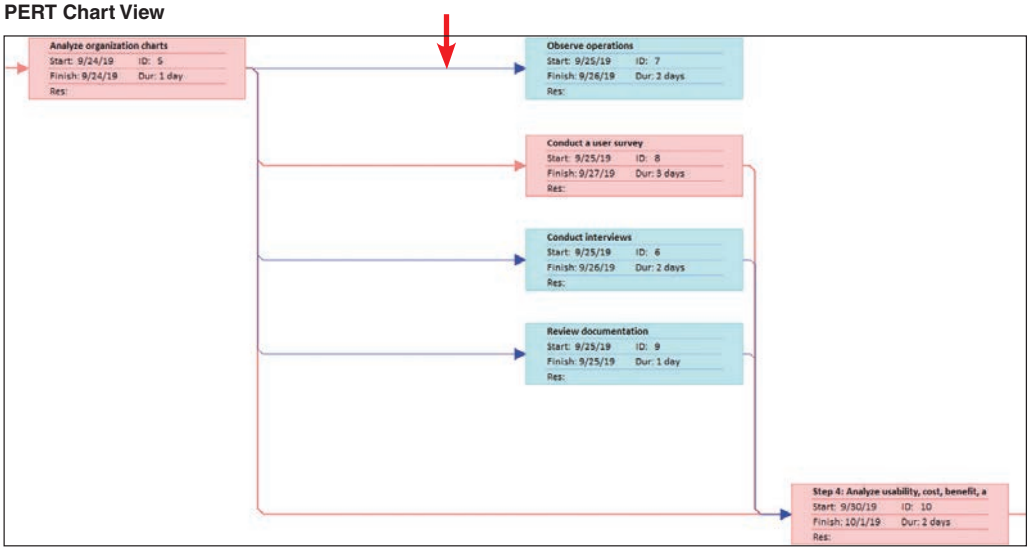
CALENDAR VIEW: Calendar view is a good way to manage day-to-day activity. This view shows the tasks, similar to a PERT chart, as an overlay on the actual calendar. Because the critical path is highlighted in red, it is easy for a project manager to determine priorities at any point in time.

Suppose the project manager wants to view the preliminary investigation in Figure 3-24 as a Gantt chart, a PERT chart, and a day-to-day calendar. All three views are shown in Figure 3-25. Each view shows the tasks, the timing, the dependencies, and the critical path. Note that of the four tasks scheduled for September 25, only the user survey is on the critical path, therefore that should be the project manager's primary concern.

Gantt Chart View



PERT Chart View



Calendar View

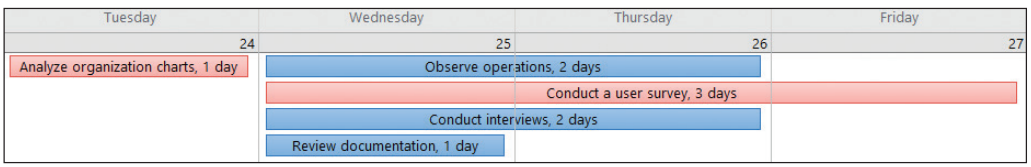


FIGURE 3-25 Note how each view displays the project and highlights the critical path. If you were the project manager on September 25, your primary concern should be conducting the user survey.

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3.8 Risk Management

Every IT project involves risks that systems analysts and project managers must address. A **risk** is an event that could affect the project negatively. **Risk management** is the process of identifying, analyzing, anticipating, and monitoring risks to minimize their impact on the project.

Although project management experts differ with regard to the number of steps or phases, a basic list of risk management tasks would include the following:

- *Develop a risk management plan*. A **risk management plan** includes a review of the project's scope, stakeholders, budget, schedule, and any other internal or external factors that might affect the project. The plan should define project roles and responsibilities, risk management methods and procedures, categories of risks, and contingency plans.
- *Identify the risks*. **Risk identification** lists each risk and assesses the likelihood that it could affect the project. The details would depend on the specific project, but most lists would include a means of identification, and a brief description of the risk, what might cause it to occur, who would be responsible for responding, and the potential impact of the risk.
- *Analyze the risks*. This typically is a two-step process: Qualitative risk analysis and quantitative risk analysis. **Qualitative risk analysis** evaluates each risk by estimating the probability that it will occur and the degree of impact. Project managers can use a formula to weigh risk and impact values, or they can display the results in a two-axis grid. For example, a Microsoft Excel XY chart can be used to display the matrix, as shown in Figure 3-26. In the chart, note the various combinations of risk and impact ratings for the five sample values. This tool can help a project manager focus on the most critical areas, where risk probability and potential impact are high.

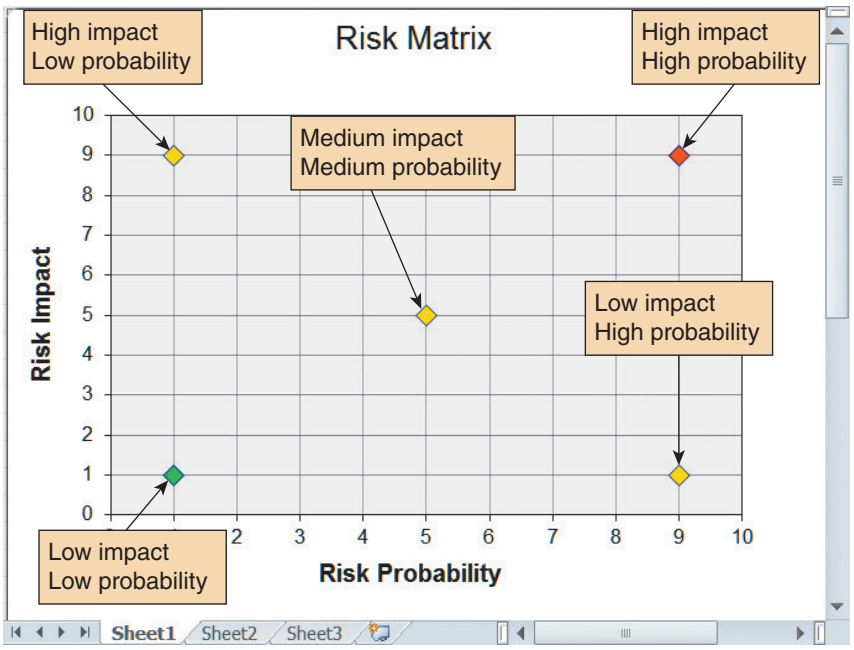


FIGURE 3-26 You can use a Microsoft Excel XY chart type to display a risk matrix that shows risk probability and potential impact.

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The purpose of **quantitative risk analysis** is to understand the actual impact in terms of dollars, time, project scope, or quality. Quantitative risk analysis can involve a modeling process called what-if analysis, which allows a project manager to vary one or more element(s) in a model to measure the effect on other elements. This topic is discussed in more detail in Chapter 12.

- *Create a risk response plan*. A **risk response plan** is a proactive effort to anticipate a risk and describe an action plan to deal with it. An effective risk response plan can reduce the overall impact by triggering timely and appropriate action.
- *Monitor risks*. This activity is ongoing throughout the risk management process. It is important to conduct a continuous tracking process that can identify new risks, note changes in existing risks, and update any other areas of the risk management plan.

Fortunately, there is a wide variety of risk management software available to help a project manager with these tasks. Most packages allow a project manager to assign specific dates as constraints, align task dependencies, note external factors that might affect a task, track progress, and display tasks that are behind schedule. Armed with this information, the IT team can quantify the project's risks, just as they use financial analysis tools to quantify costs and benefits.

3.9 Managing for Success

Project management is a challenging task. Project managers must be alert, technically competent, and highly resourceful. They also must be good communicators with strong human resource skills. Project managers can be proud when they handle a successful project that helps the company achieve its business objectives.

Unfortunately, projects can and do get derailed for a wide variety of reasons. When problems occur, the project manager's ability to handle the situation becomes the critical factor. When a project manager first recognizes that a project is in trouble, what options are available? Alternatives can include trimming the project requirements, adding to the project resources, delaying the project deadline, and improving management controls and procedures. Sometimes, when a project experiences delays or cost overruns, the system still can be delivered on time and within budget if several less critical requirements are trimmed. The system can be delivered to satisfy the most necessary requirements, and additional features can be added later as a part of a maintenance or enhancement project.

If a project is in trouble because of a lack of resources or organizational support, management might be willing to give the project more commitment and higher priority. For example, management might agree to add more people to a project that is behind schedule. Adding staff, however, will reduce the project's completion time only if the additional people can be integrated effectively into the development team. If team members lack experience with certain aspects of the required technology, temporary help might be obtained from IT consultants or part-time staff. Adding staff can mean training and orienting the new people, however. In some situations, adding more people to a project actually might increase the time necessary to complete the project because of a principle called **Brooks' law**. Frederick Brooks, Jr., then an IBM engineer, observed that adding manpower to a late software project only makes it later. Brooks reached this conclusion when he saw that new workers on a project first had to be educated and instructed by existing employees whose own productivity was reduced accordingly.

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To be successful, an information system must satisfy business requirements, stay within budget, be completed on time, and—most important of all—be managed effectively. As stated earlier and detailed next, when a project develops problems, the reasons typically involve business, budget, or schedule issues, as explained in the following sections. In addition to planning and managing the project, a project manager must be able to recognize these problems and deal with them effectively.

CASE IN POINT 3.3: JUST-IN-TIME SOFTWARE

You are a systems analyst at Just-in-Time Software, a company that specializes in short delivery cycles for its products. The current project is running behind schedule, and the project manager wants to bring a few extra programmers onboard to help with the work.

You are familiar with Brook's Law. How can you best explain to the project manager that adding more people to the project at this late stage may make things worse? You don't want to be seen as a negative team player, but you're convinced that if you don't speak up, the project's schedule will slip even more.

3.9.1 Business Issues

The major objective of every system is to provide a solution to a business problem or opportunity. If the system does not do this, then it is a failure—regardless of positive reaction from users, acceptable budget performance, or timely delivery. When the information system does not meet business requirements, causes can include unidentified or unclear requirements, inadequately defined scope, imprecise targets, shortcuts or sloppy work during systems analysis, poor design choices, insufficient testing or inadequate testing procedures, and lack of change control procedures. Systems also fail because of changes in the organization's culture, funding, or objectives. A system that falls short of business needs also produces problems for users and reduces employee morale and productivity.

As explained in Chapter 2, projects without clear scope definitions are risky because they tend to expand gradually, without specific authorization, in a process called *project creep*. However, even when a project is clearly described, it must be managed constantly.

3.9.2 Budget Issues

Cost overruns typically result from one or more of the following:

- Unrealistic estimates that are too optimistic or based on incomplete information
- Failure to develop an accurate forecast that considers all costs over the life of the project
- Poor monitoring of progress and slow response to early warning signs of problems
- Schedule delays due to factors that were not foreseen
- Human resource issues, including turnover, inadequate training, and motivation

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3.9.3 Schedule Issues

Problems with timetables and project milestones can indicate a failure to recognize task dependencies, confusion between effort and progress, poor monitoring and control methods, personality conflicts among team members, or turnover of project personnel. The failure of an IT project also can be caused by poor project management techniques.

If the project manager fails to plan, staff, organize, supervise, communicate, motivate, evaluate, direct, and control properly, then the project is certain to fail. Even when factors outside his or her control contribute to the failure, the project manager is responsible for recognizing the early warning signs and handling them effectively.

A QUESTION OF ETHICS



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"Better blow the whistle," says your friend and project teammate at work. "The project is out of control, and you know it!" "Maybe so," you respond, "But that's not my call—I'm not the project manager." What you don't say is that the project manager feels like her career is on the line, and she is reluctant to bring bad news to management at this time. She honestly believes that the project can catch up and says that a bad report on a major project could result in bad publicity for the firm and frighten potential customers.

To be fair, the next management progress report is scheduled in three weeks. It is possible that the team could catch up, but you doubt it. You wonder if there is an ethical question here: Even though the report isn't due yet, should a significant problem be reported to management as soon as possible? You are concerned about the issue, and you decide to discuss it with Stephanie. What will you say to her?

3.10 Summary

Project management is the process of planning, scheduling, monitoring, and reporting on the development of an information system. Planning includes identifying all project tasks and estimating the completion time and cost of each. Project scheduling involves the creation of a specific timetable, usually in the form of charts that show tasks, task dependencies, and critical tasks that might delay the project. Project monitoring requires guiding, supervising, and coordinating the project team's workload. The project manager must monitor the progress, evaluate the results, and take corrective action when necessary to control the project and stay on target. Project reporting includes regular progress reports to management, users, and the project team itself. Effective reporting requires strong communication skills and a sense of what others want and need to know about the project. A successful project must be completed on time, be within budget, and deliver a quality product that satisfies users and meets requirements.

A project triangle shows three legs: project cost, scope, and time. A project manager must find the best balance among these elements because a change in any leg of the triangle will affect the other two legs. Project management techniques can be used throughout the SDLC.

Planning, scheduling, monitoring, and reporting—all take place within a larger project development framework, which includes three key steps: creating a WBS, identifying task patterns, and calculating the critical path. A WBS must clearly

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identify each task and include an estimated duration. A task, or activity, is any work that has a beginning and an end and requires the use of company resources such as people, time, or money. Time and cost estimates for tasks usually are made in person-days. A person-day represents the work that one person can accomplish in one day. Estimating the time for project activities is more difficult with larger systems. Project managers must consider the project size and scope, IT resources, prior experience with similar projects or systems, and applicable constraints. In addition to tasks, every project has events, or milestones. An event, or a milestone, is a recognizable reference point that can be used to monitor progress.

Task patterns establish the sequence of work in a project. Task patterns involve dependent tasks, multiple successor tasks, and multiple predecessor tasks. In larger projects, these patterns can be very complex.

A critical path is a series of tasks that, if delayed, would affect the completion date of the overall project. If any task on the critical path falls behind schedule, the entire project will be delayed. Tasks on the critical path cannot have slack time. To identify the critical path, calculate the start and finish date for each task, which will determine the critical path for the project.

In project scheduling, the project manager develops a specific time for each task, based on available resources and whether or not the task is dependent on other predecessor tasks. The manager can use graphical tools such as Gantt charts and PERT charts to assist in the scheduling process.

A Gantt chart is a horizontal bar chart that represents the project schedule with time on the horizontal axis and tasks arranged vertically. It shows individual tasks and task groups, which include several tasks. In a Gantt chart, the length of the bar indicates the duration of the tasks. A Gantt chart can display progress but does not show task dependency details or resource assignment unless the chart was created with a project management program that supports dependency linking and the entry of other information.

A PERT/CPM chart shows the project as a network diagram with tasks connected by arrows. Using a prescribed calculation method, the project manager uses a PERT chart to determine the overall duration of the project and provide specific information for each task, including the task IDs, their durations, start and finish times, and the order in which they must be performed. With this information, the manager can determine the critical path, which is the sequence of tasks that has no slack time and must be performed on schedule in order to meet the overall project deadline.

Most project managers use software applications such as Microsoft Project to plan, schedule, and monitor projects. Project managers are responsible for risk management, which is the process of identifying, analyzing, anticipating, and monitoring risks to minimize their impact on the project.

In the end, project management involves the same skills as any other management. The project manager must be perceptive, analytical, well organized, and a good communicator. If the project manager senses that the project is off-track, he or she must take immediate steps to diagnose and solve the problem. If the project manager fails to plan, staff, organize, supervise, communicate, motivate, evaluate, direct, and control properly, then the project is certain to fail. Even when factors outside his or her control contribute to the failure, the project manager is responsible for recognizing the early warning signs and handling them effectively.

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Key Terms

activity Any work that has a beginning and an end and requires the use of company resources including people, time, and/or money. Examples include conducting a series of interviews, designing a report, selecting software, waiting for the delivery of equipment, and training users. *See also* **task**.

best-case estimate The most optimistic outcome.

bottom-up technique A method for analyzing a large, complex project as a series of individual tasks, called project tasks.

Brooks' law Frederick Brooks, an IBM engineer, observed that adding more manpower to a late software project only makes it later.

code review *See* **structured walk-through**.

concurrent task A task that can be completed at the same time as (in parallel with) another task.

critical path A series of events and activities with no slack time. If any activity along the critical path falls behind schedule, the entire project schedule is similarly delayed. As the name implies, a critical path includes all activities that are vital to the project schedule.

Critical Path Method (CPM) Shows a project as a network diagram. The activities are shown as vectors, and the events are displayed graphically as nodes. Although CPM developed separately from the Program Evaluation Review Technique (PERT), the two methods are essentially identical. *See also* **PERT/CPM**.

dependent task A task is said to be dependent when it has to be completed in a serial sequence.

design review *See* **structured walk-through**.

duration The amount of time it will take to complete a task.

event A reference point that marks a major occurrence. Used to monitor progress and manage a project. *See also* **milestone**.

finish day/date The day or date when a task is scheduled to be finished.

Gantt chart A horizontal bar chart that illustrates a schedule. Developed many years ago by Henry L. Gantt as a production control technique. Still are in common use today.

milestone A reference point that marks a major occurrence. Used to monitor progress and manage a project. *See also* **event**.

network diagram A PERT chart also is referred to as a network diagram.

open source Software that is supported by a large group of users and developers. The source code is made freely available.

person-day The amount of work that one person can complete in one day.

PERT/CPM The Program Evaluation Review Technique (PERT) was developed by the U.S. Navy to manage very complex projects, such as the construction of nuclear submarines. At approximately the same time, the Critical Path Method (CPM) was developed by private industry to meet similar project management needs. The important distinctions between the two methods have disappeared over time, and today the technique is called either PERT, CPM, or PERT/CPM.

predecessor task A single prior task upon which two or more concurrent tasks depend.

probable-case estimate The most likely outcome is called a probable-case estimate.

Program Evaluation Review Technique (PERT) *See* **PERT/CPM**.

project coordinator The person who handles administrative responsibilities for the development team and negotiates with users who might have conflicting requirements or want changes that would require additional time or expense.

project leader The person charged with leading a project from a technical perspective.

project management The process of planning, scheduling, monitoring, controlling, and reporting upon the development of an information system.

project manager The person charged with managing a project from an administrative perspective.

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project monitoring Guiding, supervising, and coordinating the project team's workload.

project planning Identifying project tasks and estimating completion time and costs.

project reporting Providing regular progress reports to management, users, and the project team itself.

project scheduling The creation of a specific timetable to facilitate completion of a project. Also involves selecting and staffing the project team and assigning specific tasks to team members.

project triangle The three major components of a project: cost, scope, and time. A project manager tries to find the optimal balance among these factors.

qualitative risk analysis Evaluating risk by estimating the probability that it will occur and the degree of impact.

quantitative risk analysis Evaluating risk in terms of the actual impact in terms of dollars, time, project scope, or quality.

risk An event that could affect the project negatively.

risk identification Listing each risk and assessing the likelihood that it could affect a project.

risk management The process of identifying, evaluating, tracking, and controlling risks to minimize their impact.

risk management plan Includes a review of the project's scope, stakeholders, budget, schedule, and any other internal or external factors that might affect the project. The plan should define project roles and responsibilities, risk management methods and procedures, categories of risks, and contingency plans.

risk response plan A proactive effort to anticipate a risk and describe an action plan to deal with it. An effective risk response plan can reduce the overall impact by triggering a timely and appropriate action.

slack time The amount of time by which an event can be late without delaying the project. The difference between latest completion time (LCT) and earliest completion time (ECT).

start day/date The day or date when a task is scheduled to begin.

structured walk-through A review of a project team member's work by other members of the team. Generally, systems analysts review the work of other systems analysts, and programmers review the work of other programmers, as a form of peer review. Should take place throughout the SDLC and are called requirement reviews, design reviews, code reviews, or testing reviews, depending on the phase in which they occur.

successor task Each of the concurrent tasks of a predecessor task.

task Any work that has a beginning and an end and requires the use of company resources including people, time, and/or money. Examples include conducting a series of interviews, designing a report, selecting software, waiting for the delivery of equipment, and training users. *See also* **activity**.

task box A component of a PERT/CPM chart that contains important scheduling and duration information about a task. Each task in a project is represented by its own task box in the PERT/CPM chart.

task group A task that represents several activities.

task ID A number or code that uniquely identifies a task.

task name A brief descriptive name for a task, which does not have to be unique in the project. For example, a task named Conduct Interviews might appear in several phases of the project.

task pattern A logical sequence of tasks in a WBS. Can involve sequential tasks, multiple successor tasks, and multiple predecessor tasks.

testing review *See* **structured walk-through**.

weight An important multiplier that managers factor into estimates so they can be analyzed.

work breakdown structure (WBS) A project broken down into a series of smaller tasks. *See also* **Gantt chart**; **PERT/CPM chart**.

worst-case estimate The most pessimistic outcome.

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Exercises

Questions

1. Draw a project triangle that shows the relationship among project cost, scope, and time.
2. Write the script for a one-minute explanation of basic project management concepts.
3. Explain the differences between a Gantt chart and a PERT/CPM chart.
4. What are the three main task patterns types? Provide an example of each.
5. Why is the critical path important?
6. What is a structured walk-through?
7. What are the two main ways project status is reported to management?
8. What is a significant advantage of project management software?
9. List the basic tasks in a risk management plan.
10. Explain Brooks' law.

Discussion Topics

1. When using a project triangle to illustrate conflicting priorities, Microsoft suggests that if the problem is in the fixed leg, work on the other two legs. For example, if the project must not exceed the budget and it is starting to run over, adjust the schedule, or the scope, or both. However, if the problem is not related to the fixed leg, the adjustment might have to be in the remaining leg. So, when faced with an inflexible budget (fixed leg) and the schedule is slipping (problem leg), the project's scope (remaining leg) might have to be adjusted. Why is explaining this situation to management sometimes a very difficult task for the systems analyst?
2. If you are managing a large project, would you prefer Gantt charts or PERT/CPM charts to represent project status? Explain why.
3. Consider a scenario where a task is dependent on another task being started but not necessarily completed. For example, a project may depend on a task being started and one-fourth completed before the group could start their portion of the project. Do you think this situation occurs frequently in systems projects? Why or why not?
4. Some project management applications can be quite expensive. As a manager, how would you justify the purchase of this software?
5. Risk analysis is typically a two-step process: qualitative risk analysis and quantitative risk analysis. As a systems analyst, for which sorts of project management decisions would you use the results from qualitative risk analysis? From the quantitative risk analysis?

Projects

1. Think of all the tasks that you perform when you purchase a car. Include any research, decisions, or financial issues that relate to the purchase. Create a WBS that shows all the tasks, their estimated duration, and any predecessor tasks.
2. Figure 3-27 shows a WBS with 11 tasks. Note that each task has an ID, a description, duration, and a reference to predecessor tasks, if any, which must be completed before the task can begin. Also note that dependent tasks can have one predecessor task or several. Construct a PERT/CPM chart from these tasks. Recall that this is done as a two-step process: (1) display the tasks and task patterns, and (2) enter start and finish time.

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Task No.	Description	Duration (Days)	Predecessor Tasks
1	Develop Plan	1	-
2	Assign Tasks	4	1
3	Obtain Hardware	17	1
4	Programming	70	2
5	Install Hardware	10	3
6	Program Test	30	4
7	Write User Manual	25	5
8	Convert Files	20	5
9	System Test	25	6
10	User Training	20	7, 8
11	User Test	25	9,10

FIGURE 3-27 Example of a work breakdown structure listing 11 tasks, together with their descriptions, durations, and predecessor tasks.

3. Many of today's projects involve team members scattered across different time zones and in different physical locations. Moreover, the projects may have adopted an agile methodology, which reduces cycle time dramatically. Write a brief report that summarizes some of the key differences a manager would face managing this type of project, as opposed to a traditional project.
4. Go to the websites for project management tools (besides Microsoft Project), such as Apptivo (*www.apptivo.com*), GanttProject (*www.ganttproject.biz*), Gantter (*www.gantter.com*), smartsheet (*www.smartsheet.com/product-tour/gantt-charts*), Monday (*www.monday.com*), and Trello (*www.trello.com*). Explore each program's features and describe what you like and don't like.
5. Perform an Internet research to learn more about project risk management and write a summary of the results. Be sure to search for the classic book titled *Waltzing with Bears: Managing Risk on Software Projects*, by Tom Demarco and Timothy Lister.

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PHASE 2 SYSTEMS ANALYSIS

DELIVERABLE
System requirements document

Systems analysis is the second of five phases in the systems development life cycle. In the previous phase, systems planning, a preliminary investigation was conducted to determine the project's feasibility. The output of that phase, the preliminary investigation report, is used as input to the systems analysis phase, where a system requirements document is created that captures the needs of the all stakeholders.

A successful project manager must determine the requirements before starting the design process, not the other way around. It may be tempting to "just do something" to give the appearance of productivity, but a systems project that does not satisfy business requirements serves no useful purpose.

Chapter 4 focuses on the requirements engineering process. This includes system requirements, team-based techniques, gathering requirements through interviews and other methods, gathering requirements in agile projects, representing requirements, validating and verifying requirements, and requirements tools.

Chapter 5 focuses on data and process modeling techniques that analysts use to show how the system transforms data into useful information. This includes logical versus physical models, data flow diagrams and symbols, drawing data flow diagrams, drawing context diagrams, drawing diagram 0 DFDs, drawing lower-level DFDs, data dictionaries, and process descriptions.

Chapter 6 focuses on object modeling techniques that analysts use to create a logical model. This includes object-oriented analysis, objects, attributes, methods, messages, classes, relationships among objects and classes, the Unified Modeling Language (UML), and tools.

Chapter 7 focuses on development strategies for the new system and plans for the transition to the systems design phase. This includes traditional versus web-based systems development, evolving trends, in-house software development options, outsourcing, offshoring, Software as a Service (SaaS), selecting a development strategy, the software acquisition process, and completion of systems analysis tasks.

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CHAPTER 4 Requirements Engineering

Chapter 4 is the first of the four chapters in the systems analysis phase. This chapter describes the requirements engineering process: gathering facts about a systems project, creating models that will be used to design and develop the system, and verifying and validating that the models are correct before proceeding to the next phase of the SDLC.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" raises the issue of considering a request by a supervisor to identify departments that reported the lowest ratings in a survey that was supposed to be kept anonymous.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Explain system requirements and the challenges associated with the requirements engineering process
2. Compare and contrast functional and non-functional requirements
3. Apply team-based requirements engineering techniques, including joint application development (JAD), rapid application development (RAD), and agile methods
4. Develop a fact-finding plan for gathering requirements
5. Conduct an interview to gather system requirements
6. Use other requirements gathering techniques, including document review, observation, questionnaires and surveys, brainstorming, sampling, and research
7. Explain how requirements are gathered in agile projects
8. Utilize different requirements representation techniques, including natural language, diagrams, and models
9. Explain how to validate and verify requirements
10. Explain how tools can help with requirements engineering activities

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4.1 System Requirements

During the first part of the systems analysis phase of the SDLC, systems analysts must identify and describe all system requirements. A **system requirement** is a characteristic or feature that must be included in an information system to satisfy business requirements and be acceptable to users. System requirements serve as benchmarks to measure the overall acceptability of the finished system.

Because system requirements are the focus of the start of the systems analysis phase, it's important to get them correct, right at the start of the process. Any problems with the requirements will have a ripple effect that could negatively affect subsequent phases of the SDLC. In fact, poor **requirements engineering** is a leading cause of failed projects.

Requirements engineering is composed of three main activities:

1. Gathering requirements: *understanding* the problem
2. Representing requirements: *describing* the problem
3. Validating and verifying requirements: *agreeing* upon the problem

Each of these activities is described in more detail in this chapter. The output of requirements engineering are requirements documents that capture the essence of what the system should do. These documents are the input to the next step in the SDLC, data and process modeling, which is described in Chapter 5.

4.1.1 Types of Requirements

Requirements can be classified according to various characteristics. For example, requirements may be primarily for the system user, in which case they are referred to as **requirements definitions**. Requirements may also be primarily for the engineering team, in which case they are referred to as **requirements specifications**.

System requirements can also be classified as functional and non-functional. A **functional requirement** is a statement of the services a system provides. Examples of functional requirements include the following:

- The website shall report online volume statistics every four hours and hourly during peak periods.
- The inventory system shall produce a daily report showing the part number, description, quantity on hand, quantity allocated, quantity available, and unit cost of all sorted by part number.
- The contact management system shall generate a daily reminder list for all sales representatives.
- Each input form must include date, time, product code, customer number, and quantity.
- The system must provide logon security at the operating system level and at the application level.

A **non-functional requirement** is a statement of operational system constraints. Non-functional requirements are also known as **quality attributes**. Examples of functional requirements include the following:

- Data entry screens must be uniform, except for background color, which can be changed by the user.
- The system must support 25 users online simultaneously.

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- Response time must not exceed four seconds.
- The system must be operational 7 days a week, 365 days a year.
- The system should work on Windows and Mac platforms.

Non-functional requirements may be more critical than functional requirements; if the former are not satisfied, the system is useless. Conflicts between different non-functional requirements are common in complex systems. For example, a user may request that a system be 100% secure but very usable—two requirements that are hard to reconcile.

4.1.2 Requirements Challenges

Requirements present numerous challenges to the systems analyst. Three of the most important are imprecision, agreement, and creep.

IMPRECISION: Requirements are often imprecise because they are usually represented using natural language, such as the examples shown in Section 4.1.1. Natural language is expressive, but it is prone to misinterpretation. It is not uncommon for various stakeholders to completely disagree as to the meaning of a simple requirement. It is for this reason that other techniques are used to represent requirements, as described in Section 4.7.

A requirement may be a high-level abstract statement of a service or of a system constraint, but it can also be a detailed mathematical specification. This is because requirements often serve two functions: as a basis for a bid for a contract, and as the basis for the contract itself.

If the requirements are the basis for the contract bid, it must be open to interpretation. But if the requirements are the basis for the contract itself, it must be defined in detail. These two constraints are difficult to satisfy.

AGREEMENT: One of the main problems with requirements is getting everyone to agree on the exact meaning of the requirements statements. In other words, we want to develop requirements in such a way that, upon completion of the system, both the systems analyst and the client can agree on whether or not a specific requirement has been met.

In theory, requirements should be both complete and consistent. A requirement is complete if it includes descriptions of all facilities needed by the system. In practice, it's impossible to completely describe the requirements for a complex system.

A requirement is consistent if there are no conflicts or contradictions in the description of the system facilities. In practice, ensuring that there are no conflicts in the system requirements when there may be thousands is quite challenging.

CREEP: There are many social and organizational factors that influence system requirements. For example, business changes inevitably lead to changing requirements—usually more of them as the project progresses. This is particularly true for long-lived projects where the personnel involved change over time. This phenomenon is known as "feature creep."

Rapidly changing requirements can cause numerous problems for systems analysts and other team members. This is particularly true for projects that follow a traditional waterfall model of the SDLC. It is partly for this reason that agile methods are popular: They explicitly address changing requirements as part of the project's management structure.

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4.1.3 Additional Considerations

In addition to the three challenges outlined earlier, systems analysts must consider three important supplementary factors: (1) scalability, which determines how a system will handle future growth and demands; (2) security, which is all-important for today's networked systems; and (3) the total cost of ownership, which includes all future operational and support costs.

SCALABILITY: Scalability refers to a system's ability to handle increased business volume and transactions in the future. Because it will have a longer useful life, a scalable system offers a better return on the initial investment.

To evaluate scalability, information is needed about projected future volume for all outputs, inputs, and processes. For example, for a web-based order processing system, one needs to know the maximum projected number of concurrent users, the periods of peak online activity, the number and types of data items required for each transaction, and the method of accessing and updating customer files.

Even to print customer statements, the analyst needs to know the number of active accounts and have a forecast for one, two, or five years because that information affects future hardware decisions. In addition, with realistic volume projections, reliable cost estimates for related expenses, such as postage and online charges, can be provided.

Similarly, to ensure that a web-based hotel reservation system is sufficiently scalable, the analyst would need to project activity levels for several years of operation. For example, one might forecast the frequency of online queries about room availability and estimate the time required for each query and the average response time. With that information, server transaction volume and network requirements could be estimated.

Transaction volume has a significant impact on operating costs. When volume exceeds a system's limitations, maintenance costs increase sharply. Volume can change dramatically if a company expands or enters a new line of business. For example, a new Internet-based marketing effort might require an additional server and a 24-hour technical support.

Data storage also is an important scalability issue. The analyst must determine how much data storage is required currently and predict future needs based on system activity and growth. Those requirements affect hardware, software, and network bandwidth needed to maintain system performance. Data retention requirements must also be considered to determine whether data can be deleted or archived on a specific timetable.

SECURITY: In the past, security was considered an add-on to a system's design. This is particularly true for legacy systems that have been deployed for some time. Nowadays, security is so important for networked systems that it has changed from a non-functional requirement to a functional requirement. In other words, security is an essential consideration for all systems development.

Incorporating security as a first-class requirement is particularly important in light of the seemingly endless news reports of massive data breaches. These hacks release personal information from online systems at a scale previously unseen. If the systems had been made with security in mind from the beginning, they would be much harder to infiltrate.

The challenge with security as a system requirement is that it is often in conflict with other user requirements. For example, a requirement that the system should be accessible online using a web interface immediately makes securing the system much more challenging. The systems analyst must attempt to reconcile and prioritize the conflicting requirements during the requirements engineering process.

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TOTAL COST OF OWNERSHIP: In addition to direct costs, systems developers must identify and document indirect expenses that contribute to the **total cost of ownership (TCO)**. TCO is especially important if the development team is assessing several alternatives. After considering the indirect costs, which are not always apparent, a system that seems inexpensive initially might actually turn out to be the costliest choice. One problem is that cost estimates tend to understate indirect costs such as user support and downtime productivity losses. Even if accurate figures are unavailable, systems analysts should try to identify indirect costs and include them in TCO estimates.

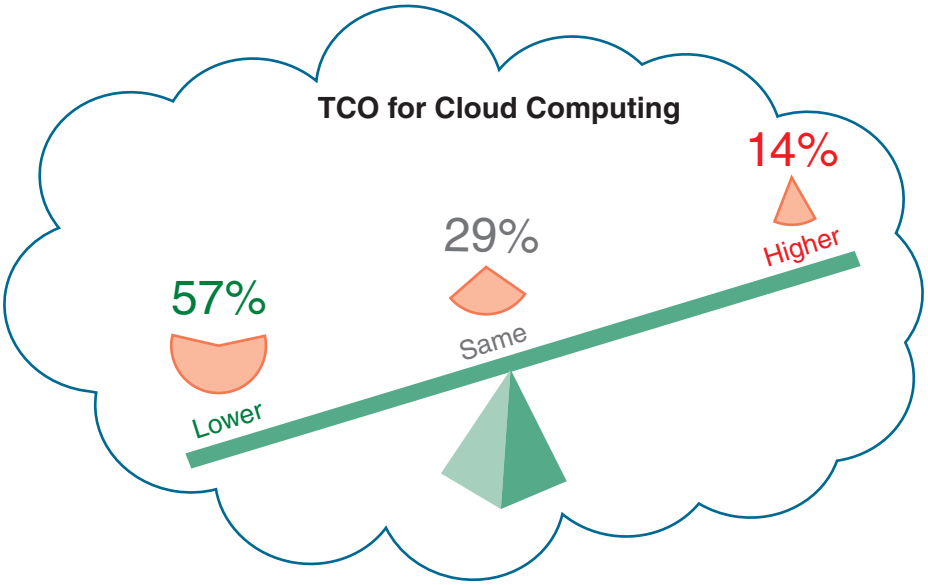


FIGURE 4-1 Total cost of ownership when migrating to the cloud can be significantly less than current computing platforms.

Because cost control is so important, vendors often claim that their products or services will reduce TCO significantly. For example, one of the most common reasons to migrate a legacy system to the cloud is reduced TCO. As shown in Figure 4-1, cloud computing offers the opportunity for lower operational costs due to the outsourcing of expenses such as capital investment in exchange for a pay-as-you-go pricing model.

4.2 Team-Based Techniques

The IT department's goal is to deliver the best possible information system, at the lowest possible cost, in the shortest possible time. To achieve the best results, systems developers view users as partners in the development process. Greater user involvement usually results in better communication, faster development times, and more satisfied users.

The traditional model for systems development was an IT department that used structured analysis and consulted users only when their input or approval was needed. Although the IT staff still has a central role, and structured analysis remains a popular method of systems development, most IT managers invite system users to participate actively in various development tasks.

As described in Chapter 1, team-based approaches have been around for some time. A popular example is joint application development (JAD), which is a user-oriented technique for fact-finding and requirements engineering. Because it is not linked to a specific development methodology, systems developers use JAD whenever group input and interaction are desired.

Another popular user-oriented method is rapid application development (RAD). RAD resembles a condensed version of the entire SDLC, with users involved every step of the way. While JAD typically focuses only on fact-finding and requirements determination, RAD provides a fast-track approach to a full spectrum of systems development tasks, including planning, design, construction, and implementation.

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Finally, as described in Chapter 1, agile methods represent a recent trend that stresses intense interaction between systems developers and users. JAD, RAD, and agile methods are discussed in the following sections.

4.2.1 Joint Application Development

Joint application development (JAD) is a popular fact-finding technique that brings users into the development process as active participants.

USER INVOLVEMENT: Users have a vital stake in an information system, and they should participate fully in the development process. Many years ago, the IT department usually had sole responsibility for systems development and users had a relatively passive role. During the development process, the IT staff would collect information from users, define system requirements, and construct the new system. At various stages of the process, the IT staff might ask users to review the design, offer comments, and submit changes.

Today, users typically have a much more active role in systems development. IT professionals now recognize that successful systems must be user oriented, and users need to be involved, formally or informally, at every stage of systems development.

One popular strategy for user involvement is a JAD team approach, which involves a task force of users, managers, and IT professionals who work together to gather information, discuss business needs, and define the new system requirements.

JAD PARTICIPANTS AND ROLES: A JAD team usually meets over a period of days or weeks in a special conference room or at an off-site location. Either way, JAD participants should be insulated from the distraction of day-to-day operations. The objective is to analyze the existing system, obtain user input and expectations, and document user requirements for the new system.

The JAD group usually has a project leader, who needs strong interpersonal and organizational skills, and one or more members who document and record the results and decisions. Figure 4-2 describes typical JAD participants and their roles. IT staff members often serve as JAD project leaders, but that is not always the case.

JAD PARTICIPANT	ROLE
JAD project leader	Develops an agenda, acts as a facilitator, and leads the JAD session
Top management	Provides enterprise-level authorization and support for the project
Managers	Provide department-level support for the project and understanding of how the project must support business functions and requirements
Users	Provide operational-level input on current operations, desired changes, input and output requirements, user interface issues, and how the project will support day-to-day tasks
Systems analysts and other IT staff members	Provide technical assistance and resources for JAD team members on issues such as security, backup, hardware, software, and network capability
Recorder	Documents results of JAD sessions and works with systems analysts to build system models and develop CASE tool documentation

FIGURE 4-2 Typical JAD participants and roles.

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Systems analysts on the JAD team participate in discussions, ask questions, take notes, and provide support to the team. If CASE tools are available, analysts can develop models and enter documentation from the JAD session directly into the CASE tool.

A typical JAD session agenda is shown in Figure 4-3. The JAD process involves intensive effort by all team members. Because of the wide range of input and constant interaction among the participants, many companies believe that a JAD group produces the best possible definition of the new system.

Project leader	• Introduce all JAD team members • Discuss ground rules, goals, and objectives for the JAD sessions • Explain methods of documentation and use of CASE tools, if any
Top management (sometimes called the project owner or sponsor)	• Explain the reason for the project and express top management authorization and support
Project leader	• Provide overview of the current system and proposed project scope and constraints • Present outline of specific topics and issues to be investigated
Open discussion session, moderated by project leader	• Review the main business processes, tasks, user roles, input, and output • Identify specific areas of agreement or disagreement • Break team into smaller groups to study specific issues and assign group leaders
JAD team members working in smaller group sessions, supported by IT staff	• Discuss and document all system requirements • Develop models and prototypes
Group leaders	• Report on results and assigned tasks and topics • Present issues that should be addressed by the overall JAD team
Open discussion session, moderated by project leader	• Review reports from small group sessions • Reach consensus on main issues • Document all topics
Project leader	• Present overall recap of JAD session • Prepare report that will be sent to JAD team members

FIGURE 4-3 Typical agenda for a JAD session.

JAD ADVANTAGES AND DISADVANTAGES: Compared with traditional methods, JAD is more expensive and can be cumbersome if the group is too large relative to the size of the project. Many companies find, however, that JAD allows key users to participate effectively in the requirements engineering process. When users participate in the systems development process, they are more likely to feel a sense of ownership in the results and support for the new system. When properly used, JAD can result in a more accurate statement of system requirements, a better understanding of common goals, and a stronger commitment to the success of the new system.

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CASE IN POINT 4.1: North Hills College

North Hills College has decided to implement a new registration system that will allow students to register online as well as in person. As IT manager, you decide to set up a JAD session to help define the requirements for the new system. The North Hills organization is fairly typical, with administrative staff that includes a registrar, a student support and services team, a business office, an IT group, and a number of academic departments. Using this information, you start work on a plan to carry out the JAD session. Who would you invite to the session, and why? What would be your agenda for the session, and what would take place at each stage of the session?

4.2.2 Rapid Application Development

Rapid application development (RAD) is a team-based technique that speeds up information systems development and produces a functioning information system. Like JAD, RAD uses a group approach but goes much further. While the end product of JAD is a requirements model, the end product of RAD is the new information system. RAD is a complete methodology, with a four-phase life cycle that parallels the traditional SDLC phases. Companies use RAD to reduce cost and development time and increase the probability of success.

RAD relies heavily on prototyping and user involvement. The RAD process allows users to examine a working model as early as possible, determine if it meets their needs, and suggest necessary changes. Based on user input, the prototype is modified, and the interactive process continues until the system is completely developed and users are satisfied. The project team uses CASE tools to build the prototypes and create a continuous stream of documentation.

RAD PHASES AND ACTIVITIES: The RAD model consists of four phases: requirements planning, user design, construction, and cutover, as shown in Figure 4-4. Note the continuous interaction between the user design and construction phases.

Requirements planning. The **requirements planning phase** combines elements of the systems planning and systems analysis phases of the SDLC. Users, managers, and IT staff members discuss and agree on business needs, project scope, constraints, and system requirements. The requirements planning phase ends when the team agrees on the key issues and obtains management authorization to continue.

User design. During the **user design phase**, users interact with systems analysts and develop models and prototypes that represent all system processes, outputs, and inputs. The RAD group or subgroups typically use a combination of JAD techniques and CASE tools to translate user needs into working models. User design is a continuous, interactive process that allows users to understand, modify, and eventually approve a working model of the system that meets their needs.

Construction. The **construction phase** focuses on program and application development tasks similar to the SDLC. In RAD, however, users continue to participate and still can suggest changes or improvements as actual screens or reports are developed.

Cutover. The **cutover phase** resembles the final tasks in the SDLC implementation phase, including data conversion, testing, changeover to the new system, and user training. Compared with traditional methods, the entire process is compressed. As a result, the new system is built, delivered, and placed in operation much sooner.

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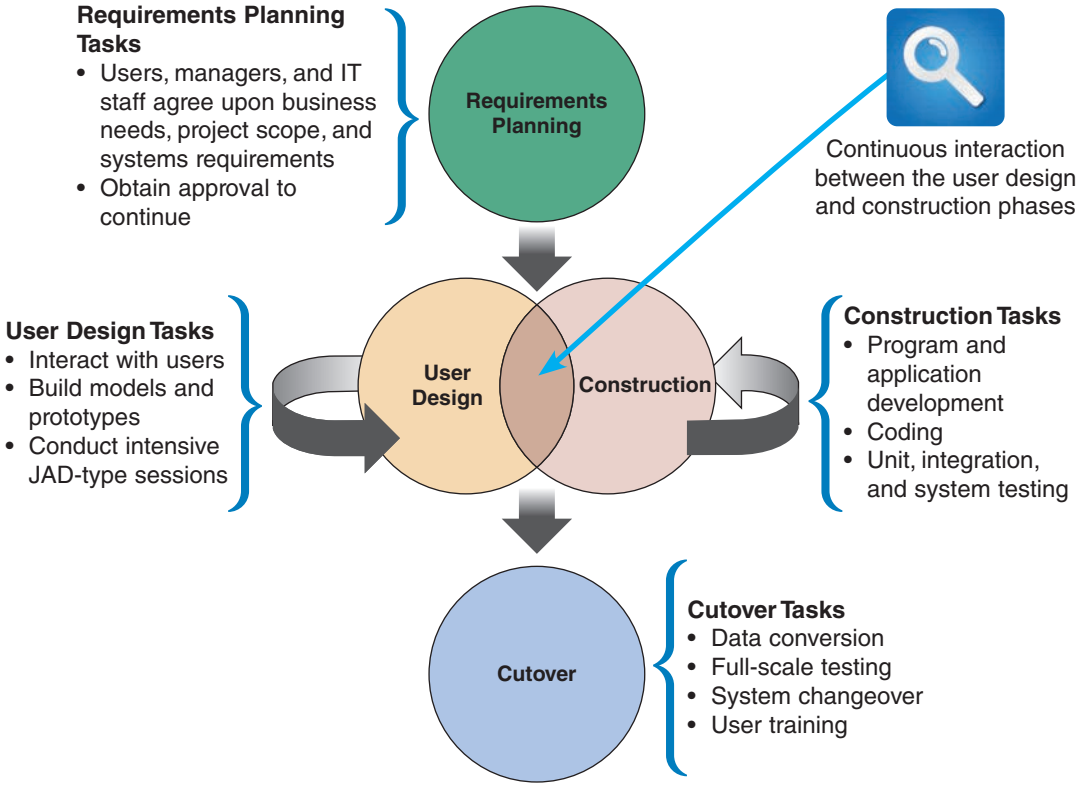


FIGURE 4-4 The four phases of the RAD model are requirements planning, user design, construction, and cutover. Note the continuous interaction between the user design and construction phases.

RAD OBJECTIVES: The main objective of all RAD approaches is to cut development time and expense by involving users in every phase of systems development. Because it is a continuous process, RAD allows the development team to make necessary modifications quickly, as the design evolves. In times of tight corporate budgets, it is especially important to limit the cost of changes that typically occur in a long, drawn-out development schedule.

In addition to user involvement, a successful RAD team must have IT resources, skills, and management support. Because it is a dynamic, user-driven process, RAD is especially valuable when a company needs an information system to support a new business function. By obtaining user input from the beginning, RAD also helps a development team design a system that requires a highly interactive or complex user interface.

RAD ADVANTAGES AND DISADVANTAGES: RAD has advantages and disadvantages compared with traditional structured analysis methods. The primary advantage is that systems can be developed more quickly with significant cost savings. A disadvantage is that RAD stresses the mechanics of the systems itself and does not emphasize the company's strategic business needs. The risk is that a system might work well in the short term, but the corporate and long-term objectives for the system might not be met. Another potential disadvantage is that the accelerated time cycle might allow less time to develop quality, consistency, and design standards. RAD can be an attractive alternative, however, if an organization understands the possible risks.

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4.2.3 Agile Methods

Chapter 1 explained that **agile methods** attempt to develop a system incrementally by building a series of prototypes and constantly adjusting them to user requirements. As the agile process continues, developers revise, extend, and merge earlier versions into the final product. An agile approach emphasizes continuous feedback, and each incremental step is affected by what was learned in the prior steps.

As agile methods become more popular, a large community of agile-related software and services has evolved. Many agile developers prefer not to use CASE tools at all, and as shown in Figure 4-5 rely instead on whiteboard displays and arrangements of movable sticky notes. This approach, they believe, reinforces the agile strategy: simple, rapid, flexible, and user oriented.



FIGURE 4-5 Reinforcing the agile strategy: simple, rapid, flexible, and user oriented.
Sam Edwards/OJO Images/Getty Images

Scrum is another agile approach. The name comes from the rugby term *scrum*, where team members lunge at each other to achieve their objectives, as shown in Figure 4-6. The systems development version of Scrum involves the same intense interaction, though it is more mental than physical. In a Scrum session, agile team members play specific roles, including colorful designations such as pigs or chickens. These roles are based on the old joke about the pig and chicken who discuss a restaurant where ham and eggs would be served. However, the pig declines, because that role would require a total commitment, while for the chicken, it would only be a contribution.

In the agile world, the pigs include the product owner, the facilitator, and the development team, while the chickens include users, other stakeholders, and managers. Scrum sessions have specific guidelines that emphasize time blocks, interaction, and team-based activities that result in deliverable software. An agile team uses a series of scrums to pause the action and allow the players to reset the game plan, which remains in effect until the next scrum.

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FIGURE 4-6 In a rugby scrum, team members prepare to lunge at each other to achieve their objectives.
getnikov/Shutterstock.com

AGILE METHOD ADVANTAGES AND DISADVANTAGES: Agile, or adaptive, methods are very flexible and efficient in dealing with change. They are popular because they stress team interaction and reflect a set of community-based values. Also, frequent deliverables constantly validate the project and reduce risk.

However, some potential problems exist. For example, team members need a high level of technical and interpersonal skills. Also, a lack of structure and documentation can introduce risk factors, such as blurring of roles and responsibilities, and loss of corporate knowledge. Finally, the overall project may be subject to significant change in scope as user requirements continue to evolve during the project.

4.3 Gathering Requirements

Gathering requirements is the first step in the requirements engineering process. This step is also known as **requirements elicitation** or **fact-finding** (collecting information). Whether working solo or as a member of a team, during requirements gathering, the systems analyst will use various techniques, including interviews, document review, observation, surveys and questionnaires, sampling, and research.

Although software can help gather and analyze requirements, no program actually gathers them automatically. First, the information needed must be identified. Typically, this activity begins by asking a series of questions, such as the following:

- What business functions are supported by the current system?
- What strategic objectives and business requirements must be supported by the new system?

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- What are the benefits and TCO of the proposed system?
- What transactions will the system process?
- What information do users and managers need from the system?
- Must the new system interface with legacy systems?
- What procedures could be eliminated by business process reengineering?
- What security issues exist?
- What risks are acceptable?
- What budget and timetable constraints will affect systems development?

To obtain answers to these questions, the analyst develops a fact-finding plan, which involves answers to five familiar questions: who, what, where, when, and how. For each of those questions, one also must ask another very important question: why. Some examples of these questions are as follows:

1. *Who*? Who performs each of the procedures within the system? Why? Are the correct people performing the activity? Could other people perform the tasks more effectively?
2. *What*? What is being done? What procedures are being followed? Why is the process necessary? Often, procedures are followed for many years and no one knows why. Question why a procedure is being followed at all.
3. *Where*? Where are operations being performed? Why? Where could they be performed? Could they be performed more efficiently elsewhere?
4. *When*? When is a procedure performed? Why is it being performed at this time? Is this the best time?
5. *How*? How is a procedure performed? Why is it performed in that manner? Could it be performed better, more efficiently, or less expensively in some other manner?

There is a difference between asking what is being done and what could or should be done. The systems analyst first must understand the current situation. Only then can the question of what should be done be answered. Figure 4-7 lists the basic questions and when they should be asked. Note that the first two columns relate to the current system but the third column focuses on the proposed system.

CURRENT SYSTEM		PROPOSED SYSTEM
Who does it?	Why does this person do it?	Who should do it?
What is done?	Why is it done?	What should be done?
Where is it done?	Why is it done there?	Where should it be done?
When is it done?	Why is it done then?	When should it be done?
How is it done?	Why is it done this way?	How should it be done?

FIGURE 4-7 Sample questions during requirements elicitation as the focus shifts from the current system to the proposed system.

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4.4 Gathering Requirements Through Interviews

Interviewing is an important requirement gathering technique during the systems analysis phase. An **interview** is a planned meeting during which the analyst obtains information from another person. The skills needed to plan, conduct, document, and evaluate interviews successfully must be understood.

4.4.1 The Interview Process

After identifying the information needed, as described earlier in the chapter, the interviewing process commences, which consists of seven steps for each interview:

1. Determine the people to interview.
2. Establish objectives for the interview.
3. Develop interview questions.
4. Prepare for the interview.
5. Conduct the interview.
6. Document the interview.
7. Evaluate the interview.

STEP 1: DETERMINE THE PEOPLE TO INTERVIEW: To get an accurate picture, the analyst must select the right people to interview and ask them the right questions. The preliminary investigation involved mainly middle managers or department heads. Now, during the systems analysis phase, people from all levels of the organization should be interviewed. In some situations, it might be prudent to interview stakeholders that are not members of the organization, because their opinion is valuable.

Although interview candidates can be selected from the formal organization charts reviewed earlier, one must also consider any informal structures that exist in the organization. **Informal structures** usually are based on interpersonal relationships and can develop from previous work assignments, physical proximity, unofficial procedures, or personal relationships such as the informal gathering shown in Figure 4-8. In an informal structure, some people have more influence or knowledge than appears on



FIGURE 4-8 When setting up interviews, an analyst should look outside a formal organization chart to identify people who might provide valuable information.

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an organization chart. The analyst's knowledge of the company's formal and informal structures helps determine the people to interview during the systems analysis phase.

Should several people be interviewed at the same time? Group interviews can save time and provide an opportunity to observe interaction among the participants. Group interviews also can present problems. One person might dominate the conversation, even when questions are addressed specifically to others. Organization level also can present a problem because the presence of senior managers in an interview might prevent lower-level employees from expressing themselves candidly.

STEP 2: ESTABLISH OBJECTIVES FOR THE INTERVIEW: After deciding on the people to interview, objectives for the session must be established. First, the general areas to be discussed should be determined, and then the facts to be gathered should be listed. Soliciting ideas, suggestions, and opinions during the interview is also a good idea.

The objectives of an interview depend on the role of the person being interviewed. Upper-level managers can provide the big picture to help understand the system as a whole. Specific details about operations and business processes are best learned from people who actually work with the system on a daily basis.

In the early stages of systems analysis, interviews usually are general. As the fact-finding process continues, however, the interviews focus more on specific topics. Interview objectives also vary at different stages of the investigation. Interviews should be as brief as possible (though as long as needed), since time is so valuable to employees, especially managers. By setting specific objectives, a framework is created that helps the analyst decide what questions to ask and how to phrase them.

STEP 3: DEVELOP INTERVIEW QUESTIONS: Creating a standard list of interview questions helps to keep the session on track and avoid unnecessary tangents. Also, if several people who perform the same job are interviewed, a standard question list permits a comparison of their answers. Although there may be a list of specific questions, the interviewer might decide to depart from it because an answer to one question leads to another topic that warrants pursuing. That question or topic then should be included in a revised set of questions used to conduct future interviews. If the question proves to be extremely important, it may be needed to return to a previous interviewee to query him or her on the topic.

The interview should consist of several different kinds of questions: open-ended, closed-ended, or questions with a range of responses. When phrasing questions, avoid **leading questions** that suggest or favor a particular reply. For example, rather than asking, "What advantages do you see in the proposed system?" ask instead, "Do you see any advantages in the proposed system?"

Open-ended questions. **Open-ended questions** encourage spontaneous and unstructured responses. Such questions are useful to understand a larger process or draw out the interviewee's opinions, attitudes, or suggestions. Here are some examples of open-ended questions:

- What are users saying about the new system?
- How is this task performed?
- Why do you perform the task that way?
- How are the checks reconciled?
- What added features would you like to have in the new billing system?

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Also, an open-ended question can be used to probe further by asking: Is there anything else you can tell me about this topic?

Closed-ended questions. Closed-ended questions limit or restrict the response. Closed-ended questions are used when information that is more specific is needed or when facts must be verified. Examples of closed-ended questions include the following:

- How many personal computers do you have in this department?
- Do you review the reports before they are sent out?
- How many hours of training does a clerk receive?
- Is the calculation procedure described in the manual?
- How many customers ordered products from the website last month?

Range-of-response questions. Range-of-response questions are closed-ended questions that ask the person to evaluate something by providing limited answers to specific responses or on a numeric scale. This method makes it easier to tabulate the answers and interpret the results. Range-of-response questions might include the following:

- On a scale of 1 to 10, with 1 the lowest and 10 the highest, how effective was your training?
- How would you rate the severity of the problem: low, medium, or high?
- Is the system shutdown something that occurs never, sometimes, often, usually, or always?

STEP 4: PREPARE FOR THE INTERVIEW: After setting the objectives and developing the questions, preparing for the interview is next. Careful preparation is essential because an interview is an important meeting and not just a casual chat. When the interview is scheduled, suggest a specific day and time and let the interviewee know how long the meeting is expected to last. It is also a good idea to send an email or place a reminder call the day before the interview.

Remember that the interview is an interruption of the other person's routine, so the interview should be limited to no more than one hour. If business pressures force a postponement of the meeting, schedule another appointment as soon as it is convenient. Remember to keep department managers informed of meetings with their staff members. Sending a message to each department manager listing planned appointments is a good way to keep them informed. Figure 4-9 is an example of such a message.

A list of topics should be sent to an interviewee several days before the meeting, especially when detailed information is needed, so the person can prepare for the interview and minimize the need for a follow-up meeting. Figure 4-10 shows a sample message that lists specific questions and confirms the date, time, location, purpose, and anticipated duration of the interview.

If there are questions about documents, ask the interviewee to have samples available at the meeting. The advance memo should include a list of the documents to discuss (if it is known what they are). Also, a general request for documents can be made, as the analyst did in the email shown in Figure 4-10.

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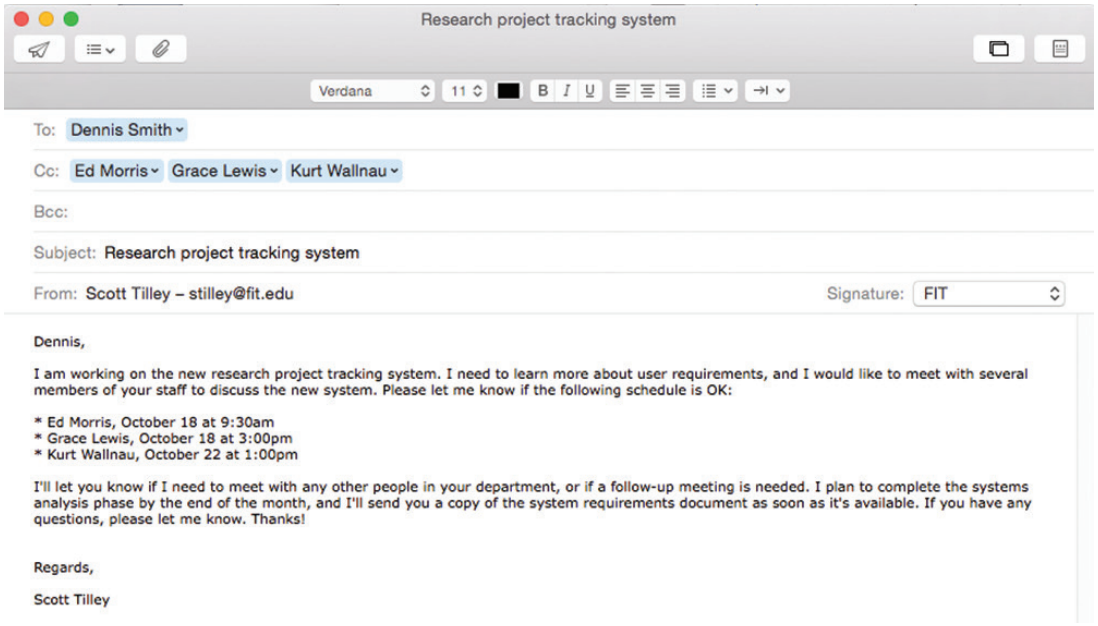


FIGURE 4-9 Sample message to a department head about interviews.

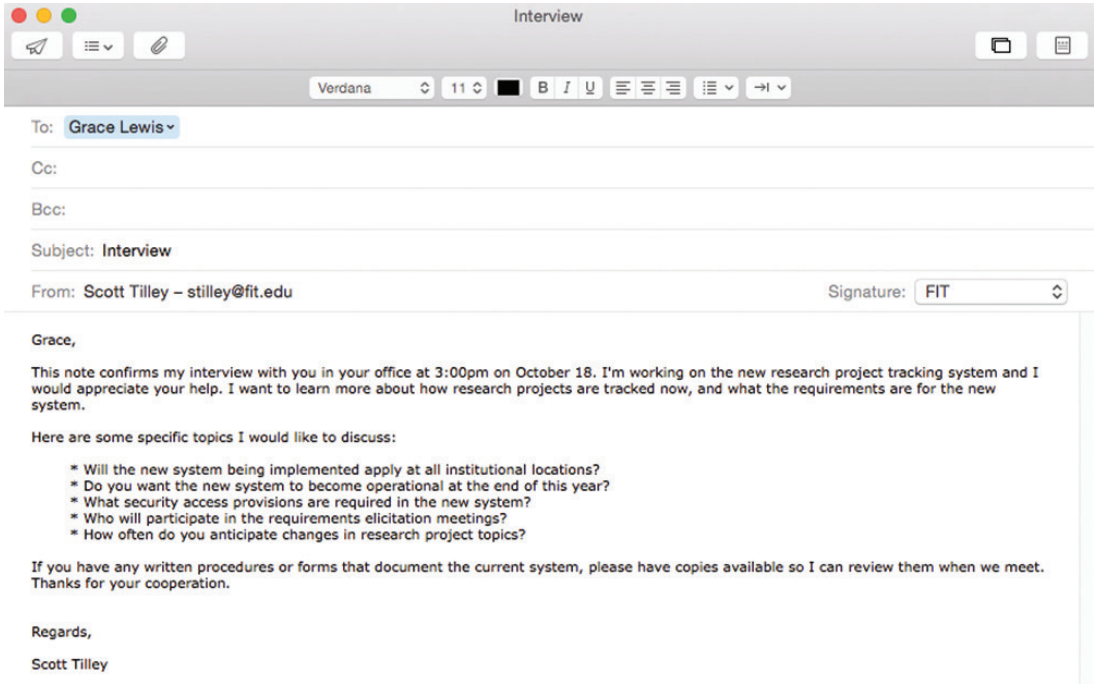


FIGURE 4-10 Sample message to confirm an interview.

Two schools of thought exist about the best location for an interview. Some analysts believe that interviews should take place in the interviewee's office, whereas other analysts feel that a neutral location such as a conference room is better.

Supporters of interviews in the interviewee's office believe that is the best location because it makes the interviewee feel comfortable during the meeting. A second argument in favor of the interviewee's office is that the office is where he or she has

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the easiest access to supporting material that might be needed during the discussion. If a complete list of topics is provided in advance, however, the interviewee can bring the necessary items to a conference room or other location.

Supporters of neutral locations stress the importance of keeping interruptions to a minimum so both people can concentrate fully. In addition, an interview that is free of interruptions takes less time. If the meeting does take place in the interviewee's office, tactfully suggest that all calls be held until the conclusion of the interview.

STEP 5: CONDUCT THE INTERVIEW: After determining the people to interview, setting the objectives, and preparing the questions, a specific plan for the meeting should be developed. When conducting an interview, begin with introductions, describe the project, and explain the interview objectives.

During the interview, ask questions in the order in which they were prepared and give the interviewee sufficient time to provide thoughtful answers. Some answers will lead to additional questions, which should be asked in a logical order. Establishing a good rapport with the interviewee is important, especially if this is the first meeting. If the other person feels comfortable and at ease, they will probably provide more complete and candid answers. The analyst's primary responsibility during an interview is to listen carefully to the answers. Analysts sometimes hear only what they expect to hear. Concentrate on what is said and notice any nonverbal communication that takes place. This process is called **engaged listening**.

After asking a question, allow the person enough time to think about the question and arrive at an answer. Studies have shown that the maximum pause during a conversation is usually three to five seconds. After that interval, one person will begin talking. An analyst needs to be patient and practice his or her skills in many actual interview situations to be successful.

When all the questions have been asked, summarize the main points covered in the interview and explain the next course of action. For example, mention that a follow-up memo will be sent or that the interviewee should send certain requested information after the meeting. When the interview has concluded, thank the person and encourage him or her to reach out with any questions or additional comments. Also, when the interview ends, it is a good idea to ask the interviewee whether he or she can suggest any additional topics that should be discussed.

After an interview, summarize the session and seek a confirmation from the other person. By stating the interviewer's understanding of the discussion, the interviewee can respond and provide corrections, if necessary. One approach is to rephrase the interviewee's answers. For example, the analyst could say, "If I understand you correctly, you are saying that . . . ." and then reiterate the information given by the interviewee.

STEP 6: DOCUMENT THE INTERVIEW: Although taking notes during an interview has both advantages and disadvantages, it should be kept to a minimum. It is a good idea to write down a few notes to remember key points after the interview but avoid writing down everything that is said. Too much writing distracts the other person and makes it harder to establish a good rapport.

After conducting the interview, record the information quickly. Set aside time right after the meeting to record the facts and evaluate the information. For that reason, try not to schedule back-to-back interviews. Studies have shown that 50% of a conversation is forgotten within 30 minutes. Therefore, use the notes to record the facts immediately so they will not be forgotten. Summarize the facts by preparing a narrative describing what took place or by recording the answers received next to each question on the prepared list.

Small, portable recorders are effective tools for interviews, but some people are uncomfortable when they are used. Before using a recorder, discuss its use with the

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interviewee. Assure the interviewee that the recording will be erased after its contents are transcribed into note form and that the interview can be stopped at any time at the interviewee's request. If sensitive questions are asked, or the interviewee wants to answer a question without being recorded, explain that the recorder can be turned off for a period of time during the interview.

Instead of using a traditional recorder that calls attention to its presence, an interviewer can use built-in audio (or even video) recording features on a notebook or mobile device. Also, as pointed out in Section 4.9, an interviewer can use powerful information management software, such as Microsoft OneNote, to record the meeting, store the results, and create a searchable file for easy access. Irrespective of the mechanism used to record the meeting, all participants should be aware that what they say is being recorded.

Whether or not the meeting is recorded, listen carefully to the interviewee's responses so good follow-up questions can be asked. Otherwise, a second visit might be needed to ask the questions missed the first time. Also, remember that each recorded interview takes twice the amount of time, because the analyst must listen to or view the recorded meeting again after conducting the interview itself.

After the meeting, a memo should be sent to the interviewee, expressing appreciation for his or her time and cooperation. In the memo, note the date, time, location, purpose of the interview, and the main points discussed, so the interviewee has a written summary and can offer additions or corrections.

STEP 7: EVALUATE THE INTERVIEW: In addition to recording the facts obtained in an interview, try to identify any possible biases. For example, an interviewee who tries to protect his or her own area or function might give incomplete answers or refrain from volunteering information. Or, an interviewee with strong opinions about the current or future system might distort the facts. Some interviewees might answer questions in an attempt to be helpful even though they do not have the necessary experience to provide accurate information.

Some interviews are unsuccessful irrespective of the amount of preparation. One of the main reasons could be that the interviewer and the interviewee did not get along well. Such a situation can be caused by several factors. For example, a misunderstanding or personality conflict could affect the interview negatively, or the interviewee might be afraid that the new system will eliminate or change his or her job.

In other cases, the interviewee might give only short or incomplete responses to the open-ended questions. If so, switching to closed-ended questions, or questions with a range of replies, may elicit more favorable responses. If that still does not help, find a tactful way to conclude the meeting.

Continuing an unproductive interview is difficult. The interviewee could be more cooperative later, or the analyst might find the information required elsewhere. If failure to obtain specific information will jeopardize the success of the project, the supervisor should be informed, who can help decide what action to take. The supervisor might contact the interviewee's supervisor, ask another systems analyst to interview the person, or find some other way to get the needed information.

4.5 Gathering Requirements Using Other Techniques

In addition to interviewing, systems analysts use other requirement gathering techniques, including document review, observation, questionnaires and surveys, sampling, and research. Such techniques are used before interviewing begins to obtain a good overview and to help develop better interview questions.

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4.5.1 Document Review

Document review can help the analyst understand how the current system is supposed to work. Remember that system documentation sometimes is out of date. Forms can change or be discontinued, and documented procedures often are modified or eliminated. It is prudent to obtain copies of actual forms and operating documents currently in use, and to review blank copies of forms, as well as samples of actual completed forms. Document samples can be obtained during interviews with the people who perform that procedure. If the system uses a software package, review the documentation for that software.

4.5.2 Observation

The **observation** of current operating procedures is another fact-finding technique. Seeing the system in action provides additional perspective and a better understanding of system procedures. Personal observation also allows the analyst to verify statements made in interviews and determine whether procedures really operate as they are described. Through observation, it might be discovered that neither the system documentation nor the interview statements are accurate.

Personal observation also can provide important advantages as the development process continues. For example, recommendations often are better accepted when they are based on personal observation of actual operations. Observation also can provide the knowledge needed to test or install future changes and can help build relationships with the users who will work with the new system.

Plan observations in advance by preparing a checklist of specific tasks to observe and questions to ask. Consider the following issues when preparing the list:

- Ask sufficient questions to ensure a complete understanding of the present system operation. A primary goal is to identify the methods of handling situations that are not covered by standard operating procedures. For example, what happens in a payroll system if an employee loses a time card? What is the procedure if an employee starts a shift 10 minutes late but then works 20 minutes overtime? Often, the rules for exceptions such as these are not written or formalized; therefore, try to document any procedures for handling exceptions.
- Observe all the steps in a transaction and note the documents, inputs, outputs, and processes involved.
- Examine each form, record, and report. Determine the purpose each item of information serves.
- Consider each user who works with the system and the following questions: What information does that person receive from other people? What information does this person generate? How is the information communicated? How often do interruptions occur? How much downtime occurs? How much support does the user require, and who provides it?
- Talk to the people who receive current reports to see whether the reports are complete, timely, accurate, and in a useful form. Ask whether information can be eliminated or improved and whether people would like to receive additional information.

As people are observed at work, as shown in Figure 4-11, consider a factor called the **Hawthorne Effect**. The name comes from a well-known study performed in the Hawthorne plant of the Western Electric Company in the 1920s. The purpose of the study was to determine how various changes in the work environment would affect

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employee productivity. The surprising result was that productivity improved during observation whether the conditions were made better or worse. Researchers concluded that productivity seemed to improve whenever the workers knew they were being observed.



FIGURE 4-11 The Hawthorne study suggested that worker productivity improves during observation. Always consider the Hawthorne Effect when observing the operation of an existing system.
Monkey Business Images/Shutterstock.com

Although some recent studies have raised questions about the original findings, be aware that observation can and does have an effect on normal operations. With this in mind, always give advance notice to the supervisor in that area. In some situations, it might be helpful to explain the purpose of the visit to the people being observed.

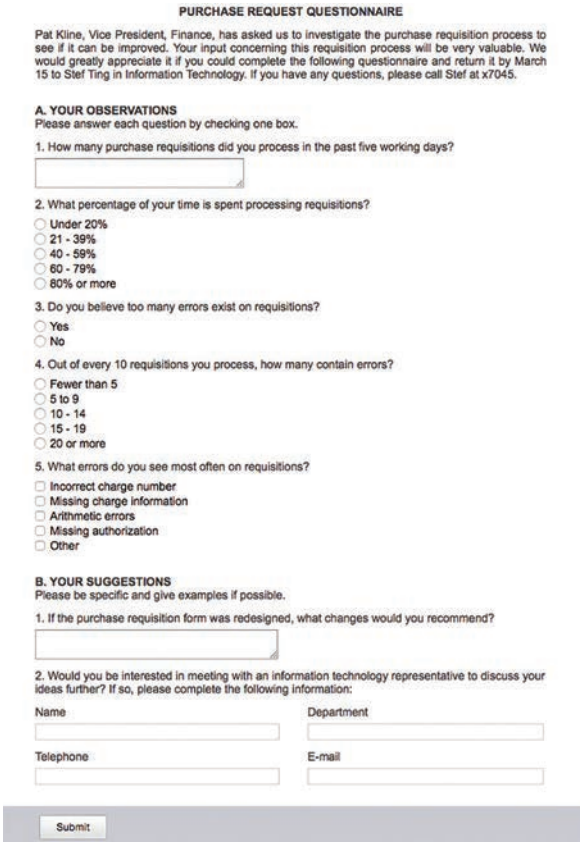
4.5.3 Questionnaires and Surveys

In projects where it is desirable to obtain input from a large number of people, a questionnaire can be a valuable tool. A **questionnaire**, also called a **survey**, is a document containing a number of standard questions that can be sent to many individuals.

Questionnaires can be used to obtain information about a wide range of topics, including workloads, reports received, volumes of transactions handled, job duties, difficulties, and opinions of how the job could be performed better or more efficiently. Figure 4-12 shows a sample questionnaire that includes several different question and response formats.

A typical questionnaire starts with a heading, which includes a title, a brief statement of purpose, the name and telephone number of the contact person, the deadline date for completion, and how and where to return the form. The heading usually is followed by general instructions that provide clear guidance on how

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PURCHASE REQUEST QUESTIONNAIRE

Pat Kline, Vice President, Finance, has asked us to investigate the purchase requisition process to see if it can be improved. Your input concerning this requisition process will be very valuable. We would greatly appreciate it if you could complete the following questionnaire and return it by March 15 to Stef Ting in Information Technology. If you have any questions, please call Stef at x7045.

A. YOUR OBSERVATIONS
Please answer each question by checking one box.

1. How many purchase requisitions did you process in the past five working days?

2. What percentage of your time is spent processing requisitions?
- Under 20%
- 21 - 39%
- 40 - 59%
- 60 - 79%
- 80% or more

3. Do you believe too many errors exist on requisitions?
- Yes
- No

4. Out of every 10 requisitions you process, how many contain errors?
- Fewer than 5
- 5 to 9
- 10 - 14
- 15 - 19
- 20 or more

5. What errors do you see most often on requisitions?
- Incorrect charge number
- Missing charge information
- Arithmetic errors
- Missing authorization
- Other

B. YOUR SUGGESTIONS
Please be specific and give examples if possible.

1. If the purchase requisition form was redesigned, what changes would you recommend?

2. Would you be interested in meeting with an information technology representative to discuss your ideas further? If so, please complete the following information:

Name Department

Telephone E-mail

Submit

FIGURE 4-12 Online version of a sample questionnaire. Does it follow the suggested guidelines?
Source: Created by author using Adobe Online Forms

to answer the questions. Headings also are used to introduce each main section or portion of the survey and include instructions when the type of question or response changes. A long questionnaire might end with a conclusion that thanks the participants and reminds them how to return the form.

What about the issue of anonymity? Should people be asked to sign the questionnaire, or is it better to allow anonymous responses? The answer depends on two questions. First, does an analyst really need to know who the respondents are in order to match or correlate information? For example, it might be important to know what percentage of users need a certain software feature, but specific usernames might not be relevant. Second, does the questionnaire include any sensitive or controversial topics? Many people do not want to be identified when answering a question such as "How well has your supervisor explained the system to you?" In such cases, anonymous responses might provide better information.

When designing a questionnaire, the most important rule of all is to make sure that the questions collect the right data in a form that can be used to further the fact-finding effort. Here are some additional ideas to keep in mind when designing the questionnaire:

- Keep the questionnaire brief and user-friendly.
- Provide clear instructions that will answer all anticipated questions.
- Arrange the questions in a logical order, going from simple to more complex topics.
- Phrase questions to avoid misunderstandings; use simple terms and wording.
- Try not to lead the response or use questions that give clues to expected answers.
- Limit the use of open-ended questions that are difficult to tabulate.
- Limit the use of questions that can raise concerns about job security or other negative issues.
- Include a section at the end of the questionnaire for general comments.
- Test the questionnaire whenever possible on a small test group before finalizing it and distributing to a large group.

A questionnaire can be a traditional paper form, or it can be created in a **fill-in form**, and the data can be collected on the Internet or a company intranet. Before publishing the form, protect it so users can fill it in but cannot change the layout or design. Online survey websites, such as SurveyMonkey and Google Forms, can also be used to create and manage questionnaires.

4.5.4 Interviews Versus Questionnaires

When seeking input from a large group, a questionnaire is a very useful tool. On the other hand, if detailed information is required from only a few people, then each

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person should probably be interviewed individually. Is it better to interview or use a questionnaire? Each situation is different; consider the type of information, time constraints, and expense factors.

The interview is more familiar and personal than a questionnaire. People who are unwilling to put critical or controversial comments in writing might talk more freely in person. Moreover, during a face-to-face interview, the interviewer can react immediately to anything the interviewee says. If surprising or confusing statements are made, the topic can be pursued with additional questions. In addition, during a personal interview, the analyst can watch for clues to help determine if responses are knowledgeable and unbiased. Participation in interviews also can affect user attitudes because people who are asked for their opinions often view the project more favorably.

Interviewing, however, is a costly and time-consuming process. In addition to the meeting itself, both people must prepare, and the interviewer has to do follow-up work. When a number of interviews are planned, the total cost can be quite substantial. The personal interview usually is the most expensive fact-finding technique.

In contrast, a questionnaire gives many people the opportunity to provide input and suggestions. Questionnaire recipients can answer the questions at their convenience and do not have to set aside a block of time for an interview. If the questionnaire allows anonymous responses, people might offer more candid responses than they would in an interview.

Preparing a good questionnaire, however, like a good interview, requires skill and time. If a question is misinterpreted, its meaning cannot be clarified as easily as in a face-to-face interview. Furthermore, unless questionnaires are designed well, recipients might view them as intrusive, time-consuming, and impersonal. The analyst should select the technique that will work best in a particular situation.

4.5.5 Brainstorming

Another popular method of obtaining input is called **brainstorming**, which refers to a small group discussion of a specific problem, opportunity, or issue. This technique encourages new ideas, allows team participation, and enables participants to build on each other's inputs and thoughts. Brainstorming can be structured or unstructured. In **structured brainstorming**, each participant speaks when it is his or her turn or passes. In **unstructured brainstorming**, anyone can speak at any time. At some point, the results are recorded and made part of the fact-finding documentation process.

4.5.6 Sampling

When studying an information system, examples of actual documents should be collected using a process called **sampling**. The samples might include records, reports, operational logs, data entry documents, complaint summaries, work requests, and various types of forms. Sampling techniques include systematic sampling, stratified sampling, and random sampling.

Suppose there is a list of 200 customers who complained about errors in their statements, and a representative sample of 20 customers will be reviewed. A **systematic sample** would select every tenth customer for review. To ensure that the sample is balanced geographically, however, a **stratified sample** could be used to select five customers from each of the four postal codes. Another example of stratified sampling is to select a certain percentage of transactions from each postal code, rather than a fixed number. Finally, a **random sample** selects any 20 customers.

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The main objective of a sample is to ensure that it represents the overall population accurately. If inventory transactions are being analyzed, for example, select a sample of transactions that is typical of actual inventory operations and does not include unusual or unrelated examples. For instance, if a company performs special processing on the last business day of the month, that day is not a good time to sample typical daily operations. To be useful, a sample must be large enough to provide a fair representation of the overall data.

Sampling should also be considered when using interviews or questionnaires. Rather than interviewing everyone or sending a questionnaire to the entire group, a sample of participants can be used. Sound sampling techniques must be used to reflect the overall population and obtain an accurate picture.

4.5.7 Research

Research is another important fact-finding technique. Research can include the Internet, IT magazines, and books to obtain background information, technical material, and news about industry trends and developments. In addition, attending professional meetings, seminars, and discussions with other IT professionals can be very helpful in problem solving.

The Internet is an extremely valuable resource. Using the Internet, the analyst can access information from federal and state governments as well as from publishers, universities, and libraries around the world. Online forums and newsgroups are good resources for exchanging information with other professionals, seeking answers to questions, and monitoring discussions that are of mutual interest.

All major hardware and software vendors maintain websites with information about products and services offered by the company. There are also websites maintained by publishers and independent firms that provide links to hundreds of hardware and software vendors. Examples of popular websites for IT professionals include Ars Technica, CNET, InfoWorld, TechCrunch, and the *Wall Street Journal*'s Technology pages (shown in Figure 4-13).

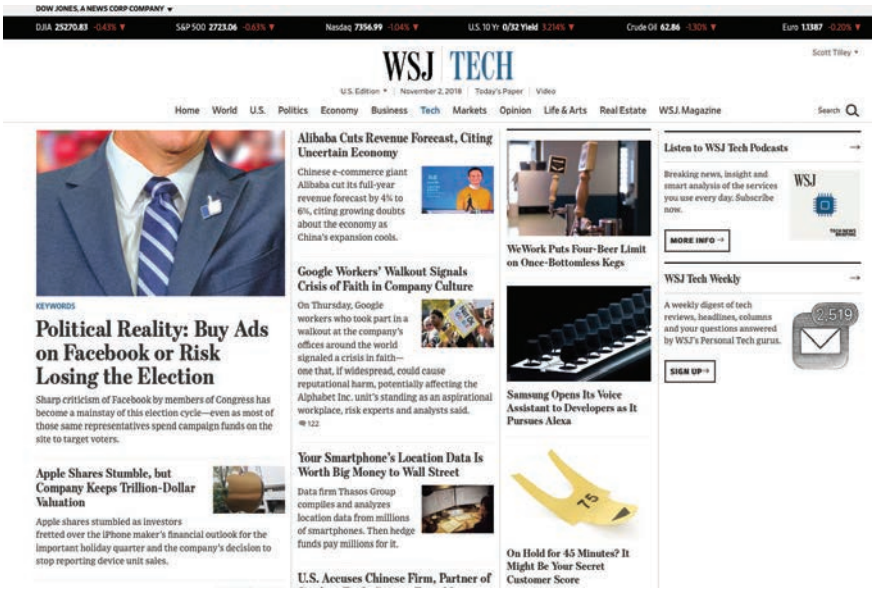


FIGURE 4-13 The *Wall Street Journal's* Technology website contains valuable information for IT professionals.

Source: The Wall Street Journal

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Research also can involve a visit to a physical location, called a **site visit**, where the objective is to observe a system in use at another location. For example, if a firm's human resources information system is the subject of study, it might be beneficial to see how another company's system works. Site visits also are important when considering the purchase of a software package. If the software vendor suggests possible sites to visit, be aware that such sites might constitute a biased sample. A single site visit seldom provides true pictures, so try to visit more than one installation.

Before a site visit, prepare just as for an interview. Contact the appropriate manager and explain the purpose of the visit. Decide what questions will be asked and what processes will be observed. During the visit, observe how the system works and note any problems or limitations. Also learn about the support provided by the vendor, the quality of the system documentation, and so on.

CASE IN POINT 4.2: CyberStuff

CyberStuff is a large company that sells computer hardware and software via telephone and online. CyberStuff processes several thousand transactions per week on a three-shift operation and employs 50 full-time and 125 part-time employees. Lately, the billing department has experienced an increase in the number of customer complaints about incorrect bills. You have been tasked with finding out why this is happening.

During your preliminary investigation, you discovered that some CyberStuff representatives did not follow established order entry procedures. You feel that with more information, you might find a pattern and identify a solution for the problem, but you are not sure how to proceed.

Is a questionnaire the best approach, or would interviews be better? And whether you use interviews, a questionnaire, or both techniques, should you select the participants at random, include an equal number of people from each shift, or use some other approach? How do you proceed?

4.6 Gathering Requirements in Agile Projects

If agile methods are used for requirements gathering, a variation on interviews that focuses on **features**, **user stories**, **scenarios**, and **storyboards** is used. A feature (sometimes called an **epic**) is a simple, high-level statement of a requirement. A feature has a descriptive name, an estimate of its size in terms of derived requirements or user stories, and a priority. Features are typically provided by the stakeholders through initial interviews with the systems analyst.

User stories represent more fine-grained requirements. Taken together, a set of user stories forms a feature. A user story also has a descriptive name, along with a simple sentence of the form "As a [user role], I want [action] so that [goal]." *User roles*, *actions*, and *goals* are terms that represent a category of stakeholder, a particular effect, and an outcome, respectively. User stories also include an optional condition of satisfaction, which can be used as a guide to determine whether or not the requirement was satisfied by the product. A user story is meant to be succinct and is often drawn on a 3″ × 5″ index card (or the software equivalent).

A scenario is a real-world example of how users will interact with the system. A scenario describes a particular set of steps taken or events that will occur while the

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system is used for a specific function. It is used to refine the system requirements to better reflect actual usage of the system.

A storyboard is a simple graphic organizer that helps systems analysts visualize the status of a project. A storyboard can be as rudimentary as a wall with sticky notes. There are also many software tools that enhance storyboards while still maintaining their essential feel.

Because agile methods are iterative in nature, requirements are gathered and successively refined. They begin as features, which are then split into smaller user stories, which in turn are refined into scenarios. Agile methods are particularly well suited to projects where the requirements are expected to change frequently.

4.7 Representing Requirements

Once requirements have been gathered, they must be recorded. Keeping accurate records of interviews, facts, ideas, and observations is essential to successful systems development. As information is gathered, the importance of a single item can be overlooked or complex system details can be forgotten. The ability to manage information is the mark of a successful systems analyst and an important skill for all IT professionals. The basic rule is to write it down. Analysts should document their work according to the following principles:

- Record information as soon as it is obtained.
- Use the simplest recording method possible.
- Record findings in such a way that someone else can understand them.
- Organize documentation so related material is located easily.

There are several techniques used to do this, ranging from an unordered collection of sentences to a structured database of formal models. Whatever representation is chosen, properly managing the requirements over the lifetime of a project is a key to its success.

4.7.1 Natural Language

The vast majority of requirements are represented using unstructured natural language, that is, plain English. Examples of these requirements were shown in Section 4.1.1. This representation is easy to create but is prone to problems such as imprecision and a lack of shared understanding.

Requirements represented as unstructured natural language can be stored in a simple file, in a database that may facilitate searching its contents, or in an Excel spreadsheet. The latter choice is a popular one, because most systems analysts are familiar with the tool, and they are likely to have access to it already.

An improvement upon unstructured natural language is structured natural language. This representation tags part of the requirement, rather like an XML document. This facilitates automated processing of the requirement statements, but it's not very user-friendly.

Requirements represented as structured natural language can be stored on a simple index card. The Volere shell from the Atlantic Systems Guild, shown in Figure 4-14, is a mature method of representing single requirements on a 3″ × 5″ card. There are several tools that mimic these features, providing automation while maintaining the simple representational format.

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There are also formal techniques, based on mathematics, that can be used to represent complex requirements. Languages such as VDM and Z are used for this purpose. They have the advantage of mathematical consistency, but a major disadvantage of this technique is that many systems analysts are unfamiliar with the language's constructs, which can affect the requirements' understandability.

Irrespective of the natural language technique chosen, individual requirements must be collected into a requirements document. This document is the official statement of what is required of the system by the users. The Volere template is a good template for a comprehensive requirements document. It is populated by atomic requirements from the Volere shells.

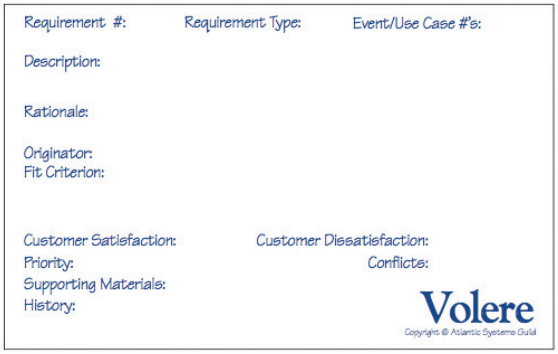


FIGURE 4-14 The Volere shell.
Source: Atlantic Systems Guild

CASE IN POINT 4.3: Digital Pen Transcription

You are the lead systems analyst on a large project. A big part of your responsibilities is to handle the system requirements. Extensive interviews have taken place, and you have written down your notes using a digital pen system. This system recognizes letters and words while you write on paper and stores them in digital format on your computer. In this way, the requirements are written in unstructured natural language but stored digitally, which means they can be searched and processed. Do you think it would be worthwhile to edit the transcription and insert tags to delineate key terms in the requirements, so that a CASE tool could better analyze them? There's a lot of effort required to do the manual tagging, but the rewards could be better requirements. How would you perform the tradeoff analysis?

4.7.2 Diagrams

Many people are more visual than textual. For them, diagrams are an excellent choice to represent system requirements. Diagrams help users, managers, and IT professionals understand the design of a system. Diagramming involves graphical methods and nontechnical language that represent the system at various stages of development. During requirements engineering, the analyst can use various tools to describe business processes, requirements, and user interaction with the system.

Systems analysts use diagramming and fact-finding interactively—first they build fact-finding results into diagrams, then they study the diagrams to determine whether additional fact-finding is needed. To help them understand system requirements, analysts use functional decomposition diagrams, business process diagrams, and data flow diagrams. Any of these diagrams can be created with CASE tools or stand-alone drawing tools if desired.

FUNCTIONAL DECOMPOSITION DIAGRAMS: A **functional decomposition diagram (FDD)** is a top-down representation of a function or process. Using an FDD, an analyst can show business functions and break them down into lower-level functions and processes. Creating an FDD is similar to drawing an organization chart: Start at the top and work downward. Figure 4-15 shows an FDD of a library system drawn with the Visible Analyst CASE tool. FDDs can be used at several stages of

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systems development. During requirements engineering, analysts use FDDs to model business functions and show how they are organized into lower-level processes. These processes translate into program modules during application development.

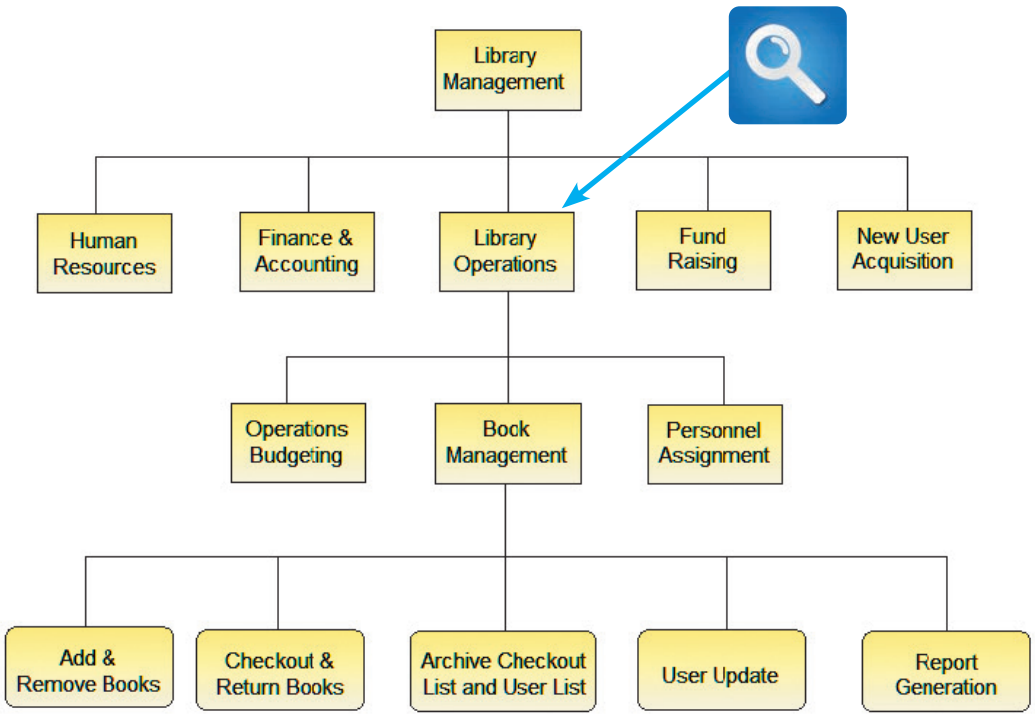


FIGURE 4-15 This Visible Analyst FDD shows a library system with five top-level functions. The Library Operations function includes two additional levels of processes and sub-processes.

Source: Screenshot used with permission from Visible Systems Corporation.

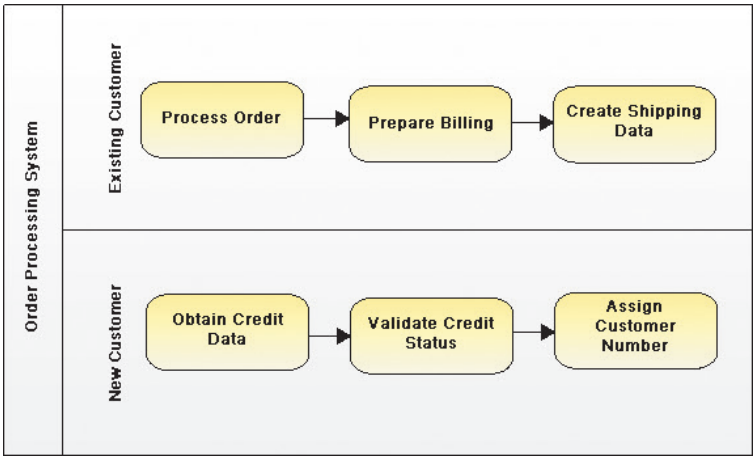


FIGURE 4-16 Using the Visible Analyst CASE tool, an analyst can create a business process diagram. The overall diagram is called a pool, and the two separate customer areas are called swim lanes.

Source: Screenshot used with permission from Visible Systems Corporation.

BUSINESS PROCESS DIAGRAMS: As described in Chapter 1, a **business process model (BPM)** represents one or more business processes, such as handling an airline reservation, filling a product order, or updating a customer account. During requirements engineering, analysts often create diagrams that use a standard syntax called **business process modeling notation (BPMN)**. BPMN includes various shapes and symbols to represent events, processes, and workflows.

When creating a business process diagram using a CASE tool such as Visible Analyst, the diagram automatically becomes part of the overall model. In the example shown in Figure 4-16, using BPMN terminology, the overall diagram is called a **pool** and the designated customer areas are called **swim lanes**. Integrating BPM into the CASE development process leads to faster results, fewer errors, and reduced cost.

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DATA FLOW DIAGRAMS: Working from an FDD, analysts can create **data flow diagrams (DFDs)** to show how the system stores, processes, and transforms data. The DFD in Figure 4-17 describes adding and removing books, which is a function shown in the Library Management diagram in Figure 4-15. Note that the two boxes in the DFD represent processes, each with various inputs and outputs. Additional levels of information and detail are depicted in other, related DFDs. Data and process modeling is described in detail in Chapter 5.

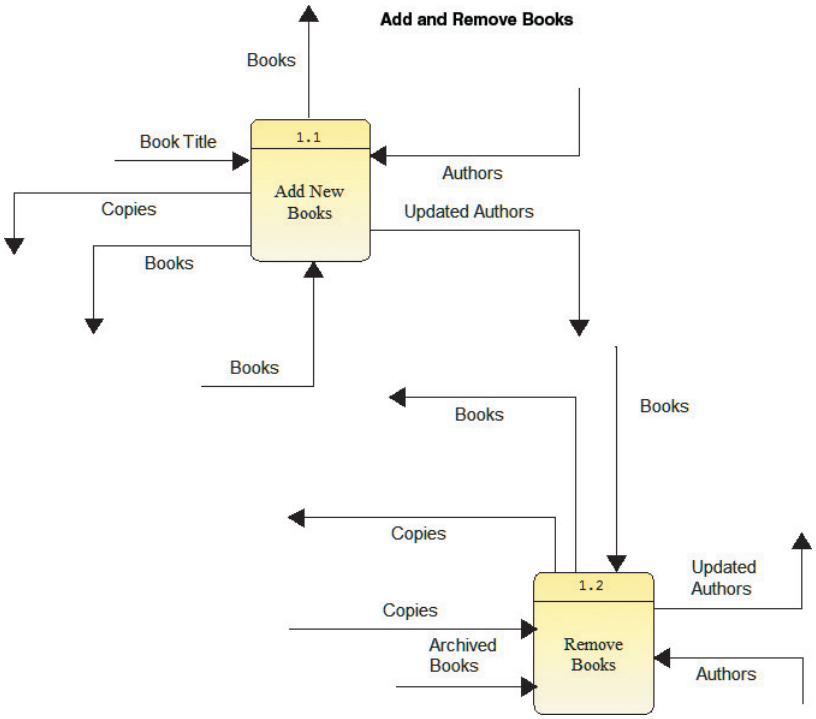


FIGURE 4-17 This Visible Analyst DFD shows how books are added and removed in a library system.
Source: Screenshot used with permission from Visible Systems Corporation

4.7.3 Models

Models provide a more formal representation of system requirements. They are often depicted as graphical in nature, so they share some of the characteristics of the techniques described in Section 4.7.2. But models have an additional feature: The underlying language has semantics, which means the diagram has a significance that can be automatically analyzed by a CASE tool.

The **Unified Modeling Language (UML)** is perhaps the most widely used modeling technique for visualizing and documenting software systems design. UML uses object-oriented design concepts, but it is independent of any specific programming language and can be used to describe business processes and requirements generally. **SysML** is a dialect of UML and has become the standard for Model-Based Systems Engineering (MBSE) applications.

UML provides various graphical tools, such as use case diagrams and sequence diagrams. During requirements engineering, a systems analyst can utilize the UML to represent the information system from a user's viewpoint. Use case diagrams, sequence diagrams, and other UML concepts are discussed in more detail in Chapter 6, along with other object-oriented analysis concepts. A brief description of each technique follows.

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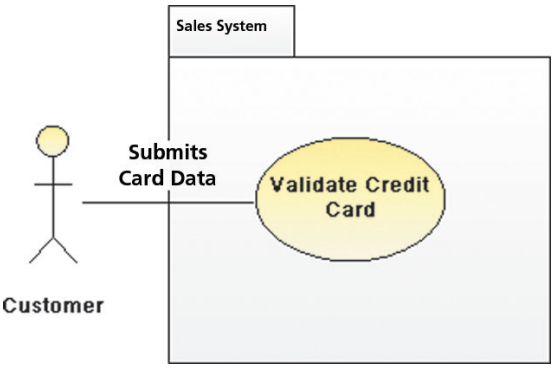


FIGURE 4-18 This Visible Analyst use case diagram shows a sales system, where the actor is a customer and the use case is a credit card validation.
Source: Screenshot used with permission from Visible Systems Corporation.

USE CASE DIAGRAMS: During requirements engineering, systems analysts and users work together to document requirements and model system functions. A **use case diagram** visually represents the interaction between users and the information system. In a use case diagram, the user becomes an **actor**, with a specific role that describes how he or she interacts with the system. Systems analysts can draw use case diagrams freehand or use CASE tools that integrate the use cases into the overall systems design.

Figure 4-18 shows a simple use case diagram for a sales system where the actor is a customer and the use case involves a credit card validation that is performed by the system. Because use cases depict the system through the eyes of a user, common business language can be used to describe the transactions. For example, Figure 4-19 shows a table that documents the credit card validation use case, and Figure 4-20 shows a student records system, with several use cases and actors.

SEQUENCE DIAGRAM: A **sequence diagram** shows the timing of interactions between objects as they occur. A systems analyst might use a sequence diagram to show all possible outcomes or focus on a single scenario. Figure 4-21 shows a simple sequence diagram of a successful credit card validation. The interaction proceeds from top to bottom along a vertical timeline, while the horizontal arrows represent messages from one object to another.

Name of Use Case:	Credit card validation process
Actor:	Customer
Description:	Describes the credit card validation process
Successful Completion:	1. Customer clicks the input selector and enters credit card number and expiration date 2. System verifies card 3. System sends authorization message
Alternative:	1. Customer clicks the input selector and enters credit card number and expiration date 2. System rejects card 3. System sends rejection message
Precondition:	Customer has selected at least one item and has proceeded to checkout area
Postcondition:	Credit card information has been validated Customer can continue with order
Assumptions:	None

FIGURE 4-19 This table documents the credit card validation use case shown in Figure 4-18.

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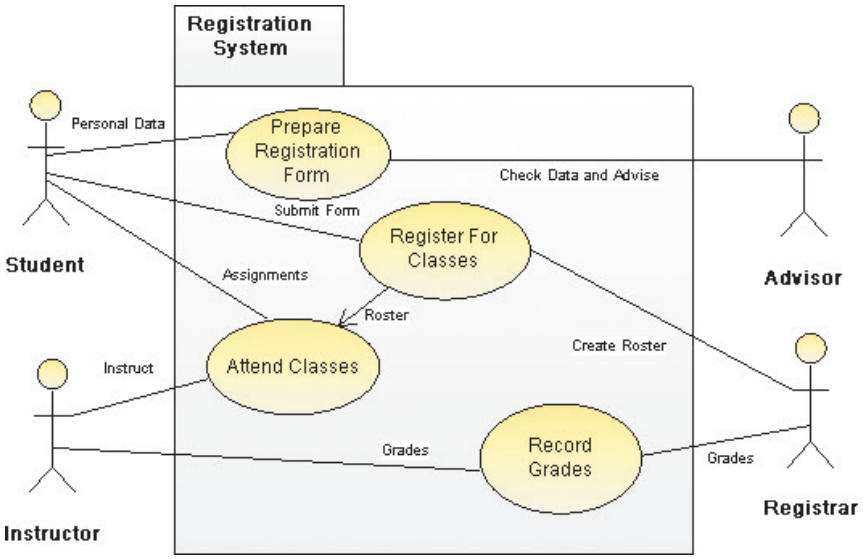


FIGURE 4-20 This Visible Analyst use case diagram shows a student records system.
Source: Screenshot used with permission from Visible Systems Corporation.

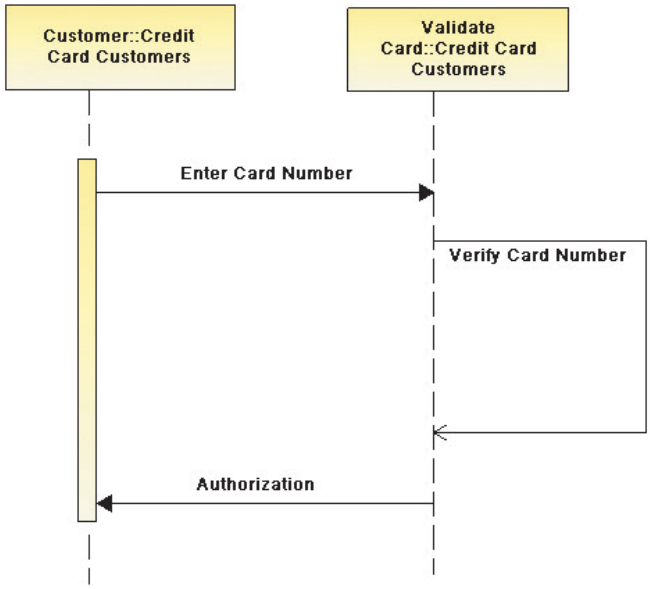


FIGURE 4-21 This Visible Analyst sequence diagram shows a credit card validation process.
Source: Screenshot used with permission from Visible Systems Corporation.

4.8 Validating and Verifying Requirements

Requirements validation and verification (V&V) is concerned with demonstrating that the requirements define the system that the customer really wants. Since requirements error costs are high, V&V is very important; it is many times more expensive to fix a system later in the SDLC than it is to fix it during requirements engineering.

Requirements V&V focuses on answering two important questions:

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- Validation: Are the correct requirements stated?
- Verification: Are the requirements stated correctly?

To answer these questions, the following requirements attributes should be checked:

- Validity: Does the system provide the functions that best support the customer's needs?
- Consistency: Are there conflicting requirements?
- Completeness: Are all functions required by the customer included?
- Realism: Can the requirements be implemented given available budget and technology?
- Verifiability: Can the requirements be checked?
- Comprehensibility: Is the requirement properly understood?
- Traceability: Is the origin of the requirement clearly stated?
- Adaptability: Can the requirement be changed without a large impact on other requirements?

To check these, the following techniques can be used:

- Requirements reviews: Systematic manual analysis of the requirements.
- Prototyping: Using an executable model of the system to check the requirements.
- Test-case generation: Developing tests for requirements to check testability.
- Automated consistency analysis: Checking the consistency of a structured or formal requirements descriptions.

Consider requirements reviews. Regular reviews can be held while the requirements are initially being formulated. Ideally, the systems analyst and the customer (and perhaps other key stakeholders) should be involved in the reviews. The reviews can be formal (with complete documentation) or informal. The key is that good communications between analysts, customers, and others can resolve problems at an early stage, which is better for everyone.

4.9 Tools

All requirements engineering activities can be helped through the judicious use of tools. For example, many software programs are available to help record and document information elicited during the requirements gathering process. This type of **productivity software** includes automation, word processing, spreadsheet, database management, presentation graphics, and collaboration software programs. Although Microsoft Office is the best-known set of productivity software programs, other vendors offer products in each of these categories.

A **personal information manager (PIM)**, such as Microsoft Outlook, includes a personal calendar, a to-do list with priorities and the capability to check off completed items, and powerful contact management features. Outlook can manage email and appointments and supports collaboration and team projects.

Although a PIM such as Microsoft Outlook can handle day-to-day activities, tasks, and schedules, it is not the best way to capture and organize large amounts of

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information. Instead, analysts use information management software such as Microsoft OneNote, which is a powerful, flexible tool that can handle many different types of input, including text, handwritten notes, images, audio and video recording, web links, and much more. OneNote is included in several versions of the Office suite.

Figure 4-22 shows another popular PIM called Evernote. It is available for free on most computing platforms, including smartphones and on the web. There are also premium versions available on a monthly subscription model. Evernote does a great job of handling all sorts of multimedia content, adding free-form notes, and providing templates for organizing projects. It also syncs files across all devices.

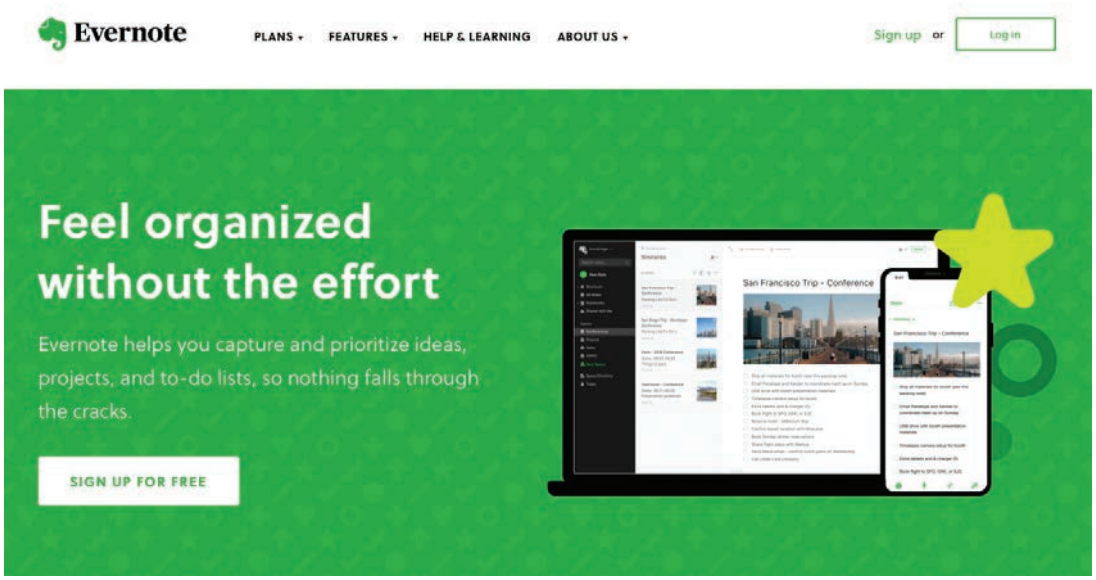


FIGURE 4-22 Evernote offers a free version of its popular information management software for most computing platforms, including smartphones and on the web.
Source: Evernote

Using word processing software such as Microsoft Word, the analyst can create reports, summaries, tables, and forms. In addition to standard document preparation, the program can help organize a presentation with templates, bookmarks, annotations, revision control, and an index. Fill-in forms can also be created to conduct surveys and questionnaires, as described earlier in this chapter.

Spreadsheet software, such as Microsoft Excel, can help track and manage numeric data or financial information. In fact, Excel is one of the most popular ways of representing requirements in an informal manner. Graphs and charts can also be generated that display the data and show possible patterns. The statistical functions in a spreadsheet can be used to tabulate and analyze questionnaire data. A graphical format often is used in quality control analysis because it highlights problems and their possible causes, and it is effective when presenting results to management. A common tool for showing the distribution of questionnaire or sampling results is a vertical bar chart called a **histogram**. Most spreadsheet programs can create histograms and other charts that can display the data collected. Figure 4-23 displays a typical histogram that might have resulted from the questionnaire shown in Figure 4-12.

Database management software allows the analyst to document and organize fact-finding results such as events, observations, and data samples. A database program such as Microsoft Access can be used to manage the details of a complex project, create queries to retrieve specific information, and generate custom reports.

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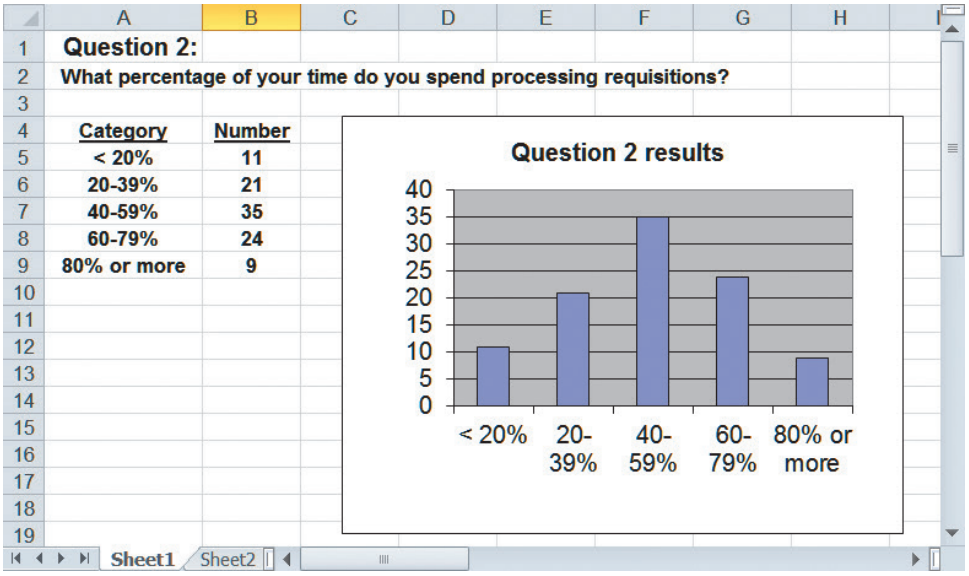


FIGURE 4-23 This histogram displays the results from Question 2 in the questionnaire shown in Figure 4-12.

Presentation graphics software, such as Microsoft PowerPoint, is a powerful tool for organizing and developing formal presentations. Presentation graphics programs enable the creation of organization charts that can be used in a preliminary investigation and later during requirements engineering. These high-quality charts also can be included in written reports and management presentations.

Collaboration software is the latest weapon in the struggle to boost productivity. People work in teams and use web-based software such as Google Docs and Microsoft Office 365 to access data and share files. Google and others are betting that cloud computing will create a virtual workplace, where people will be able to interact in real time, with all the benefits of a traditional face-to-face workplace but none of the limitations.

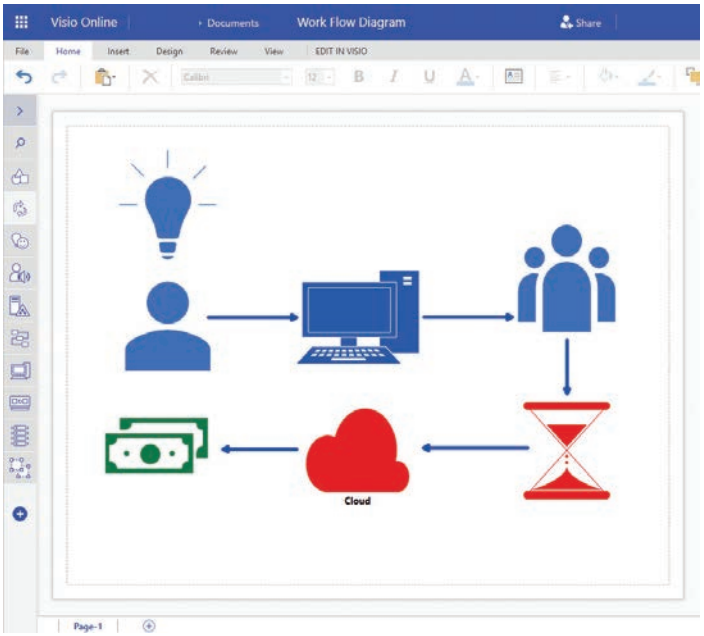


FIGURE 4-24 This Visio drawing uses drag-and-drop shapes to represent a business process.

When it comes to creating diagrams that represent requirements, Microsoft Visio is a popular graphic modeling tool that can produce a wide range of charts and diagrams. Visio includes a library of templates, stencils, and shapes. An analyst can use Visio to create many types of visual models, including business processes, flowcharts, network diagrams, organization charts, and many more. For example, in Figure 4-24, the analyst used drag-and-drop shapes to represent a business process.

For more formal models of requirements, special-purpose tools such as IBM Rational DOORS are used. These tools facilitate the use of UML (and SysML) to model system requirements in a way that enables desirable characteristics, such as **traceability**, where the origin of a requirement is connected back to the requirement itself, which in turn is linked forward to design artifacts, code fragments, and even test cases in the SDLC. Figure 4-25 illustrates some of the capabilities of DOORS Next Generation.

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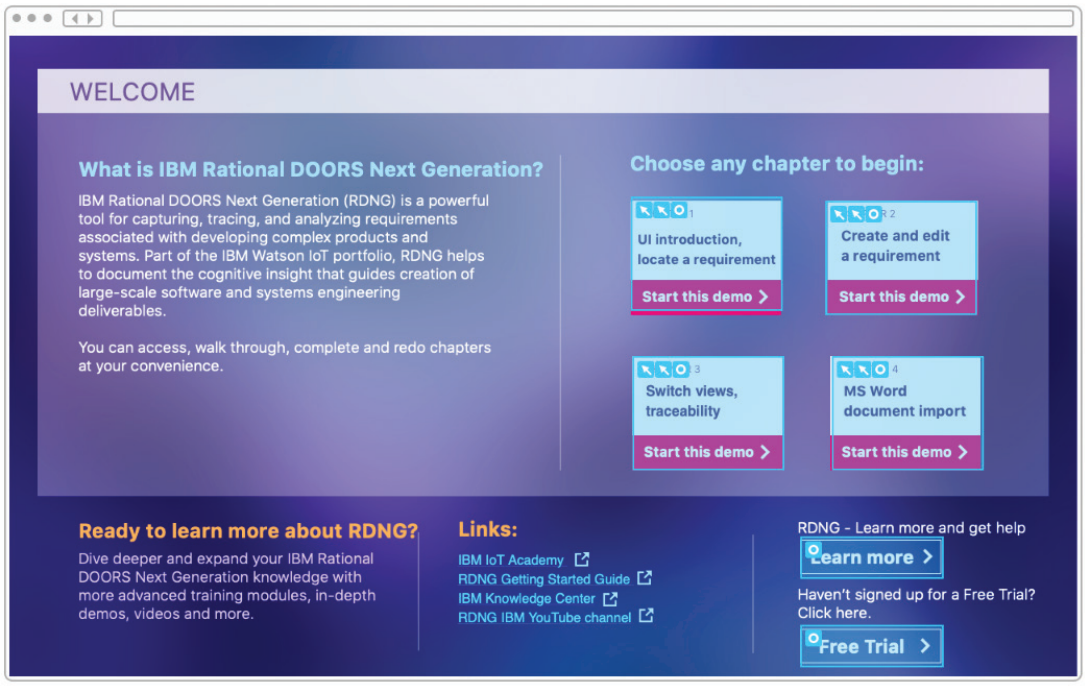


FIGURE 4-25 IBM DOORS is a tool for capturing, analyzing, and tracing system requirements.
IBM Corporation

A QUESTION OF ETHICS



iStock.com/faberfoto_it

Your supervisor manages the corporate office where you work as a systems analyst. Several weeks ago, after hearing rumors of employee dissatisfaction, he asked you to create a survey for all IT employees. After the responses were returned and tabulated, he was disappointed to learn that many employees assigned low ratings to morale and management policies.

This morning he called you into his office and asked whether you could identify the departments that submitted the lowest ratings. No names were used on the individual survey forms. However, with a little analysis, you probably could identify the departments because several questions were department related.

Now you are not sure how to respond. The expectation was that the survey would be anonymous. Even though no individuals would be identified, would it be ethical to reveal which departments sent in the low ratings? Would your supervisor's motives for wanting this information matter?

4.10 Summary

The systems analysis phase includes three activities: requirements engineering, data and process modeling, and consideration of development strategies. The main objective is to understand the proposed project, ensure that it will support business requirements, and build a solid foundation for the systems design phase. Requirements

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engineering itself is composed of three main parts: (1) gathering requirements, (2) representing requirements, and (3) validating and verifying requirements.

During requirements engineering, the business-related requirements for the new information system are identified. Scalability is considered to ensure that the system can support future growth and expansion. Security is an essential requirement of all modern connected systems. The TCO is also estimated to identify all costs, including indirect costs.

Popular team-based approaches include JAD, RAD, and agile methods. JAD is a popular, team-based approach to fact-finding and requirements engineering. JAD involves an interactive group of users, managers, and IT professionals who participate in requirements engineering and develop a greater commitment to the project and to their common goals.

RAD is a team-based technique that speeds up information systems development and produces a functioning information system. RAD is a complete methodology, with a four-phase life cycle that parallels the traditional SDLC phases.

Agile methods attempt to develop a system incrementally by building a series of prototypes and constantly adjusting them to user requirements. Tools are often avoided and replaced with simpler aids, such as whiteboards and sticky notes to facilitate communication.

The requirements gathering process includes interviewing, document review, observation, questionnaires, sampling, and research. Successful interviewing requires good planning and strong interpersonal and communication skills. The systems analyst must decide on the people to interview; set interview objectives; and prepare for, conduct, and analyze interviews. The analyst also might find it helpful to use one or more software tools during fact-finding.

Systems analysts use various tools and techniques to represent system requirements. Natural language, structured or unstructured, is still the default. Requirements can be stored as simple text in a plain file or in an Excel spreadsheet. They can also be stored online for automated search and analysis.

Diagrams are another way of representing requirements. They are suitable for analysts who are more visually oriented. They can also capture complementary aspects of the system requirements. Sample diagram types include FDDs, business process diagrams, and DFDs.

Models provide a more formal representation of system requirements. The UML is a widely used method of visualizing and documenting software design through the eyes of the business user. UML tools include use case diagrams and sequence diagrams to represent actors, their roles, and the sequence of transactions that occurs.

Systems analysts should carefully record and document factual information as it is collected, and various software tools can help an analyst visualize and describe an information system.

Requirements V&V is concerned with demonstrating that the requirements define the system that the customer really wants. Validation asks if the correct requirements are stated, while verification asks if the requirements are stated correctly.

All requirements engineering activities can be helped through the judicious use of tools. They provide automated support for requirements attributes such as traceability. For very large systems with thousands of requirements to manage, CASE tool assistance is necessary.

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Key Terms

actor An external entity with a specific role. In a use case model, actors are used to model interaction with the system.

agile methods Systems development methods that attempt to develop a system incrementally by building a series of prototypes and constantly adjusting them to user requirements. Also called adaptive methods.

brainstorming A fact-finding technique for gaining information through the use of a small group discussion of a specific problem, opportunity, or issue.

business process model (BPM) A graphical representation of one or more business processes.

business process modeling notation (BPMN) A standard set of shapes and symbols used to represent events, processes, and workflows in computer-based modeling tools.

closed-ended questions Queries that limit or restrict the range of responses. Used in the interview process when specific information or fact verification is desired.

construction phase A phase that focuses on program and application development tasks similar to the SDLC.

cutover phase A phase that resembles the final tasks in the SDLC implementation phase, including data conversion, testing, changeover to the new system, and user training.

data flow diagram (DFD) Diagram that shows how the system stores, processes, and transforms data into useful information.

document review A review of baseline documentation. A useful fact-finding technique that helps an analyst understand how the current system is supposed to work.

engaged listening The ability to really concentrate on what someone is saying and avoid the temptation to hear what is expected. Also includes noticing nonverbal communication.

epic In an agile project, a simple, high-level statement of a requirement. *See* **feature**.

fact-finding The process of gathering requirements. *See* **requirements elicitation**.

feature In an agile project, a simple, high-level statement of a requirement. *See* **epic**.

fill-in form A template used to collect data on the Internet or a company intranet

functional decomposition diagram (FDD) A top-down representation of business functions and processes. Also called a structure chart.

functional requirement A statement of the services a system provides.

Hawthorne Effect A phenomenon where employees who know they are being observed are more productive.

histogram A common tool for showing the distribution of questionnaire or sampling results. It takes the form of a vertical bar chart.

informal structure An organization based on interpersonal relationships, which can develop from previous work assignments, physical proximity, unofficial procedures, or personal relationships.

interview A planned meeting during which information is obtained from another person.

joint application development (JAD) A systems development technique that uses a task force of users, managers, and IT professionals who work together to gather information, discuss business needs, and define the new system requirements.

leading questions Queries that suggest or favor a particular reply.

non-functional requirements A statement of operational system constraints.

observation A fact-finding technique where an analyst sees a system in action. Observation allows the verification of statements made in interviews.

open-ended questions Queries that allow for a range of answers. They encourage spontaneous and unstructured responses and are useful in understanding a larger process.

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personal information manager (PIM) A tool that helps manage tasks and schedules. Many handheld devices also include this function.

pool The overall diagram in BPMN.

productivity software Applications such as word processing, spreadsheet, database management, and presentation graphics programs.

quality attributes *See* **non-functional requirements**.

questionnaire A document containing a number of standard questions that can be sent to many individuals. Also called a survey.

random sample A selection taken in a random, unplanned manner. For example, a random sample might be a sample that selects any 20 customers.

range-of-response questions Closed-ended questions that ask the person to evaluate something by providing limited answers to specific responses or on a numeric scale.

rapid application development (RAD) A team-based technique that speeds up information systems development and produces a functioning information system. RAD is similar in concept to JAD but goes further by including all phases of the SDLC.

requirements definitions A description of the system requirements from the user's point of view.

requirements elicitation The process of gathering requirements. *See* **fact-finding**.

requirements engineering Used in the systems planning phase of the SDLC. It involves fact-finding to describe the current system and identify the requirements for the new system.

requirements planning phase A phase that combines elements of the systems planning and systems analysis phases of the SDLC.

requirements specifications A description of the system requirements from the analyst or engineering team's point of view.

research An important fact-finding technique that includes the review of journals, periodicals, and books to obtain background information, technical material, and news about industry trends and developments.

sampling A process where an analyst collects examples of actual documents, which could include records, reports, or various forms.

scalability A characteristic of a system, implying that the system can be expanded, modified, or downsized easily to meet the rapidly changing needs of a business enterprise.

scenarios In an agile project, a real-world example of how users will interact with the system.

Scrum A popular technique for agile project management. Derived from a rugby term. In Scrum, team members play specific roles and interact in intense sessions.

sequence diagram A UML diagram that shows the timing of transactions between objects as they occur during system execution.

site visit A trip to a physical location to observe a system in use at another location.

stratified sample A set metric is collected across functional areas. For example, a certain percentage of transactions from every work shift, or five customers from each of four zip codes, could be a stratified sample.

storyboard In an agile project, a simple graphic organizer that helps systems analysts visualize the status of a project.

structured brainstorming A group discussion where each participant speaks when it is his or her turn or passes.

survey A document containing a number of standard questions that can be sent to many individuals. Also called a questionnaire.

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swim lanes In a business process diagram, the overall diagram is called a pool and the designated customer areas are called swim lanes.

SysML A dialect of UML 2, used for representing requirements (and other things), primarily in MBSE applications.

system requirement A characteristic or feature that must be included in an information system to satisfy business requirements and be acceptable to users.

systematic sample A sample that occurs at a predetermined periodicity. For example, every tenth customer record might be selected as a systematic sample for review.

total cost of ownership (TCO) A number used in assessing costs, which includes ongoing support and maintenance costs as well as acquisition costs.

traceability The ability to follow a requirement backward to its origins and forward through the SDLC to link design documents, code fragments, and test artifacts.

Unified Modeling Language (UML) A widely used method of visualizing and documenting software systems design. UML uses object-oriented design concepts, but it is independent of any specific programming language and can be used to describe business processes and requirements generally.

unstructured brainstorming A group discussion where any participant can speak at any time.

use case diagram A visual representation that represents the interaction between users and the information system in UML.

user design phase In this phase, users interact with systems analysts and develop models and prototypes that represent all system processes, outputs, and inputs.

user stories In an agile project, a set of more refined requirements derived from **features**.

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Exercises

Questions

1. What is a system requirement and what are the three challenges it presents to the systems analyst?
2. Is the requirement "The system shall respond within 2 seconds" a functional or non-functional requirement?
3. What is scrum?
4. What five questions typically are used in fact-finding?
5. Provide three examples each of closed-ended, open-ended, and range-of-response questions.
6. Explain how the observation fact-finding technique works, including the Hawthorne Effect.
7. What is the relationship between user stories and features in agile projects?
8. What is an FDD and why would you use one?
9. What is the difference between validation and verification of system requirements?
10. Why is traceability important in tool support for requirements engineering?

Discussion Topics

1. JAD requires strong interpersonal and communication skills on the part of the systems analyst. Are those skills different from the ones that an analyst needs when conducting one-to-one interviews? Explain your answer.
2. Agile methods use rapid development cycles to iteratively produce running versions of the system. How would these shorter cycles affect the ability of the analyst to manage system requirements?
3. A group meeting sometimes is suggested as a useful compromise between interviews and questionnaires. In a group meeting, a systems analyst meets with a number of users at one time. Discuss the advantages and disadvantages of group meetings.
4. Research the Internet, magazines, or textbooks to find examples of visual aids, including a bar chart, pie chart, line chart, table, diagram, and bulleted list. How effective was each example? Find at least one example that you could improve. Explain your choice.
5. Traceability is an important requirements attribute. It's one of the things that should be checked when performing V&V of the system requirements. Describe how you would manually check traceability for an existing system and list a few features of a CASE tool that you think would help you with the task.

Projects

1. Use the requirements gathering techniques of document review, observation, brainstorming, sampling, and research to capture the requirements of a typical elevator control system. Use natural language and the UML to represent the situation where people on different floors push the "Up" button at the same time.
2. Prepare a presentation summarizing JAD and RAD. Explain how they differ from traditional fact-finding methods. What are the main advantages of team-based methods?

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3. Design a questionnaire to learn what students think of the registration process at your school. Apply the guidelines you learned in this chapter.
4. Create an FDD similar to the one in Figure 4-15 but showing your school instead of the library example.
5. A desirable characteristic of a requirement is that it be both consistent and complete. Examine several requirements engineering CASE tools and document how (if at all) they support automated consistency analysis for validating and verifying requirements.

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CHAPTER 5 Data and Process Modeling

Chapter 5 is the second of four chapters in the systems analysis phase of the SDLC. This chapter discusses data and process modeling techniques that analysts use to show how the system transforms data into useful information. Data and process modeling involves three main items: data flow diagrams, a data dictionary, and process descriptions. The deliverable, or end product, of data and process modeling is a logical model that will support business operations and meet user needs.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" raises the issue of how to respond to subtle but insistent requests by an IT manager in a systems analyst's new organization for proprietary information related to the business processes used by the analyst's previous employer, which is a competitor of the analyst's current company.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Describe the relationship between logical and physical models
2. Explain data flow diagrams
3. Draw the four basic data flow diagram symbols
4. Explain the six guidelines used when drawing data flow diagrams
5. Draw context diagrams
6. Draw diagram 0 data flow diagrams
7. Draw lower-level data flow diagrams
8. Explain how to level and balance data flow diagrams
9. Create a data dictionary
10. Apply process description tools in modular design

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5.1 Logical Versus Physical Models
5.2 Data Flow Diagrams
5.3 Data Flow Diagram Symbols
5.4 Drawing Data Flow Diagrams
5.5 Drawing a Context Diagram
5.6 Drawing a Diagram 0 DFD
5.7 Drawing Lower-Level DFDs
Case in Point 5.1: Big Ten University
5.8 Data Dictionary
5.9 Process Description Tools in Modular Design
Case in Point 5.2: Rock Solid Outfitters (Part 1)
Case in Point 5.3: Rock Solid Outfitters (Part 2)
A Question of Ethics
5.10 Summary
Key Terms
Exercises

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5.1 Logical Versus Physical Models

During the requirements engineering process described in Chapter 4, fact-finding techniques were used to investigate the current system and identify user requirements. Chapters 5 and 6 explain how that information is used to develop a logical model of the proposed system and document the system requirements. A **logical model** shows *what* the system must do, regardless of how it will be implemented physically. Later, in the systems design phase, a **physical model** is built that describes *how* the system will be constructed.

While structured analysis tools are used to develop a logical model for a new information system, such tools also can be used to develop physical models of an information system. A physical model shows how the system's requirements are implemented. During the systems design phase, a physical model of the new information system is created that follows from the logical model and involves operational tasks and techniques.

To understand the relationship between logical and physical models, think back to the beginning of the systems analysis phase. To understand how the current tasks were carried out in the existing system, the physical operations of the existing system were studied before the logical model. Many systems analysts create a physical model of the current system and then develop a logical model of the current system before tackling a logical model of the new system. Performing that extra step allows them to understand the current system better.

Many analysts follow a **four-model approach**, which means that they develop a physical model of the current system, a logical model of the current system, a logical model of the new system, and a physical model of the new system. The major benefit of the four-model approach is that it provides a clear picture of current system functions before any modifications or improvements are made. That is important because mistakes made early in systems development will affect later SDLC phases and can result in unhappy users and additional costs. Taking additional steps to avoid these potentially costly mistakes can prove to be well worth the effort. Another advantage is that the requirements of a new information system often are quite similar to those of the current information system, especially where the proposal is based on new computer technology rather than a large number of new requirements. Adapting the current system logical model to the new system logical model in these cases is a straightforward process.

The only disadvantage of the four-model approach is the added time and cost needed to develop a logical and physical model of the current system. Most projects have very tight schedules that might not allow time to create the current system models. Additionally, users and managers want to see progress on the new system—they are much less concerned about documenting the current system. The systems analyst must stress the importance of careful documentation and resist the pressure to hurry the development process at the risk of creating serious problems later.

5.2 Data Flow Diagrams

Systems analysts use many graphical techniques to describe an information system. One popular method is to draw a set of data flow diagrams. A **data flow diagram (DFD)** uses various symbols to show how the system transforms input data into useful information. Other graphical tools include object models, which are explained in

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Chapter 6 (Object Modeling), and entity-relationship diagrams, which are described in Chapter 9 (Data Design).

During the systems analysis phase of the SDLC, the systems analyst creates a visual model of the information system using a set of DFDs. In his seminal book *The Visual Display of Quantitative Information*, author and renowned academic Edward Tufte provides guidance on creating effective diagrams to concisely convey complex information. A DFD is an example of this type of visual explanation of system behavior.

A DFD shows how data moves through an information system but does not show program logic or processing steps. A set of DFDs provides a logical model that shows *what* the system does, not *how* it does it. That distinction is important because focusing on implementation issues at this point would restrict the search for the most effective system design.

5.3 Data Flow Diagram Symbols

DFDs use four basic symbols that represent processes, data flows, data stores, and entities. Several different versions of DFD symbols exist, but they all serve the same purpose. DFD examples in this text use the **Gane and Sarson** symbol set. Another popular symbol set is the **Yourdon** symbol set. Figure 5-1 shows examples of both versions. In this text, symbols are referenced using all capital letters for the symbol name.

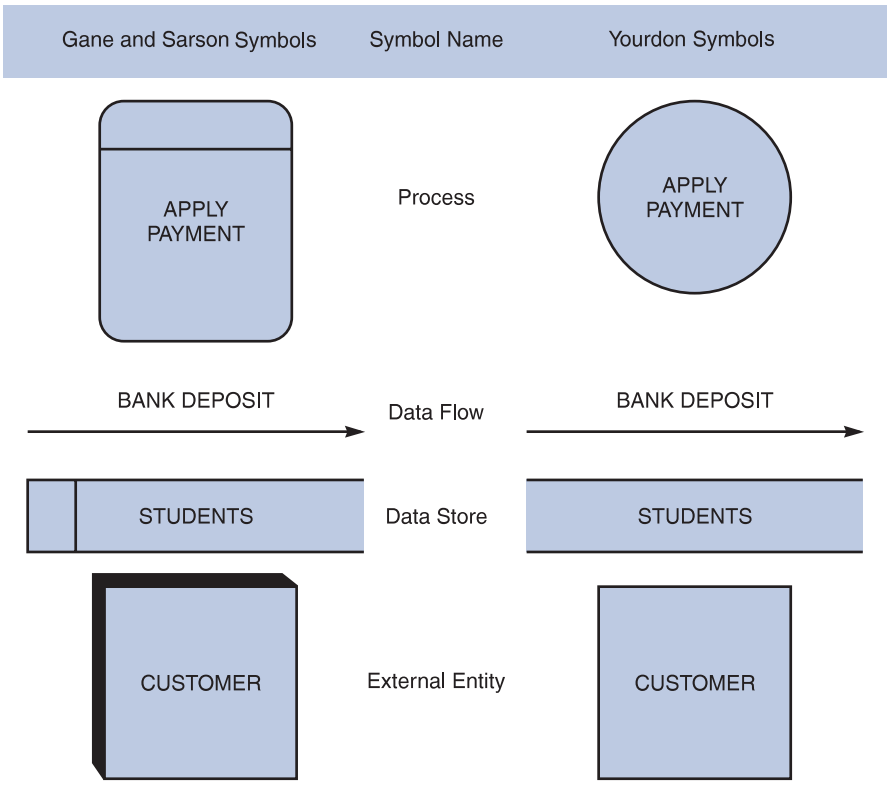


FIGURE 5-1 Data flow diagram symbols, symbol names, and examples of the Gane and Sarson and Yourdon symbol sets.

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5.3.1 Process Symbols

A **process** receives input data and produces output that has a different content, form, or both. For instance, the process for calculating pay uses two inputs (pay rate and hours worked) to produce one output (total pay). Processes can be very simple or quite complex. In a typical company, processes might include calculating sales trends, filing online insurance claims, ordering inventory from a supplier's system, or verifying email addresses for web customers. Processes contain the **business logic**, also called **business rules**, that transforms the data and produces the required results.

The symbol for a process is a rectangle with rounded corners. The name of the process appears inside the rectangle. The process name identifies a specific function and consists of a verb (and an adjective, if necessary) followed by a singular noun. Examples of process names are APPLY RENT PAYMENT, CALCULATE COMMISSION, ASSIGN FINAL GRADE, VERIFY ORDER, and FILL ORDER.

Processing details are not shown in a DFD. For example, there might be a process named DEPOSIT PAYMENT. The process symbol does not reveal the business logic for the DEPOSIT PAYMENT process. To document the logic, a process description is created, which is explained later in this chapter.

In DFDs, a process symbol can be referred to as a **black box**, because the inputs, outputs, and general functions of the process are known, but the underlying details and logic of the process are hidden. By showing processes as black boxes, an analyst can create DFDs that show how the system functions but avoid unnecessary detail and clutter. When the analyst wishes to show additional levels of detail, he or she can zoom in on a process symbol and create a more in-depth DFD that shows the process's internal workings—which might reveal even more processes, data flows, and data stores. In this manner, the information system can be modeled as a series of increasingly detailed pictures.

The network router shown in Figure 5-2 is an example of a black box. An observer can see cables that carry data into and out of the router, but the router's internal operations are not revealed—only the results are apparent.

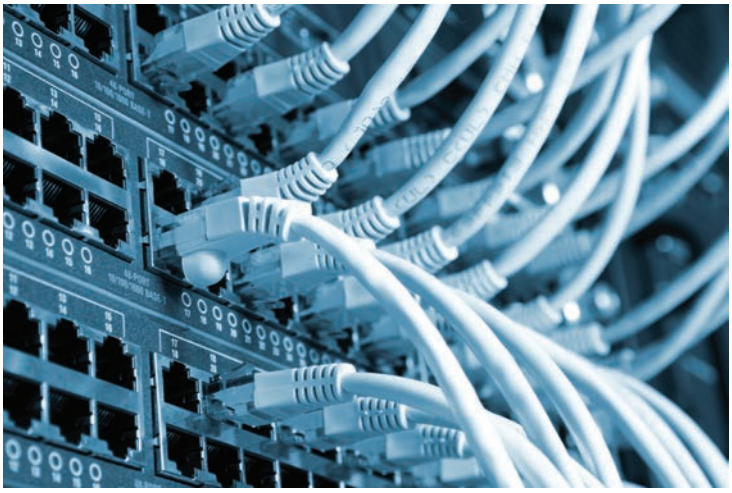


FIGURE 5-2 A router acts like a *black box* for network data. Cables carry data in and out, but internal operations are hidden inside the case.
macka/Shutterstock.com

5.3.2 Data Flow Symbols

A **data flow** is a path for data to move from one part of the information system to another. A data flow in a DFD represents one or more data items. For example, a data

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flow could consist of a single data item (such as a student ID number), or it could include a set of data (such as a class roster with student ID numbers, names, and registration dates for a specific class). Although the DFD does not show the detailed contents of a data flow, that information is included in the data dictionary, which is described later in this chapter.

The symbol for a data flow is a line with a single or double arrowhead. The data flow name appears above, below, or alongside the line. A data flow name consists of a singular noun and an adjective, if needed. Examples of data flow names are DEPOSIT, INVOICE PAYMENT, STUDENT GRADE, ORDER, and COMMISSION. Exceptions to the singular name rule are data flow names, such as GRADING PARAMETERS, where a singular name could mislead the analyst into thinking a single parameter or single item of data exists.

Figure 5-3 shows correct examples of data flow and process symbol connections. Because a process changes the data's content or form, at least one data flow must enter and one data flow must exit each process symbol, as they do in the CREATE INVOICE process. A process symbol can have more than one outgoing data flow, as shown in the GRADE STUDENT WORK process, or more than one incoming data flow, as shown in the CALCULATE GROSS PAY process. A process also can connect to any other symbol, including another process symbol, as shown by the connection between VERIFY ORDER and ASSEMBLE ORDER in Figure 5-3. A data flow, therefore, *must* have a process symbol on at least one end.

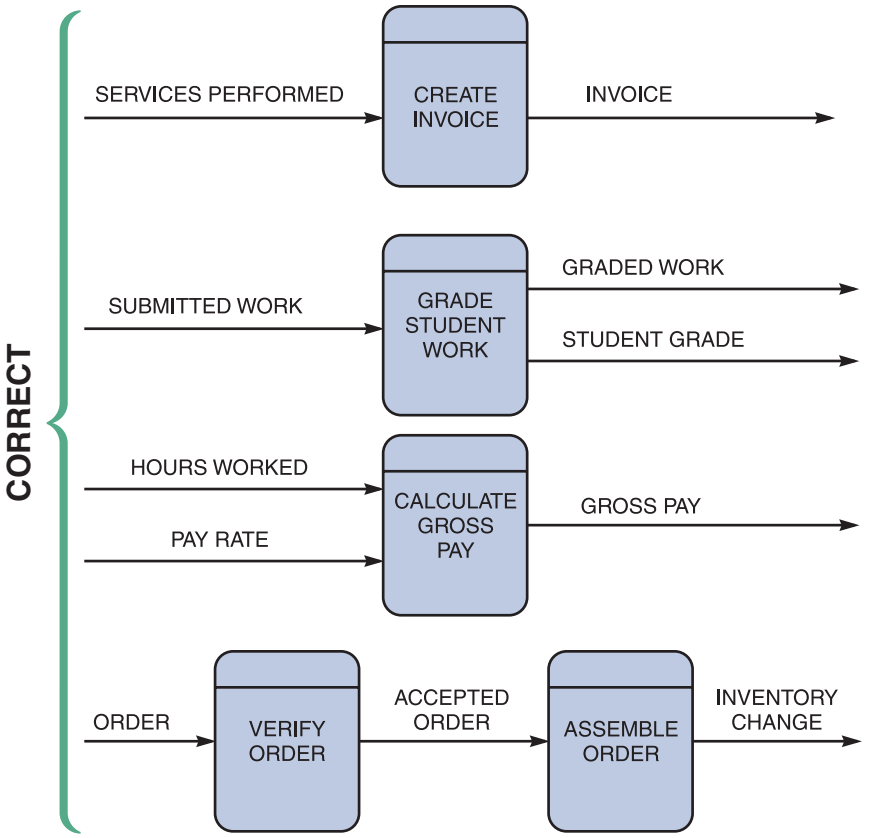


FIGURE 5-3 Examples of correct combinations of data flow and process symbols.

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Figure 5-4 shows three data flow and process combinations that must be avoided:

- **Spontaneous generation**. The APPLY INSURANCE PREMIUM process, for instance, produces output but has no input data flow. Because it has no input, the process is called a spontaneous generation process.
- **Black hole**. CALCULATE GROSS PAY is called a black hole process, which is a process that has input but produces no output.
- **Gray hole**. A gray hole is a process that has at least one input and one output, but the input obviously is insufficient to generate the output shown. For example, a date of birth input is not sufficient to produce a final grade output in the CALCULATE GRADE process.

Spontaneous generation, black holes, and gray holes are impossible logically in a DFD because a process must act on input, shown by an incoming data flow, and produce output, represented by an outgoing data flow.

5.3.3 Data Store Symbols

A **data store** is used in a DFD to represent data that the system stores because one or more processes need to use the data at a later time. For instance, instructors need to store student scores on tests and assignments during the semester, so they can assign final grades at the end of the term. Similarly, a company stores employee salary and deduction data during the year in order to print W-2 forms with total earnings and deductions at the end of the year. A DFD does not show the detailed contents of a data store—the specific structure and data elements are defined in the data dictionary, which is discussed later in this chapter.

The physical characteristics of a data store are unimportant because the logical model is the only concern at this point. Also, the length of time that the data is stored is unimportant—it can be a matter of seconds while a transaction is processed or a period of months while data is accumulated for year-end processing. What is important is that a process needs access to the data at some later time.

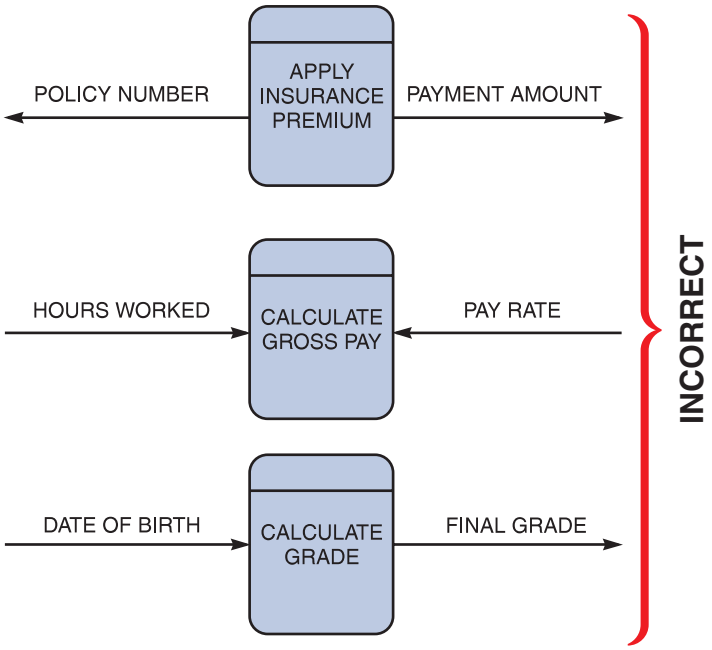


FIGURE 5-4 Examples of incorrect combinations of data flow and process symbols. APPLY INSURANCE PREMIUM has no input and is called a spontaneous generation process. CALCULATE GROSS PAY has no outputs and is called a black hole process. CALCULATE GRADE has an input that is obviously unable to produce the output. This process is called a gray hole.

In a DFD, the Gane and Sarson symbol for a data store is a flat rectangle that is open on the right side and closed on the left side. The name of the data store appears between the lines and identifies the data it contains. A data store name is a plural name consisting of a noun and adjectives, if needed. Examples of data store names are STUDENTS, ACCOUNTS RECEIVABLE, PRODUCTS, DAILY PAYMENTS, PURCHASE ORDERS, OUTSTANDING CHECKS, INSURANCE POLICIES, and EMPLOYEES. Exceptions to the plural name rule are collective nouns that represent multiple occurrences of objects. For example, GRADEBOOK represents a group of students and their scores.

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A data store must be connected to a process with a data flow. Figure 5-5 illustrates typical examples of data stores. Since data stores represent data storage for use by another process in the future, in each case, the data store has at least one incoming and one outgoing data flow and is connected to a process symbol with a data flow.

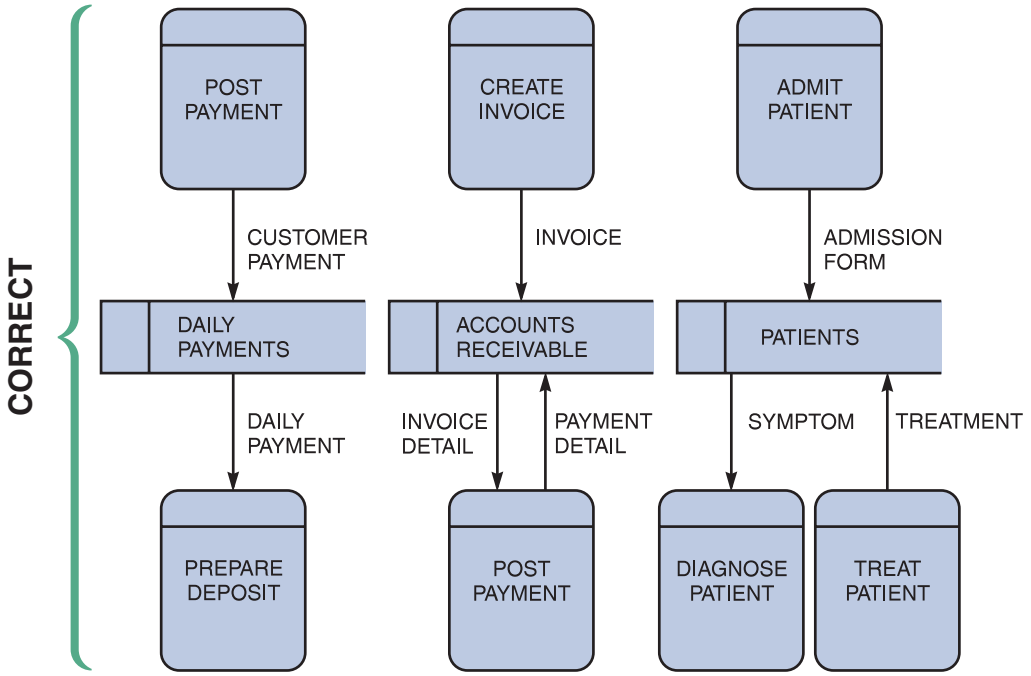


FIGURE 5-5 Examples of correct use of data store symbols in a data flow diagram.

Violations of the rule that a data store must have at least one incoming and one outgoing data flow are shown in Figure 5-6. In the first example, two data stores are connected incorrectly because no process is between them. Also, COURSES has no incoming data flow and STUDENTS has no outgoing data flow. In the second and third examples, the data stores lack either an outgoing or incoming data flow.

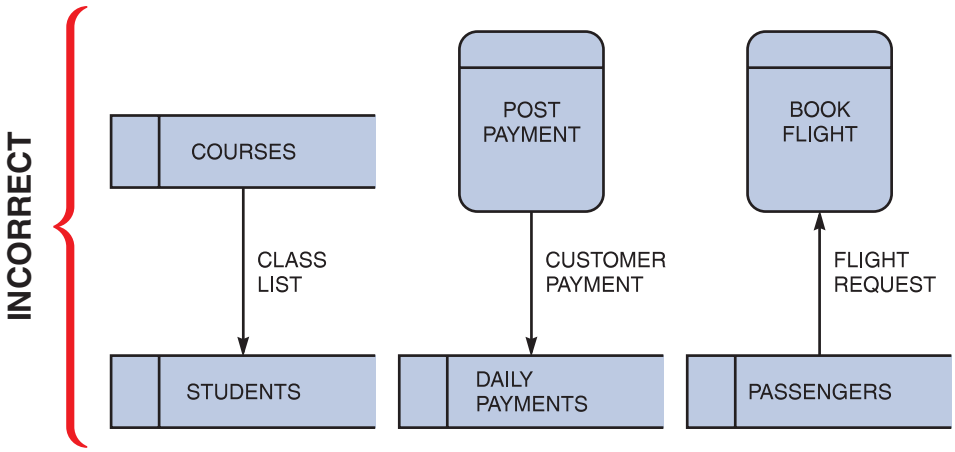


FIGURE 5-6 Examples of incorrect use of data store symbols in a data flow diagram. Two data stores cannot be connected by a data flow without an intervening process, and each data store should have an outgoing and incoming data flow.

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There is an exception to the requirement that a data store must have at least one incoming and one outgoing data flow. In some situations, a data store has no input data flow because it contains fixed reference data that is not updated by the system. For example, consider a data store called TAX TABLE, which contains withholding tax data that a company downloads from the Internal Revenue Service. When the company runs its payroll, the CALCULATE WITHHOLDING process accesses data from this data store. On a DFD, this would be represented as a one-way outgoing data flow from the TAX TABLE data store into the CALCULATE WITHHOLDING process.

5.3.4 Entity Symbols

The symbol for an **entity** is a rectangle, which may be shaded to make it look three-dimensional. The name of the entity appears inside the symbol.

A DFD shows only external entities that provide data to the system or receive output from the system. A DFD shows the boundaries of the system and how the system interfaces with the outside world. For example, a customer entity submits an order to an order processing system. Other examples of entities include a patient who supplies data to a medical records system, a homeowner who receives a bill from a city property tax system, or an accounts payable system that receives data from the company's purchasing system.

DFD entities also are called **terminators** because they are data origins or final destinations. Systems analysts call an entity that supplies data to the system a **source** and an entity that receives data from the system a **sink**. An entity name is the singular form of a department, an outside organization, other information system, or a person. An external entity can be a source or a sink or both, but each entity must be connected to a process by a data flow. Figure 5-7 and Figure 5-8 show correct and incorrect examples of this rule, respectively.

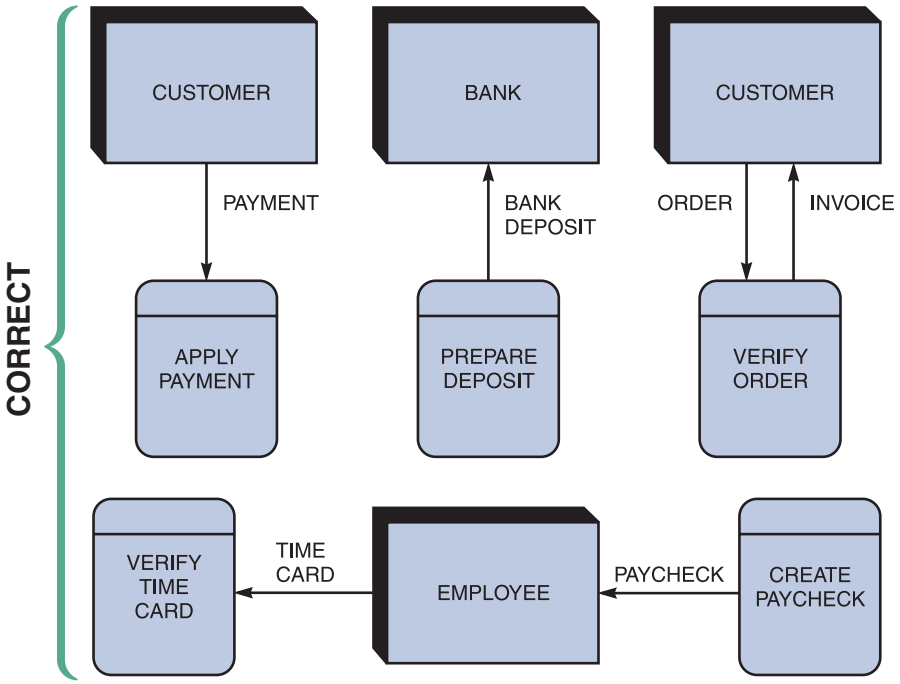


FIGURE 5-7 Examples of correct uses of external entities in a data flow diagram.

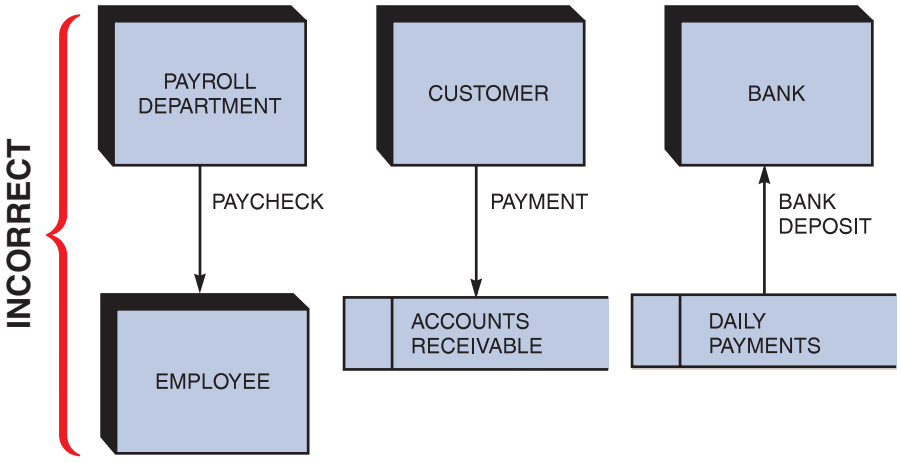


FIGURE 5-8 Examples of incorrect uses of external entities in a data flow diagram. An external entity must be connected by a data flow to a process and not directly to a data store or to another external entity.

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5.3.5 Using DFD Symbols

With an understanding of the proper use of DFD symbols, the next step is to construct diagrams that use these symbols. Figure 5-9 shows a summary of the rules for using DFD symbols.



FIGURE 5-9 Examples of correct and incorrect uses of data flows.

5.4 Drawing Data Flow Diagrams

During requirements engineering, interviews, questionnaires, and other techniques were used to gather facts about the system, and it was explained how the various people, departments, data, and processes fit together to support business operations. Now a graphical model of the information system is created based on the fact-finding results.

To learn how to draw DFDs, examples of two information systems will be used. The first example is a grading system that instructors use to assign final grades based on the scores that students receive during the term. The second example is an order system that a company uses to enter orders and apply payments against a customer's balance.

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When drawing a context diagram and other DFDs, these guidelines should be followed:

- Draw the context diagram so it fits on one page.
- Use the name of the information system as the process name in the context diagram. For example, the process name in Figure 5-10 is GRADING SYSTEM. Note that the process name is the same as the system name. This is because the context diagram shows the entire information system as if it were a single process. For processes in lower-level DFDs, use a verb followed by a descriptive noun, such as ESTABLISH GRADEBOOK, ASSIGN FINAL GRADE, or PRODUCE GRADE REPORT.
- Use unique names within each set of symbols. For instance, the diagram in Figure 5-10 shows only one entity named STUDENT and only one data flow named FINAL GRADE. Whenever the entity STUDENT appears on any other DFD in the grading system, it indicates that it is the same entity. Whenever the FINAL GRADE data flow appears, it indicates that it is the same data flow. The naming convention also applies to data stores.
- Do not cross lines. One way to achieve that goal is to restrict the number of symbols in any DFD. On lower-level diagrams with multiple processes, there should not be more than nine process symbols. Including more than nine symbols usually is a signal that the diagram is too complex and that the analysis should be reconsidered. Another way to avoid crossing lines is to duplicate an entity or a data store. When duplicating a symbol on a diagram, make sure to document the duplication to avoid possible confusion. A special notation, such as an asterisk, next to the symbol name and inside the duplicated symbols signifies that they are duplicated on the diagram.

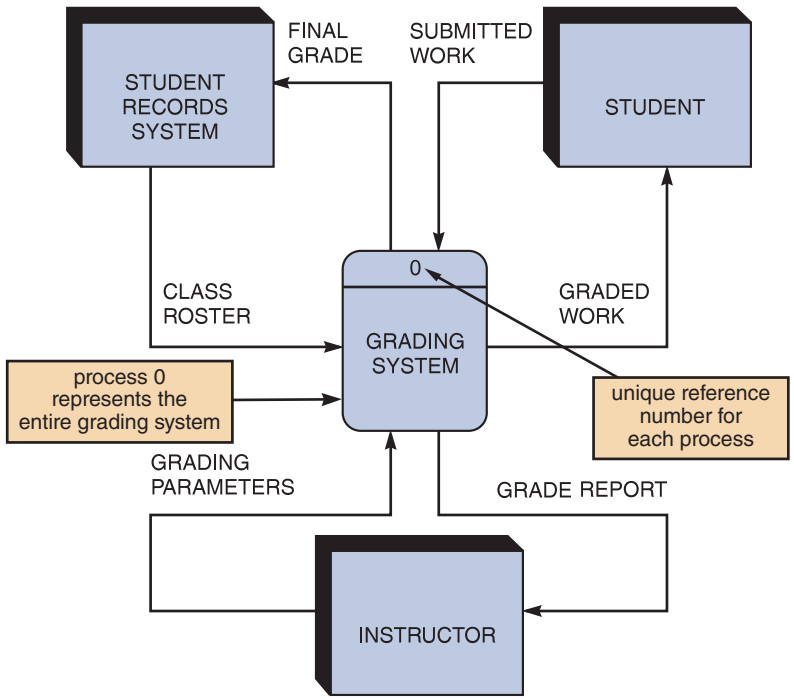


FIGURE 5-10 Context diagram DFD for a grading system.

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- Provide a unique name and reference number for each process. Because it is the highest-level DFD, the context diagram contains process 0, which represents the entire information system, but does not show the internal workings. To describe the next level of detail inside process 0, create a DFD named diagram 0, which will reveal additional processes that must be named and numbered. As lower-level DFDs are created, assign unique names and reference numbers to all processes, until the logical model is completed.
- Obtain as much user input and feedback as possible. The main objective is to ensure that the model is accurate, is easy to understand, and meets the needs of its users.

5.5 Drawing a Context Diagram

The first step in constructing a set of DFDs is to draw a context diagram. A **context diagram** is a top-level view of an information system that shows the system's boundaries and scope. To draw a context diagram, start by placing a single process symbol in the center of the page. The symbol represents the entire information system, and it is identified as **process 0** (the numeral zero, and not the letter O). Then place the system entities around the perimeter of the page and use data flows to connect the entities to the central process. Data stores are not shown in the context diagram because they are contained within the system and remain hidden until more detailed diagrams are created.

To determine which entities and data flows to place in the context diagram, begin by reviewing the system requirements to identify all external data sources and destinations. During that process, identify the entities, the name and content of the data flows, and the direction of the data flows. If that is done carefully, and the job of fact-finding was done well in the previous stage, drawing the context diagram should be relatively easy. Now review the following context diagram examples.

EXAMPLE: CONTEXT DIAGRAM FOR A GRADING SYSTEM: The context diagram for a grading system is shown in Figure 5-10. The GRADING SYSTEM process is at the center of the diagram. The three entities (STUDENT RECORDS SYSTEM, STUDENT, and INSTRUCTOR) are placed around the central process. Interaction among the central process and the entities involves six different data flows. The STUDENT RECORDS SYSTEM entity supplies data through the CLASS ROSTER data flow and receives data through the FINAL GRADE data flow. The STUDENT entity supplies data through the SUBMITTED WORK data flow and receives data through the GRADED WORK data flow. Finally, the INSTRUCTOR entity supplies data through the GRADING PARAMETERS data flow and receives data through the GRADE REPORT data flow.

EXAMPLE: CONTEXT DIAGRAM FOR AN ORDER SYSTEM: The context diagram for an order system is shown in Figure 5-11. Note that the ORDER SYSTEM process is at the center of the diagram and five entities surround the process. Three of the entities, SALES REP, BANK, and ACCOUNTING, have single incoming data flows for COMMISSION, BANK DEPOSIT, and CASH RECEIPTS ENTRY, respectively. The WAREHOUSE entity has one incoming data flow—PICKING LIST—that is, a report that shows the items ordered and their quantity, location, and sequence to pick from the warehouse. The WAREHOUSE entity has one outgoing data flow: COMPLETED ORDER. Finally, the CUSTOMER entity has two outgoing data flows, ORDER and PAYMENT, and two incoming data flows, ORDER REJECT NOTICE and INVOICE.

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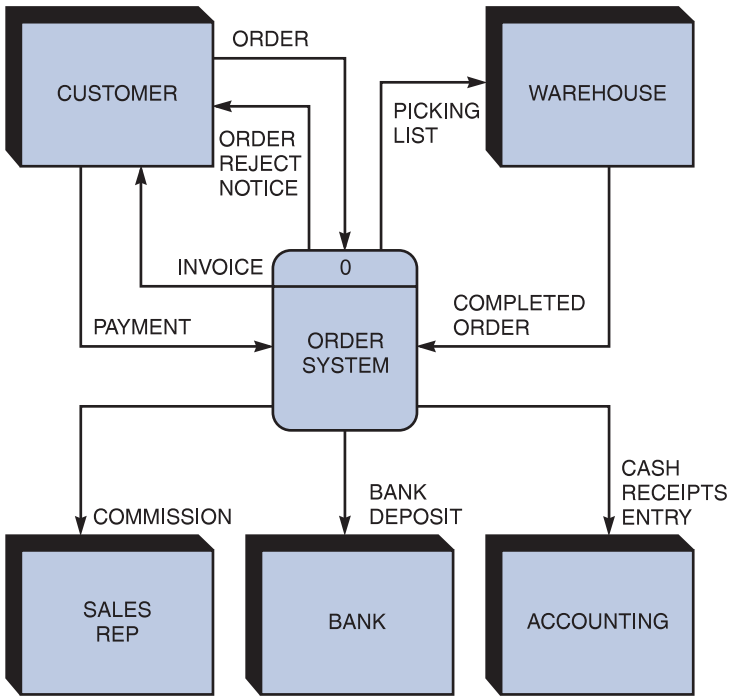


FIGURE 5-11 Context diagram DFD for an order system.

The context diagram for the order system appears more complex than the grading system because it has two more entities and three more data flows. What makes one system more complex than another is the number of components, the number of levels, and the degree of interaction among its processes, entities, data stores, and data flows.

5.6 Drawing a Diagram 0 DFD

In the previous step, it was explained how a context diagram provides the most general view of an information system and contains a single process symbol, which is like a black box. To show the detail inside the black box, a DFD diagram 0 is created. **Diagram 0** (the numeral zero, and not the letter O) provides an overview of all the components that interact to form the overall system. It zooms in on the system and shows major internal processes, data flows, and data stores. Diagram 0 also repeats the entities and data flows that appear in the context diagram. When the context diagram is expanded into DFD diagram 0, all the connections that flow into and out of process 0 must be retained.

EXAMPLE: DIAGRAM 0 DFD FOR A GRADING SYSTEM: Figure 5-12 shows a context diagram at the top and diagram 0 beneath it. Note that diagram 0 is an expansion of process 0. Also note that the three same entities (STUDENT RECORDS SYSTEM, STUDENT, and INSTRUCTOR) and the same six data flows (FINAL GRADE, CLASS ROSTER, SUBMITTED WORK, GRADED WORK, GRADING PARAMETERS, and GRADE REPORT) appear in both diagrams. In addition, diagram 0 expands process 0 to reveal four internal processes, one data store, and five additional data flows.

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Context Diagram for Grading System

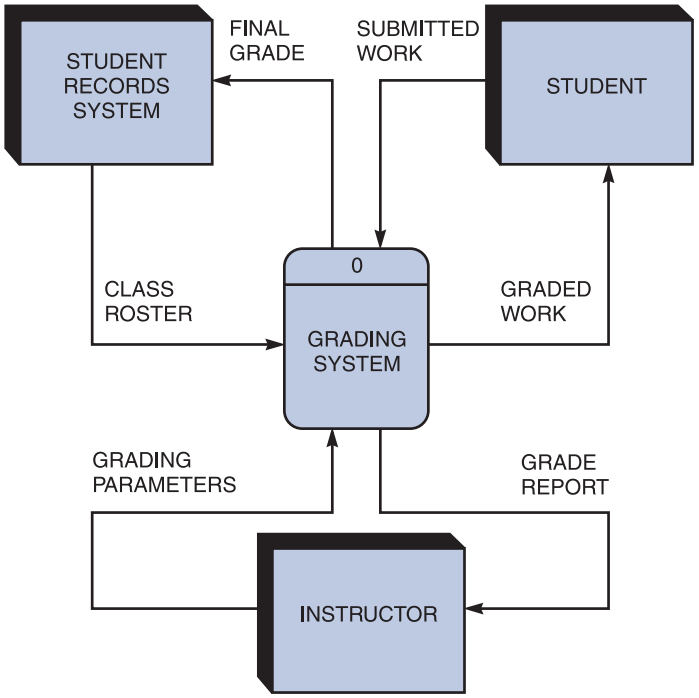


Diagram 0 for Grading System

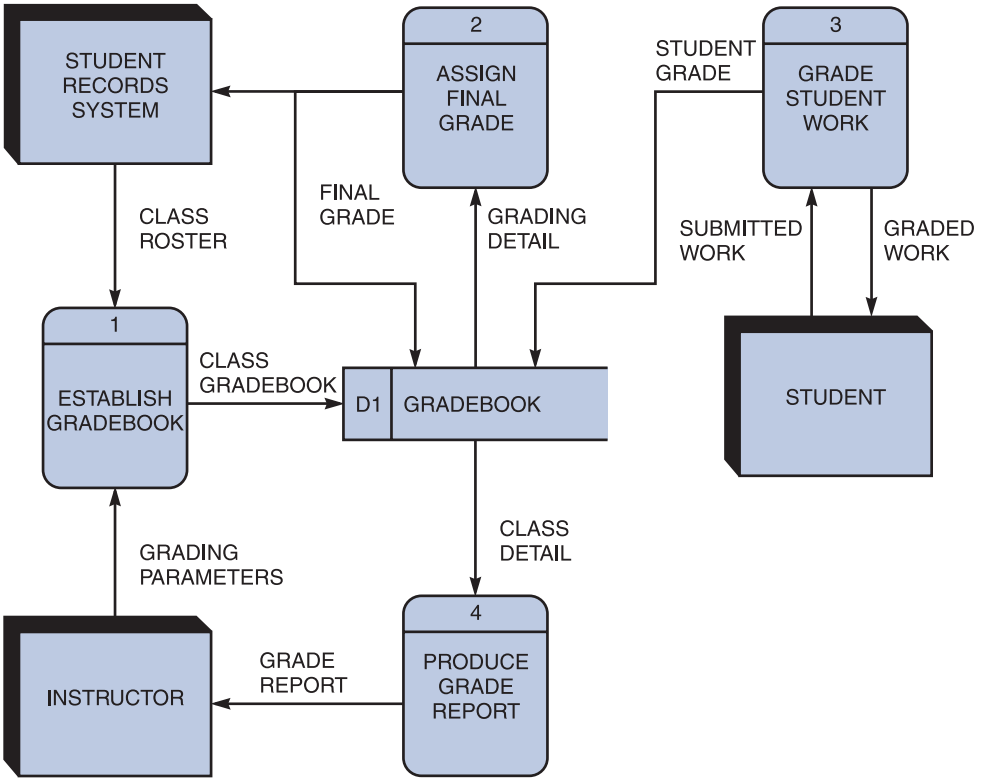


FIGURE 5-12 Context diagram and diagram 0 for the grading system.

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Note that each process in diagram 0 has a reference number: ESTABLISH GRADEBOOK is 1, ASSIGN FINAL GRADE is 2, GRADE STUDENT WORK is 3, and PRODUCE GRADE REPORT is 4. These reference numbers are important because they identify a series of DFDs. If more detail were needed for ESTABLISH GRADEBOOK, for example, a diagram 1 would be drawn, because ESTABLISH GRADEBOOK is process 1.

The process numbers do not suggest that the processes are accomplished in a sequential order. Each process always is considered to be available, active, and awaiting data to be processed. If processes must be performed in a specific sequence, the information should be documented in the process descriptions (discussed later in this chapter), not in the DFD.

The FINAL GRADE data flow output from the ASSIGN FINAL GRADE process is a diverging data flow that becomes an input to the STUDENT RECORDS SYSTEM entity and to the GRADEBOOK data store. A **diverging data flow** is a data flow in which the same data travels to two or more different locations. In that situation, a diverging data flow is the best way to show the flow rather than showing two identical data flows, which could be misleading.

If the same data flows in both directions, a double-headed arrow can be used to connect the symbols. To identify specific data flows into and out of a symbol, however, separate data flow symbols with single arrowheads should be used. For example, in Figure 5-12, the separate data flows (SUBMITTED WORK and GRADED WORK) go into and out of the GRADE STUDENT WORK process.

Because diagram 0 is an exploded version of process 0, it shows considerably more detail than the context diagram. Diagram 0 can also be referred to as a partitioned or decomposed view of process 0. When a DFD is exploded, the higher-level diagram is called the **parent diagram** and the lower-level diagram is referred to as the **child diagram**. The grading system is simple enough that no additional DFDs are needed to model the system. At that point, the four processes, the one data store, and the 10 data flows can be documented in the data dictionary.

When a set of DFDs is created for a system, the processing logic is broken down into smaller units, called functional primitives, which programmers will use to develop code. A **functional primitive** is a process that consists of a single function that is not exploded further. For example, each of the four processes shown in the lower portion of Figure 5-12 is a functional primitive. The logic for a functional primitive is documented by writing a process description in the data dictionary. Later, when the logical design is implemented as a physical system, programmers will transform each functional primitive into program code and modules that carry out the required steps. Deciding whether to explode a process further or determine that it is a functional primitive is a matter of experience, judgment, and interaction with programmers who must translate the logical design into code.

EXAMPLE: DIAGRAM 0 DFD FOR AN ORDER SYSTEM: Figure 5-13 is the diagram 0 for an order system. Process 0 on the order system's context diagram is exploded to reveal three processes (FILL ORDER, CREATE INVOICE, and APPLY PAYMENT), one data store (ACCOUNTS RECEIVABLE), two additional data flows (INVOICE DETAIL and PAYMENT DETAIL), and one diverging data flow (INVOICE).

The following walk-through explains the DFD shown in Figure 5-13:

1. A CUSTOMER submits an ORDER. Depending on the processing logic, the FILL ORDER process either sends an ORDER REJECT NOTICE back to the customer or sends a PICKING LIST to the WAREHOUSE.

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2. A COMPLETED ORDER from the WAREHOUSE is input to the CREATE INVOICE process, which outputs an INVOICE to both the CUSTOMER process and the ACCOUNTS RECEIVABLE data store.
3. A CUSTOMER makes a PAYMENT that is processed by APPLY PAYMENT. APPLY PAYMENT requires INVOICE DETAIL input from the ACCOUNTS RECEIVABLE data store along with the PAYMENT. APPLY PAYMENT also outputs PAYMENT DETAIL back to the ACCOUNTS RECEIVABLE data store and outputs COMMISSION to the SALES DEPT, BANK DEPOSIT to the BANK, and CASH RECEIPTS ENTRY to ACCOUNTING.

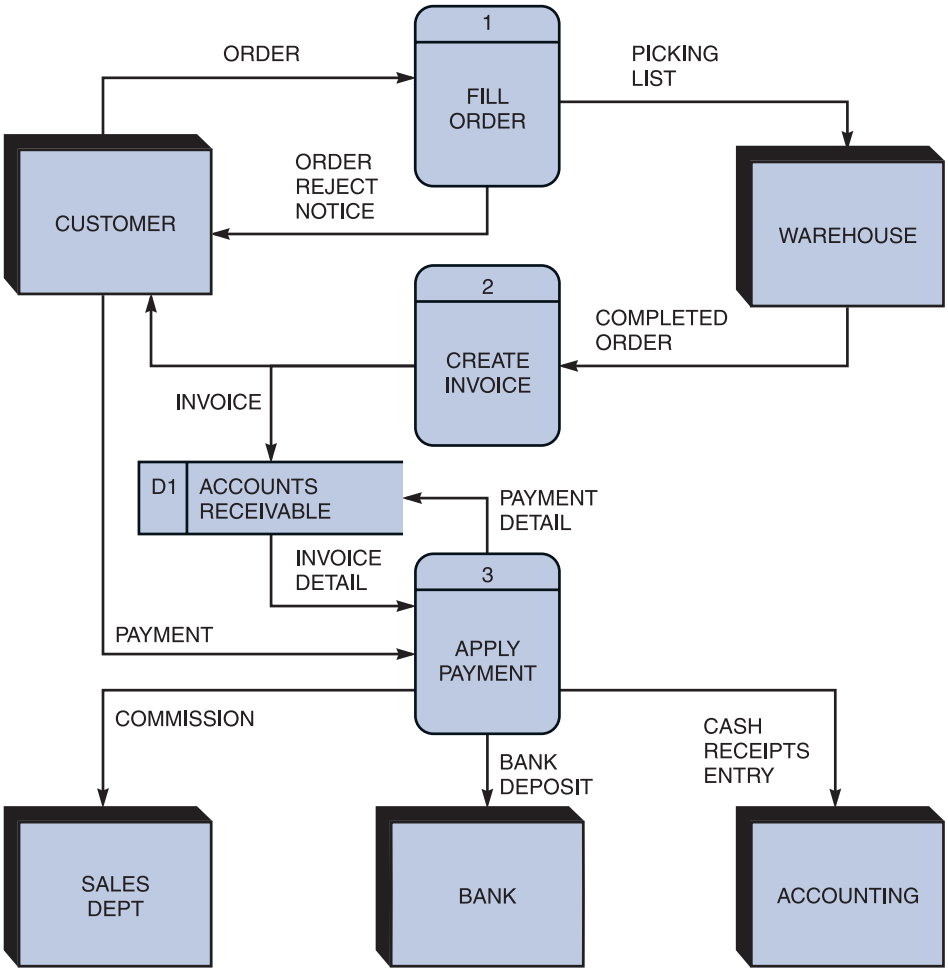


FIGURE 5-13 Diagram 0 DFD for the order system.

The walk-through of diagram 0 illustrates the basic requirements of the order system. Examine the detailed description of each separate process to learn more.

5.7 Drawing Lower-Level DFDs

This set of lower-level DFDs is based on the order system. To create lower-level diagrams, leveling and balancing techniques must be used. **Leveling** is the process of drawing a series of increasingly detailed diagrams, until all functional primitives are identified.

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Balancing maintains consistency among a set of DFDs by ensuring that input and output data flows align properly. Leveling and balancing are described in more detail in the following sections.

EXAMPLE: LEVELING EXAMPLES: Leveling uses a series of increasingly detailed DFDs to describe an information system. For example, a system might consist of dozens, or even hundreds, of separate processes. Using leveling, an analyst starts with an overall view, which is a context diagram with a single process symbol. Next, the analyst creates diagram 0, which shows more detail. The analyst continues to create lower-level DFDs until all processes are identified as functional primitives, which represent single processing functions. More complex systems have more processes, and analysts must work through many levels to identify the functional primitives. Leveling also is called **exploding**, **partitioning**, or **decomposing**.

Figures 5-13 and 5-14 provide an example of leveling. Figure 5-13 shows diagram 0 for an order system, with the FILL ORDER process labeled as process 1. Now consider Figure 5-14, which provides an exploded view of the FILL ORDER process. Note that FILL ORDER (process 1) actually consists of three processes: VERIFY ORDER (process 1.1), PREPARE REJECT NOTICE (process 1.2), and ASSEMBLE ORDER (process 1.3).

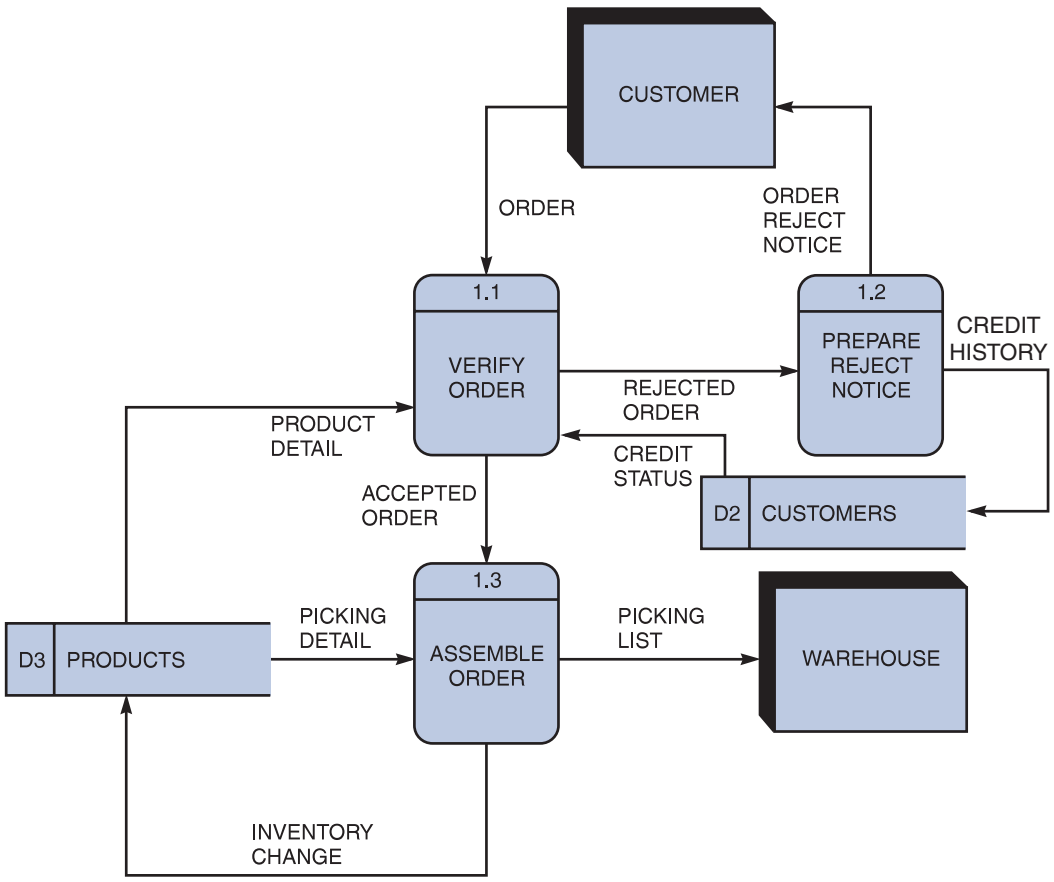


FIGURE 5-14 Diagram 1 DFD shows details of the FILL ORDER process in the order system.

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As Figure 5-14 shows, all processes are numbered using a decimal notation consisting of the parent's reference number, a decimal point, and a sequence number within the new diagram. In Figure 5-14, the parent process of diagram 1 is process 1, so the processes in diagram 1 have reference numbers of 1.1, 1.2, and 1.3. If process 1.3, ASSEMBLE ORDER, is decomposed further, then it would appear in diagram 1.3 and the processes in diagram 1.3 would be numbered as 1.3.1, 1.3.2, 1.3.3, and so on. This numbering technique makes it easy to integrate and identify all DFDs.

When Figure 5-13 and Figure 5-14 are compared, it is apparent that Figure 5-14 (the exploded FILL ORDER process) shows two data stores (CUSTOMER and PRODUCTS) that do not appear on Figure 5-13, which is the parent DFD. Why not? The answer is based on a simple rule: When drawing DFDs, a data store is shown only when two or more processes use that data store. The CUSTOMER and PRODUCTS data stores were internal to the FILL ORDER process, so the analyst did not show them on diagram 0, which is the parent. When the FILL ORDER process is exploded into a diagram 1 DFD, however, three processes (1.1, 1.2, and 1.3) interacting with the two data stores are now shown.

Now compare Figure 5-14 and Figure 5-15. Note that Figure 5-15 shows the same data flows as Figure 5-14 but does not show the CUSTOMER and WAREHOUSE entities. Analysts often use this technique to simplify a DFD and reduce unnecessary clutter. Because the missing symbols appear on the parent DFD, that diagram can be used to identify the source or destination of the data flows.

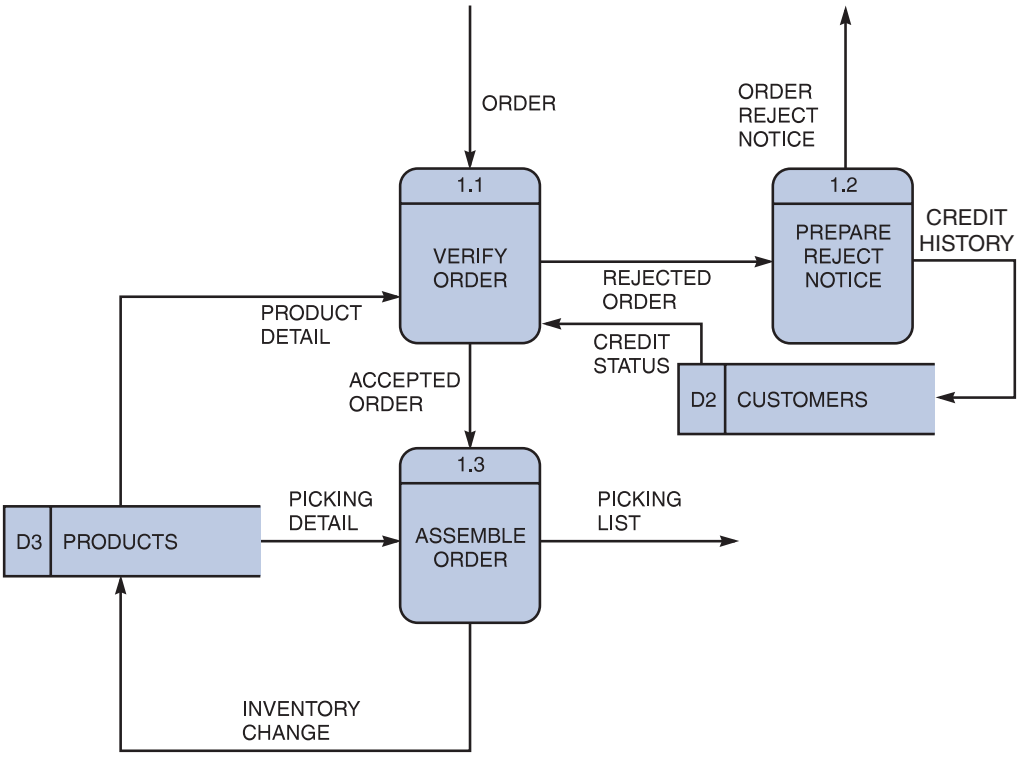


FIGURE 5-15 This diagram does not show the symbols that connect to data flows entering or leaving FILL ORDER on the context diagram.

BALANCING EXAMPLES: Balancing ensures that the input and output data flows of the parent DFD are maintained on the child DFD. For example, Figure 5-16 shows two DFDs: The order system diagram 0 is shown at the top of the figure, and the exploded diagram 3 DFD is shown at the bottom.

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The two DFDs are balanced because the child diagram at the bottom has the same input and output flows as the parent process 3 shown at the top. To verify the

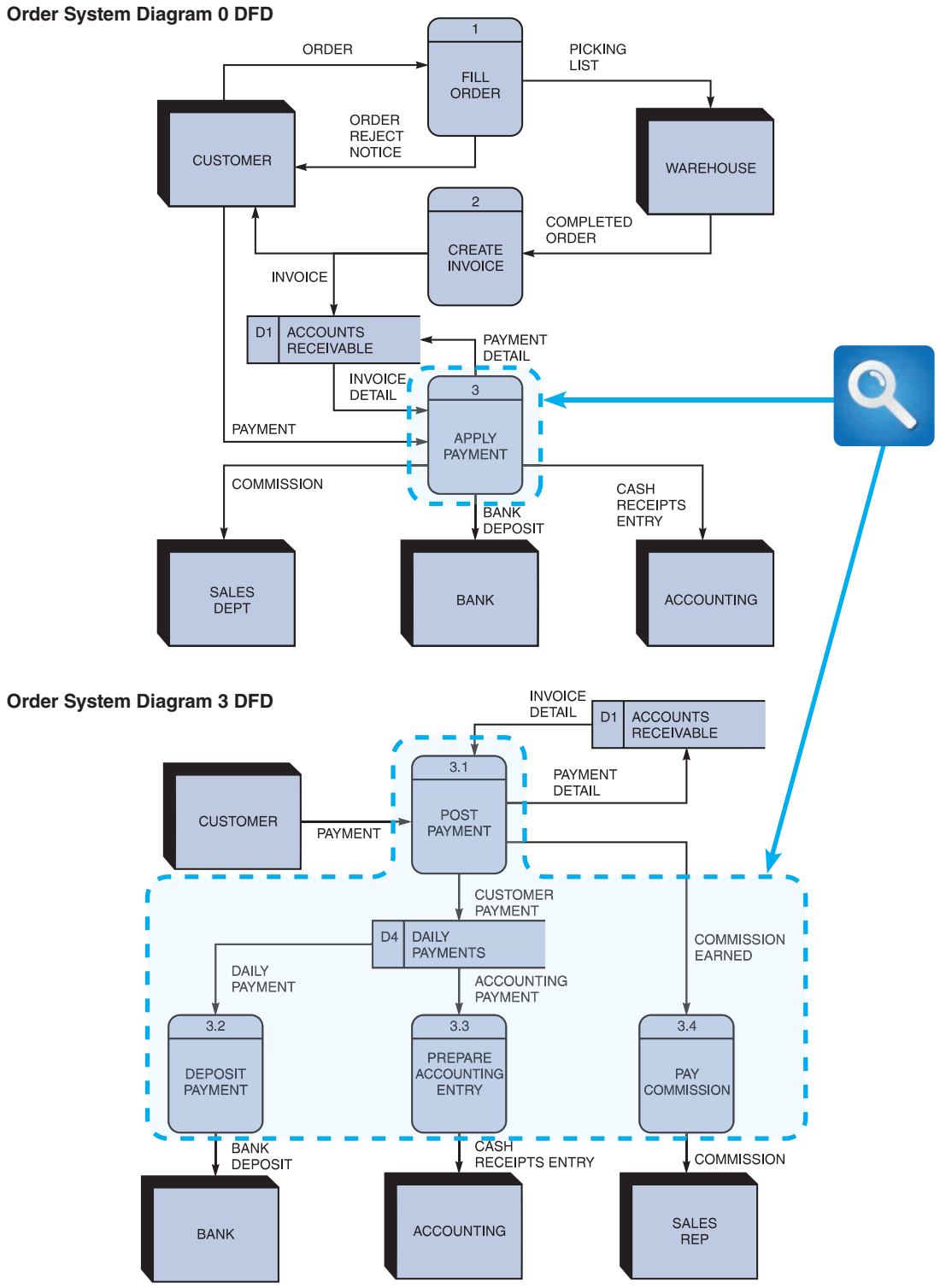


FIGURE 5-16 The order system diagram 0 is shown at the top of the figure, and the exploded diagram 3 DFD (for the APPLY PAYMENT process) is shown at the bottom. The two DFDs are balanced because the child diagram at the bottom has the same input and output flows as the parent process 3 shown at top.

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balancing, note that the parent process 3, APPLY PAYMENT, has one incoming data flow from an external entity and three outgoing data flows to external entities. Examine the child DFD, which is diagram 3. Ignore the internal data flows and count the data flows to and from external entities. From the diagram, it is evident that the three processes maintain the same one incoming and three outgoing data flows as the parent process.

Another example of balancing is shown in Figures 5-17 and 5-18. The DFDs in these figures were created using the Visible Analyst CASE tool.

Figure 5-17 shows a sample context diagram. The process 0 symbol has two input flows and two output flows. Note that process 0 can be considered as a black box

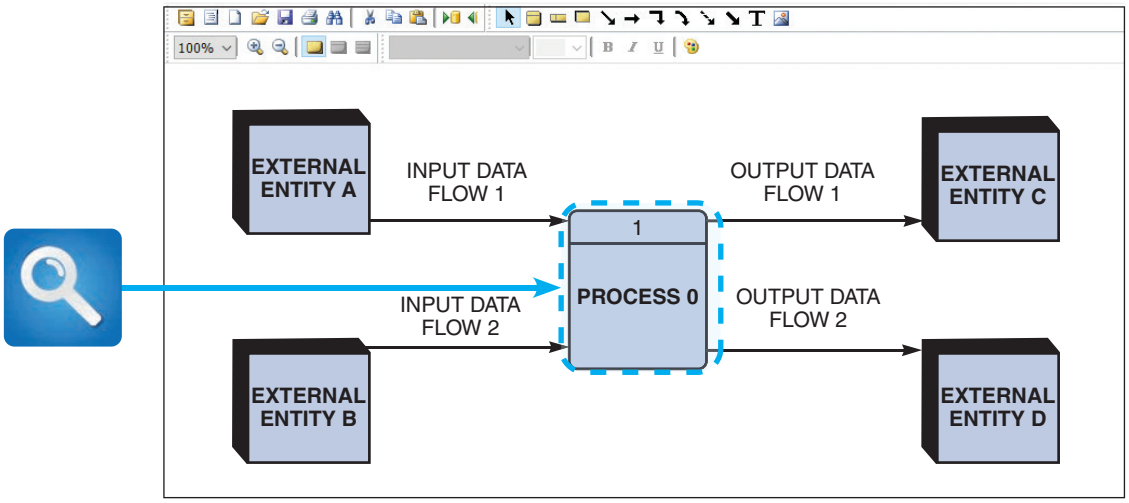


FIGURE 5-17 Examples of a parent DFD diagram, showing process 0 as a black box.

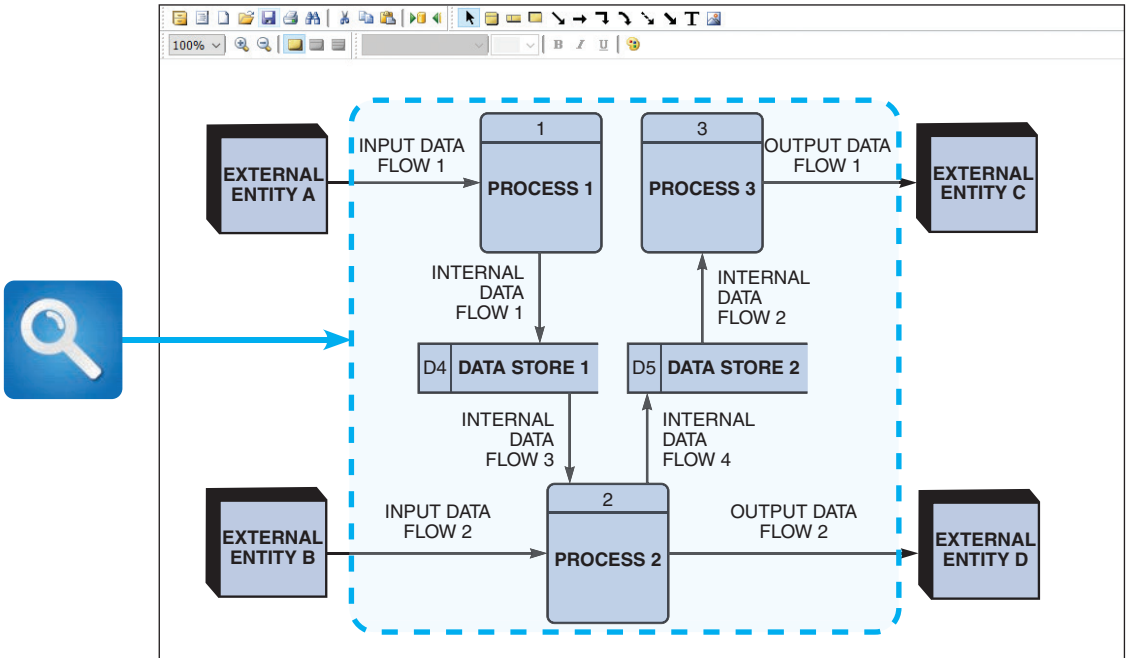


FIGURE 5-18 In the next level of detail, the process 0 black box reveals three processes, two data stores, and four internal data flows—all of which are shown inside the dashed line.

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with no internal detail shown. In Figure 5-18, process 0 (the parent DFD) is exploded into the next level of detail. Now three processes, two data stores, and four internal data flows are visible. Note that the details of process 0 are shown inside a dashed line, just as if the inside of the process was visible.

The DFDs in Figures 5-17 and 5-18 are balanced because the four data flows into and out of process 0 are maintained on the child DFD. The DFDs also are leveled because each internal process is numbered to show that it is a child of the parent process.

CASE IN POINT 5.1: Big Ten University

You are the IT director at Big Ten University. As part of a training program, you decide to draw a DFD that includes some obvious mistakes to see whether your newly hired junior analysts can find them. You came up with the diagram 0 DFD shown in Figure 5-19. Based on the rules explained in this chapter, how many problems should the analysts find?

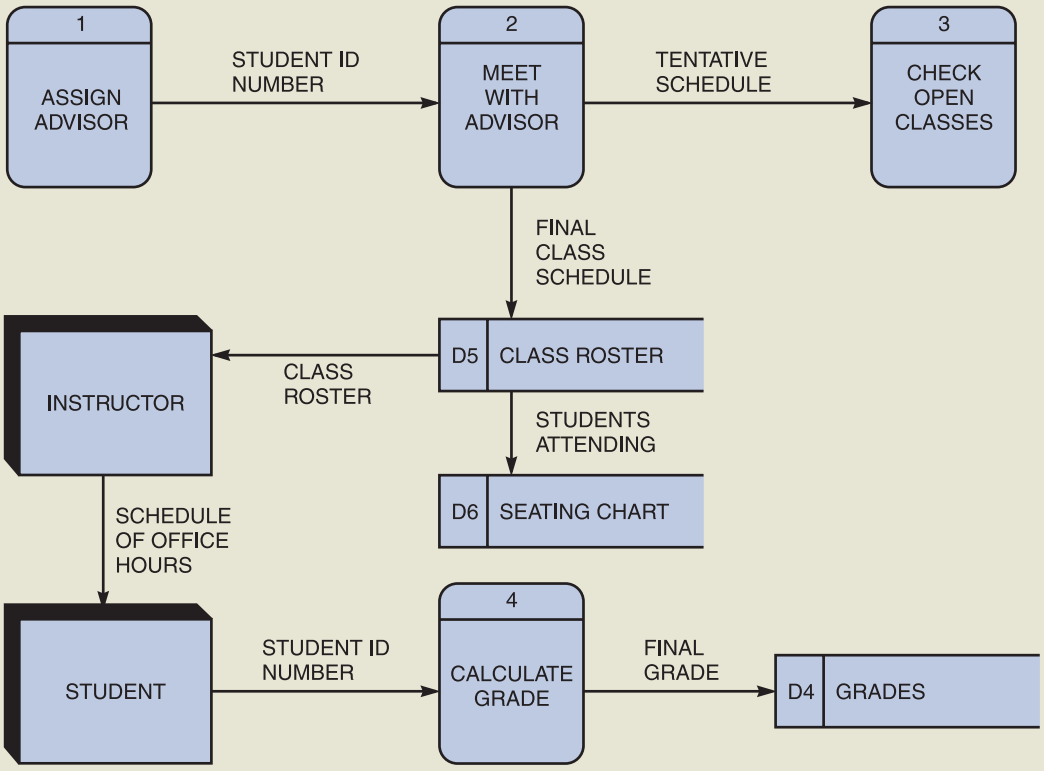


FIGURE 5-19 What are the mistakes in this diagram 0 DFD?

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5.8 Data Dictionary

A set of DFDs produces a logical model of the system, but the details within those DFDs are documented separately in a data dictionary, which is the second component of structured analysis.

A **data dictionary**, or **data repository**, is a central storehouse of information about the system's data. An analyst uses the data dictionary to collect, document, and organize specific facts about the system, including the contents of data flows, data stores, entities, and processes. The data dictionary also defines and describes all data elements and meaningful combinations of data elements. A **data element**, also called a **data item** or **field**, is the smallest piece of data that has meaning within an information system. Examples of data elements are student grade, salary, Social Security number, account balance, and company name. Data elements are combined into **records**, also called **data structures**. A record is a meaningful combination of related data elements that is included in a data flow or retained in a data store. For example, an auto parts store inventory record might include part number, description, supplier code, minimum and maximum stock levels, cost, and list price.

Significant relationships exist among the items in a data dictionary. For example, data stores and data flows are based on data structures, which in turn are composed of data elements. Data flows are connected to data stores, entities, and processes. Accurately documenting these relationships is essential so the data dictionary is consistent with the DFDs. The more complex the system, the more difficult it is to maintain full and accurate documentation. Fortunately, modern CASE tools simplify the task by flowing documentation automatically from the modeling diagrams into the central repository, along with information entered by the user.

A CASE repository ensures data consistency, which is especially important where multiple systems require the same data. In a large company, for example, the sales, accounting, and shipping systems all might use a data element called CUSTOMER NUMBER. Once the CUSTOMER NUMBER element has been defined in the repository, other processes can access it, data flows, and data stores. The result is that all systems across the enterprise can share data that is up to date and consistent.

5.8.1 Documenting the Data Elements

Every data element in the data dictionary must be documented. Some analysts like to record their notes in online or manual forms. Others prefer to enter the information directly into a CASE tool. Irrespective of the specific CASE tool used, the objective is the same: to provide clear, comprehensive information about the data and processes that make up the system.

Figure 5-20 shows a sample screen that illustrates how a data element representing a SOCIAL SECURITY NUMBER might be recorded in the Visible Analyst data dictionary. Regardless of the terminology or method, the following attributes usually are recorded and described in the data dictionary:

- *Data element name or label*. The data element's standard name, which should be meaningful to users.
- *Alias*. Any name(s) other than the standard data element name; this alternate name is called an **alias**. For example, if there is a data element named CURRENT BALANCE, various users might refer to it by alternate names such as OUTSTANDING BALANCE, CUSTOMER BALANCE, RECEIVABLE BALANCE, or AMOUNT OWED.

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- *Type and length*. Type refers to whether the data element contains numeric, alphabetic, or character values. Length is the maximum number of characters for an alphabetic or a character data element or the maximum number of digits and number of decimal positions for a numeric data element. In addition to text and numeric data, sounds and images also can be stored in digital form. In some systems, these binary data objects are managed and processed just as traditional data elements are. For example, an employee record might include a digitized photo image of the person.
- *Default value*. The default value is the value for the data element if a value otherwise is not entered for it. For example, all new customers might have a default value of $500 for the CREDIT LIMIT data element.
- *Acceptable values*. Specification of the data element's **domain**, which is the set of values permitted for the data element. These values either can be specifically listed or referenced in a table or can be selected from a specified range of values. Also indicate if a value for the data element is optional. Some data elements have additional **validity rules**. For example, an employee's salary must be within the range defined for the employee's job classification.

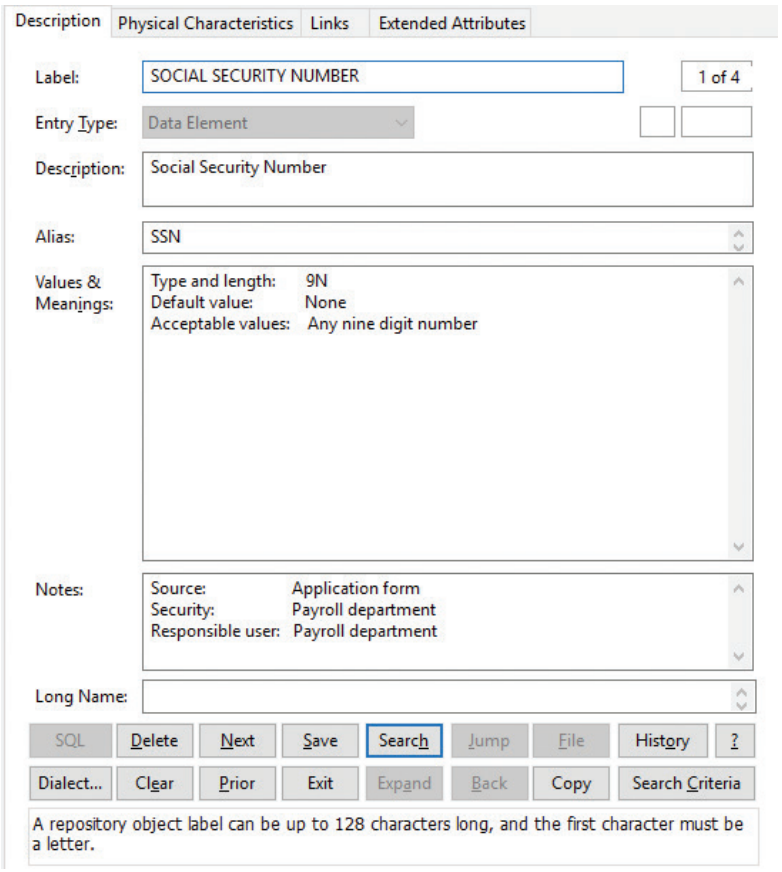


FIGURE 5-20 A Visible Analyst screen describes the data element named SOCIAL SECURITY NUMBER.
Source: Screenshot used with permission from Visible Systems Corp.

- *Source*. The specification for the origination point for the data element's values. The source could be a specific form, a department or an outside organization, another information system, or the result of a calculation.
- *Security*. Identification for the individual or department that has access or update privileges for each data element. For example, only a credit manager has the authority to change a credit limit, while sales reps are authorized to access data in a read-only mode.
- *Responsible user(s)*. Identification of the user(s) responsible for entering and changing values for the data element.
- *Description and comments*. This part of the documentation permits the entry of additional notes.

5.8.2 Documenting the Data Flows

In addition to documenting each data element, all data flows in the data dictionary must be documented. Although terms can vary, the typical attributes are as follows:

- *Data flow name or label*. The data flow name as it appears on the DFDs.
- *Description*. Describes the data flow and its purpose.

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- *Alternate name(s)*. Aliases for the DFD data flow name(s).
- *Origin*. The DFD beginning, or source, for the data flow; the origin can be a process, a data store, or an entity.
- *Destination*. The DFD ending point(s) for the data flow; the destination can be a process, a data store, or an entity.
- *Record*. Each data flow represents a group of related data elements called a record or data structure. In most data dictionaries, records are defined separately from the data flows and data stores. When records are defined, more than one data flow or data store can use the same record, if necessary.
- *Volume and frequency*. Describes the expected number of occurrences for the data flow per unit of time. For example, if a company has 300 employees, a TIME CARD data flow would involve 300 transactions and records each week as employees submit their work hour data.

5.8.3 Documenting the Data Stores

Every DFD data store in the data dictionary must be documented. Figure 5-21 shows the definition of a data store named IN STOCK. Typical characteristics of a data store are as follows:

- *Data store name or label*. The data store name as it appears on the DFDs.
- *Description*. Describes the data store and its purpose.
- *Alternate name(s)*. Aliases for the DFD data store name.
- *Attributes*. Standard DFD names that enter or leave the data store.
- *Volume and frequency*. Describes the estimated number of records in the data store and how frequently they are updated.

1. This data store has an alternative name, or alias.
2. For consistency, data flow names are standardized throughout the data dictionary.
3. It is important to document these estimates because they will affect design decisions in subsequent SDLC phases.

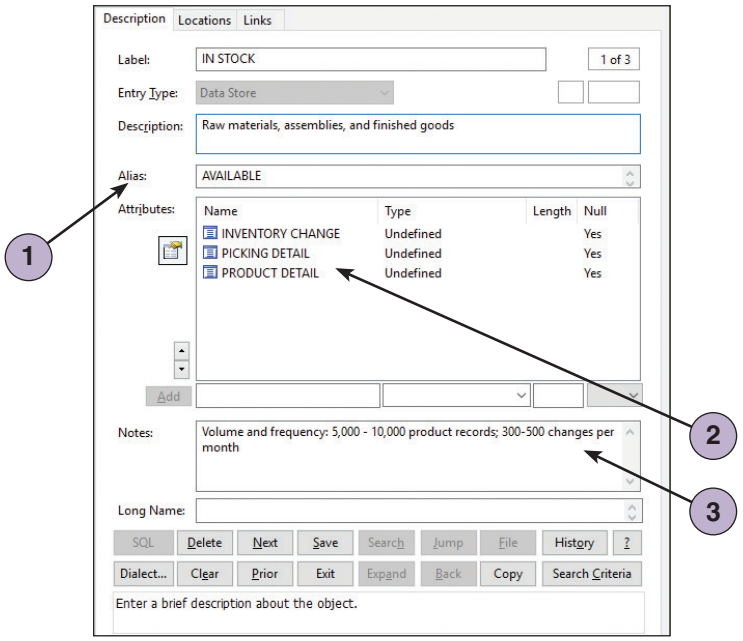


FIGURE 5-21 A Visible Analyst screen that documents a data store named IN STOCK.

Source: Screenshot used with permission from Visible Systems Corp.

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5.8.4 Documenting the Processes

Every process must be documented, as shown in Figure 5-22. The documentation includes a description of the process's characteristics and, for functional primitives, a process description, which is a model that documents the processing steps and business logic.

The following are typical characteristics of a process:

- *Process name or label*. The process name as it appears on the DFDs.
- *Description*. A brief statement of the process's purpose.
- *Process number*. A reference number that identifies the process and indicates relationships among various levels in the system.
- *Process description*. This section includes the input and output data flows. For functional primitives, the process description also documents the processing steps and business logic. The next section explains how to write process descriptions.

1. The process number identifies this process. Any subprocesses are numbered 1.1, 1.2, 1.3, and so on.
2. These data flows will be described specifically elsewhere in the data dictionary.

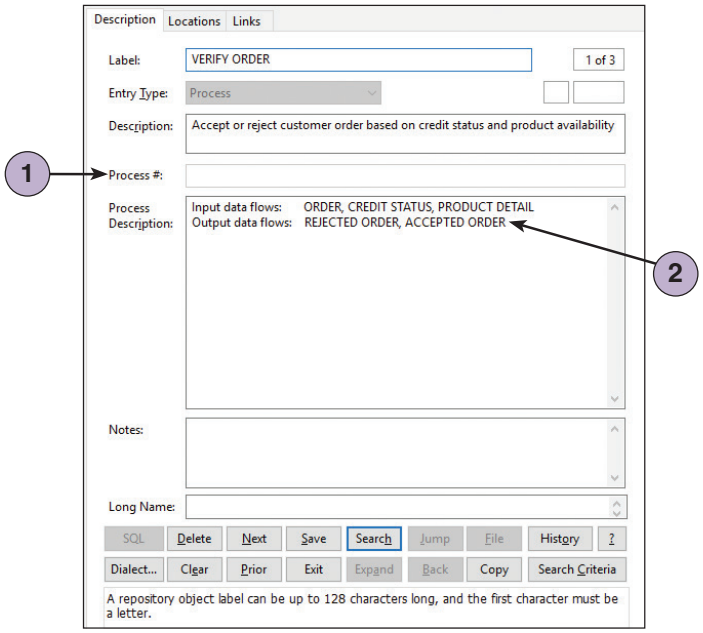


FIGURE 5-22 A Visible Analyst screen that describes a process named VERIFY ORDER.

Source: Screenshot used with permission from Visible Systems Corp.

5.8.5 Documenting the Entities

By documenting all entities, the data dictionary can describe all external entities that interact with the system. Typical characteristics of an entity include the following:

- *Entity name*. The entity name as it appears on the DFDs.
- *Description*. Describe the entity and its purpose.
- *Alternate name(s)*. Any aliases for the entity name.
- *Input data flows*. The standard DFD names for the input data flows to the entity.
- *Output data flows*. The standard DFD names for the data flows leaving the entity.

5.8.6 Documenting the Records

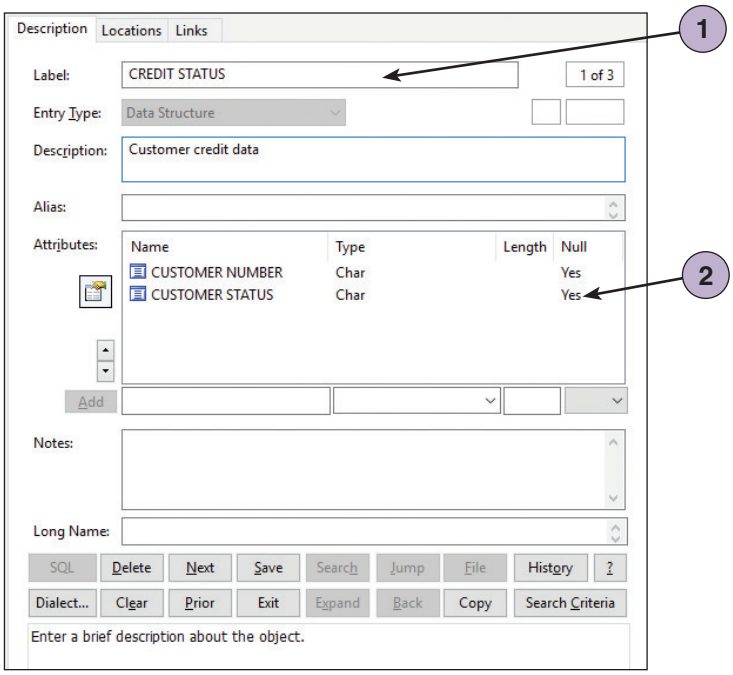
A record is a data structure that contains a set of related data elements that are stored and processed together. Data flows and data stores consist of records that must

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be documented in the data dictionary. Characteristics of each record must also be defined, as shown in Figure 5-23.

Typical characteristics of a record include the following:

- *Record or data structure name*. The record name as it appears in the related data flow and data store entries in the data dictionary.
- *Definition or description*. A brief definition of the record.
- *Alternate name(s)*. Any aliases for the record name.
- *Attributes*. A list of all the data elements, or fields, included in the record. The data element names must match exactly those entered in the data dictionary.



1. This data structure is named CREDIT STATUS.
2. The CREDIT STATUS data structure consists of two data elements: CUSTOMER NUMBER and CUSTOMER STATUS CODE.

FIGURE 5-23 A Visible Analyst screen that documents a record, or data structure, named CREDIT STATUS.

Source: Screenshot used with permission from Visible Systems Corp.

5.8.7 Data Dictionary Reports

The data dictionary serves as a central storehouse of documentation for an information system. A data dictionary is created when the system is developed and is updated constantly as the system is implemented, operated, and maintained. In addition to describing each data element, data flow, data store, record, entity, and process, the data dictionary documents the relationships among these components.

Many valuable reports can be obtained from a data dictionary, including the following:

- An alphabetized list of all data elements by name
- A report describing each data element and indicating the user or department that is responsible for data entry, updating, or deletion
- A report of all data flows and data stores that use a particular data element
- Detailed reports showing all characteristics of data elements, records, data flows, processes, or any other selected item stored in the data dictionary

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5.9 Process Description Tools in Modular Design

A **process description** documents the details of a functional primitive and represents a specific set of processing steps and business logic. When a functional primitive is analyzed, the processing steps are broken down into smaller units in a process called modular design. Using a set of process description tools, a model is created that is accurate, complete, and concise. Typical process description tools include structured English, decision tables, and decision trees.

5.9.1 Process Descriptions in Object-Oriented Development

This chapter deals with structured analysis, but the process descriptions can also be used in object-oriented (O-O) development, which is described in Chapter 6. As explained in Chapter 1, O-O analysis combines data and the processes that act on the data into things called objects, and similar objects can be grouped together into classes, and O-O processes are called methods. Although O-O programmers use different terminology, they create the same kind of modular coding structures, except that the processes, or methods, are stored inside the objects, rather than as separate components.

5.9.2 Modular Design

Modular design is based on combinations of three **logical structures**, sometimes called **control structures**, which serve as building blocks for the process. Each logical structure must have a single entry and exit point. The three structures are called sequence, selection, and iteration. A rectangle represents a step or process, a diamond shape represents a condition or decision, and the logic follows the lines in the direction indicated by the arrows.

1. **Sequence**. The completion of steps in sequential order, one after another, as shown in Figure 5-24. One or more of the steps might represent a subprocess that contains additional logical structures.
2. **Selection**. The completion of one of two or more process steps based on the results of a test or condition. In the example shown in Figure 5-25, the system tests the input, and if the hours are greater than 40, it performs the CALCULATE OVERTIME PAY process.
3. **Iteration**. The completion of a process step that is repeated until a specific condition changes, as shown in Figure 5-26. An example of iteration is a process that continues to print paychecks until it reaches the end of the payroll file. Iteration also is called **looping**.



FIGURE 5-24 Sequence structure.

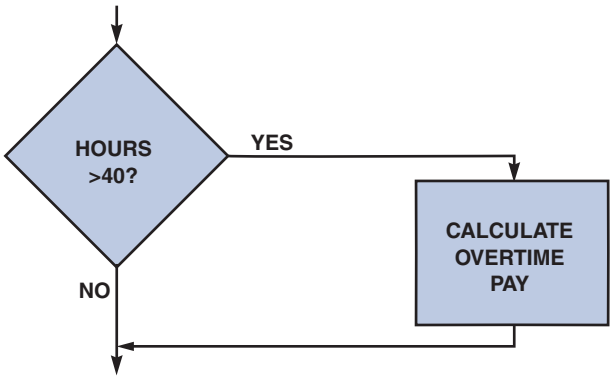


FIGURE 5-25 Selection structure.

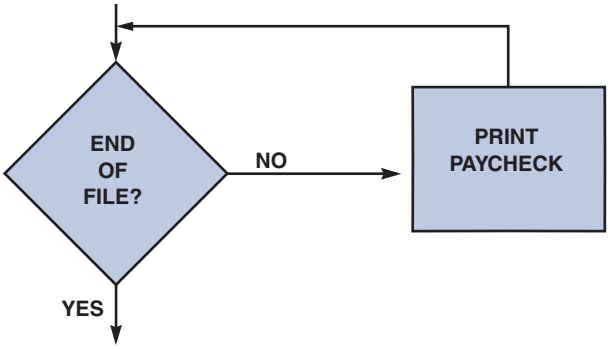


FIGURE 5-26 Iteration structure.

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Sequence, selection, and iteration structures can be combined in various ways to describe processing logic.

5.9.3 Structured English

Structured English is a subset of standard English that describes logical processes clearly and accurately. When using structured English, be mindful of the following guidelines:

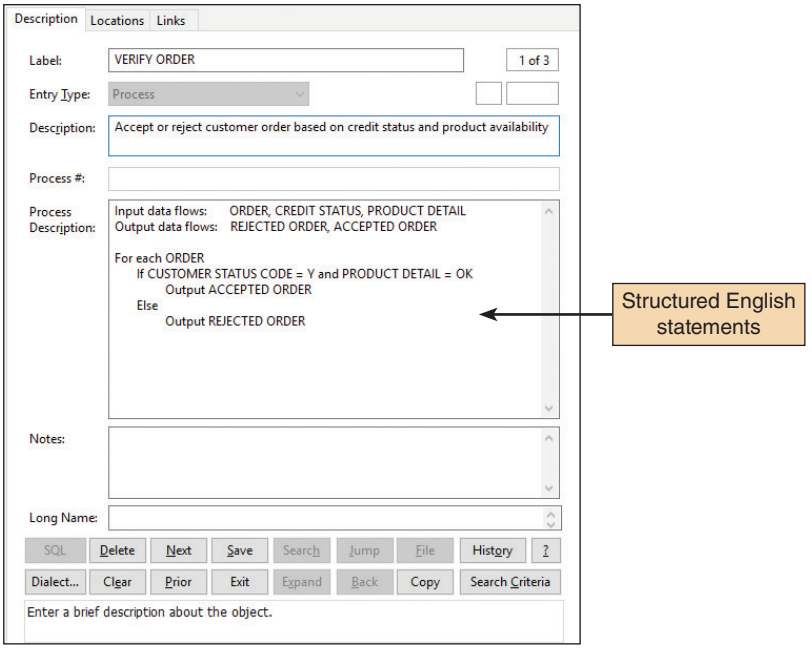


FIGURE 5-27 The VERIFY ORDER process description includes logical rules and a structured English version of the policy. Note the alignment and indentation of the logic statements.

Source: Screenshot used with permission from Visible Systems Corp.

- Use only the three building blocks of sequence, selection, and iteration.
- Use indentation for readability.
- Use a limited vocabulary, including standard terms used in the data dictionary and specific words that describe the processing rules.

An example of structured English appears in Figure 5-27, which shows the VERIFY ORDER process that was illustrated earlier. Note that the structured English version documents the actual logic that will be coded into the system. Structured English can help process descriptions accurate and understandable to users and system developers.

Structured English might look familiar to programming students because it resembles pseudocode, which is used in program design. Although the techniques are similar, the primary purpose of structured English is to describe the underlying business logic, while programmers, who are concerned with coding, mainly use pseudocode as a shorthand notation for the actual code.

Following structured English rules ensures that process descriptions are understandable to users who must confirm that the process is correct, as well as to other analysts and programmers who must design the information system from the descriptions.

5.9.4 Decision Tables

A decision table is a logical structure that shows every combination of conditions and outcomes. Analysts often use decision tables to describe a process and ensure that they have considered all possible situations. Decision tables can be created using tools such as Microsoft PowerPoint, Word, or Excel.

TABLES WITH ONE CONDITION: If a process has a single condition, there only are two possibilities—*yes* or *no*. Either the condition is present or it is not, so there are only two rules. For example, to trigger an overtime calculation, the process condition might be: *Are the hours greater than 40?* If so, the calculation is made. Otherwise, it is not.

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TABLES WITH TWO CONDITIONS: Suppose there is a need to create a decision table based on the VERIFY ORDER business process shown in Figure 5-28. When documenting a process, it is important to ensure that every possibility is listed. In this example, the process description contains two conditions: product stock status and customer credit status. If *both* conditions are met, the order is accepted. Otherwise the order is rejected.

VERIFY ORDER Business Process with Two Conditions

- An order will be accepted only if the product is in stock and the customer's credit status is OK.
- All other orders will be rejected.

FIGURE 5-28 The VERIFY ORDER business process has two conditions. For an order to be accepted, the product must be in stock and the customer must have an acceptable credit status.

After all the conditions and outcomes have been identified, the next step is to create a decision table similar to the one shown in Figure 5-29. Note that each condition has two possible values, so the number of rules doubles each time another condition is added. For example, one condition creates two rules, two conditions create four rules, three conditions create eight rules, and so on. In the two-condition example in Figure 5-29, four possibilities exist, but Rule 1 is the *only* combination that will accept an order.

TABLES WITH THREE CONDITIONS: Suppose the company now decides that the credit manager can waive the customer credit requirement, as shown in Figure 5-30. That creates a third condition, so there will be eight possible rules. The new decision table might resemble the one shown in Figure 5-31.

1. Place the name of the process in a heading at the top left.
2. Enter the conditions under the heading, with one condition per line, to represent the customer status and availability of products.
3. Enter all potential combinations of Y/N for the conditions. Each column represents a numbered possibility called a rule.
4. Place an X in the action entries area for each rule to indicate whether to accept or reject the order.

1 → VERIFY ORDER Process

	1	2	3	4	
2 → Credit status is OK	Y	Y	N	N	3
2 → Product is in stock	Y	N	Y	N	3
Accept order	X				4
Reject order		X	X	X	4

FIGURE 5-29 Example of a simple decision table showing the processing logic of the VERIFY ORDER process. To create the table, follow the four steps shown.

VERIFY ORDER Business Process with Three Conditions

- An order will be accepted only if the product is in stock and the customer's credit status is OK.
- The credit manager can waive the credit status requirement.
- All other orders will be rejected.

FIGURE 5-30 A third condition has been added to the VERIFY ORDER business process. For an order to be accepted, the product must be in stock and the customer must have an acceptable credit status. However, the credit manager now has the authority to waive the credit status requirements.

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First, the Y-N patterns must be filled in, as shown in Figure 5-31. The best way to assure that all combinations appear is to use patterns like these. The first condition uses a pattern of Y-Y-Y-Y followed by N-N-N-N, the second condition uses a repeating Y-Y-N-N pattern, and the pattern in the third condition is a series of Y-Ns.

VERIFY ORDER Process with Credit Waiver (initial version)

	1	2	3	4	5	6	7	8
Credit status is OK	Y	Y	Y	Y	N	N	N	N
Product is in stock	Y	Y	N	N	Y	Y	N	N
Waiver from credit manager	Y	N	Y	N	Y	N	Y	N
Accept order	X	X			X			
Reject order			X	X		X	X	X

FIGURE 5-31 This decision table is based on the VERIFY ORDER conditions shown in Figure 5-30. With three conditions, there are eight possible combinations or rules.

The next step is very important, regardless of the number of conditions. Each numbered column, or rule, represents a different set of conditions. The logic must be carefully analyzed and the outcome for each rule shown. Before going further, study the table in Figure 5-31 to be sure the logical outcome for each of the eight rules is understood.

When all the outcomes have been determined, the next step is to simplify the table. In a multi-condition table, some rules might be duplicates, redundant, or unrealistic. To simplify the table, follow these steps:

1. Study each combination of conditions and outcomes. When there are rules with three conditions, only one or two of them may control the outcome, and the other conditions simply do not matter.
2. If there are conditions that do not affect the outcome, mark them with dashes (-) as shown in the first table in Figure 5-32.
3. Now combine and renumber the rules, as shown in the second table in Figure 5-32.

After following these steps, Rules 1 and 2 can be combined, because credit status is OK in both rules, so the waiver would not matter. Rules 3, 4, 7, and 8 also can be combined because the product is not in stock, so other conditions do not matter. The result is that instead of eight possibilities, only four logical rules control the Verify Order process.

MULTIPLE OUTCOMES: In addition to multiple conditions, decision tables can have more than two possible outcomes. For example, the sales promotion policy shown in Figure 5-33 includes three conditions: Was the customer a preferred customer, did the customer order $1,000 or more, and did the customer use our company charge card? Based on these conditions, four possible actions can occur, as shown in the decision table in Figure 5-34.

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VERIFY ORDER Process with Credit Waiver (with rules marked for combination)

	1	2	3	4	5	6	7	8
Credit status is OK	Y	Y	-	-	N	N	-	-
Product is in stock	Y	Y	N	N	Y	Y	N	N
Waiver from credit manager	-	-	-	-	Y	N	-	-
Accept order	X	X			X			
Reject order			X	X		X	X	X

1. Because the product is not in stock, the other conditions do not matter.
2. Because the other conditions are met, the waiver does not matter.

VERIFY ORDER Process with Credit Waiver (after rule combination and simplification)

	1 (COMBINES PREVIOUS 1, 2)	2 (PREVIOUS 5)	3 (PREVIOUS 6)	4 (COMBINES PREVIOUS 3, 4, 7, 8)
Credit status is OK	Y	N	N	-
Product is in stock	Y	Y	Y	N
Waiver from credit manager	-	Y	N	-
Accept order	X	X		
Reject order			X	X

FIGURE 5-32 In the first decision table, dashes have been added to indicate that a condition is not relevant. In the second version of the decision table, rules have been combined following the steps shown below. Note that in the final version, only four rules remain. These rules document the logic and will be transformed into program code when the system is developed.

SALES PROMOTION POLICY – Holiday Season

- Preferred customers who order $1,000 or more are entitled to a 5% discount and an additional 5% discount if they use our charge card.
- Preferred customers who do not order $1,000 or more will receive a $25 bonus coupon.
- All other customers will receive a $5 bonus coupon.

FIGURE 5-33 A sales promotion policy with three conditions. Note that the first statement contains two *separate* conditions: one for the 5% discount and another for the additional discount.

Sales Promotion Policy (initial version)

	1	2	3	4	5	6	7	8
Preferred customer	Y	Y	Y	Y	N	N	N	N
Ordered $1,000 or more	Y	Y	N	N	Y	Y	N	N
Used our charge card	Y	N	Y	N	Y	N	Y	N
5% discount	X	X						
Additional 5% discount	X							
$25 bonus coupon			X	X				
$5 bonus coupon					X	X	X	X

FIGURE 5-34 This decision table is based on the sales promotion policy in Figure 5-33. This is the initial version of the table before simplification.

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As explained in the preceding section, most tables can be simplified, and this one is no exception. After studying the conditions and outcomes, the following becomes apparent:

- In Rule 1, all three conditions are met, so *both* 5% discounts apply.
- In Rule 2, a preferred customer orders $1,000 or more but does not use our charge card, so only *one* 5% discount applies.
- Rules 3 and 4 can be combined into a single rule. Why? If preferred customers do not order $1,000 or more, it does not matter whether they use our charge card—either way, they earn only a $25 bonus coupon. Therefore, Rules 3 and 4 really are a single rule.
- Rules 5, 6, 7, and 8 also can be combined into a single rule—because if the person is *not* a preferred customer, he or she can *only* receive a $5 bonus coupon, and the other conditions simply do not matter. A dash is inserted if a condition is irrelevant, as shown in Figure 5-35.

If dashes are added for rules that are not relevant, the table should resemble the one shown in Figure 5-35. When the results are combined and simplified, only four rules remain: Rule 1, Rule 2, Rule 3 (a combination of initial Rules 3 and 4), and Rule 4 (a combination of initial Rules 5, 6, 7, and 8).

Sales Promotion Policy (final version)

	1	2	3	4	5	6	7	8
Preferred customer	Y	Y	Y	Y	N	N	N	N
Ordered $1,000 or more	Y	Y	N	N	-	-	-	-
Used our charge card	Y	N	-	-	-	-	-	-
5% discount	X	X						
Additional 5% discount	X							
$25 bonus coupon			X	X				
$5 bonus coupon					X	X	X	X

FIGURE 5-35 In this version of the decision table, dashes have been added to indicate that a condition is not relevant. As this point, it appears that several rules can be combined.

Decision tables often are the best way to describe a complex set of conditions. Many analysts use decision tables because they are easy to construct and understand, and programmers find it easy to work from a decision table when developing code.

CASE IN POINT 5.2: Rock Solid Outfitters (Part 1)

The marketing director at Rock Solid Outfitters, a medium-sized supplier of outdoor climbing and camping gear, has asked the IT manager to develop a special web-based promotion. Rock Solid will provide free shipping for any customer who either completes an online survey form or signs up for the Rock Solid online newsletter. Additionally, if a customer completes the survey and signs up for the newsletter, Rock Solid will provide a $10 merchandise credit for orders of $100 or more. The IT manager has asked you to develop a decision table that will reflect the promotional rules that a programmer will use. She wants you to show all possibilities, and then to simplify the results to eliminate any combinations that would be unrealistic or redundant. How will you proceed?

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5.9.5 Decision Trees

A **decision tree** is a graphical representation of the conditions, actions, and rules found in a decision table. Decision trees show the logic structure in a horizontal form that resembles a tree with the roots at the left and the branches to the right. Like flowcharts, decision trees are useful ways to present the system to management. Decision trees and decision tables provide the same results but in different forms. In many situations, a graphic is the most effective means of communication.

Figure 5-36 is based on the sales promotion policy shown in Figure 5-33. A decision tree is read from left to right, with the conditions along the various branches and the actions at the far right. Because the example has two conditions with four resulting sets of actions, the example has four terminating branches at the right side of the tree.

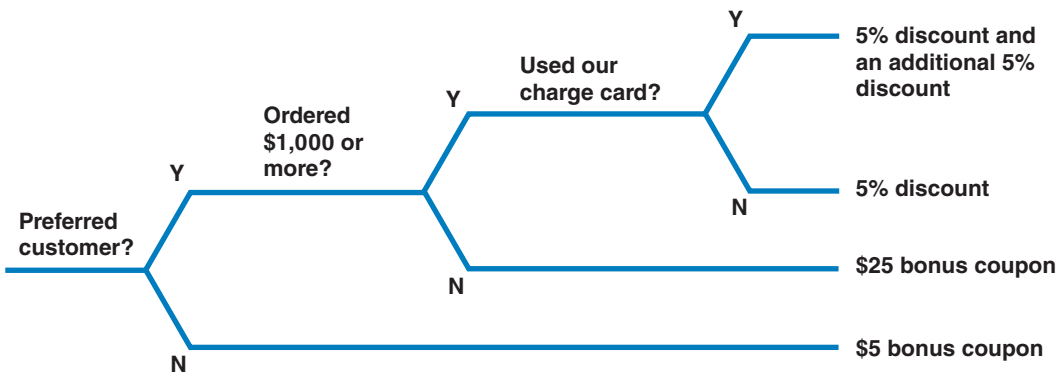


FIGURE 5-36 This decision tree example is based on the same Sales Promotion Policy shown in the decision tables in Figures 5-34 and 5-35. Like a decision table, a decision tree shows all combinations of conditions and outcomes. The main difference is the graphical format, which some viewers may find easier to interpret.

Whether to use a decision table or a decision tree often is a matter of personal preference. A decision table might be a better way to handle complex combinations of conditions. On the other hand, a decision tree is an effective way to describe a relatively simple process.

CASE IN POINT 5.3: Rock Solid Outfitters (Part 2)

The IT manager at Rock Solid Outfitters thinks you did a good job on the decision table task she assigned to you. Now she wants you to use the same data to develop a decision tree that will show all the possibilities for the web-based promotion described in Part 1 of the case. She also wants you to discuss the pros and cons of decision tables versus decision trees. How shall you proceed this time?

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A QUESTION OF ETHICS



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This is your first week in your new job at Safety Zone, a leading producer of IT modeling software. Your prior experience with a smaller competitor gave you an edge in landing the job, and you are excited about joining a larger company in the same field.

So far, all is going well, and you are getting used to the new routine. However, you are concerned about one issue. In your initial meeting with the IT manager, she seemed very interested in the details of your prior position, and some of her questions made you a little uncomfortable. She did not actually ask you to reveal any proprietary information, but she made it clear that Safety Zone likes to know as much as possible about its competitors.

Thinking about it some more, you try to draw a line between information that is OK to discuss and topics such as software specifics or strategy that should be considered private. This is the first time you have ever been in a situation like this. How will you handle it?

5.10 Summary

Structured analysis tools can be used to develop a logical model during one systems analysis phase and a physical model during the systems design phase. Many analysts use a four-model approach, which involves a physical model of the current system, a logical model of the current system, a logical model of the new system, and a physical model of the new system.

During data and process modeling, a systems analyst develops graphical models to show how the system transforms data into useful information. The end product of data and process modeling is a logical model that will support business operations and meet user needs. Data and process modeling involves three main tools: DFDs, a data dictionary, and process descriptions.

DFDs graphically show the movement and transformation of data in the information system. DFDs use four symbols: The process symbol transforms data, the data flow symbol shows data movement, the data store symbol shows data at rest, and the external entity symbol represents someone or something connected to the information system. Various rules and techniques are used to name, number, arrange, and annotate the set of DFDs to make them consistent and understandable.

A set of DFDs is like a pyramid with the context diagram at the top. The context diagram represents the information system's scope and its external connections but not its internal workings. Diagram 0 displays the information system's major processes, data stores, and data flows and is the exploded version of the context diagram's process symbol, which represents the entire information system. Lower-level DFDs show additional detail of the information system through the leveling technique of numbering and partitioning. Leveling continues until the functional primitive processes are reached, which are not decomposed further and are documented with process descriptions. All diagrams must be balanced to ensure their consistency and accuracy.

The data dictionary is the central documentation tool for structured analysis. All data elements, data flows, data stores, processes, entities, and records are documented in the data dictionary. Consolidating documentation in one location allows the analyst to verify the information system's accuracy and consistency more easily and generate a variety of useful reports.

Each functional primitive process is documented using structured English, decision tables, and decision trees. Structured English uses a subset of standard English that defines each process with combinations of the basic building blocks of sequence, selection, and iteration. Using decision tables or decision trees can also document the logic.

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Key Terms

alias A term used in various data dictionaries to indicate an alternate name, or a name other than the standard data element name, that is used to describe the same data element.

balancing A process used to maintain consistency among an entire series of diagrams, including input and output data flows, data definition, and process descriptions.

black box A metaphor for a process or an action that produces results in a non-transparent or non-observable manner. In DFDs, a process appears as a black box where the inputs, outputs, and general function of the process are known, but the underlying details are not shown.

black hole A process that has no output.

business logic Rules to determine how a system handles data and produces useful information, reflecting the operational requirements of the business. Examples include adding the proper amount of sales tax to invoices, calculating customer balances and finance charges, and determining whether a customer is eligible for a volume-based discount. Also called **business rules**.

business rules *See* **business logic**.

child diagram The lower-level diagram in an exploded DFD.

context diagram A top-level view of an information system that shows the boundaries and scope.

control structure Serve as building blocks for a process. Control structures have one entry and exit point. They may be completed in sequential order, as the result of a test or condition, or repeated until a specific condition changes. Also called **logical structure**.

data dictionary A central storehouse of information about a system's data.

data element A single characteristic or fact about an entity. A data element, field, or attribute is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of a data element. Also called **data item**.

data flow A path for data to move from one part of the information system to another.

data flow diagram (DFD) Diagram that shows how the system stores, processes, and transforms data into useful information.

data item *See* **data element**.

data repository A symbol used in DFDs to represent a situation in which a system must retain data because one or more processes need to use that stored data at a later time. Used interchangeably with the term **data store**.

data store *See* **data repository**.

data structure A meaningful combination of related data elements that are included in a data flow or retained in a data store. A framework for organizing and storing data.

decision table A table that shows a logical structure, with all possible combinations of conditions and resulting actions.

decision tree A graphical representation of the conditions, actions, and rules found in a decision table.

decomposing Another way of conveying a process or system that has been broken down from a general, top-level view to more detail. The terms *exploded* and *partitioned* also can be used.

diagram 0 A diagram depicting the first level of detail below the initial context diagram. Diagram 0 (zero) zooms in on the context diagram and shows major processes, data flows, and data stores, as well as repeating the external entities and data flows that appear in the context diagram.

diverging data flow A data flow in which the same data travels to two or more different locations.

domain The set of values permitted for a data element.

entity A person, a place, a thing, or an event for which data is collected and maintained. For example, an online sales system may include entities named CUSTOMER, ORDER, PRODUCT, and SUPPLIER.

exploding A diagram is said to be exploded if it "drills down" to a more detailed or expanded view

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field A single characteristic or fact about an entity. A field, or attribute, is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of a field. The terms *data element*, *data item*, and *field* are used interchangeably.

four-model approach A physical model of the current system, a logical model of the current system, a logical model of the new system, and a physical model of the new system are all developed.

functional primitive A single function that is not exploded further. The logic for functional primitives is documented in a data dictionary process description.

Gane and Sarson A popular symbol set used in DFDs. Processes, data flows, data stores, and external entities all have a unique symbol.

gray hole A process with an input obviously insufficient to generate the shown output.

iteration The completion of a process step that is repeated until a specific condition changes.

leveling The process of drawing a series of increasingly detailed diagrams to reach the desired level of detail.

logical model Shows what a system must do, regardless of how it will be implemented physically.

logical structure *See* **control structure**.

looping Refers to a process step that is repeated until a specific condition changes. For example, a process that continues to print paychecks until it reaches the end of the payroll file is looping. Also known as repetition.

modular design A design that can be broken down into logical blocks. Also known as partitioning or top-down design.

parent diagram The higher or more top-level diagram in an exploded DFD.

partitioning The breaking down of overall objectives into subsystems and modules.

physical model A model that describes how a system will be constructed.

process Procedure or task that users, managers, and IT staff members perform. Also, the logical rules of a system that are applied to transform data into meaningful information. In DFDs, a process receives input data and produces output that has a different content, form, or both.

process 0 In a DFD, process 0 (zero) represents the entire information system but does not show the internal workings.

process description A documentation of a functional primitive's details, which represents a specific set of processing steps and business logic.

pseudocode A technique for representing program logic.

record A set of related fields that describes one instance, or member of an entity, such as one customer, one order, or one product. A record might have one or dozens of fields, depending on what information is needed. Also called a tuple.

selection A control structure in modular design, it is the completion of two or more process steps based on the results of a test or condition.

sequence The completion of steps in sequential order, one after another.

sink An external entity that receives data from an information system.

source An external entity that supplies data to an information system.

spontaneous generation An unexplained generation of data or information. With respect to DFDs, processes cannot spontaneously generate data flows—they must have an input to have an output.

structured English A subset of standard English that describes logical processes clearly and accurately.

terminator A DFD symbol that indicates a data origin or final destination. Also called an external entity.

validity rules Checks that are applied to data elements when data is entered to ensure that the value entered is valid. For example, a validity rule might require that an employee's salary number be within the employer's predefined range for that position.

Yourdon A type of symbol set that is used in DFDs. Processes, data flows, data stores, and external entities each have a unique symbol in the Yourdon symbol set.

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Exercises

Questions

1. What is the relationship between logical and physical models?
2. What is the function of a DFD in the SDLC?
3. Draw examples of the four basic DFD symbols.
4. What are the six guidelines to follow when drawing DFDs?
5. What is the difference between a context diagram and diagram 0?
6. Which symbol is *not* used in a context diagram?
7. How would you level a DFD?
8. How would you balance a DFD?
9. What is a data element?
10. What is the purpose of a decision table?

Discussion Topics

1. How would you convince management that following a four-model approach is wise?
2. When might it be appropriate to violate the "no crossed lines" guideline in DFDs?
3. What is the relationship between system requirements and context diagrams?
4. How might CASE tools be used to document the design of a data dictionary?
5. Some systems analysts find it better to start with a decision table, and then construct a decision tree. Others believe it is easier to do it in the reverse order. Which do you prefer? Why?

Projects

1. The data flow symbols shown in Figure 5-1 were designed by Ed Yourdon, who was a well-known IT author, lecturer, and consultant. Many IT professionals consider him to be among the most influential men and women in the software field. Learn more about Mr. Yourdon by visiting online resources and write a brief review of his work.
2. Explore three CASE tools that provide the ability to draw the four basic DFD symbols and describe what you liked and disliked about each tool.
3. Draw a context diagram and a diagram 0 DFD that represents the information system at a typical library.
4. Create a decision table with three conditions. You can make one up or use a scenario from everyday life. Either way, be sure to show all possible outcomes.
5. Explore the use of Structured English to describe processes in fields other than systems analysis.

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CHAPTER 6 Object Modeling

Chapter 6 is the third of the four chapters in the systems analysis phase of the SDLC. This chapter discusses object modeling techniques that analysts use to create a logical model. In addition to structured analysis, object-oriented analysis is another way to represent and design an information system.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. A "Question of Ethics" considers the situation where an employee wants to skip a course and just sit the exam and requests a copy of the training materials from someone else who took the course.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Demonstrate how object-oriented analysis can be used to describe an information system
2. Explain what an object represents in an information system
3. Explain object attributes
4. Explain object methods
5. Explain object messages
6. Explain classes
7. Explain relationships among objects and classes
8. Draw an object relationship diagram
9. Demonstrate use of the UML to describe object-oriented systems, including use cases, use case diagrams, class diagrams, sequence diagrams, state transition diagrams, activity diagrams, and business process models
10. Explain how tools can support object modeling

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Case in Point 6.1: TravelBiz
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6.3 Attributes
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6.5 Messages
6.6 Classes
6.7 Relationships Among Objects and Classes
6.8 The Unified Modeling Language (UML)
Case in Point 6.2: Hilltop Motors
Case in Point 6.3: Train the Trainers, Inc.
6.9 Tools
A Question of Ethics
6.10 Summary
Key Terms
Exercises

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6.1 Object-Oriented Analysis

As stated in Chapter 1, the most popular systems development options are structured analysis, object-oriented (O-O) analysis, and agile methods. The table in Figure 1-17 shows the three alternatives and describes some pros and cons for each approach. As the table indicates, O-O methodology is popular because it integrates easily with O-O programming languages such as C++, Java, and Python. Programmers also like O-O code because it is modular, reusable, and easy to maintain.

Object-oriented (O-O) analysis describes an information system by identifying things called objects. An **object** represents a real person, place, event, or transaction. For example, when a patient makes an appointment to see a doctor, the patient is an object, the doctor is an object, and the appointment itself is an object.

O-O analysis is a popular approach that sees a system from the viewpoint of the objects themselves as they function and interact. The end product of O-O analysis is an **object model**, which represents the information system in terms of objects and O-O concepts.

Chapter 4 stated that the **Unified Modeling Language (UML)** is a widely used method of visualizing and documenting an information system. In this chapter, the UML is used to develop object models. The first step is to understand basic O-O terms, including objects, attributes, methods, messages, and classes. This chapter shows how systems analysts use those terms to describe an information system.

CASE IN POINT 6.1: TravelBiz

TravelBiz is a nationwide travel agency that specializes in business travel. It has decided to expand into the vacation travel market by launching a new business division called TravelFun. The IT director assigned two systems analysts to create a flexible and an efficient information system for the new division. One analyst wants to use traditional analysis and modeling techniques for the project, while the other analyst wants to use an O-O methodology. Which approach would you suggest and why?

6.2 Objects

An object represents a person, a place, an event, or a transaction that is significant to the information system. In Chapter 5, DFDs were created that treated data and processes separately. An object, however, includes data *and* the processes that affect that data. For example, a customer object has a name, an address, an account number, and a current balance. Customer objects also can perform specific tasks, such as placing an order, paying a bill, and changing their address.

Consider a simplistic example of how the UML might describe a family with parents and children. UML represents an object as a rectangle with the object name at the top, followed by the object's attributes and methods.

Figure 6-1 shows a PARENT object with certain attributes such as name, age, sex, and hair color. If there are two parents, then there are two instances of the PARENT object. The PARENT object can perform methods, such as reading a bedtime story, driving the carpool van, or preparing a school lunch. When a PARENT object receives a message, it performs an action, or method.

For example, the message GOOD NIGHT from a child might tell the PARENT object to read a bedtime story, while the message DRIVE from another parent signals that it is the PARENT object's turn to drive in the carpool.

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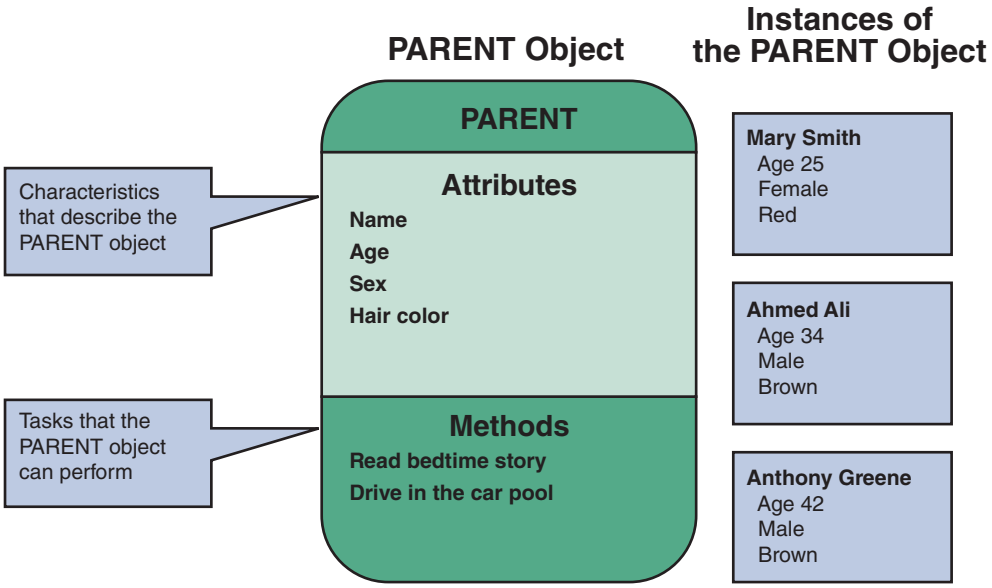


FIGURE 6-1 The PARENT object has four attributes and two methods. Mary Smith, Ahmed Ali, and Anthony Greene are instances of the PARENT object.

Continuing with the family example, the CHILD object in Figure 6-2 possesses the same attributes as the PARENT object and an additional attribute that shows the number of siblings. A CHILD object performs certain methods, such as picking up toys, eating dinner, playing, cooperating, and getting ready for bed. To signal the CHILD object to perform those tasks, a parent can send certain messages that the CHILD object will understand. For example, the DINNER'S READY message tells a CHILD object to come to the table, while the SHARE WITH YOUR BROTHER/SISTER message tells a CHILD object to cooperate with other CHILD objects.

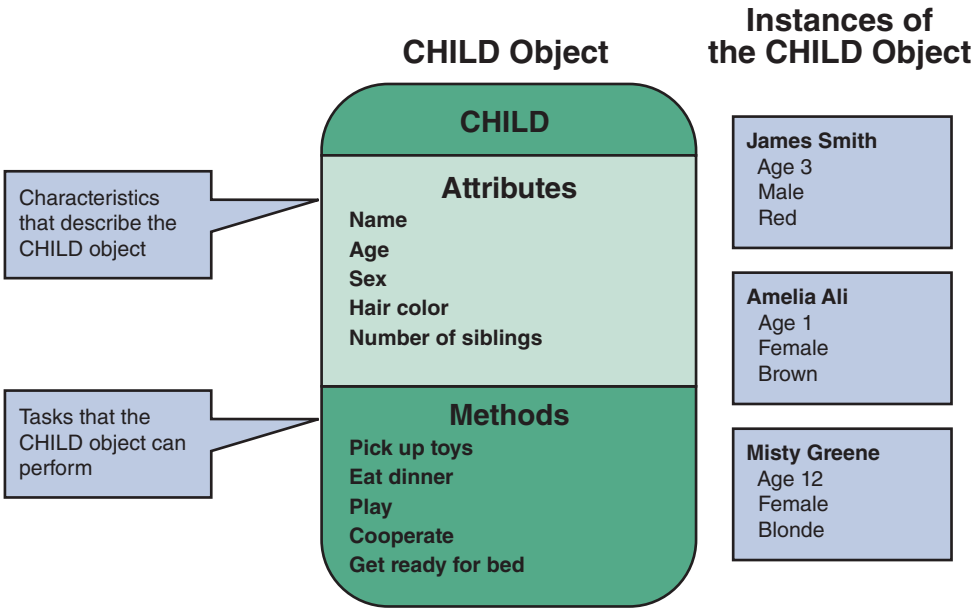


FIGURE 6-2 The CHILD object has five attributes and five methods. James Smith, Amelia Ali, and Misty Greene are instances of the CHILD object.

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6.3 Attributes

An object has certain **attributes**, which are characteristics that describe the object. If objects are similar to nouns, attributes are similar to adjectives that describe the characteristics of an object. For example, a car has attributes such as make, model, and color. Some objects might have a few attributes; others might have dozens.

Systems analysts define an object's attributes during the systems design process. In an O-O system, objects can inherit, or acquire, certain attributes from other objects.

Objects can have a specific attribute called a **state**. The state of an object is an adjective that describes the object's current status. For example, depending on the state, a student can be a future student, a current student, or a past student. Similarly, a bank account can be active, inactive, closed, or frozen.

6.4 Methods

An object also has **methods**, which are tasks or functions that the object performs when it receives a **message**, or command, to do so. For example, a car performs a method called OPERATE WIPERS when it is sent a message with the wiper control, and it can APPLY BRAKES when it is sent a message by pressing the brake pedal. A method defines specific tasks that an object can perform. Just as objects are similar to nouns and attributes are similar to adjectives, methods resemble verbs that describe *what* and *how* an object does something.

Consider a server who prepares fries in a fast-food restaurant. A systems analyst might describe the operation as a method called MORE FRIES, as shown in Figure 6-3. The MORE FRIES method includes the steps required to heat the oil, fill the fry basket with frozen potato strips, lower it into the hot oil, check for readiness, remove the basket when ready and drain the oil, pour the fries into a warming tray, and add salt.

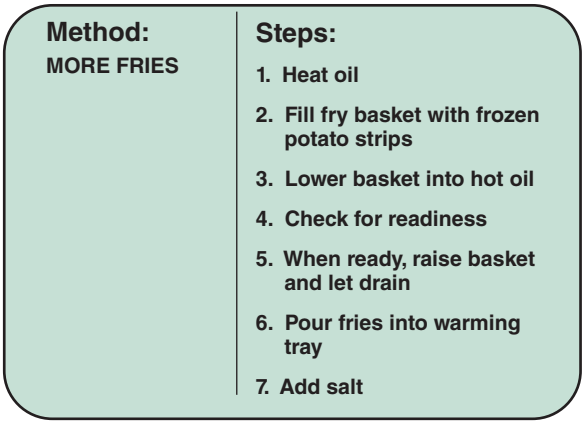


FIGURE 6-3 The MORE FRIES method requires the server to perform seven specific steps.

6.5 Messages

A message is a command that tells an object to perform a certain method. For example, the message PICK UP TOYS directs the CHILD class to perform all the necessary steps to pick up the toys. The CHILD class understands the message and executes the method.

The same message to two different objects can produce different results. The concept that a message gives different meanings to different objects is called **polymorphism**. For example, in Figure 6-4, the message GOOD NIGHT signals the PARENT object to read a

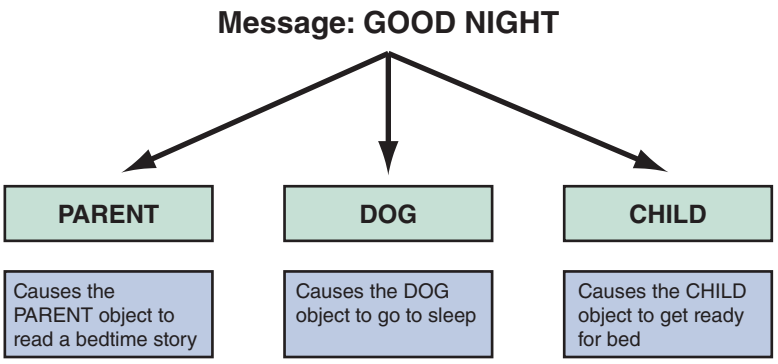


FIGURE 6-4 In an example of polymorphism, the message GOOD NIGHT produces different results, depending on which object receives it.

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bedtime story, but the same message to the CHILD object signals it to get ready for bed. If the family also had a DOG object, the same message would tell the dog to sleep.

An object can be viewed as a **black box**, because a message to the object triggers changes within the object without specifying how the changes must be carried out. A gas pump is an example of a black box. When the economy grade is selected at a pump, it is not necessary to think about how the pump determines the correct price and selects the right fuel, as long as it does so properly.

The black box concept is an example of **encapsulation**, which means that all data and methods are self-contained. A black box does not want or need outside interference. By limiting access to internal processes, an object prevents its internal code from being altered by another object or process. Encapsulation allows objects to be used as modular components anywhere in the system, because objects send and receive messages but do not alter the internal methods of other objects.

O-O designs typically are implemented with O-O programming languages. A major advantage of O-O designs is that systems analysts can save time and avoid errors by using modular objects, and programmers can translate the designs into code, working with reusable program modules that have been tested and verified. For example, in Figure 6-5, an INSTRUCTOR object sends an ENTER GRADE message to an instance of the STUDENT RECORD class. Note that the INSTRUCTOR object and STUDENT RECORD class could be reused, with minor modifications, in other school information systems where many of the attributes and methods would be similar.



FIGURE 6-5 In a school information system, an INSTRUCTOR object sends an ENTER GRADE message to an instance of the STUDENT RECORD class.

6.6 Classes

An object belongs to a group or category called a **class**. For example, Ford Fiestas belong to a class called CAR. An **instance** is a specific member of a class. A Toyota Camry, for example, is an instance of the CAR class. At an auto dealership, many instances of the CAR class may be observed: the TRUCK class, the MINIVAN class, and the SPORT UTILITY VEHICLE class, among others.

All objects within a class share common attributes and methods, so a class is like a blueprint or template for all the objects within the class. Objects within a class can be grouped into **subclasses**, which are more specific categories within a class. For example, TRUCK objects represent a subclass within the VEHICLE class, along with other subclasses called CAR, MINIVAN, and SCHOOL BUS, as shown in Figure 6-6. Note that all four subclasses share common traits of the VEHICLE class, such as make, model, year, weight, and color. Each subclass also can possess traits that are uncommon, such as a load limit for the TRUCK or an emergency exit location for the SCHOOL BUS.

A class can belong to a more general category called a **superclass**. For example, a NOVEL class belongs to a superclass called BOOK, because all novels are books in this example. The NOVEL class can have subclasses called HARDCOVER, PAPERBACK, and DIGITAL.

Similarly, consider a fitness center illustrated in Figure 6-7 that might have students, instructors, class schedules, and a registration process. As shown in Figure 6-8, the EMPLOYEE class belongs to the PERSON superclass, because every employee is a person, and the INSTRUCTOR class is a subclass of EMPLOYEE.

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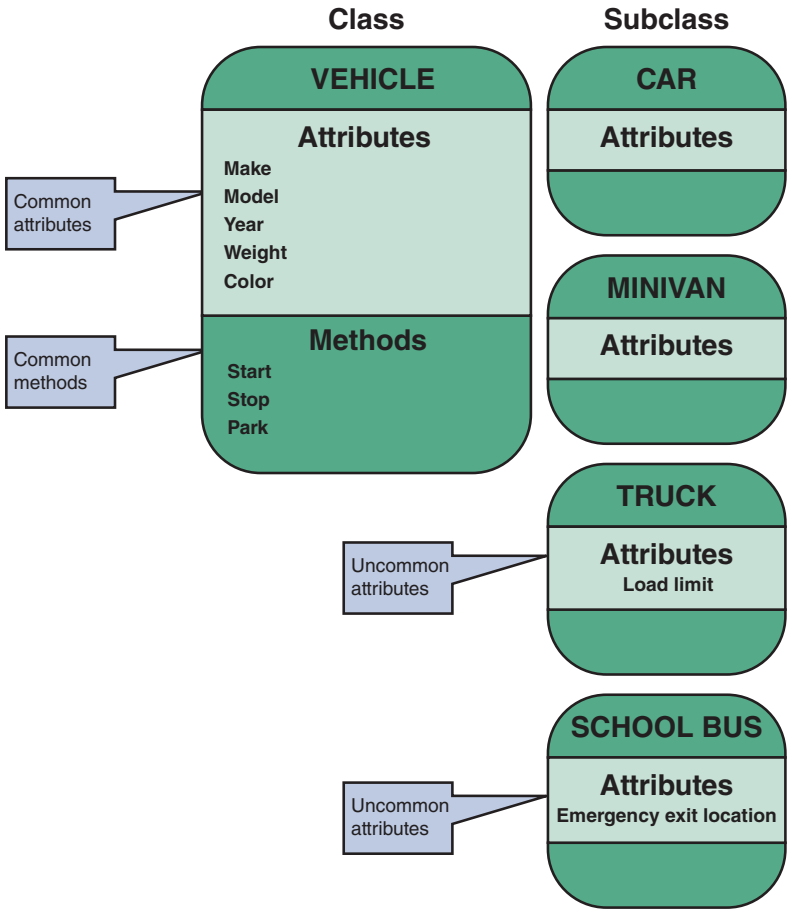




FIGURE 6-7 A typical fitness center might have students, instructors, class schedules, and a registration process.
StockLite/Shutterstock.com

FIGURE 6-6 The VEHICLE class includes common attributes and methods. CAR, TRUCK, MINIVAN, and SCHOOL BUS are instances of the VEHICLE class.

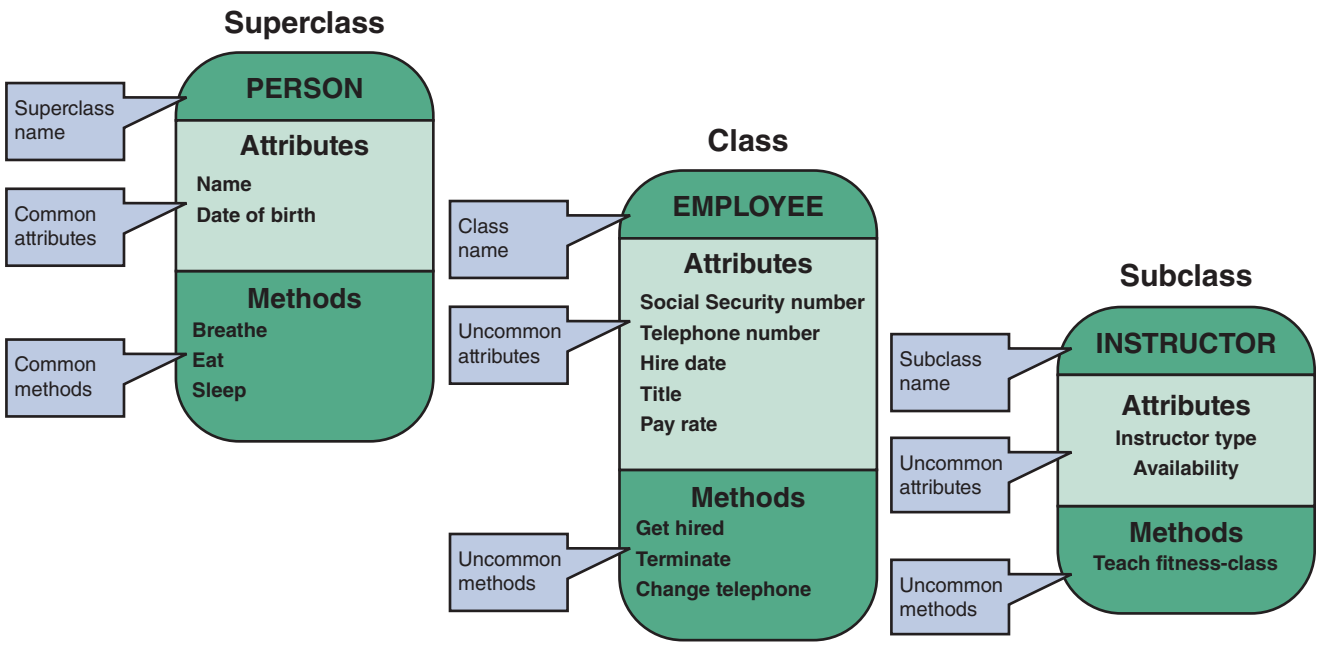


FIGURE 6-8 At the fitness center, the PERSON subclass includes common attributes and methods. EMPLOYEE is a class within the PERSON superclass. INSTRUCTOR is a subclass within the EMPLOYEE class.

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6.7 Relationships Among Objects and Classes

Relationships enable objects to communicate and interact as they perform business functions and transactions required by the system. Relationships describe what objects need to know about each other, how objects respond to changes in other objects, and the effects of membership in classes, superclasses, and subclasses. Some relationships are stronger than others (just as a relationship between family members is stronger than one between casual acquaintances). The strongest relationship is called inheritance. **Inheritance** enables an object, called a **child**, to derive one or more of its attributes from another object, called a **parent**. In the example in Figure 6-9, the INSTRUCTOR object (child) inherits many traits from the EMPLOYEE object (parent), including SOCIAL SECURITY NUMBER, TELEPHONE NUMBER, and HIRE DATE. The INSTRUCTOR object also can possess additional attributes, such as TYPE OF INSTRUCTOR. Because all employees share certain attributes, those attributes are assumed through inheritance and do not need to be repeated in the INSTRUCTOR object.

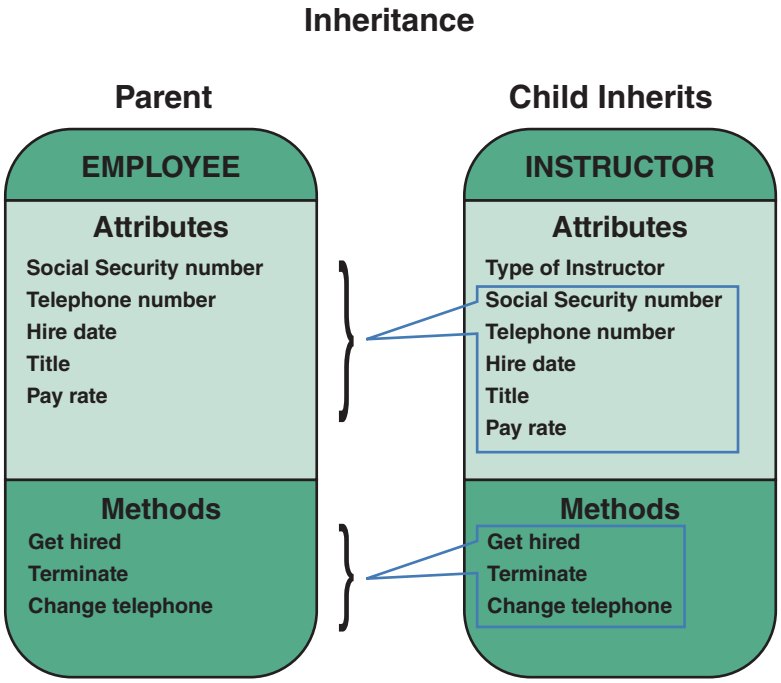


FIGURE 6-9 An inheritance relationship exists between the INSTRUCTOR and EMPLOYEE objects. The INSTRUCTOR (child) object inherits characteristics from the EMPLOYEE (parent) class, and can have additional attributes of its own.

After objects, classes, and relationships have been identified, an object relationship diagram can be prepared to provide an overview of the system. That model is used as a guide to continue to develop additional diagrams and documentation. Figure 6-10 shows an object relationship diagram for a fitness center. Note that the model shows the objects and how they interact to perform business functions and transactions.

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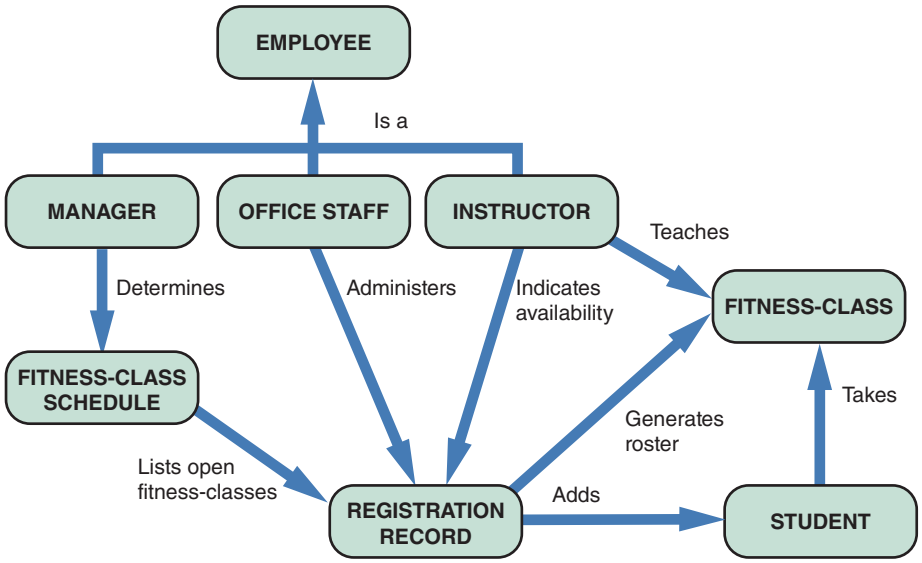


FIGURE 6-10 An object relationship diagram for a fitness center.

6.8 The Unified Modeling Language (UML)

Just as structured analysis uses DFDs to model data and processes, systems analysts use UML to describe O-O systems. Chapter 4 explained that UML is a popular technique for documenting and modeling a system. UML uses a set of symbols to represent graphically the various components and relationships within a system. Although the UML can be used for business process modeling and requirements modeling, it is mainly used to support O-O system analysis and to develop object models.

6.8.1 Use Case Modeling

A **use case** represents the steps in a specific business function or process. An external entity, called an **actor**, initiates a use case by requesting the system to perform a function or process. For example, in a medical office system, a PATIENT (actor) can MAKE APPOINTMENT (use case), as shown in Figure 6-11.

Note that the UML symbol for a use case is an oval with a label that describes the action or event. The actor is shown as a stick figure, with a label that identifies the actor's role. The line from the actor to the use case is called an association, because it links a particular actor to a use case.

Use cases also can interact with other use cases. When the outcome of one use case is incorporated by another use case, we say that the second case *uses* the first case. UML indicates the relationship with an arrow that *points at* the use case being used. Figure 6-12 shows an example where a student adds a fitness class and PRODUCE FITNESS-CLASS ROSTER *uses* the results of ADD FITNESS-CLASS to generate a new fitness-class roster. Similarly, if an instructor changes his or her availability, UPDATE INSTRUCTOR INFORMATION *uses* the CHANGE AVAILABILITY

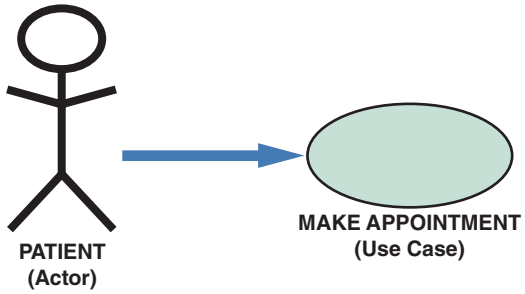


FIGURE 6-11 In a medical office system, a PATIENT (actor) can MAKE APPOINTMENT (use case). The UML symbol for a use case is an oval. The actor is shown as a stick figure.

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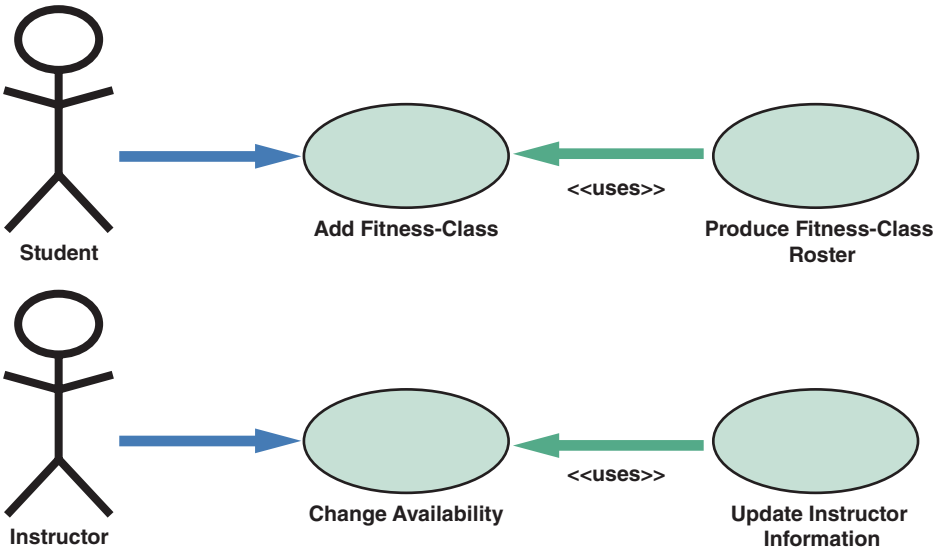
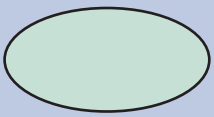


FIGURE 6-12 When a student adds a class, PRODUCE FITNESS-CLASS ROSTER uses the results of ADD FITNESS-CLASS to generate a new roster. When an instructor changes his or her availability, UPDATE INSTRUCTOR INFORMATION uses the CHANGE AVAILABILITY use case to update the instructor's information.

use case to update the instructor's information.

To create use cases, start by reviewing the information that gathered during the requirements modeling phase. The objective is to identify the actors and the functions or transactions they initiate. For each use case, develop a **use case description** in the form of a table. A use case description documents the name of the use case, the actor, a description of the use case, a step-by-step list of the tasks and actions required for successful completion, a description of alternative courses of action, preconditions, postconditions, and assumptions. Figure 6-13 shows an example of the ADD NEW STUDENT use case for the fitness center.



ADD NEW STUDENT Use Case

Name:	Add New Student
Actor:	Student/Manager
Description:	Describes the process used to add a student to a fitness-class
Successful completion:	1. Manager checks FITNESS-CLASS SCHEDULE object for availability 2. Manager notifies student 3. Fitness-class is open and student pays fee 4. Manager registers student
Alternative:	1. Manager checks FITNESS-CLASS SCHEDULE object for availability 2. Fitness-class is full 3. Manager notifies student
Precondition:	Student requests fitness-class
Postcondition:	Student is enrolled in fitness-class and fees have been paid
Assumptions:	None

FIGURE 6-13 The ADD NEW STUDENT use case description documents the process used to add a current student into an existing class at the fitness center.

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When use cases are identified, all the related transactions should be grouped into a single use case. For example, when a hotel customer reserves a room, the reservation system blocks a room, updates the occupancy forecast, and sends the customer a confirmation. Those events are all part of a single use case called RESERVE ROOM, and the specific actions are step-by-step tasks within the use case.

6.8.2 Use Case Diagrams

A **use case diagram** is a visual summary of several related use cases within a system or subsystem. Consider a typical auto service department, as shown in Figure 6-14. The service department involves customers, service writers who prepare work orders and invoices, and mechanics who perform the work. Figure 6-15 shows a possible use case diagram for the auto service department.



FIGURE 6-14 A typical auto service department might involve customers, service writers who prepare work orders and invoices, and mechanics who perform the work.
michaeljung/Shutterstock.com

When a use case diagram is created, the first step is to identify the system boundary, which is represented by a rectangle. The **system boundary** shows what is included in the system (inside the rectangle) and what is not included in the system (outside the rectangle). After the system boundary is identified, use cases are placed on the diagram, the actors are added, and the relationships shown.

CASE IN POINT 6.2: HILLTOP MOTORS

You were hired by Hilltop Motors as a consultant to help the company plan a new information system. Hilltop is an old-line dealership, and the prior owner was slow to change. A new management team has taken over, and they are eager to develop a first-class system. Right now, you are reviewing the service department, which is going through a major expansion. You decide to create a model of the service department in the form of a use case diagram. The main actors in the service operation are customers, service writers who prepare work orders and invoices, and mechanics who perform the work. You are meeting with the management team tomorrow morning. How would you create a draft of the diagram to present to them?

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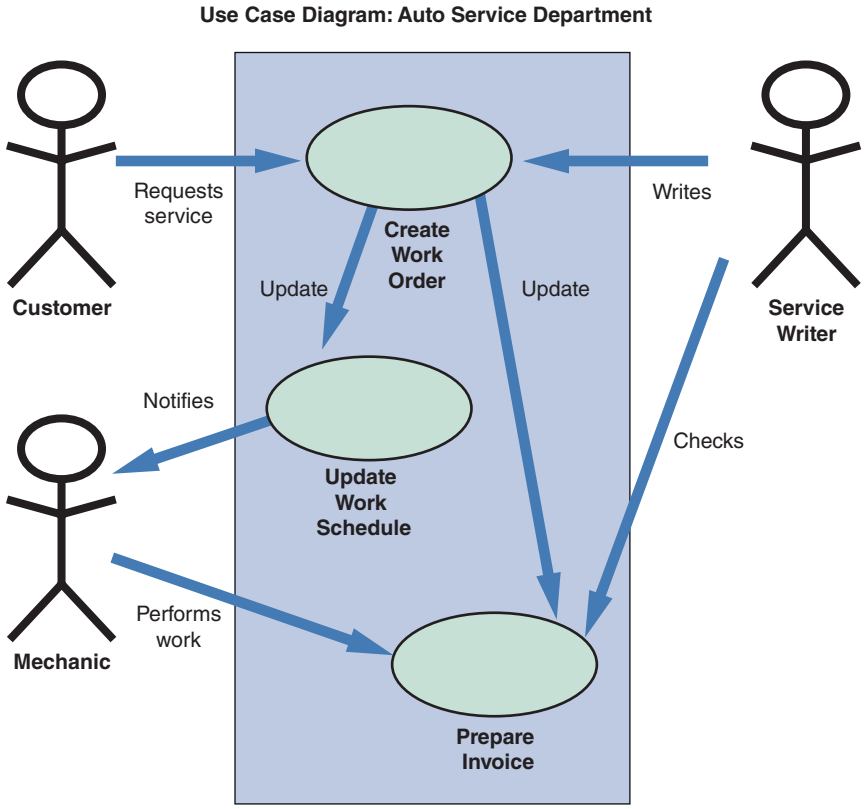


FIGURE 6-15 A use case diagram to handle work at an auto service department.

6.8.3 Class Diagrams

A **class diagram** shows the object classes and relationships involved in a use case. Like a DFD, a class diagram is a logical model, which evolves into a physical model and finally becomes a functioning information system. In structured analysis, entities, data stores, and processes are transformed into data structures and program code. Similarly, class diagrams evolve into code modules, data objects, and other system components.

In a class diagram, each class appears as a rectangle, with the class name at the top, followed by the class's attributes and methods. Lines show relationships between classes and have labels identifying the action that relates the two classes. To create a class diagram, review the use case and identify the classes that participate in the underlying business process.

The class diagram also includes a concept called **cardinality**, which describes how instances of one class relate to instances of another class. For example, an employee might have earned no vacation days or one vacation day or many vacation days. Similarly, an employee might have no spouse or one spouse. Figure 6-16 shows various UML notations and cardinality examples. Note that in Figure 6-16, the first column shows a UML notation symbol that identifies the relationship shown in the second column. The third column provides a typical example of the relationship, which is described in the last column. In the first row of the figure, the UML notation *0..** identifies a *zero or many* relation. The example is that an employee can have no payroll deductions or many deductions.

Figure 6-17 shows a class diagram for a sales order use case. Note that the sales office has one sales manager who can have anywhere from zero to many sales reps. Each sales rep can have anywhere from zero to many customers, but each customer has only one sales rep.

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UML Notation	Nature of the Relationship	Example	Description
0..*	Zero or many	Employee — Payroll Deduction (1 — 0..*)	An employee can have no payroll deductions or many deductions.
0..1	Zero or one	Employee — Spouse (1 — 0..1)	An employee can have no spouse or one spouse.
1	One and only one	Office Manager — Sales Office (1 — 1)	An office manager manages one and only one office.
1..*	One or many	Order — Item Ordered (1 — 1..*)	One order can include one or many items ordered.

FIGURE 6-16 Examples of UML notations that indicate the nature of the relationship between instances of one class and instances of another class.

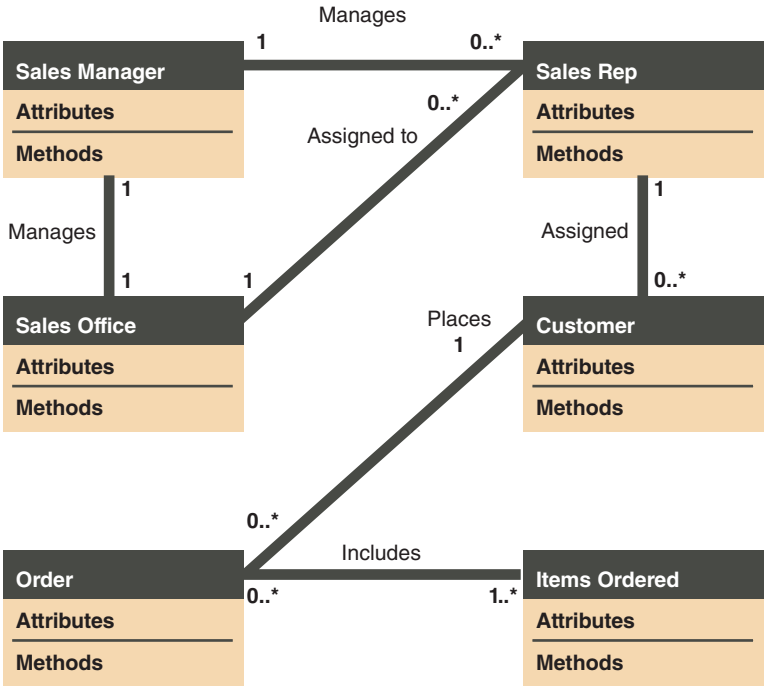


FIGURE 6-17 Class diagram for a sales order use case (attributes and methods omitted for clarity).

CASE IN POINT 6.3: TRAIN THE TRAINERS, INC.

Train the Trainer develops seminars and workshops for corporate training managers, who in turn train their employees. Your job at Train the Trainer is to put together the actual training materials. Right now, you are up against a deadline. The new object modeling seminar has a chapter on cardinality, and the client wants you to come up with at least three more examples for each of the four cardinality categories listed in Figure 6-16. The four categories are *zero or many*, *zero or one*, *one and only one*, and *one or many*. Even though you are under pressure, you are determined to use examples that are realistic and familiar to the students. What examples will you submit?

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6.8.4 Sequence Diagrams

A **sequence diagram** is a dynamic model of a use case, showing the interaction among classes during a specified time period. A sequence diagram graphically documents the use case by showing the classes, the messages, and the timing of the messages. Sequence diagrams include symbols that represent classes, lifelines, messages, and focuses. These symbols are shown in Figure 6-18.

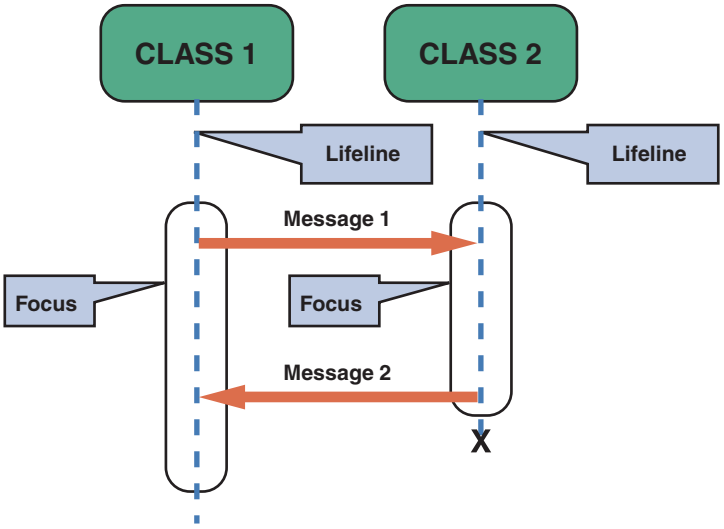


FIGURE 6-18 A sequence diagram with two classes. Notice the X that indicates the end of the CLASS 2 lifeline. Also notice that each message is represented by a line with a label that describes the message, and that each class has a focus that shows the period when messages are sent or received.

CLASSES: A class is identified by a rectangle with the name inside. Classes that send or receive messages are shown at the top of the sequence diagram.

LIFELINES: A lifeline is identified by a dashed line. The **lifeline** represents the time during which the object above it is able to interact with the other objects in the use case. An *X* marks the end of the lifeline.

MESSAGES: A message is identified by a line showing direction that runs between two objects. The label shows the name of the message and can include additional information about the contents.

FOCUSES: A focus is identified by a narrow vertical shape that covers the lifeline. The **focus** indicates when an object sends or receives a message.

Figure 6-19 shows a sequence diagram for the ADD NEW STUDENT use case in the fitness center example. Note that the vertical position of each message indicates the timing of the message.

6.8.5 State Transition Diagrams

Earlier in this chapter, it was explained that state refers to an object's current status. A **state transition diagram** shows how an object changes from one state to another, depending on events that affect the object. All possible states must be documented in the state transition diagram, as shown in Figure 6-20. A bank account, for example, could be opened as a NEW account, change to an ACTIVE or EXISTING account, and eventually become a CLOSED or FORMER account. Another possible state for a bank account could be FROZEN, if the account's assets are legally attached.

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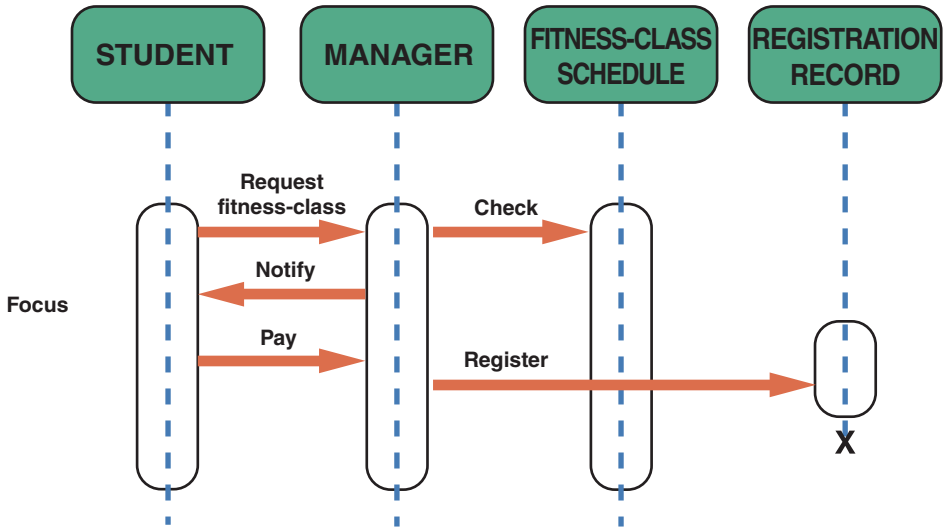


FIGURE 6-19 The sequence diagram for the ADD NEW STUDENT use case. The use case description for ADD NEW STUDENT is shown in Figure 6-13.

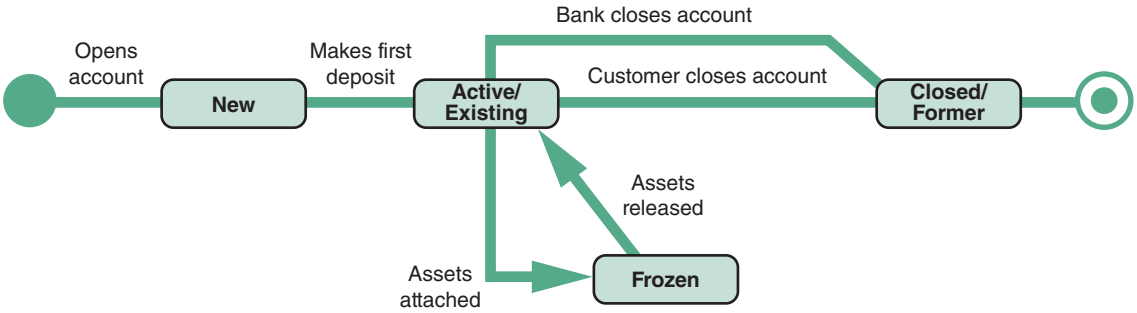


FIGURE 6-20 An example of a state transition diagram for a bank account.

In a state transition diagram, the states appear as rounded rectangles with the state names inside. The small circle to the left is the initial state or the point where the object first interacts with the system. Reading from left to right, the lines show direction and describe the action or event that causes a transition from one state to another. The circle at the right with a hollow border is the final state.

6.8.6 Activity Diagrams

An **activity diagram** resembles a horizontal flowchart that shows the actions and events as they occur. Activity diagrams show the order in which the actions take place and identify the outcomes. Figure 6-21 shows an activity diagram for a cash withdrawal at an ATM machine. Note that the customer initiates the activity by inserting an ATM card and requesting cash. Activity diagrams also can display multiple use cases in the form of a grid, where classes are shown as vertical bars and actions appear as horizontal arrows.

Sequence diagrams, state transition diagrams, and activity diagrams are dynamic modeling tools that can help a systems analyst understand how objects behave and interact with the system.

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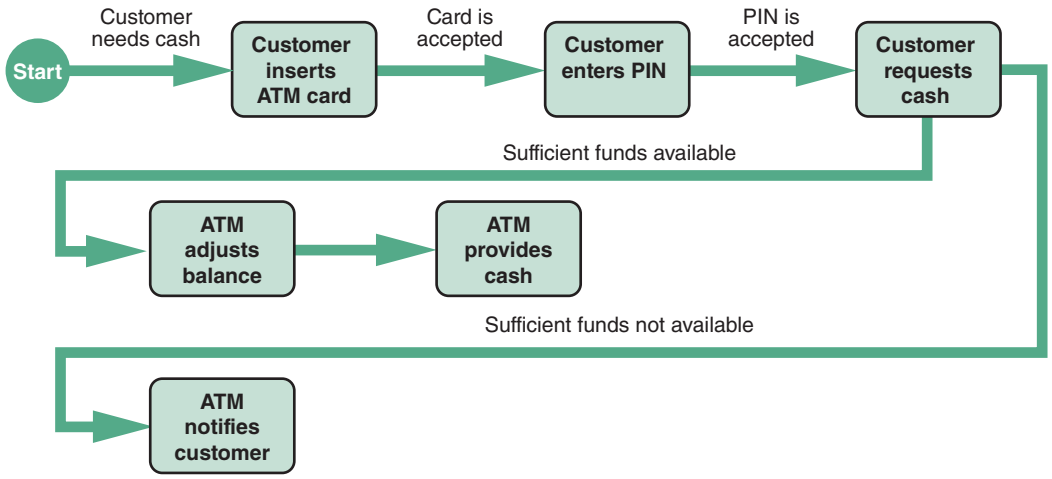


FIGURE 6-21 An activity diagram showing the actions and events involved in withdrawing cash from an ATM.

6.8.7 Business Process Modeling

In addition to sequence diagrams and activity diagrams, business process modeling (BPM) can be used to represent the people, events, and interaction in a system. BPM initially was discussed in Chapter 4 as a requirement diagramming tool, but it can be used anytime during the systems development process. BPM works well with object modeling, because both methods focus on the actors and the way they behave.

There are a number of tools supporting BPM. For example, on Windows, the Bizagi Modeler tool supports business process modeling and simulation using the standard BPM notation. On the Mac, Visual Paradigm supports the creation of BPM diagrams (and several other modeling notations). Figure 6-22 shows a sample BPM for an online discussion cycle.

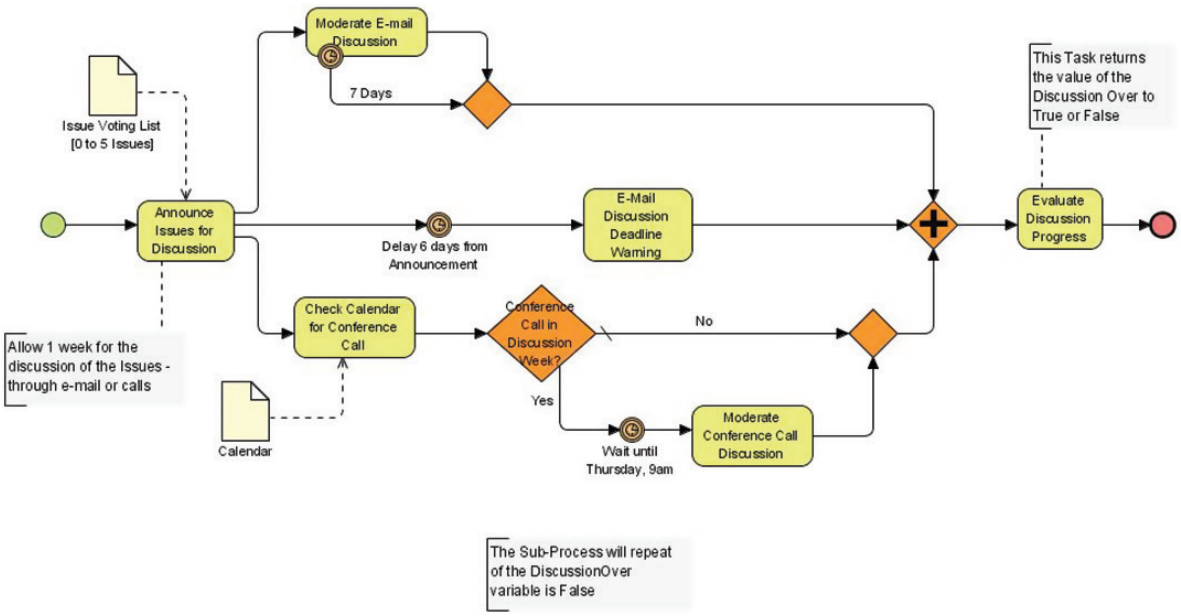


FIGURE 6-22 A BPM for an online discussion cycle.
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6.9 Tools

Object modeling requires many types of diagrams to represent the proposed system. Creating the diagrams by hand is time consuming and tedious, so systems analysts rely on tools to speed up the process and provide an overall framework for documenting the system components. In addition, tools ensure consistency and provide common links so that once objects are described and used in one part of the design, they can be reused multiple times without further effort.

There are many CASE tools tailored to UML. Tools such as Visio are popular for drawing UML diagrams, but they lack semantics: They are useful for creating visually pleasing figures, but they have no knowledge of the underlying artifacts. This means a systems analyst can create diagrams that appear to be correct but are in fact incorrect when it comes to the rules of the UML.

To overcome this shortcoming, proper systems modeling tools, such as Cameo Systems Modeler or IBM's Rational product family, are typically used. These tools understand the meaning of the diagrams they help create, which suggests it's difficult to create a UML diagram that is syntactically incorrect. These tools also provide traceability, an important feature in the SDLC that links design artifacts backward to requirements and forward to development and testing.

A QUESTION OF ETHICS



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Your company sent several staff members for UML training by an outside vendor. Everyone who attended the training received a copy of the instructor's materials, which included study guides and sample exam questions and solutions.

After completing the training course, you are eligible to sit a certification exam. If you pass the exam, you will be credentialed as a "UML Expert" by an independent agency. You can parlay these credentials into a higher salary and boost your career.

A coworker who did not attend the training asks for a copy of the training materials. He wants to take the exam without "wasting his time in class." Should you give him a copy of the training materials? If you do, how might this diminish your accomplishments? If you don't, would you be hurting the team by not helping another member become more knowledgeable about the UML?

6.10 Summary

This chapter introduced object modeling, which is a popular technique that describes a system in terms of objects. Objects represent real people, places, events, and transactions. Unlike structured analysis, which treats data and processes separately, objects include data and processes that can affect the data. During the implementation process, systems analysts and programmers transform objects into program code modules that can be optimized, tested, and reused as often as necessary.

O-O terms include attributes, methods, messages, and classes. Attributes are characteristics that describe the object. Methods are tasks or functions that the object performs when it receives a command to do so. Objects can send messages, or commands, that require other objects to perform certain methods, or tasks. The concept that a message gives different meanings to different objects is called polymorphism. An object resembles a black box with encapsulated, or self-contained, data and methods.

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Classes include objects that have similar attributes, or characteristics. Individual members of a class are called object instances. Objects within a class can be grouped into subclasses, which are more specific categories within the class. A class also can belong to a more general category called a superclass.

After identifying the objects, classes, and relationships, an object relationship diagram is prepared that shows the objects and how they interact to perform business functions and transactions. The strongest relationship between objects is inheritance.

The UML is a widely used method of visualizing and documenting an information system. UML techniques include use cases, use case diagrams, class diagrams, sequence diagrams, state transition diagrams, and activity diagrams.

A use case describes a business situation initiated by an actor, who interacts with the information system. Each use case represents a specific transaction, or scenario. A use case diagram is a visual summary of related use cases within a system or subsystem. A class diagram represents a detailed view of a single use case, showing the classes that participate in the underlying business transaction, and the relationship among class instances, which is called cardinality. A sequence diagram is a dynamic model of a use case, showing the interaction among classes during a specified time period. Sequence diagrams include lifelines, messages, and focuses. A state transition diagram shows how an object changes from one state to another, depending on events that affect the object. An activity diagram resembles a horizontal flowchart that shows actions and events as they occur in a system.

In addition to object models, business process modeling (BPM) can be used to represent the people, events, and interaction in a system.

CASE tools provide an overall framework for system documentation. CASE tools can speed up the development process, ensure consistency, and provide common links that enable reuse during O-O analysis.

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Key Terms

activity diagram A diagram that resembles a horizontal flowchart that shows the actions and events as they occur. Activity diagrams show the order in which actions take place and identify the outcome.

actor An external entity with a specific role. In a use case model, actors are used to model interaction with the system.

attribute A single characteristic or fact about an entity. An attribute, or field, is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of an attribute. In O-O analysis, an attribute is part of a class diagram that describes the characteristics of objects in the class. Also known as a data element.

black box A metaphor for a process or an action that produces results in a non-transparent or non-observable manner. In data flow diagrams, a process appears as a black box where the inputs, outputs, and general function of the process are known, but the underlying details are not shown.

cardinality A concept that describes how instances of one entity relate to instances of another entity. Described in entity-relationship diagrams by notation that indicates combinations that include zero or one-to-many, one-to-one, and many-to-many.

child In inheritance, a child is the object that derives one or more attributes from another object, called the parent.

class A term used in object-oriented modeling to indicate a collection of similar objects.

class diagram A detailed view of a single use case, showing the classes that participate in the use case, and documenting the relationship among the classes.

encapsulation The idea that all data and methods are self-contained, as in a black box.

focus In a sequence diagram, a focus indicates when an object sends or receives a message. It is indicated by a narrow vertical rectangle that covers the lifeline.

inheritance A type of object relationship. Inheritance enables an object to derive one or more of its attributes from another object (e.g., an INSTRUCTOR object may inherit many traits from the EMPLOYEE object, such as hire date).

instance A specific member of a class.

lifeline In a sequence diagram, a lifeline is used to represent the time during which the object above it is able to interact with the other objects in the use case. An X marks the end of a lifeline.

message An O-O command that tells an object to perform a certain method.

method Defines specific tasks that an object must perform. Describes what and how an object does something.

object Represents a real person, place, event, or transaction.

object model Describes objects, which combine data and processes. Object models are the end product of O-O analysis.

object-oriented (O-O) analysis Describes an information system by identifying things called objects. An object represents a real person, place, event, or transaction. O-O analysis is a popular approach that sees a system from the viewpoint of the objects themselves as they function and interact with the system.

parent In inheritance, a parent is the object from which the other object, the child, derives one or more attributes.

polymorphism The concept that a message gives different meanings to different objects (e.g., a GOOD NIGHT message might produce different results depending if it is received by a child or the family dog).

relationships Enable objects to communicate and interact as they perform the business functions and transactions required by a system. Relationships describe what objects need to know about each other,

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how objects respond to changes in other objects, and the effects of membership in classes, superclasses, and subclasses.

sequence diagram A diagram that shows the timing of transactions between objects as they occur.

state An adjective that describes an object's current status (e.g., a student could be a CURRENT, FUTURE, or PAST student).

state transition diagram Shows how an object changes from one state to another, depending on the events that affect the object.

subclass A further division of objects in a class. Subclasses are more specific categories within a class.

superclass A more generalized category to which objects may belong (e.g., a NOVEL class might belong to a superclass called BOOK).

system boundary Shows what is included and excluded from a system. Depicted by a shaded rectangle in use case diagrams.

Unified Modeling Language (UML) A widely used method of visualizing and documenting software systems design. UML uses O-O design concepts, but it is independent of any specific programming language and can be used to describe business processes and requirements generally.

use case Represents the steps in a specific business function or process in UML.

use case description A description in UML that documents the name of the use case, the actor, a description of the use case, a step-by-step list of the tasks required for successful completion, and other key descriptions and assumptions.

use case diagram A visual representation that illustrates the interaction between users and the information system in UML.

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Exercises

Questions

1. What is O-O analysis?
2. Define an *object* in an information system and provide three examples.
3. Define an *attribute* and provide three examples.
4. Define a *method* and provide three examples.
5. Define *encapsulation* and explain how it is used in O-O analysis.
6. Define a *class*, *subclass*, and *superclass* and provide three examples of each.
7. Explain the concept of inheritance in object relationships.
8. Draw an object relationship diagram for a typical library system.
9. Define a *use case* and a *use case diagram* and prepare a sample of each.
10. Why is it important to use a modeling tool and not just a diagramming tool during O-O analysis?

Discussion Topics

1. You are an IT consultant, and you are asked to create a new system for a small real estate brokerage firm. You have no experience with O-O approach, and you decide to try it. How will you begin? How will the tasks differ from structured analysis?
2. Some professionals believe that it is harder for experienced analysts to learn object-modeling techniques, because the analysts are accustomed to thinking about data and processes as separate entities. Others believe that solid analytical skills are easily transferable and do not see a problem in crossing over to the newer approach. What do you think, and why?
3. The concept that the same message gives different meanings to different objects is called polymorphism. Can you think of examples where this behavior may provide unexpected results?
4. You are creating a system for a bowling alley to manage information about its leagues. During the modeling process, you create a state transition diagram for an object called *League Bowlers*. What are the possible states of a league bowler, and what happens to a bowler who quits the league and rejoins the following season?
5. The UML is a large and complex modeling language. How can an IT professional tell when a UML diagram is correct and not just visually pleasing?

Projects

1. Contact the IT staff at your school or at a local business to learn if they use O-O programming languages. If so, determine what languages and versions are used, how long they have been in use, and why they were selected.
2. Create a presentation explaining O-O analysis, including definitions of basic terms, including objects, attributes, methods, messages, and classes.
3. Draw an activity diagram showing the actions and events involved in depositing a check to a bank account using a mobile app.
4. Investigate business process modeling languages, such as BPEL.
5. Prepare a report on at least three tools that provide UML support. Use the tools' capabilities for creating class diagrams and sequence diagrams as a key requirement.

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CHAPTER 7 Development Strategies

Chapter 7 is the final chapter in the systems analysis phase of the SDLC. The main objective of the systems analysis phase is to build a logical model of the new information system. Chapters 4, 5, and 6 explained requirements modeling, data and process modeling, and object modeling. Chapter 7 describes the remaining activities in the systems analysis phase, which include evaluation of alternative solutions, preparation of the system requirements document, and presentation of the system requirements document to management. The chapter also explains the transition to systems design.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" concerns how truthful an answer should be when submitting a response to an RFP. Is a slight exaggeration acceptable if it means the company will win the contract?

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Explain the differences between traditional and web-based systems development
2. Explain how Web 2.0, cloud computing, and mobile devices may affect systems development
3. Explain how to select one of the four in-house software development options
4. Explain outsourcing
5. Explain the main advantages and the unique concerns of offshoring
6. Describe the concept of Software as a Service
7. Explain how a systems analyst helps in selecting a development strategy
8. Execute the five steps in the software acquisition process
9. Describe a request for proposal (RFP) and a request for quotation (RFQ)
10. Summarize the tasks involved in completing the systems analysis phase of the SDLC

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7.1 Traditional Versus Web-Based Systems Development

Just a few years ago, a typical company either developed software itself, purchased a software package (which might need some modification), or hired consultants or outside resources to perform the work. Today, a company has many more choices for software acquisition, including application service providers, web-hosted software options, and firms that offer a variety of enterprise-wide software solutions. This proliferation of choices is due in part due to the enormous changes in business methods and operations made possible by the Internet.

A systems analyst must consider whether development will take place in a traditional environment or in a web-centric framework. There are similarities and differences with both approaches. For example, in an Internet-based system, the web becomes an integral part of the application, rather than just a communication channel, and systems analysts need new application development tools and solutions to handle the new systems.

Two representative web-based development environments are Microsoft's .NET and the open source MERN stack. Microsoft describes .NET as a developer platform for building and running a variety of application types written in C# and Visual Basic, including web-based, mobile, and traditional desktop applications. The acronym MERN stands for MongoDB, Express, React, and Node. MERN is used to develop universal applications in JavaScript. MongoDB is a database, and Express, React, and Node are libraries or frameworks used for full-stack web development.

Although there is a major trend toward web-based architecture, many firms rely on traditional systems, either because they are using legacy applications that are not easily replaced, or because they do not require a web component to satisfy user needs. To choose between traditional and web-based development, consider some key differences between them. Building the application in a web-based environment can offer greater benefits (and sometimes greater risks) when compared to a traditional environment. The following sections list some characteristics of traditional versus web-based development.

7.1.1 Traditional Development: In a traditional systems development environment

- Compatibility issues, including existing hardware and software platforms and legacy system requirements, influence systems design.
- Systems are designed to run on local and wide-area company networks.
- Systems often utilize Internet links and resources, but web-based features are treated as enhancements rather than core elements of the design.
- Development typically follows one of three main paths: in-house development, purchase of a software package with possible modification, or use of outside consultants.
- Scalability can be affected by network limitations and constraints.
- Many applications require substantial desktop computing power and resources.
- Security issues usually are less complex than with web-based systems, because the system operates on a private company network, rather than the Internet.

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7.1.2 Web-Based Development: In a web-based systems development environment

- Systems are developed and delivered in an Internet-based framework such as .NET
- Internet-based development treats the web as the platform, rather than just a communication channel.
- Web-based systems are easily scalable and can run on multiple hardware environments.
- Large firms tend to deploy web-based systems as enterprise-wide software solutions for applications such as customer relationship management, order processing, and materials management.
- Web-based software treats the software application as a service that is less dependent on desktop computing power and resources.
- When companies acquire web-based software as a *service* rather than a *product* they purchase, they can limit in-house involvement and have the vendor install, configure, and maintain the system by paying agreed-upon fees.
- Web-based software usually requires additional layers, called **middleware**, to communicate with existing software and legacy systems.
- Web-based solutions open more complex security issues that should be addressed.

7.2 Evolving Trends

In the constantly changing world of IT, no area is more dynamic than Internet technology. Three examples of evolving trends are Web 2.0, cloud computing, and mobile devices. Systems analysts should be aware of these trends and consider them as they plan large-scale systems.


NIST Cloud Computing Program - NCCP

DESCRIPTION

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics (On-demand self-service, Broad network access, Resource pooling, Rapid elasticity, Measured Service); three service models (Cloud Software as a Service (SaaS), Cloud Platform as a Service (PaaS), Cloud Infrastructure as a Service (IaaS)); and, four deployment models (Private cloud, Community cloud, Public cloud, Hybrid cloud). Key enabling technologies include: (1) fast wide-area networks, (2) powerful, inexpensive server computers, and (3) high-performance virtualization for commodity hardware.

The Cloud Computing model offers the promise of massive cost savings combined with increased IT agility. It is considered critical that government and industry begin adoption of this technology in response to difficult economic constraints. However, cloud computing technology challenges many traditional approaches to datacenter and enterprise application design and management. Cloud computing is currently being used; however, security, interoperability, and portability are cited as major barriers to broader adoption.

FIGURE 7-1 NIST definition of cloud computing.
Source: NIST

Many IT professionals use the term **Web 2.0** to describe a second generation of the web that enables people to collaborate, interact, and share information much more effectively. This new environment is based on continuously available user applications rather than static HTML webpages, without limitations regarding the number of users or how they access, modify, and exchange data. The Web 2.0 environment enhances interactive experiences, including wikis and blogs, and social networking applications such as Facebook, LinkedIn, and Twitter.

As shown in Figure 7-1, the National Institute of Standards and Technology (NIST) defines **cloud computing** as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." Cloud computing is often represented by a cloud symbol that indicates a network or the Internet. Cloud computing can be viewed as an online SaaS and data environment supported by powerful computers that makes Web 2.0 possible.

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Mobile devices have become ubiquitous. Smartphones and tablets are now found in personal use and across the enterprise in most organizations. Today's mobile devices have enough computing power to provide processing "at the edge," which means at the end of a network, in the user's hands. Developing apps for mobile devices requires many new platforms, although many of today's development tools support web-based and mobile application development at the same time.

7.3 In-House Software Development Options

A company can choose to develop its own systems or purchase (and possibly customize) a software package. These development alternatives are shown in Figure 7-2. Although many factors influence this decision, the most important consideration is the total cost of ownership (TCO), which was explained in Chapter 4. In addition to these options, companies also develop user applications designed around commercial software packages, such as Microsoft Office, to improve user productivity and efficiency.

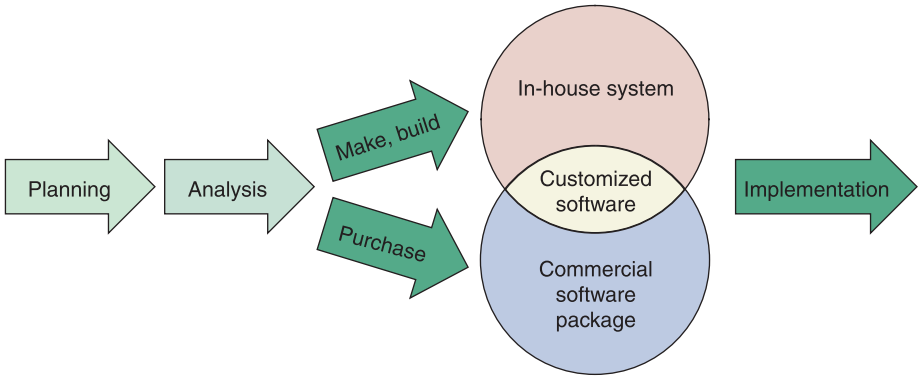


FIGURE 7-2 Instead of outsourcing, a company can choose to develop a system in-house or purchase and possibly customize a commercial package.

7.3.1 Make or Buy Decision

The choice between developing versus purchasing software often is called a **make or buy**, or **build or buy**, decision. The company's IT department makes, builds, and develops **in-house software**. A **software package** is obtained from a vendor or an application service provider.

The package might be a standard commercial application or a customized package designed specifically for the purchaser. Companies that develop software for sale are called **software vendors**. A firm that enhances a commercial package by adding custom features and configuring it for a particular industry is called a **value-added reseller (VAR)**.

Software packages are available for every type of business activity. A software package that can be used by many different types of organizations is called a **horizontal application**. An accounting package is a good example of a horizontal application because many different businesses or separate divisions that exist in large, diversified companies can utilize it.

In contrast, a software package developed to handle information requirements for a specific type of business is called a **vertical application**. For example, organizations

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with special system requirements include colleges, banks, hospitals, insurance companies, construction companies, real estate firms, and airlines. Figure 7-3 shows a typical restaurant point of sale (POS) system running on various devices. The organizations may need vertical applications to handle their unique business requirements but often use horizontal applications for basic business needs, such as payroll processing and accounts payable.



FIGURE 7-3 Restaurants use vertical applications like point of sale (POS) systems to support their unique business requirements.
Source: rmpos

Of the in-house software acquisition options—developing a system, buying a software package, or customizing a software package—each has advantages, disadvantages, and cost considerations, as shown in Figure 7-4. These software acquisition options are described in detail in the following sections.

REASONS FOR IN-HOUSE DEVELOPMENT	REASONS FOR PURCHASING A SOFTWARE PACKAGE
Satisfy unique business requirements	Lower costs
Minimize changes in business procedures and policies	Requires less time to implement
Meet constraints of existing systems	Proven reliability and performance benchmarks
Meet constraints of existing technology	Requires less technical development staff
Develop internal resources and capabilities	Future upgrades provided by the vendor
Satisfy unique security requirements	Obtain input from other companies

FIGURE 7-4 Companies consider various factors when comparing in-house development with the purchase of a software package.

7.3.2 Developing Software In-House

With an enormous variety of software packages available to handle horizontal and vertical business operations, why would a firm choose to develop its own software? Typically, companies choose in-house development to satisfy unique business

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requirements, minimize changes in business procedures and policies, meet constraints of existing systems and existing technology, and develop internal resources and capabilities.

SATISFY UNIQUE BUSINESS REQUIREMENTS: Companies often decide to develop software in-house because no commercially available software package can meet their unique business requirements. A college, for example, needs a course scheduling system based on curriculum requirements, student demand, classroom space, and available instructors. A package delivery company needs a system to identify the best combination of routes and loading patterns for the company's fleet of delivery trucks. If existing software packages cannot handle those requirements, then in-house developed software might be the only choice.

MINIMIZE CHANGES IN BUSINESS PROCEDURES AND POLICIES: A company also might choose to develop its own software if available packages will require changes in current business operations or processes. Installing a new software package almost always requires some degree of change in how a company does business; however, if the installation of a purchased package will be too disruptive, the organization might decide to develop its own software instead.

MEET CONSTRAINTS OF EXISTING SYSTEMS: Any new software installed must work with existing systems. For example, if a new budgeting system must interface with an existing accounting system, finding a software package that works correctly with the existing accounting system might prove difficult. If so, a company could develop its own software to ensure that the new system will interface with the old system.

MEET CONSTRAINTS OF EXISTING TECHNOLOGY: Another reason to develop software in-house is that the new system must work with existing hardware and legacy systems. That could require a custom design, an upgrade to the environment, or in-house software that can operate within those constraints. A systems analyst addresses the issue of technical feasibility during the preliminary investigation. Now, in the systems analysis phase, the analyst must determine whether in-house software development is the best overall solution.

DEVELOP INTERNAL RESOURCES AND CAPABILITIES: By designing a system in-house, companies can develop and train an IT staff who understands the organization's business functions and information support needs. Many firms feel that in-house IT resources and capabilities provide a competitive advantage because an in-house team can respond quickly when business problems or opportunities arise. For example, if a company lacks internal resources, it must depend on an outside firm for vital business support. Also, outsourcing options might be attractive, but a series of short-term solutions would not necessarily translate into lower TCO over the long term. Top managers often feel more comfortable with an internal IT team to provide overall guidance and long-term stability. In-house development also allows a firm to leverage the skill set of the IT team, which is already on board and being compensated.

7.3.3 Purchasing a Software Package

If a company decides not to outsource, a commercially available software package might be an attractive alternative to developing its own software. Advantages of purchasing a software package over developing software in-house include lower costs,

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less time to implement a system, proven reliability and performance benchmarks, less technical development staff, future upgrades that are provided by the vendor, and the ability to obtain input from other companies who already have implemented the software.

LOWER COSTS: Because many companies use software packages, software vendors spread the development costs over many customers. Compared with software developed in-house, a software package almost always is less expensive, particularly in terms of initial investment. However, even though the initial cost is less, purchased software can involve expenses caused by business disruption, changing business processes, and retraining employees.

REQUIRES LESS TIME TO IMPLEMENT: When a software package is purchased, it already has been designed, programmed, tested, and documented. The in-house time normally spent on those tasks, therefore, is eliminated. Of course, the software must still be installed and integrated into the systems environment, which can take a significant amount of time. Also, even though implementation is quicker, TCO can be higher due to added training expenses and software modifications.

PROVEN RELIABILITY AND PERFORMANCE BENCHMARKS: If the package has been on the market for any length of time, any major problems probably have been detected already and corrected by the vendor. If the product is popular, it almost certainly has been rated and evaluated by independent reviewers.

REQUIRES LESS TECHNICAL DEVELOPMENT STAFF: Companies that use commercial software packages often are able to reduce the number of programmers and systems analysts on the IT staff. Using commercial software also means that the IT staff can concentrate on systems whose requirements cannot be satisfied by software packages.

FUTURE UPGRADES PROVIDED BY THE VENDOR: Software vendors regularly upgrade software packages by adding improvements and enhancements to create a new version or release. A new release of a software package, for example, can include drivers to support a new laser printer or a new type of data storage technology. In many cases, the vendor receives input and suggestions from current users when planning future upgrades.

INPUT FROM OTHER COMPANIES: Using a commercial software package means that users in other companies can be contacted to obtain their input and impressions. Trying the package or making a site visit to observe the system in operation may be very useful before a final decision is made. Companies can make use of user groups to share experiences with a software package.

7.3.4 Customizing a Software Package

If the standard version of a software product does not satisfy a company's requirements, the firm can consider adapting the package to meet its needs. Three ways to customize a software package are as follows:

- Purchase a basic package that vendors will customize to suit the project's needs. Many vendors offer basic packages in a standard version with add-on components that are configured individually. A vendor offers options when the

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standard application will not satisfy all customers. A human resources information system is a typical example, because each company handles employee compensation and benefits differently.

- Negotiate directly with the software vendor to make enhancements to meet the project's needs by paying for the changes.
- Purchase the package and make project-specific modifications, if this is permissible under the terms of the software license. A disadvantage of this approach is that systems analysts and programmers might be unfamiliar with the software and will need time to learn the package and make the modifications correctly.

Additionally, some advantages of purchasing a standard package disappear if the product must be customized. If the vendor does the customizing, the modified package probably will cost more and take longer to obtain. Another issue is future support: Although vendors regularly upgrade their standard software packages, they might not upgrade a customized version. In addition, if the modifications are done by the company purchasing the software, when a new release of the package becomes available, the company might have to modify the new version on its own, because the vendor will not support modifications installed by the customer.

7.3.5 Creating User Applications

Business requirements sometimes can be fulfilled by a user application, rather than a formal information system or commercial package. User applications are examples of user productivity systems, which were discussed in Chapter 1.

A **user application** utilizes standard business software, such as Microsoft Word or Microsoft Excel, which has been configured in a specific manner to enhance user productivity. For example, to help a sales rep respond rapidly to customer price requests, an IT support person can set up a form letter with links to a spreadsheet that calculates incentives and discounts. In addition to configuring the software, the IT staff can create a **user interface**, which includes screens, commands, controls, and features that enable users to interact more effectively with the application.

In some situations, user applications offer a simple, low-cost solution. Most IT departments have a backlog of projects, and IT solutions for individuals or small groups do not always receive a high priority. At the same time, application software is more powerful, flexible, and user-friendly than ever. Companies such as Apple and Microsoft offer software suites and integrated applications that can exchange data with programs that include tutorials, wizards, and Help features to guide less-experienced users who know what they need to do but do not know how to make it happen.

Many companies empower lower-level employees by providing more access to data and more powerful data management tools. The main objective is to allow lower-level employees more access to the data they require to perform their jobs, with no intervention from the IT department. This can be accomplished by creating effective user interfaces for company-wide applications, such as accounting, inventory, and sales systems. Another technique is to customize standard productivity software, such as Microsoft Word or Microsoft Excel, to create user applications. In either case, empowerment makes the IT department more productive because it can spend less time responding to the daily concerns and data needs of users and more time on high-impact systems development projects that support strategic business goals.

Empowerment reduces costs and makes good business sense, but companies that adopt this approach must provide the technical support that empowered users require. In most large- and medium-sized companies, a **service desk** within the IT

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department is responsible for providing user support. The service desk offers services such as hotline assistance, training, and guidance to users who need technical help.

Users typically require spreadsheets, database management programs, and other software packages to meet their information needs. If user applications access corporate data, appropriate controls must be provided to ensure data security and integrity. For example, some files should be hidden totally from view; others should have read-only properties, so users can view, but not change, the data.

CASE IN POINT 7.1: Doug's Sporting Goods

Doug's Sporting Goods sells hiking and camping supplies. The company has grown considerably in the past two years. They want to develop a customer order entry system and hired your IT consulting firm to advise them about development strategies. They are leaning toward in-house development because they do not want to depend on outside vendors and suppliers for technical support and upgrades. They also say they are not interested in selling on the Web, but that could change in the future. They want to meet with you tomorrow to make a decision. What will you say to them at the meeting?

7.4 Outsourcing

Outsourcing is the transfer of information systems development, operation, or maintenance to an outside firm that provides these services, for a fee, on a temporary or long-term basis. Outsourcing can refer to relatively minor programming tasks: renting software from a service provider, outsourcing a basic business process (often called **business process outsourcing**, or **BPO**), or handling a company's entire IT function.

7.4.1 The Growth of Outsourcing

Traditionally, firms outsourced IT tasks as a way of controlling costs and dealing with rapid technological change. Oracle cites data that shows that businesses spend up to 80% of their IT budgets maintaining existing software and systems, which forces IT managers ". . . to spend time managing tedious upgrades instead of revenue-generating IT projects." While those reasons still are valid, outsourcing has become part of an overall IT strategy for many organizations. The outsourcing trend also has affected software vendors, who have adjusted their marketing accordingly.

A firm that offers outsourcing solutions is called a **service provider**. Some service providers concentrate on specific software applications; others offer business services such as order processing and customer billing. Still others offer enterprise-wide software solutions that integrate and manage functions such as accounting, manufacturing, and inventory control.

Two popular outsourcing options involve application service providers and firms that offer Internet business services. These terms are explained in the following sections.

APPLICATION SERVICE PROVIDERS: An **application service provider (ASP)** is a firm that delivers a software application, or access to an application, by charging a usage or subscription fee. An ASP provides more than a license to use the software; it *rents* an operational package to the customer. ASPs typically provide commercially

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available software such as databases and accounting packages. If a company uses an ASP to supply a data management package, for example, the company does not have to design, develop, implement, or maintain the package.

INTERNET BUSINESS SERVICES: Some firms offer **Internet business services (IBSs)**, which provide powerful web-based support for transactions such as order processing, billing, and customer relationship management. Another term for IBS is **managed hosting**, because the outside firm (host) manages system operations.

An IBS solution is attractive to customers because it offers online data center support, mainframe computing power for mission-critical functions, and universal access via the Internet. Many firms, such as Rackspace, compete in the managed cloud services market, as shown in Figure 7-5.

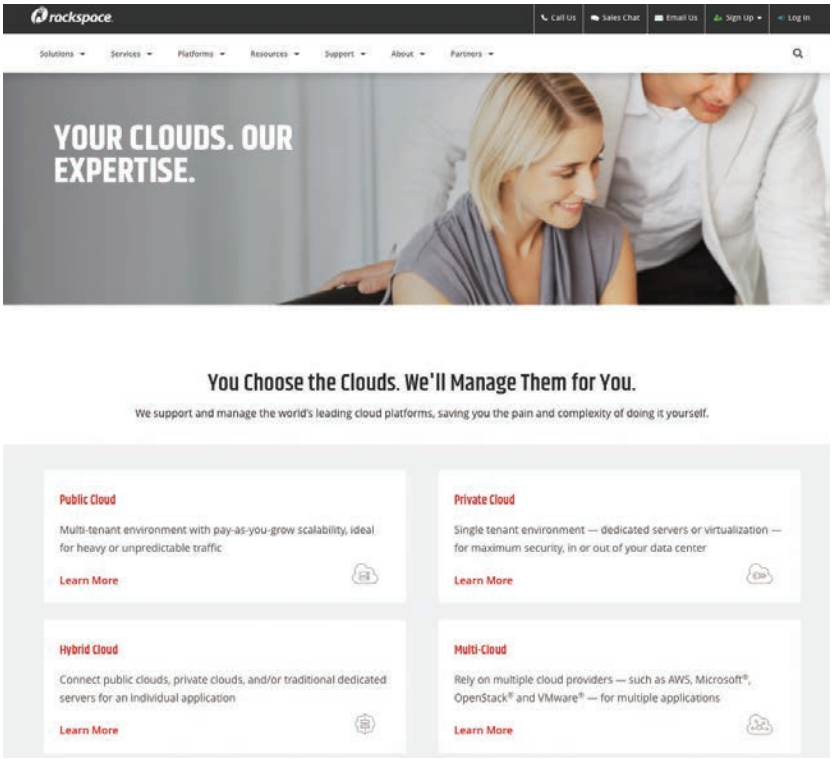


FIGURE 7-5 Rackspace managed cloud services.
Source: Rackspace

7.4.2 Outsourcing Fees

Firms that offer Software as a Service, rather than a product, have developed fee structures that are based on how the application is used by customers during a specific time period. Several models exist, including fixed fee, subscription, and usage or transaction. A **fixed fee model** uses a set fee based on a specified level of service and user support. A **subscription model** has a variable fee based on the number of users or workstations that have access to the application. Finally, a **usage model** or **transaction model** charges a variable fee based on the volume of transactions or operations performed by the application.

When a company considers outsourcing, it should estimate usage characteristics to determine which fee structure would be most desirable and then attempt to negotiate a service provider contract based on that model.

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7.4.3 Outsourcing Issues and Concerns

When a company decides to outsource IT functions, it takes an important step that can affect the firm's resources, operations, and profitability. Mission-critical IT systems should be outsourced only if the result is a cost-attractive, reliable business solution that fits the company's long-term business strategy and involves an acceptable level of risk. Moving IT work overseas raises even more issues, including potential concerns about control, culture, communication, and security.

In addition to long-term strategic consequences, outsourcing also can raise some concerns. For example, a company must turn over sensitive data to an external service provider and trust the provider to maintain security, confidentiality, and quality. Also, before outsourcing, a company must carefully review issues relating to insurance, potential liability, licensing and information ownership, warranties, and disaster recovery.

Most important, a company considering outsourcing must realize that the solution can be only as good as the outsourcing firm that provides the service. A dynamic economy can give rise to business failures and uncertainty about the future. In this climate, it is especially important to review the history and financial condition of an outsourcing firm before making a commitment.

Mergers and acquisitions also can affect outsourcing clients. Even with large, financially healthy firms, a merger or acquisition can have some impact on clients and customers. If stability is important, an outsourcing client should consider these issues.

Outsourcing can be especially attractive to a company whose volume fluctuates widely, such as a defense contractor. In other situations, a company might decide to outsource application development tasks to an IT consulting firm if the company lacks the time or expertise to handle the work on its own. Outsourcing relieves a company of the responsibility of adding IT staff in busy times and downsizing when the workload lightens. A major disadvantage of outsourcing is that it raises employee concerns about job security. Talented IT people usually prefer positions where the firm is committed to in-house IT development—if they do not feel secure, they might decide to work directly for the service provider.

7.5 Offshoring

Offshoring, also known as **offshore outsourcing** or **global outsourcing**, refers to the practice of shifting IT development, support, and operations to other countries. In a trend similar to the outflow of manufacturing jobs over a several-decade period, many firms are sending IT work overseas.

IT work can move offshore even faster than manufacturing, because it is easier to ship work across networks and put consultants on airplanes than it is to ship bulky raw materials, build factories, and deal with tariffs and transportation issues. Several years ago, the IT consulting firm Gartner, Inc., accurately forecasted the steady growth of offshore outsourcing and predicted that outsourcing would evolve from labor-intensive maintenance and support to higher-level systems development and software design.

The main reason for offshoring is the same as domestic outsourcing: lower bottom-line costs. Offshore outsourcing, however, involves some unique risks and concerns. For example, workers, customers, and shareholders in some companies have protested this trend and have raised public awareness of possible economic impact. Even more important, offshore outsourcing involves unique concerns regarding project control, security issues, disparate cultures, and effective communication with critical functions that might be located halfway around the globe.

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CASE IN POINT 7.2: Turnkey Services

Turnkey Services is an ASP that offers payroll and tax preparation services for hundreds of businesses in the Midwest. The firm is considering a major expansion into accounting and financial services and is looking into the possibility of supporting this move by hiring IT subcontractors in several foreign countries. Turnkey's president has asked you to help him reach a decision. Specifically, he wants you to cite the pros and cons of offshoring. He wants you to present your views at a meeting of Turnkey managers next week. How will you proceed?

7.6 Software as a Service

In the traditional model, software vendors develop and sell application packages to customers. Typically, customers purchase licenses that give them the right to use the software under the terms of the license agreement. Although this model still accounts for a large percentage of software acquisition, a new model, called **Software as a Service (SaaS)**, is changing the picture dramatically.

SaaS is a model of software deployment in which an application is hosted as a service provided to customers over the Internet. SaaS reduces the customer's need for software maintenance, operation, and support. In effect, SaaS provides the functionality the customer needs, but without the associated development, infrastructure, and maintenance costs.

In a highly competitive marketplace, major vendors constantly strive to deliver new and better solutions. For example, Microsoft claims that its SaaS platform offers the best solution and business value. One of their more popular consumer SaaS offerings is Office 365, shown in Figure 7-6. This is a full-fledged version of the Microsoft Office suite that runs in a browser window.

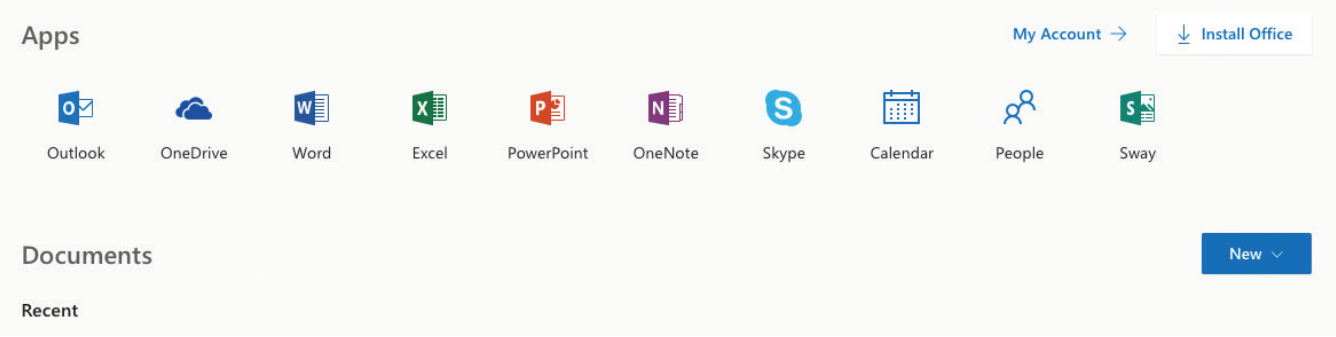


FIGURE 7-6 Microsoft Office 365 provides web-based access to the complete Office suite.
Source: Microsoft Corporation

7.7 Selecting a Development Strategy

Selecting the best development strategy is an important decision that requires companies to consider multiple factors. The systems analyst has an important role to play in this decision-making process. In particular, analyzing the costs and benefits of each development alternative is a key to providing objective data to management. A cost-benefit checklist can help guide this analysis.

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7.7.1 The Systems Analyst's Role

At some point in the systems development process, the company must decide whether to use an outsourcing option, develop software in-house, acquire a software package, develop user applications, or select some combination of these solutions. The decision depends on the company's current and anticipated future needs. It will affect the remaining SDLC phases and the systems analyst's subsequent involvement in the project. The decision to develop software in-house, for example, will require more participation from the systems analyst than outsourcing or choosing a commercial package. Management usually makes a determination after receiving written recommendations from the IT staff and a formal presentation, which is described later in this chapter.

Even a single system can use a mix of software alternatives. For example, a company might purchase a standard software package to process its payroll and then develop its own software to handle the interface between the payroll package and the company's in-house manufacturing cost analysis system.

The evaluation and selection of alternatives is not a simple process. The objective is to obtain the product with the lowest TCO, but actual cost and performance can be difficult to forecast. When selecting hardware and software, systems analysts often work as an **evaluation and selection team**. A team approach ensures that critical factors are not overlooked and that a sound choice is made. The evaluation and selection team also must include users, who will participate in the selection process and feel a sense of ownership in the new system.

The primary objective of the evaluation and selection team is to eliminate system alternatives that will not meet requirements, rank the alternatives that are feasible, and present the viable alternatives to management for a final decision. The process begins with a careful study of the costs and benefits of each alternative, as explained in the following section.

7.7.2 Analyzing Cost and Benefits

Financial analysis tools have been around for a long time. From the abacus to the pocket calculator, people have always sought easier ways to work with numbers. This section describes cost and benefit analysis and explains popular tools that can help a systems analyst examine an IT project.

Chapter 2 explained that economic feasibility is one of the four feasibility measurements that are made during the preliminary investigation of a systems request. Now, at the end of the systems analysis phase of the SDLC, financial analysis tools and techniques must be applied to evaluate development strategies and decide how the project will move forward. Part C of the Systems Analyst's Toolkit describes three popular tools, which are payback analysis, return on investment (ROI), and net present value (NPV). **Payback analysis** determines how long it takes an information system to pay for itself through reduced costs and increased benefits. **Return on investment (ROI)** is a percentage rate that compares the total net benefits (the return) received from a project to the total costs (the investment) of the project. The **net present value (NPV)** of a project is the total value of the benefits minus the total value of the costs, with both costs and benefits adjusted to reflect the point in time at which they occur.

These tools, and others, can be used to determine TCO, which was described in Chapter 4. At this stage, the analyst will identify specific systems development strategies and choose a course of action. For example, a company might find that its TCO will be higher if it develops a system in-house, compared with outsourcing the project or using an ASP.

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An accurate forecast of TCO is critical, because nearly 80% of total costs occur *after* the purchase of the hardware and software, according to Gartner, Inc. An IT department can develop its own TCO estimates or use TCO calculation tools offered by vendors. For example, as shown in Figure 7-7, HP Enterprise offers several free TCO calculators to determine the ROI of various development strategies and migration options.

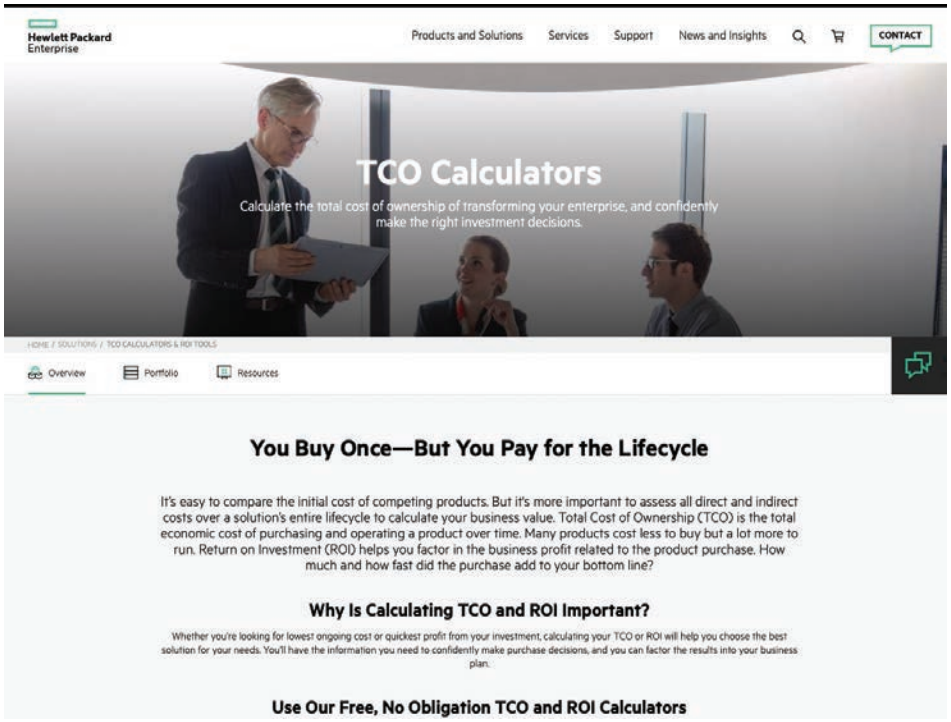


FIGURE 7-7 HP Enterprise provides several free TCO calculators.
Source: Hewlett Packard(HP)

7.7.3 Cost-Benefit Analysis Checklist

Chapter 2 explained how to use the payback analysis tool during the preliminary investigation to help determine whether a project is economically feasible. Now, all the financial analysis tools will be used to evaluate various development strategies. The best way to apply the tools is to develop a cost-benefit checklist with the following steps:

- List each development strategy being considered.
- Identify all costs and benefits for each alternative. Be sure to indicate when costs will be incurred and benefits realized.
- Consider future growth and the need for scalability.
- Include support costs for hardware and software.
- Analyze various software licensing options, including fixed fees and formulas based on the number of users or transactions.
- Apply the financial analysis tools to each alternative.
- Study the results and prepare a report to management.

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CASE IN POINT 7.3: Sterling Associates

Sterling Associates specializes in advising clients on IT projects and information systems development. Marketing is creating a brochure for prospective new clients, and they want you to develop a section that describes payback analysis, ROI, and NPV in simple terms and mentions the pros and cons of each financial analysis tool. How do you proceed?

7.8 The Software Acquisition Process

Although each situation is different, the following section describes a typical example of the issues and tasks involved in software acquisition.

Step 1: Evaluate the Information System Requirements

Based on the analysis of the system requirements, the system's key features must be identified; network and web-related issues considered; volume and future growth estimated; any hardware, software, or personnel constraints specified; and an RFP or a quotation prepared.

IDENTIFY KEY FEATURES: Whether in-house development or outsourcing options are being considered, the analyst must develop a clear, detailed list of features that can serve as an overall specification for the system. Using the data gathered during fact-finding, which was discussed in Chapter 4, list all system requirements and critical features. This information will be included in the **system requirements document**, which is the end product of the SDLC systems analysis phase.

CONSIDER NETWORK AND WEB-RELATED ISSUES: As the system requirements are evaluated, the network and web-related issues must be considered. The analyst must decide whether the system will run on a network, the Internet, or a company intranet and build these requirements into the design. Also, it must be determined whether the system will exchange data with vendor or customer systems and ensure that the system will be compatible.

ESTIMATE VOLUME AND FUTURE GROWTH: The analyst needs to know the current volume of transactions and forecast future growth. Figure 7-8 shows volume estimates for an order processing system. In addition to current levels, the figure displays two forecasts; one based on the existing order processing procedures and another that assumes a new website is operational.

A comparison of the two forecasts shows that the website will generate more new customers, process almost 80% more orders, and substantially reduces the need for sales reps and support staff. If in-house development is being considered, make sure that the software and hardware can handle future transaction volumes and data storage requirements. Conversely, if outsourcing is being considered, volume and usage data is essential to analyze ASP fee structures and develop cost estimates for outsourcing options.

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Online Order Processing System Estimated Activity During Next 12-Month Period

	CURRENT LEVEL	FUTURE GROWTH (based on existing procedures)	FUTURE GROWTH (assuming new website is operational)
Customers	36,500	40,150	63,875
Daily Orders	1,435	1,579	2,811
Daily Order Lines	7,715	7,893	12,556
Sales Reps	29	32	12
Order Processing Support Staff	2	4	3
Products	600	650	900

FIGURE 7-8 Volume estimates for an order processing system showing current activity levels and two forecasts: one based on the existing order processing procedures and another that assumes a new website is operational.

SPECIFY HARDWARE, SOFTWARE, OR PERSONNEL CONSTRAINTS: The analyst must determine whether existing hardware, software, or personnel issues will affect the acquisition decision. For example, if the firm has a large number of legacy systems or if an Enterprise Resource Planning (ERP) strategy has been adopted, these factors will have an impact on the decision. Also, the company's policy regarding outsourcing IT functions must be investigated, and whether outsourcing is part of a long-term strategy. With regard to personnel issues, in-house staffing requirements must be defined to develop, acquire, implement, and maintain the system—and determine whether the company is willing to commit to those staffing levels versus an outsourcing option.

PREPARE A REQUEST FOR PROPOSAL OR QUOTATION: To obtain the information needed to make a decision, the analyst should prepare an RFP or an RFQ. The two documents are similar but used in different situations, based on whether or not a specific software product has been selected.

A **request for proposal (RFP)** is a document that describes the company, lists the IT services or products needed, and specifies the features required. An RFP helps ensure that the organization's business needs will be met. An RFP also spells out the service and support levels required. Based on the RFP, vendors can decide if they have a product that will meet the company's needs. RFPs vary in size and complexity, just like the systems they describe. An RFP for a large system can contain dozens of pages with unique requirements and features. An RFP can be used to designate some features as essential and others as desirable. An RFP also requests specific pricing and payment terms. There are several online sources where RFP templates can be found.

When several responses to an RFP are evaluated, it is helpful to use an evaluation model. An **evaluation model** is a technique that uses a common yardstick to measure and compare vendor ratings.

Figure 7-9 shows two evaluation models for a network project. The evaluation model at the top of the figure simply lists the key elements and each vendor's score. The model at the bottom of the figure adds a weight factor. In this example, each element receives a rating based on its relative importance. Although the initial scores are the same in both models, note that vendor A has the highest point total in the top example, but vendor C emerges as the best in the weighted model.

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Unweighted Evaluation Model for a Network Project

Instructions: Rate each vendor on a scale from 1(low) to 10 (high), then add vendor scores to calculate total points.

	VENDOR A	VENDOR B	VENDOR C
Price	6	5	9
Completion Date	2	5	8
Layout/Design	8	8	5
References	10	6	3
TOTAL POINTS	26	24	25

Weighted Evaluation Model for a Network Project

Instructions: Rate each vendor on a scale from 1(low) to 10 (high), then multiply the vendor's score by the weight factor. Add vendor scores to calculate total points.

	WEIGHT FACTOR	VENDOR A	VENDOR B	VENDOR C
Price	25	6 * 25 = 150	5 * 25 = 125	9 * 25 = 225
Completion Date	25	2 * 25 = 50	5 * 25 = 125	8 * 25 = 200
Layout/Design	35	8 * 35 = 280	8 * 35 = 280	5 * 35 = 175
References	15	10 * 15 = 150	6 * 15 = 90	3 * 15 = 45
TOTAL POINTS	100	630	620	645

FIGURE 7-9 The three vendors have the same initial ratings, but the two evaluation models produce different results. In the unweighted model at the top of the figure, vendor A has the highest total points. However, after applying weighting factors, vendor C is the winner, as shown in the model at the bottom of the figure.

No standard method exists for assigning the weight factors. Each firm will have its own approach, which might be tailored to fit a specific situation. An analyst usually obtains as much input as possible and then circulates proposed values for further comment and, hopefully, a consensus.

Evaluation models are valuable tools that can be used throughout the SDLC. A spreadsheet program can be used to build an evaluation model, experiment with different weighting factors, and graph the results.

A **request for quotation (RFQ)** is more specific than an RFP. When an RFQ is used, the specific product or service desired is already known; only price quotations or bids are needed. RFQs can involve outright purchase or a variety of leasing options and can include maintenance or technical support terms. Some vendors even provide convenient RFP or RFQ forms on their websites. RFPs and RFQs have the same objective: to obtain vendor replies that are clear, comparable, and responsive, so that a well-informed selection decision can be made.

Step 2: Identify Potential Vendors or Outsourcing Options

The next step is to identify potential vendors or outsourcing providers. The Internet is a primary marketplace for all IT products and services, and descriptive information can be found on the web about all major products and acquisition alternatives.

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If vertical applications for specific industries need to be located, industry trade journals or websites can be used to find reviews for industry-specific software. Industry trade groups can often provide referrals to companies that offer specific software solutions.

Another approach is to work with a consulting firm. Many IT consultants offer specialized services that help companies select software packages. A major advantage of using a consultant is that the analyst can tap into broad experience that is difficult for any one company to acquire. Consultants can be located by contacting professional organizations or industry sources or simply by searching the Internet. Using a consultant involves additional expense but can prevent even more costly mistakes.

No matter what the topics of interest are, there are sure to be one or more online **forums** where people gather to meet, offer support, and exchange ideas. Forums can be hosted by private or public entities, or reside in larger communities such as Google Groups or Reddit, which allow users to join existing groups or start their own. A web search can locate forums of interest, or the websites of specific companies, such as Microsoft, and can provide a valuable source of information for IT professionals, including blogs, forums, webcasts, and other resources, as shown in Figure 7-10.

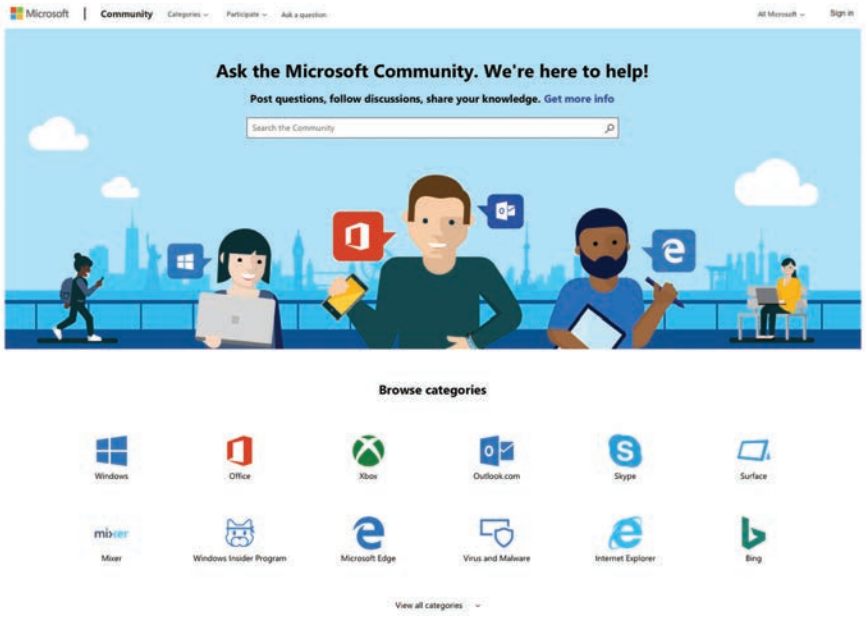


FIGURE 7-10 Microsoft Community is a valuable resource for IT professionals.
Source: Microsoft Corporation

Step 3: Evaluate the Alternatives

After identifying the alternatives, the analyst must select the one that best fits the company's needs. Information about the options should be obtained from as many sources as possible, including vendor presentations and literature, product documentation, trade publications, and companies that perform software testing and evaluation. To learn more about particular software packages, search the Internet using keywords that describe the application. Websites maintained by consultants and software publishers often include product references and links to vendors. As part of the evaluation process, try to obtain information from existing users, test the application, and benchmark the package.

EXISTING USERS: Existing users can be contacted to obtain feedback and learn about their experiences. For large-scale software packages, ASPs and vendors typically

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supply user references. User references are important because it must be known whether the software package has worked well for similar companies. Be aware that some vendors limit their reference lists to satisfied clients, so mostly positive feedback should be expected from those firms.

APPLICATION TESTING: If a software package is one of the options, find out if it is possible for users in the organization to try the product. For horizontal applications or small systems, using a demo copy to enter a few sample transactions could be an acceptable test. For vertical applications or large systems, a team of IT staff and users might need several days or weeks to perform tests.

BENCHMARKING: To determine whether a package can handle a certain transaction volume efficiently, a benchmark test can be performed. A **benchmark** measures the time a package takes to process a certain number of transactions. For example, a benchmark test can measure the time needed to post 1,000 sales transactions.

If benchmarks are used, remember that a benchmark test is conducted in a controlled environment, which might not resemble the actual day-to-day situation at the project's company. Although benchmarking cannot predict project-specific results, benchmark testing is a good way to measure relative performance of two or more competing products in a standard environment.

Many IT publications publish regular reviews of individual packages, including benchmark tests, and often have annual surveys covering various categories of software. Most of the publications now offer online and mobile versions, with additional features, search capability, and IT links.

Information can also be obtained from independent firms that benchmark various software packages and sell comparative analyses of the results, as shown in Figure 7-11. The Transaction Processing Performance Council (TPC) is an example of a nonprofit organization that publishes standards and reports for its members and the general public.

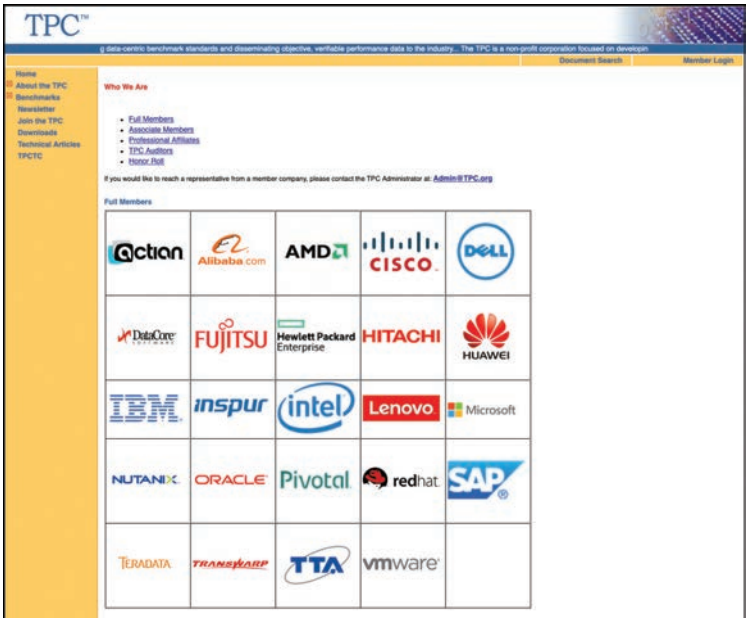


FIGURE 7-11 The Transaction Processing Performance Council (TPC) is a nonprofit organization that publishes standards and reports for its members and the general public.

Source: Transaction Processing Performance Council (TPC)

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Finally, each package should be matched against the RFP features and rank the choices. If some features are more important than others, give them a higher weight using an evaluation model similar to the one shown in Figure 7-11.

Step 4: Perform Cost-Benefit Analysis

Review the suggestions in this chapter and in Part C of the Systems Analyst's Toolkit to develop a spreadsheet to identify and calculate TCO for each option being considered. Be sure to include all costs, using the volume forecasts prepared. If outsourcing options are being considered, carefully study the alternative fee structure models described earlier. If possible, prepare charts to show the results graphically, and build in what-if capability so the impact of one or more variables changing can be gauged.

If a software package is being considered, be sure to consider acquisition options. When software is purchased, a **software license** is being bought that gives the purchaser the right to use the software under certain terms and conditions. For example, the license could allow the software to be used only on a single computer, a specified number of computers, a network, or an entire site, depending on the terms of the agreement. Other license restrictions could prohibit making the software available to others or modifying the program. For desktop applications, software license terms and conditions usually cannot be modified. For large-scale systems, license agreement terms often can be negotiated.

Also consider user support issues, which can account for a significant part of TCO. If an outsourcing alternative is selected, the arrangement probably will include certain technical support and maintenance. If in-house development is chosen, the cost of providing these services must be considered. If a software package is purchased, consider a supplemental **maintenance agreement**, which offers additional support and assistance from the vendor. The agreement might provide full support for a period of time or list specific charges for particular services. Some software packages provide free technical support for a period of time. Afterward, support is offered with a charge per occurrence, or per minute or hour of technical support time. Some software vendors contact registered owners whenever a new release is available and usually offer the new release at a reduced price.

Step 5: Prepare a Recommendation

The analyst should prepare a recommendation that evaluates and describes the alternatives, together with the costs, benefits, advantages, and disadvantages of each option. At this point, it may be required to submit a formal system requirements document and deliver a presentation. Review the suggestions for presenting written proposals and oral presentations in Part A of the Systems Analyst's Toolkit. Additional suggestions about preparing the system requirements document and the management presentation are contained in the following section.

7.9 Completion of Systems Analysis Tasks

To complete the systems analysis phase, the analyst must finalize the system requirements document, present their findings to management, and begin the transition to systems design.

7.9.1 System Requirements Document

The **system requirements document** contains the requirements for the new system, describes the alternatives that were considered, and makes a specific recommendation to management. This important document is the starting point for measuring the

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performance, accuracy, and completeness of the finished system before entering the systems design phase.

The system requirements document is like a contract that identifies what the system developers must deliver to users. Recall that system requirements are identified during the fact-finding process, and a system requirements checklist is created at that time. Various examples of system requirements are listed in Chapter 4. The system requirements document should be written in language that users can understand so they can offer input, suggest improvements, and approve the final version.

Because the system requirements document can be lengthy, they should be formatted and organized, so it is easy to read and use. The system requirements document should include a cover page and a detailed table of contents. An index and a glossary of terms can be added to make the document easier to use. The content of the system requirements document will depend on the company and the complexity of the system.

7.9.2 Presentation to Management

The presentation to management at the end of the systems analysis phase is one of the most critical milestones in the systems development process. At this point, managers make key decisions that affect the future development of the system.

Prior to a management presentation, two other presentations may be given: one to the principal individuals in the IT department to keep them posted, and another presentation to users to answer their questions and invite feedback. The system requirements document is the basis for all three presentations, and it (or a summary) should be distributed in advance so the recipients can review it.

When preparing the presentation, review the suggestions in Part A of the Systems Analyst's Toolkit, which can help design and deliver a successful presentation. If a slide presentation is planned, review the Toolkit guidelines for effective presentations. In addition to the techniques found in the Toolkit, also keep the following suggestions in mind:

- Begin the presentation with a brief overview of the purpose and primary objectives of the system project, the objectives of this presentation, and what decisions need to be made.
- Summarize the primary viable alternatives. For each alternative, describe the costs, advantages, and disadvantages.
- Explain why the evaluation and selection team chose the recommended alternative.
- Allow time for discussion and for questions and answers.
- Obtain a final decision from management or agree on a timetable for the next step in the process.

The object of the management presentation is to obtain approval for the development of the system and to gain management's full support, including necessary financial resources. Management probably will choose one of five alternatives: develop an in-house system, modify a current system, purchase or customize a software package, perform additional systems analysis work, or stop all further work. Depending on their decision, the next task of the systems analyst will be one of the following:

- Implement an outsourcing alternative. If outsourcing is selected, the analyst will work with representatives of the service provider to achieve a smooth transition to the new environment.

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- Develop an in-house system. Begin systems design tasks, as described in Chapters 8, 9, and 10.
- Purchase or customize a software package. Negotiate the purchase terms with the software vendor for management approval. Then, if the package will be used without modification, the analyst can begin planning the systems implementation phase. If modifications must be made to the package, the next step is to start the systems design phase. If the vendor will make the modifications, then the analyst's next step is to start planning the testing and documentation of the modifications as part of the systems implementation phase, which is described in Chapter 11.
- Perform additional systems analysis work. Management might want the analyst to investigate certain alternatives further, explore alternatives not examined, develop a prototype, reduce the project scope because of cost constraints, or expand the project scope based on new developments. If necessary, the analyst will perform the additional work and schedule a follow-up presentation.
- Stop all further work. The decision might be based on the analyst's recommendation, a shift in priorities or costs, or for other reasons. Whatever the reason, if that is management's decision, then there are no additional tasks for the project other than to file all the research in a logical location, so it can be retrieved if the project is reopened in the future.

After the presentation and management decision, the project will begin a transition to the systems design phase of the SDLC. If an in-house system is being developed, or a package is being modified, a model of the proposed system will be built, and the analyst will start designing the user interface, output, input, and data structures.

7.9.3 Transition to Systems Design

In a traditional SDLC environment, systems design usually started when the systems analysis phase was done. Using the system requirements specification as a blueprint, developers transformed the logical design into a working model that could be tested, reviewed by users, and implemented. Today, the process is much more dynamic. In general, systems development is faster, more flexible, and more user oriented. The introduction of agile development has changed the landscape significantly. Depending on the project, system developers often blend traditional and cutting-edge development methods, because what works in one situation might not work in another.

This textbook discusses systems analysis in Chapters 4, 5, 6, and 7 and systems design in Chapters 8, 9, and 10. However, in a typical IT workplace, all these tasks—and more—are integrated and managed together.

Regardless of the development method, systems design requires accurate documentation. Traditionally, a system requirements document provided detailed specifications for output, input, data, processes, and whatever else was needed. Although agile methods do not require a particular form of documentation, a successful development team must understand and record user requirements as they evolve during the project.

A **logical design** defines *what* must take place, not *how* it will be accomplished. Logical designs do not address the actual methods of implementation. In contrast, a **physical design** is like a set of blueprints for the actual construction of a building. Typically, a physical design describes the actual processes of entering, verifying, and storing data; the physical layout of data files and sorting procedures; the format of reports; and so on. Because logical and physical designs are related so closely, good systems design is impossible without careful, accurate systems analysis. For example,

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the analyst might return to fact-finding if it was discovered that an important issue was overlooked, if users had significant new needs, or if legal or governmental requirements changed.

A QUESTION OF ETHICS



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A junior analyst at a medium-sized IT consulting firm has been asked by her manager to draft a response to an RFP from a large company that is seeking IT consulting services in connection with a new accounting system.

As the analyst worked on the RFP, she noticed a specific question about her firm's recent experience on this type of system. To the best of her knowledge, the firm has only worked on one other accounting project in the past three years. When the manager saw the analyst's draft response, he was upset about the way she answered the question. "You don't have to be quite that candid," he said. "Even though we only had one *formal* project, we do have several people who worked on accounting systems before they came here."

"Yes," the analyst replied, "But that isn't what the question is asking." As he left her office, the manager's final comment was, "If we want that job, we'll have to come up with a better answer." Thinking about it, the analyst isn't comfortable with anything but a straight answer. Is this an ethical question? What are her options?

7.10 Summary

This chapter described system development strategies and the preparation and presentation of the system requirements document.

Traditional systems must function in various hardware and software environments, be compatible with legacy systems, and operate within the constraints of company networks and desktop computing capability. Such systems utilize Internet links and resources as enhancements. In contrast, Internet-based systems treat the web as the platform, rather than just a communication channel. Many large companies use web-based systems to handle enterprise-wide applications. Compared to traditional systems, web-based systems are more scalable, less dependent on specific hardware and software, and more adaptable to outsourcing the operation and support of a software application.

Systems analysts must consider web-based development environments such as .NET, MERN, and various outsourcing options, including ASPs and IBSs. ASPs charge subscription fees for providing application software packages. IBSs offer powerful web-based servers, software hosting, and IT support services to customers.

The web generation called Web 2.0 is fueling the expansion of information sharing, user collaboration, and social networking applications such as Twitter, LinkedIn, and Facebook. Another development, called cloud computing because of the commonly used cloud symbol for the Internet, describes an overall online software and data environment, powered by supercomputer technology that is the ultimate form of SaaS.

If a company chooses to handle its own software development needs, it can create in-house systems or purchase (and possibly customize) commercially available software packages from a software vendor or VAR.

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Compared with developing an in-house system, an existing commercial software package can be an attractive alternative, because a package generally costs less, takes less time to implement, has a proven track record, and is upgraded frequently. In-house development or customizing a software package might be the best choice when a standard software package cannot meet specific business requirements or constraints. In addition to customizing software packages, companies can create user applications based on standard software that has been specially configured to enhance user productivity.

An important trend that views SaaS, rather than a product, has created new development options. SaaS is a model of software deployment in which an application is hosted as a service provided to customers over the Internet.

Offshoring, also known as *offshore outsourcing* or *global outsourcing*, refers to the practice of shifting IT development, support, and operations to other countries. In a trend similar to the outflow of manufacturing jobs over a several-decade period, many firms are sending IT work overseas. The main reason for offshoring is the same as domestic outsourcing: lower bottom-line costs. Offshore outsourcing, however, involves some unique risks and concerns.

The systems analyst's role in the software development process depends on the specific development strategy. In-house development requires much more involvement than outsourcing or choosing a commercial package.

The most important factor in choosing a development strategy is TCO. Financial analysis tools include payback analysis, which determines how long it takes for a system to pay for itself through reduced costs and increased benefits; ROI, which compares a project's total return with its total costs; and NPV, which analyzes the value of a project by adjusting costs and benefits to reflect the time that they occur.

The process of acquiring software involves a series of steps: Evaluate the system requirements, consider network and web-related issues, identify potential software vendors or outsourcing options, evaluate the alternatives, perform cost-benefit analysis, prepare a recommendation, and implement the solution. During software acquisition, a company can use an RFP or an RFQ. An RFP invites vendors to respond to a list of system requirements and features; an RFQ seeks bids for a specific product or service.

The system requirements document is the deliverable, or end product, of the systems analysis phase. The document details all system requirements and constraints, recommends the best solution, and provides cost and time estimates for future development work. The system requirements document is the basis for the management presentation. At this point, the firm might decide to develop an in-house system, modify the current system, purchase or customize a software package, perform additional systems analysis work, or stop all further work.

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Key Terms

application service provider (ASP) A firm that delivers a software application, or access to an application, by charging a usage or subscription fee.

benchmark A measures of the time a package takes to process a certain number of transactions.

build or buy A choice between developing in-house software and purchasing software, often called a build or buy, or make or buy, decision.

business process outsourcing (BPO) The outsourcing of a basic business process. *See also* **outsourcing**.

cloud computing An online software and data environment in which applications and services are accessed and used through an Internet connection rather than on a local computer; refers to the cloud symbol for the Internet.

evaluation and selection team A group of people involved in selecting hardware and software. The group includes systems analysts and users. A team approach ensures that critical factors are not overlooked and that a sound choice is made.

evaluation model A technique that uses a common yardstick to measure and compare vendor ratings.

fixed fee model A service model that charges a set fee based on a specified level of service and user support.

forum An online discussion on a particular topic, where people meet, offer support, and exchange ideas.

global outsourcing The practice of shifting IT development, support, and operations to other countries.

horizontal application A software package that can be used by many different types of organizations.

in-house software An information center or help desk within the IT department responsible for providing user support and offering services such as hotline assistance, training, and guidance to users who need technical help.

Internet business services (IBSs) Services that provide powerful web-based support for transactions such as order processing, billing, and customer relationship management.

logical design The definition of an information system's functions and features, and the relationships among its components.

maintenance agreement A specification of the conditions, charges, and time frame for users to contact the vendor for assistance when they have system problems or questions.

make or buy The choice between developing in-house software and purchasing software often is called a make or buy, or build or buy, decision.

managed hosting An operation is managed by the outside firm, or host. Another term for IBSs.

middleware Software that connects dissimilar applications and enables them to communicate and exchange data. For example, middleware can link a departmental database to a web server that can be accessed by client computers via the Internet or a company intranet.

mobile device Smartphones, tablets, and other computing devices that are not permanently tethered to a desk. They connect to the network wirelessly.

net present value (NPV) The total value of the benefits minus the total value of the costs, with both the costs and benefits being adjusted to reflect the point in time at which they occur.

offshore outsourcing The practice of shifting IT development, support, and operations to other countries.

offshoring *See* **offshore outsourcing**.

outsourcing The transfer of information systems development, operation, or maintenance to an outside firm that provides these services, for a fee, on a temporary or long-term basis.

payback analysis A determination of how long it takes an information system to pay for itself through reduced costs and increased benefits.

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physical design A plan for the actual implementation of the system.

request for proposal (RFP) A written list of features and specifications given to prospective vendors before a specific product or package has been selected.

request for quotation (RFQ) Used to obtain a price quotation or bid on a specific product or package.

return on investment (ROI) A percentage rate that measures profitability by comparing the total net benefits (the return) received from a project to the total costs (the investment) of the project. ROI = (total benefits – total costs)/total costs.

service desk A centralized resource staffed by IT professionals that provides users with the support they need to do their jobs. Also called help desk.

service provider A firm that offers outsourcing solutions. Two popular outsourcing options involve ASPs and firms that offer IBSs.

Software as a Service (SaaS) A model of software delivery in which functionality is delivered on demand as a network-accessible service, rather than as a traditional software application that is downloaded and installed on the customer's computer.

software license A legal agreement that gives users the right to use the software under certain terms and conditions.

software package Software that is purchased or leased from another firm. A commercially produced software product, or family of products.

system requirements document A document that contains the requirements for the new system, describes the alternatives that were considered, and makes a specific recommendation to management. It is the end product of the systems analysis phase.

software vendor Company that develops software for sale.

subscription model A service model that charges a variable fee for an application based on the number of users or workstations that have access to the application.

transaction model A service model that charges a variable fee for an application based on the volume of transactions or operations performed by the application. Also called a usage model.

usage model *See* **transaction model**.

user application Programs that utilize standard business software, such as Microsoft Office, which has been configured in a specific manner to enhance user productivity.

user interface Includes screens, commands, controls, and features that enable users to interact more effectively with an application. *See also* **graphical user interface (GUI)**.

value-added reseller (VAR) A firm that enhances a commercial package by adding custom features and configuring it for a particular industry.

vertical application A software package that has been developed to handle information requirements for a specific type of business.

Web 2.0 A second generation of the web that enables people to collaborate, interact, and share information much more dynamically, based on continuously available user applications rather than static HTML web pages. Interactive experience is a hallmark of Web 2.0.

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Exercises

Questions

1. List three characteristics each of traditional and web-based development.
2. How does cloud computing support Web 2.0 applications?
3. Why would a company choose in-house software development?
4. What is outsourcing?
5. List two reasons offshoring may be risky.
6. What is SaaS?
7. What is the primary objective of the evaluation and selection team in selecting a development strategy?
8. What are the five steps in the software acquisition process?
9. What is an RFP, and how does it differ from an RFQ?
10. Explain the relationship between logical and physical design.

Discussion Topics

1. How has the proliferation of mobile devices affected IT professionals?
2. As more companies outsource systems development, will there be less need for in-house systems analysts? Why or why not?
3. Select a financial SaaS application, and describe its main features.
4. Suppose you tried to explain the concept of weighted evaluation models to a manager, and she responded by asking, "So, how do you set the weight factors? Is it just a subjective guess?" How would you reply?
5. What decisions might management reach at the end of the systems analysis phase, and what would be the next step in each case?

Projects

1. Investigate the ROI of cloud-based software development environments.
2. Many financial tools are developed using Microsoft Excel. Identify three applications built using Excel, and describe how they are used in an organization.
3. Visit the IT department at your school or at a local company, and determine whether the systems were developed in-house or purchased. If packages were acquired, find out what customizing was done, if any. Write a brief memo describing the results.
4. Profile three companies that provide offshore software development services.
5. Various firms and organizations offer IT benchmarking. Locate an example on the Internet, and describe its services.

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PHASE 3 SYSTEMS DESIGN

DELIVERABLE
Systems design specification

Systems design is the third of five phases in the systems development life cycle. In the previous phase, systems analysis, a logical model of the new system was developed. The output of that phase, the system requirements document, is used as input to the systems design phase, where a physical design is created that satisfies the system requirements.

The components of a system are interdependent; therefore, the design phase is not a series of clearly defined steps. Although work may start in one area, it is possible to be working with several different elements at the same time. For example, a decision to change a report format might require changes in data design or input screens. The design checklist will include the user interface, input and output procedures, data design, and system architecture. At the end of this phase, the analyst prepares a systems design specification and delivers a presentation to management.

The goal of systems design is to build a system that is effective, reliable, and maintainable:

- A system is *effective* if it supports business requirements and meets user needs.
- A system is *reliable* if it handles input errors, processing errors, hardware failures, or human mistakes. A good design will anticipate errors, detect them as early as possible, make it easy to correct them, and prevent them from damaging the system itself. Other characteristics of a reliable system include it being available nearly all of the time and proper backups maintained in case of system failure.
- A system is *maintainable* if it is flexible, scalable, and easily modified. Changes might be needed to correct problems, adapt to user requirements, or take advantage of new technology.

Chapter 8 focuses on user interface design. This includes human-computer interaction, seven habits of successful interface designers, guidelines for user interface design, source document and form design, printed output, technology issues, security and control issues, and emerging trends.

Chapter 9 focuses on the data design skills that are necessary for a systems analyst to construct the physical model of the information system. This includes DBMS components, web-based design, data design terms, entity-relationship diagrams, data normalization, codes, data storage and access, and data control.

Chapter 10 focuses on system architecture, which translates the logical design of an information system into a physical blueprint. This includes an architecture checklist, the evolution of system architecture, client/server architecture, the impact of the Internet, e-commerce architecture, processing methods, network models, wireless networks, and systems design completion.

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CHAPTER 8 User Interface Design

Chapter 8 is the first of three chapters in the systems design phase of the SDLC. User interface design is the first task in this phase. Designing the interface is extremely important because everyone wants a system that is easy to learn and use. This chapter explains how to design an effective user interface and how to handle data security and control issues. The chapter stresses the importance of user feedback and involvement in all design decisions.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" considers the ethical (and possibly legal) constraints on how far the creative work of others can be used without crediting the source, for example, in the design of a company's website.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Explain user interfaces
2. Explain the concept of human-computer interaction, including user-friendly interface design
3. Summarize the seven habits of successful interface designers
4. Summarize the 10 guidelines for user interface design
5. Design effective source documents and forms
6. Explain printed output report design guidelines and principles
7. Describe three types of printed output reports
8. Discuss output and input technology issues
9. Describe output and input security and control issues
10. Explain emerging user interface trends, including modular design, responsive web design, and prototypes

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8.1 User Interfaces

A **user interface (UI)** describes how users interact with a computer system and consists of all the hardware, software, screens, menus, functions, output, and features that affect two-way communications between the user and the computer. The user interface is the key to **usability**, which includes user satisfaction, support for business functions, and system effectiveness.

Traditionally, a chapter on user interface design started with a discussion of output because output is what users touched, viewed, and needed to do their jobs. Today, the situation is different, for several important reasons:

- Users can design their own output. System designers are more aware of user needs and desires. A system can maintain data integrity and still allow users to view, sort, filter, and examine data in any way that helps them do their jobs. There was a time when the MIS department made those choices and users had little or no say in the matter. Today, successful applications are designed quite differently—the system developer identifies user needs and then creates a design that will satisfy users *and* meet corporate requirements.
- Centralized IT departments no longer produce reams of printed reports. Those reports often gathered dust while sitting on top of file cabinets. While a few examples might persist, the overwhelming trend has been to customer-designed output. The customer might be an individual user, or a community of users, such as a department. As Chapter 4 pointed out, the IT team must understand user requirements before creating a solution.
- The user interface itself has evolved into a two-way channel, with powerful output capability, and most user information needs can be met with screen-generated data, which a user can print, view, or save. Well into the 1980s and beyond, a user interface was a blank character-based screen, which might or might not offer menu choices. If a user entered a command improperly, the system responded with an error message, which frustrated users and stifled productivity. Many hardware-centric vendors did not understand the importance of the user interface and its implications.

Apple was a pioneer in user interface development, introducing the **graphical user interface (GUI)**, complete with mouse and screen icons, in the early 1980s. At that point, not many companies were ready for this concept. When software giant Microsoft finally jumped on the GUI bandwagon with its Windows® operating system, the corporate doors swung open, and everyone from managers on down said, "How did we ever do without this?"

Many industry leaders believe that the best interfaces are the ones that users do not even notice—they make sense because they do what users expect them to do. For example, as shown in Figure 8-1, Apple believes that designing an exceptional user interface is essential to a successful app. Apple has long distinguished itself from its competitors by the intuitiveness of its products. Apple's command of the market suggests that consumers are willing to pay a premium for products that "just work."

When developing older systems, analysts typically designed all the printed and screen output first and then worked on the inputs necessary to produce the results. Often, the user interface mainly consisted of process-control screens that allowed the user to send commands to the system. That approach worked well with traditional systems that simply transformed input data into structured output.

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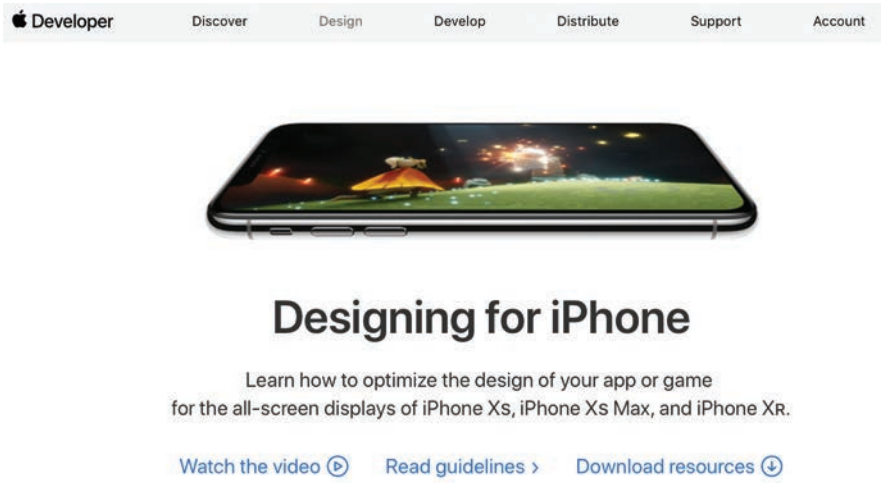


FIGURE 8-1 Apple has long been a leader in creating elegant user interfaces for its products.
Source: Apple Inc.

As information management evolved from centralized data processing to dynamic, enterprise-wide systems, the primary focus also shifted—from the IT department to the users themselves. The IT group became a supplier of information technology, rather than a supplier of information. Today, the main focus is on users within and outside the company, how they communicate with the information system, and how the system supports the firm's business operations.

In a **user-centered** system, the distinction blurs between input, output, and the interface itself. Most users work with a varied mix of input, screen output, and data queries as they perform their day-to-day job functions. Because all those tasks require interaction with the computer system, the user interface is a vital element in the systems design phase.

User interface design requires an understanding of human-computer interaction and user-centered design principles, which are discussed in the next section.

8.2 Human-Computer Interaction

A user interface is based on basic principles of human-computer interaction. **Human-computer interaction (HCI)** describes the relationship between computers and the people who use them to perform their jobs, like the worker shown in Figure 8-2. HCI concepts apply to everything from smartphones to global networks. In its broadest sense, HCI includes all the communications and instructions necessary to enter input to the system and to obtain output in the form of screen displays or printed reports.

Early user interfaces involved users typing complex commands on a keyboard, which displayed as green text on a black screen. Then came the GUI, which was a huge improvement because it used icons, graphical objects, and pointing devices. Today, designers strive to translate user behavior, needs, and desires into an interface that users don't really notice. IBM has stated that the best user interfaces are "*almost transparent*—you can see right through the interface to your own work." In other words, a **transparent interface** does not distract the user and calls no attention to itself.

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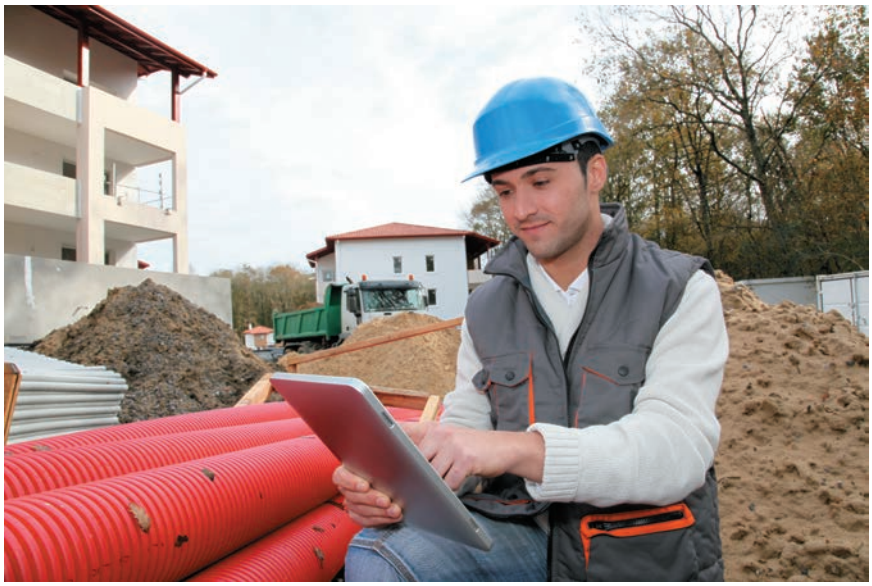


FIGURE 8-2 HCI is essential to employee productivity, whether the work is done in a traditional office setting or on a construction site like the one shown in this figure.
goodluz/Shutterstock.com

A systems analyst designs user interfaces for in-house-developed software and customizes interfaces for various commercial packages and user productivity applications. The main objective is to create a user-friendly design that is easy to learn and use.

Industry leaders Microsoft and IBM both devote considerable resources to user interface research. Figure 8-3 describes IBM Research's work on HCI. Their stated goal is to "design systems that are easier and more delightful for people to use."

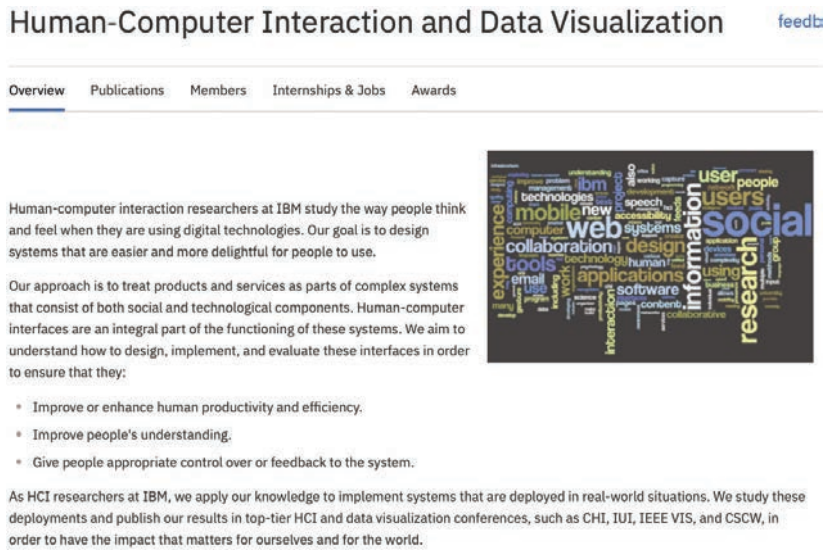


FIGURE 8-3 IBM's research division is a leader in exploring human-computer interaction (HCI).
Source: IBM Corporation

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Because HCI has a major impact on user productivity, it gets lots of attention—especially where multimillion-dollar issues are concerned. For example, in the article "Human-Computer Interaction in Electronic Medical Records: From the Perspectives of Physicians and Data Scientists" by E. Bologva et al. from *Procedia Computer Science 100* (Elsevier, 2016), the authors describe how software usability has a major impact on the medical profession, and not everyone is happy about it—particularly physicians who often struggle with **electronic health records (EHRs)** systems that are poorly designed. In her article, Ms. Gardner points out that physicians often multitask, answering a question about one patient while writing a prescription for another, and EHR software was not designed around that type of workflow.

CASE IN POINT 8.1: Casual Observer Software

Casual Observer Software's main product is a program that monitors and analyzes user keystrokes and mouse clicks to learn more about the way employees use their computer systems. The problem is that some users feel this is an unwarranted intrusion into their privacy, and they prefer not to be observed. Some even fear that the data would be used for other reasons, including performance appraisal. You are a consultant who has been hired by a client firm that is trying to decide whether or not to use this software.

Before you advise the client, remember the Hawthorne effect, which suggests that employees might behave differently when they know they are being observed. Finally, think about the ethical issues that might be involved in this situation. What will you advise your client, and why?

8.3 Seven Habits of Successful Interface Designers

Although IT professionals have different views about interface design, most would agree that good design depends on seven basic principles. Successful interface designers use these basic principles as a matter of course—they become habits. These desirable habits are described in the following sections.

8.3.1 Understand the Business

The interface designer must understand the underlying business functions and how the system supports individual, departmental, and enterprise goals. The overall objective is to design an interface that helps users to perform their jobs. A good starting point might be to analyze a functional decomposition diagram (FDD). As described in Chapter 4, an FDD is a graphical representation of business functions that starts with major functions and then breaks them down into several levels of detail. An FDD can provide a checklist of user tasks that must be included in the interface design.

8.3.2 Maximize Graphical Effectiveness

Studies show that people learn better visually. The immense popularity of Apple's iOS and Microsoft Windows is largely the result of their GUIs that are easy to learn and use. A well-designed interface can help users learn a new system rapidly and be more productive. Also, in a graphical environment, a user can display and work with

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multiple windows on a single screen and transfer data between programs. If the interface supports data entry, it must follow the guidelines for data entry screen design that are discussed later in this chapter.

8.3.3 Think like a User

A systems analyst should understand user experience, knowledge, and skill levels. If a wide range of capability exists, the interface should be flexible enough to accommodate novices as well as experienced users.

To develop a user-centered interface, the designer must learn to think like a user and see the system through a user's eyes. The user interface must be easy to learn, using terms and metaphors that are familiar to users. Users are likely to have real-world experience with many other machines and devices that provide feedback, such as automobiles, ATMs, and microwave ovens. Based on that experience, users will expect useful, understandable feedback from a computer system.

Carefully examine any point where users provide input or receive output. Input processes should be easy to follow, intuitive, and forgiving of errors. Predesigned output should be attractive and easy to understand, with an appropriate level of detail.

8.3.4 Use Models and Prototypes

From a user's viewpoint, the interface is the most critical part of the system design because it is where he or she interacts with the system—perhaps for many hours each day. It is essential to construct models and prototypes for user approval. An interface designer should obtain as much feedback as possible, as early as possible. Initial screen designs can be presented to users in the form of a **storyboard**, which is a sketch that shows the general screen layout and design. The storyboard can be created with software or drawn freehand. Users must test all aspects of the interface design and provide feedback to the designers. User input can be obtained in interviews, via questionnaires, and by observation. Interface designers also can obtain data, called **usability metrics**, by using software that can record and measure user interaction with the system.

8.3.5 Focus on Usability

The user interface should include all tasks, commands, and communications between users and the information system. The opening screen should show the main options (Figure 8-4 is an illustration). Each screen option leads to another screen, with more options. The objective is to offer a reasonable number of choices that a user easily can comprehend. Too many options on one screen can confuse a user—but too few options increase the number of submenu levels and complicate the navigation process. Often, an effective strategy is to present the most common choice as a default but allow the user to select other options.

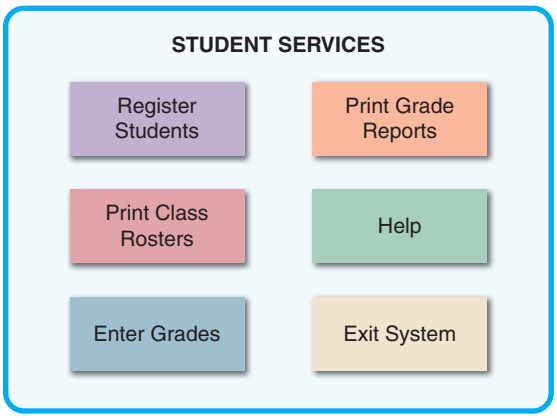


FIGURE 8-4 The opening screen displays the main options for a student registration system. A user can click an option to see lower-level actions and menu choices.

8.3.6 Invite Feedback

Even after the system is operational, it is important to monitor system usage and solicit user suggestions. The analyst can determine if system features are being used as intended by observing and surveying users. Sometimes, full-scale operations highlight problems that were not apparent when the prototype was tested. Based on user feedback, Help screens might need revision and design changes to allow the system to reach its full potential.

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8.3.7 Document Everything

All screen designs should be documented for later use by programmers. If a CASE tool or screen generator is being used, the screen designs should be numbered and saved in a hierarchy similar to a menu tree. User-approved sketches and storyboards also can be used to document the user interface.

By applying basic user-centered design principles, a systems analyst can plan, design, and deliver a successful user interface.

8.4 Guidelines for User Interface Design

A system might have advanced technology and powerful features, but the *real* test is whether users like it and feel that it meets their needs. What follows is a set of general guidelines for successful user interface design. These guidelines are distilled from years of best practices in the industry. There is some overlap because many of the main guidelines share common elements.

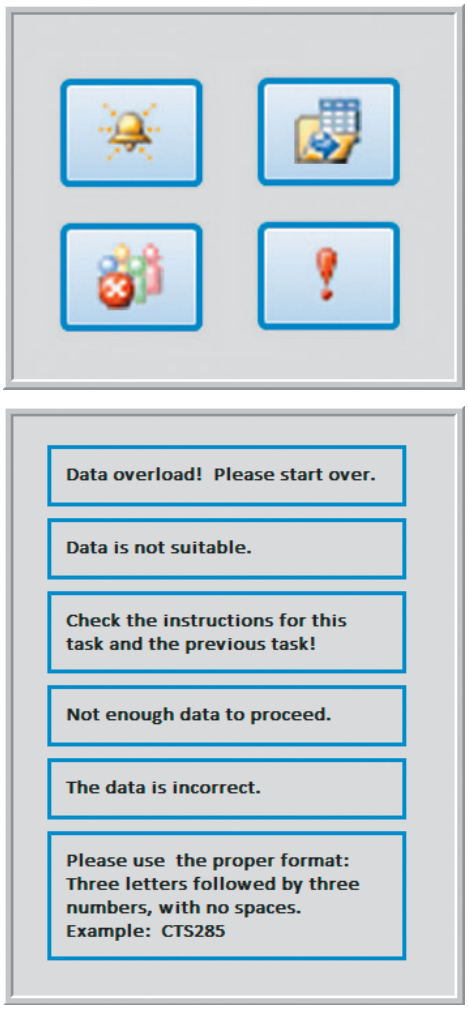


FIGURE 8-5 In the example at the top, the icons do not have a clear message. In the Help text examples at the bottom, only one message is understandable. The others would frustrate and annoy most users.

Although there is no standard approach to interface design, these guidelines are a starting point suitable for traditional systems development. User interface development for web applications or for mobile apps has its own unique considerations, above and beyond these general guidelines. Perhaps the *most* important guideline is that not all of these recommendations must be followed—the best interface is the one that works best for the users.

8.4.1 Create an Interface That Is Easy to Learn and Use

1. Focus on system design objectives, rather than calling attention to the interface.
2. Create a design that is easy to understand and remember. Maintain a common design in all modules of the interface, including the use of color, screen placements, fonts, and the overall "look and feel."
3. Provide commands, actions, and system responses that are consistent and predictable.
4. Allow users to correct errors easily.
5. Clearly label all controls, buttons, and icons.
6. Select familiar images that users can understand, and provide on-screen instructions that are logical, concise, and clear. For example, the top screen in Figure 8-5 shows four control buttons, but none of them has an obvious meaning. In the bottom screen, the first five messages provide little or no information. The last message is the only one that is easy to understand.
7. Show all commands in a list of menu items, but dim any commands that are not available to the user.
8. Make it easy to navigate or return to any level in the menu structure.

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8.4.2 Enhance User Productivity

The interface is where a user interacts with the system, so it can have a dramatic effect on productivity. If the interface empowers a user and enables him or her to handle more complex tasks, the user becomes more productive. Conversely, if the interface is difficult to work with, productivity declines.

1. Organize tasks, commands, and functions in groups that resemble actual business operations. Group functions and submenu items in a multilevel menu hierarchy, or tree, that is logical and reflects how users typically perform the tasks. Figure 8-6 shows an example of a menu hierarchy for an order tracking system.

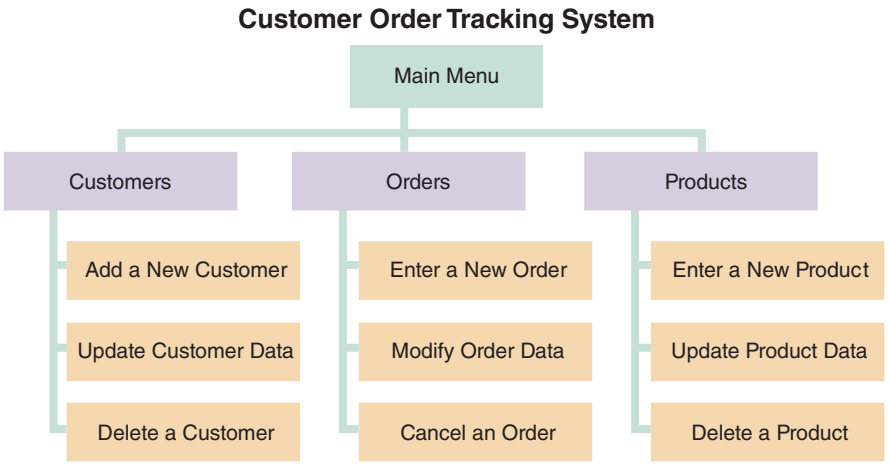


FIGURE 8-6 This menu hierarchy shows tasks, commands, and functions organized into logical groups and sequences. The structure resembles a functional decomposition diagram (FDD), which is a model of business functions and processes.

2. Create alphabetical menu lists or place the selections used frequently at the top of the menu list. No universally accepted approach to menu item placement exists. The best strategy is to design a prototype and obtain feedback from users. Some applications even allow menus to show recently used commands first. Some users like that feature, but others find it distracting. The best approach is to offer a choice and let users decide.
3. Provide shortcuts for experienced users so they can avoid multiple menu levels. Shortcuts can be created using hot keys that allow a user to press the Alt key + the underlined letter of a command.
4. Use default values if the majority of values in a field are the same. For example, if 90% of the firm's customers live in Albuquerque, use *Albuquerque* as the default value in the City field.
5. Use a duplicate value function that enables users to insert the value from the same field in the previous record, but allow users to turn this feature on or off as they prefer.
6. Provide a fast-find feature that displays a list of possible values as soon as users enter the first few letters.
7. If available, consider a **natural language** feature that allows users to type commands or requests in normal text phrases. For example, many applications allow users to request Help by typing a question into a dialog box. The software then uses natural language technology to retrieve a list of topics that

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match the request. Natural language technology is used in speech recognition systems, text-to-speech synthesizers, automated voice response systems, web search engines, text editors, and language instruction materials.

8.4.3 Provide Flexibility

Suppose that a user wants a screen display of all customer balances that exceed $5,000 in an accounts receivable system. How should that feature be designed? The program could be coded to check customer balances against a fixed value of 5000, which is a simple solution for both the programmer and the user because no extra keystrokes are required to produce the display. However, that approach is inflexible. A better approach would be to let the user enter the amount. Or start with a **default value** that displays automatically. Users can press ENTER to accept the value or type in another value. Often the best design strategy is to offer several alternatives, so users can decide what will work best for them.

8.4.4 Provide Users with Help and Feedback

This is one of the most important guidelines because it has a high impact on users. Never allow Help to slow a user down. Instead, make Help easy to find but not around when users don't need it.

1. Ensure that help is always available on demand. Help screens should provide information about menu choices, procedures, shortcuts, and errors.
2. Provide user-selected help and context-sensitive help. User-selected help displays information when the user requests it. By making appropriate choices through the menus and submenus, the user eventually reaches a screen with the desired information. Figure 8-7 shows the main Help screen for the student registration system. **Context-sensitive** help offers assistance for the task in progress.

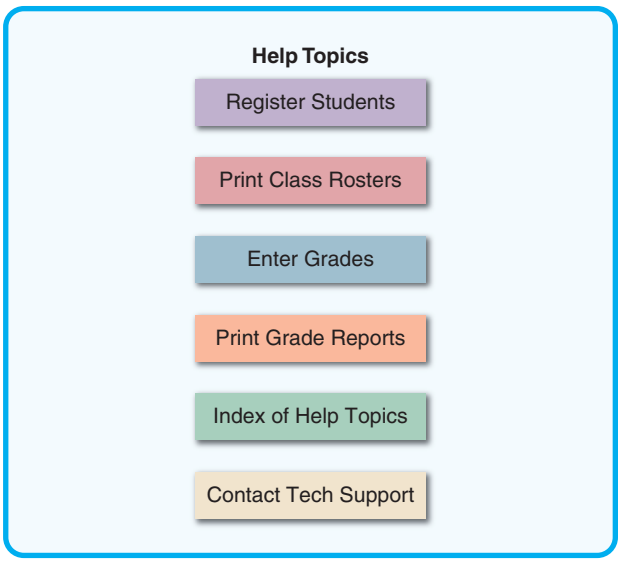


FIGURE 8-7 The main Help screen for a student registration system.

3. Provide a direct route for users to return to the point from where help was requested. Title every help screen to identify the topic, and keep help text simple and concise. Insert blank lines between paragraphs to make Help easier to read, and provide examples where appropriate.

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4. Include contact information, such as a telephone extension or email address if a department or help desk is responsible for assisting users.
5. Require user confirmation before data deletion (*Are you sure?*) and provide a method of recovering data that is deleted inadvertently. Build in safeguards that prevent critical data from being changed or erased.
6. Provide an "Undo" key or a menu choice that allows the user to undo the results of the most recent command or action.
7. When a user-entered command contains an error, highlight the erroneous part and allow the user to make the correction without retyping the entire command.
8. Use hypertext links to assist users as they navigate help topics.
9. Display messages at a logical place on the screen, and be consistent.
10. Alert users to lengthy processing times or delays. Give users an on-screen progress report, especially if the delay is lengthy.
11. Allow messages to remain on the screen long enough for users to read them. In some cases, the screen should display messages until the user takes some action.
12. Let the user know whether the task or operation was successful or not. For example, use messages such as *Update completed*, *All transactions have been posted*, or *The ID Number was not found*.
13. Provide a text explanation if an icon or image is used on a control button. This can be accomplished using a "mouse hover" to display a pop-up box with explanation when the mouse is moved over an icon or image.
14. Use messages that are specific, understandable, and professional. Avoid messages that are cute, cryptic, or vague, such as *ERROR—You have entered an unacceptable value*, or *Error DE-4-16*. Better examples are as follows:

- *Enter a number from 1 (low) to 5 (high)*
- *Customer number must be numeric*
- *Please re-enter a numeric value*
- *Call the Accounting Department, Ext. 239 for assistance*

8.4.5 Create an Attractive Layout and Design

This is a subjective area because reasonable people can differ on what is attractive. The analyst should consider color, layout, and ease of use. Screen mock-ups and menu trees can be created and tried on users to get their input. If in doubt, err on the side of doing a bit less. For example, blinking messages initially may seem like a good idea, they might not be the best choice for the interface design. Also try to avoid too many fonts, styles, and sizes, which can be distracting. Each separate style should communicate *something*—a different level of detail, another topic, mandatory versus optional actions, and so on.

1. Use appropriate colors to highlight different areas of the screen; avoid gaudy and bright colors.
2. Use special effects sparingly. For example, animation and sound might be effective in some situations, but too many special effects can be distracting and annoying to a user, especially if he or she must view them repeatedly.

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3. Use hyperlinks that allow users to navigate to related topics.
4. Group related objects and information. Visualize the screen the way a user will see it, and simulate the tasks that the user will perform.
5. Screen density is important. Keep screen displays uncluttered, with enough white space to create an attractive, readable design.
6. Display titles, messages, and instructions in a consistent manner and in the same general locations on all screens.
7. Use consistent terminology. For example, do not use the terms delete, cancel, and erase to indicate the same action. Similarly, the same sound always should signal the same event.
8. Ensure that commands always will have the same effect. For example, if the BACK control button returns a user to the prior screen, the BACK command always should perform that function throughout the application.
9. Ensure that similar mouse actions will produce the same results throughout the application. The results of pointing, clicking, and double-clicking should be consistent and predictable.
10. When the user enters data that completely fills the field, do not move automatically to the next field. Instead, require the user to confirm the entry by pressing the Enter key or Tab key at the end of every fill-in field.
11. Remember that users are accustomed to a pattern of red = stop, yellow = caution, and green = go. Stick to that pattern and use it when appropriate to reinforce on-screen instructions.
12. Provide a keystroke alternative for each menu command, with easy-to-remember letters, such as File, Exit, and Help.
13. Use familiar commands if possible, such as Cut, Copy, and Paste.
14. Provide a Windows look and feel in the interface design if users are familiar with Windows-based applications.
15. Avoid complex terms and technical jargon; instead, select terms that come from everyday business processes and the vocabulary of a typical user.



FIGURE 8-8 An example of a switchboard introducing TurboTax. The main options are clearly displayed on an uncluttered screen—something particularly important for users who are likely to be confused and/or nervous when beginning the tax preparation process.

Source: Intuit

8.4.6 Enhance the Interface

A designer can include many features, such as menu bars, toolbars, dialog boxes, text boxes, toggle buttons, list boxes, scroll bars, drop-down list boxes, option buttons, check boxes, command buttons, and calendar controls, among others. Screen design requires a sense of aesthetics as well as technical skills. User feedback should be obtained early and often as the design process continues.

1. The opening screen is especially important because it introduces the application and allows users to view the primary options. The starting point can be a **switchboard** with well-placed command buttons that allow users to navigate the system. Figure 8-8 shows the switchboard of TurboTax introducing a tax preparation program. The main options are clearly displayed on an uncluttered

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screen. The addition of the picture showing tax professionals ready to help provides a sense of calm and confidence to the user—something particularly important for users who are likely to be confused and/or nervous when beginning the tax preparation process.

2. Use a **command button** to initiate an action such as printing a form or requesting help. For example, when a user clicks the Find Student command button in Figure 8-9, a dialog box opens with instructions.

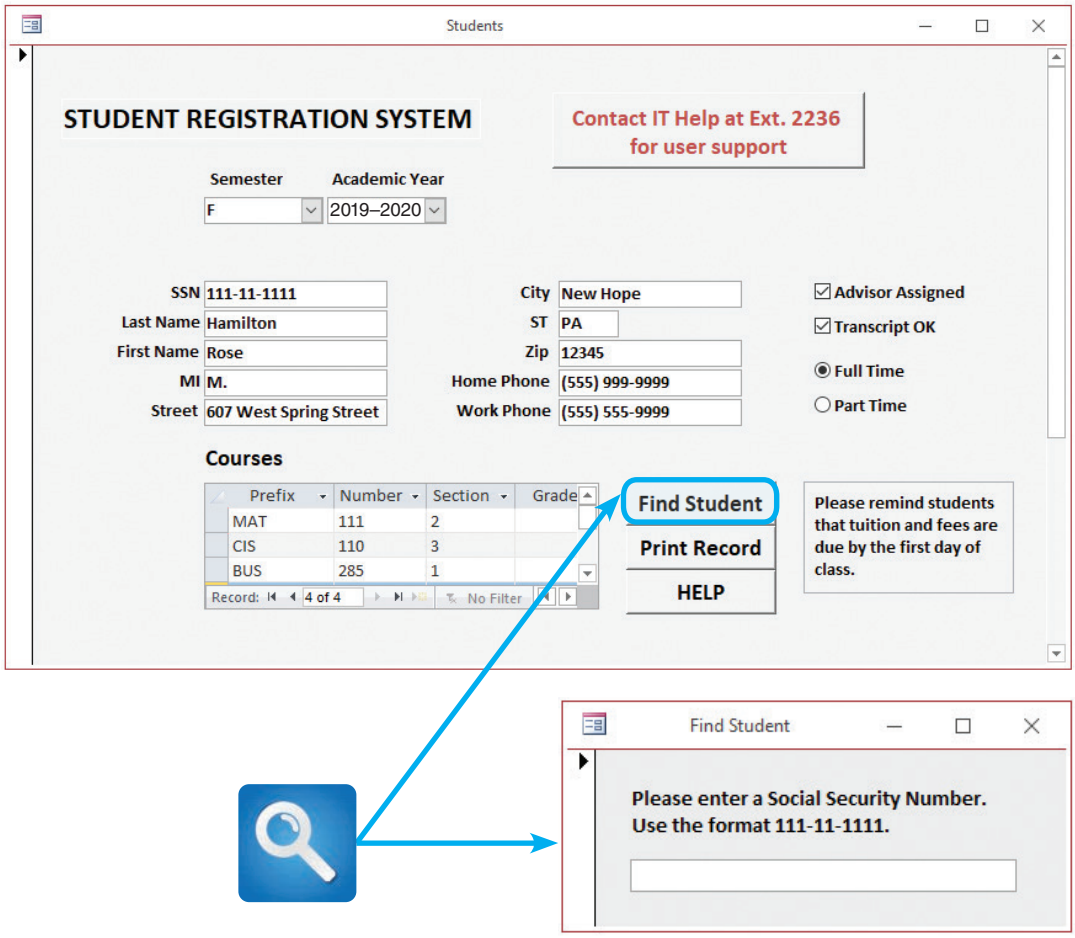


FIGURE 8-9 A data entry screen for a student registration system. This screen uses several design features that are described in the text. When a user clicks the Find Student command button, a dialog box is displayed with instructions.

3. If a software package is being used, check to see if it allows the creation of customized **menu bars** and toolbars. If so, consider these options.
4. Add a shortcut feature that lets a user select a menu command either by clicking the desired choice or by pressing the Alt key + the underlined letter. Some forms also use a **toolbar** that contains icons or buttons that represent shortcuts for executing common commands.
5. If variable input data is needed, provide a **dialog box** that explains what is required.
6. A **toggle button** makes it easy to show on or off status—clicking the toggle button switches to the other state.

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7. Use **list boxes** that display the available choices. If the list does not fit in the box, a **scroll bar** allows the user to move through the available choices. Also, be sure to provide another way to enter data that does not align with a specific list choice.
8. Use an **option button**, or **radio button**, to control user choices. For example, if the user can select only one option, display a suitable message (*Choose one item*), but if there is no restriction, display a different message (*Choose all that apply*). Use a black dot to show selected options.
9. If **check boxes** are used to select one or more choices from a group, show the choices with a checkmark or an X.
10. When dates must be entered, use a **calendar control** that allows the user to select a date that the system will use as a field value.

8.4.7 Focus on Data Entry Screens

Data entry is especially important because it is in the job description of so many users.

1. Whenever possible, use a data entry method called **form filling**, where a blank form that duplicates or resembles the source document is completed on the screen.
2. Restrict user access to screen locations where data is entered. For example, in the Eventbrite event management data entry when the screen in Figure 8-10 appears, the system should position the insertion point in the first data entry location. After the operator enters an event title, the insertion point should move automatically to the entry location for the next field (Location). A user should be able to position the insertion point only in places where data is entered on the form.

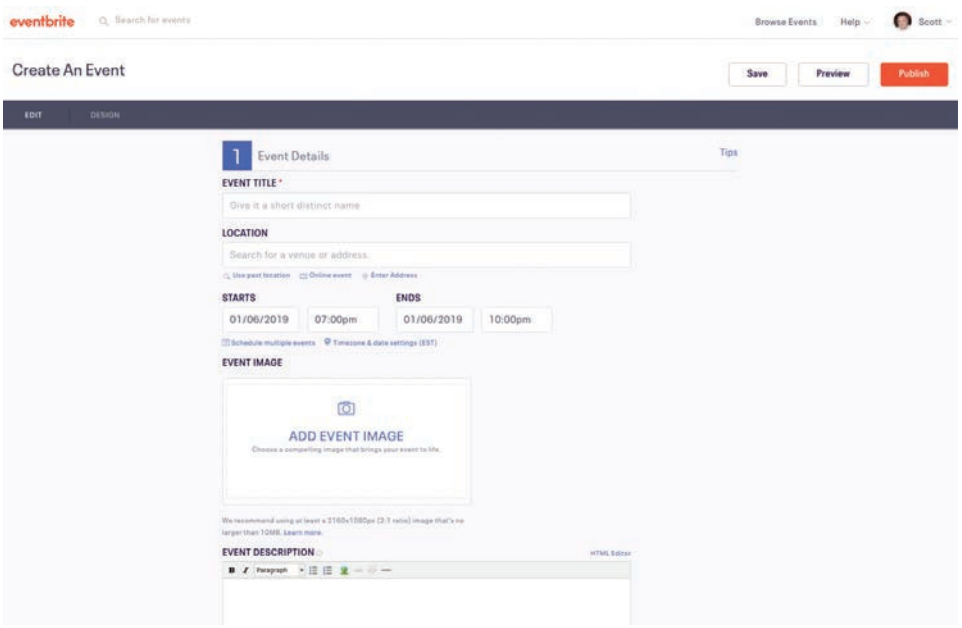


FIGURE 8-10 In this data entry screen for creating events, the system generates start and end dates and times automatically, but these can be changed by the user at any time. A red asterisk, as shown beside Event Title, indicates required fields. Gray text within the data entry field lets the user know what information to provide. This text is replaced with user input.

Source: Eventbrite

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3. Provide a way to leave the data entry screen at any time without entering the current record, such as a "Cancel" button. Since the application shown in Figure 8-10 is web based, this can be accomplished by selecting the "Back" button of the browser (not shown).
4. Provide a descriptive caption for every field, and show the user where to enter the data and the required or maximum field size. Typically, white boxes show the location and length of each field. Other methods used to indicate field locations are video highlighting, underscores, special symbols, or a combination of these features.
5. Provide a means for users to move among fields on the form in a standard order or in any order they choose. In a GUI, the user can override the standard field order and select field locations using the mouse or arrow keys.
6. Allow users to add, change, delete, and view records. Messages such as Apply these changes? (Y/N) or Delete this record? (Y/N) should require users to confirm the actions. Highlighting the letter N as a default response will avoid problems if the user presses the Enter key by mistake.
7. Design the screen form layout to match the layout of the source document. If the source document fields start at the top of the form and run down in a column, the input screen should use the same design.
8. Display a sample format if a user must enter values in a field in a specific format. For example, provide an on-screen instruction to let users know that the date format is MMDDYY, and provide an example if the user must enter separators, such as slashes.
9. In addition to the sample format in the preceding rule, it might be better to use an **input mask**, which is a template or pattern that restricts data entry and prevents errors. Microsoft Access provides standard input masks for fields such as dates, telephone numbers, postal codes, and Social Security numbers. In addition, custom input masks can be created, as shown in Figure 8-11. Note that a mask can have a specific format. For example, if a user enters text in lowercase letters, the input mask will capitalize the first letter automatically.
10. Require an ending keystroke for every field. Pressing the Enter key or the Tab key should signify the end of a field entry. Avoid a design that moves automatically to the next item when the field is full. The latter approach requires an ending keystroke only when the data entered is less than the maximum field length. It is confusing to use two different data entry procedures.
11. Do not require users to type leading zeroes for numeric fields. For example, if a three-digit project number is 045, the operator should be able to type 45 instead of 045 before pressing the Enter key. An exception to that rule might occur when entering a date, where a leading zero is needed to identify single-digit months or days, such as 06-04-2013.
12. Do not require users to type trailing zeroes for numbers that include decimals. For example, when a user types a value of 98, the system should interpret the value as 98.00 if the field has been formatted to include numbers with two decimal places. The decimal point is needed only to indicate nonzero decimal places, such as 98.76.
13. Display default values so operators can press the Enter key to accept the suggested value. If the default value is not appropriate, the operator can change it.

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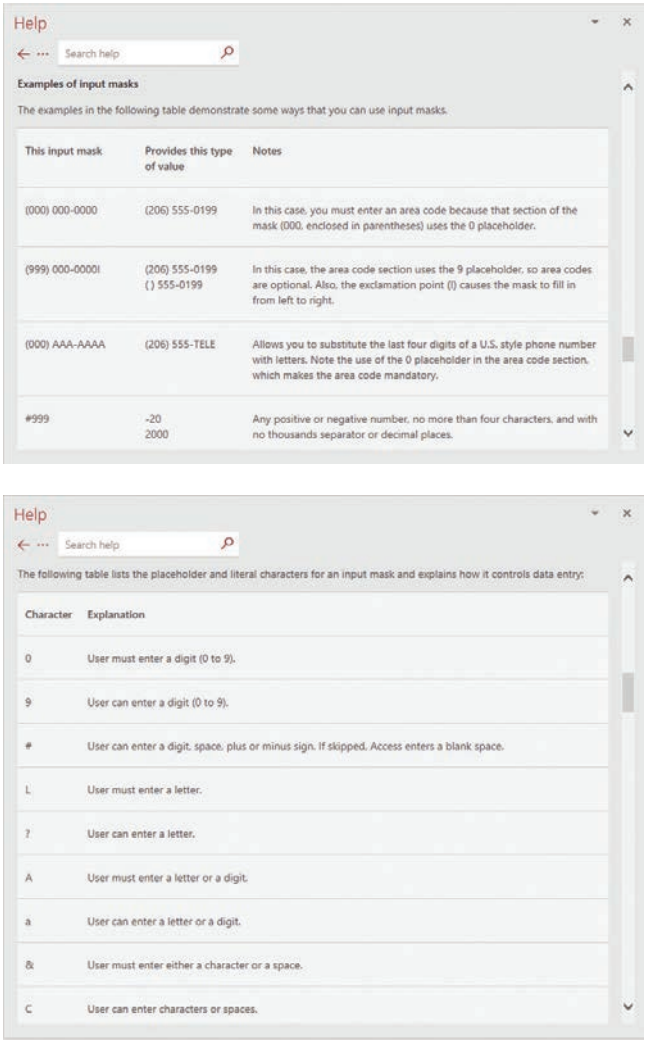


FIGURE 8-11 Microsoft Access provides various input masks for dates, phone numbers, and postcodes, among others. In addition, it is easy to create a custom mask using the characters shown here.

Source: Microsoft Corporation

14. Use a default value when a field value will be constant for successive records or throughout the data entry session. For example, if records are input in order by date, the date used in the first transaction should be used as the default date until a new date is entered, at which time the new date becomes the default value.
15. Display a list of acceptable values for fields, and provide meaningful error messages if the user enters an unacceptable value. An even better method, which was described under Rule 5: Enhance the Interface, is to provide a drop-down list box containing acceptable values that allows the user to select a value by clicking.
16. Provide users with an opportunity to confirm the accuracy of input data before entering it by displaying a message such as, Add this record? (Y/N). A positive response (Y) adds the record, clears the entry fields, and positions the insertion point in the first field so the user can input another record. If the response is negative (N), the current record is not added and the user can correct the errors.

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Data entry screens should also anticipate future needs. Consider a parts inventory database that contains a one-character field for category, such as electrical, mechanical, or hydraulic. The design works well, but what if the company decides to break these overall groups down into more specific segments? A better design would anticipate possible expansion to two or more characters. For example, in 1999, there was widespread concern about what was called the *Y2K issue* because many older programs used only two characters to store the year and might not recognize the start of a new century.

8.4.8 Use Validation Rules

Reducing input errors improves data quality. One way to reduce input errors is to eliminate unnecessary data entry. For example, a user cannot misspell a customer name if it is not entered or is entered automatically based on the user entering the customer ID. Similarly, an outdated item price cannot be used if the item price is retrieved from a master file instead of being entered manually. The best defense against incorrect data is to identify and correct errors before they enter the system by using data validation rules, as shown in Figure 8-12. A **data validation rule** improves input quality by testing the data and rejecting any entry that fails to meet specified conditions. The design can include at least eight types of data validation rules.

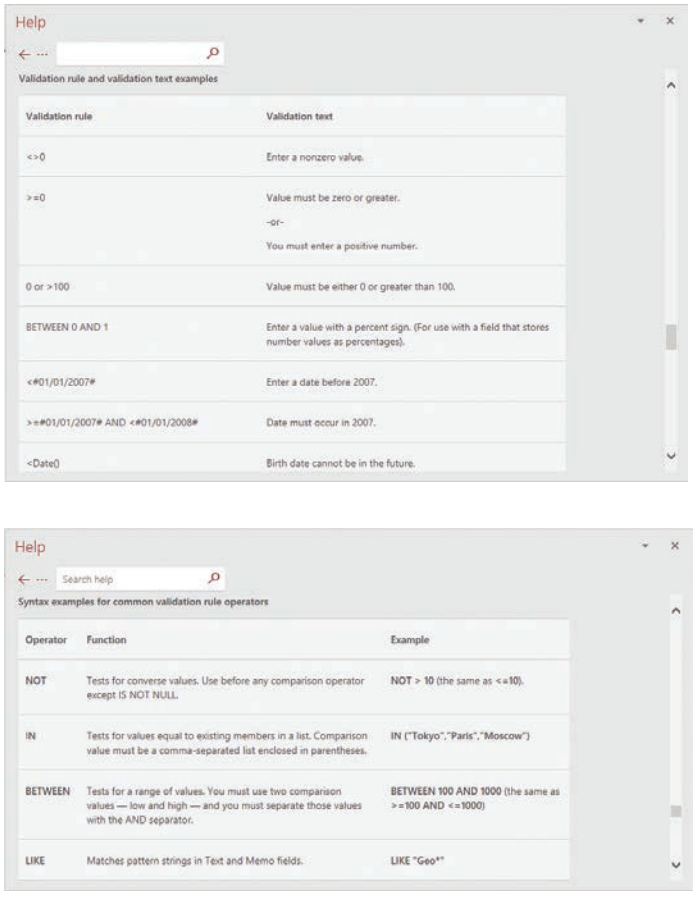


FIGURE 8-12 Microsoft Access provides validation rules that can improve data quality by requiring the input to meet specific requirements or conditions.

Source: Microsoft Corporation

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1. A **sequence check** can be used when the data must be in some predetermined sequence. If the user must enter work orders in numerical sequence, for example, then an out-of-sequence order number indicates an error, or if the user must enter transactions chronologically, then a transaction with an out-of-sequence date indicates an error.
2. An **existence check** can apply to mandatory data items. For example, if an employee record requires a Social Security number, an existence check would not allow the user to save the record until he or she enters a suitable value in the Social Security number field.
3. A **data type check** can test to ensure that a data item fits the required data type. For example, a numeric field must have only numbers or numeric symbols, and an alphabetic field can contain only the characters A through Z (or a through z).
4. A **range check** can be used to verify that data items fall between a specified minimum and maximum value. The daily hours worked by an employee, for example, must fall within the range of 0 to 24. When the validation check involves a minimum or a maximum value, but not both, it is called a **limit check**. Checking that a payment amount is greater than zero, but not specifying a maximum value, is an example of a limit check.
5. A **reasonableness check** identifies values that are questionable but not *necessarily* wrong. For example, input payment values of $0.05 and $5,000,000.00 both pass a simple limit check for a payment value greater than zero, and yet both values could be errors. Similarly, a daily-hours-worked value of 24 passes a 0 to 24 range check; however, the value seems unusual, and the system should verify it using a reasonableness check.
6. A **validity check** can be used for data items that must have certain values. For example, if an inventory system has 20 valid item classes, then any input item that does not match one of the valid classes will fail the check. Verifying that a customer number on an order matches a customer number in the customer file is another type of validity check. Because the value entered must refer to another value, that type of check also is called *referential integrity*, which is explained in Chapter 9, Data Design. Another validity check might verify that a new customer number does not match a number already stored in the customer master file.
7. A **combination check** is performed on two or more fields to ensure that they are consistent or reasonable when considered together. Even though all the fields involved in a combination check might pass their individual validation checks, the combination of the field values might be inconsistent or unreasonable. For example, if an order input for 30 units of a particular item has an input discount rate applicable only for purchases of 100 or more units, then the combination is invalid; either the input order quantity or the input discount rate is incorrect.
8. **Batch controls** are totals used to verify batch input. Batch controls might check data items such as record counts and numeric field totals. For example, before entering a batch of orders, a user might calculate the total number of orders and the sum of all the order quantities. When the batch of orders is entered, the order system also calculates the same two totals. If the system totals do

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not match the input totals, then a data entry error has occurred. Unlike the other validation checks, batch controls do not identify specific errors. For example, if the sum of all the order quantities does not match the batch control total, the only thing known is that one or more orders in that batch were entered incorrectly or not input. The batch control totals often are called **hash totals** because they are not meaningful numbers themselves but are useful for comparison purposes.

8.4.9 Manage Data Effectively

In addition to its effect on users, data management impacts company efficiency, productivity, and security. To reduce input errors, the system should enter and verify data as soon as possible, and each data item should have a specific type, such as alphabetic, numeric, or alphanumeric, and a range of acceptable values.

It is important to collect input data as close to its source as possible. For instance, using barcode scanners rather than manual forms on a warehouse freight dock, or having salespeople use tablets to record orders rather than filling in source documents. The easiest, most accurate, and least expensive data input strategy is automated data capture.

In an efficient design, data is entered only once. For example, if input data for a payroll system also is needed for a human resources system, the analyst could design an interface to transfer data automatically, or a central data storage area could be created that both systems can access. Chapter 9 describes normalization, which is a set of rules that can help avoid data design problems. A secure system also includes **audit trails** that can log every instance of data entry and changes. For example, the system should record when a customer's credit limit was set, by whom, and any other information necessary to construct the history of a transaction.

8.4.10 Reduce Input Volume

This is the final guideline, but in some ways it should be the first because it affects all the rest. When input volume is reduced, unnecessary labor costs are avoided, which in turn gets the data into the system more quickly and decreases the number of errors. Therefore, the analyst should start by reducing the number of data items required for each transaction.

1. Input necessary data only. Do not input a data item unless it is needed by the system. A completed order form, for example, might contain the name of the clerk who took the order. If that data is not needed by the system, the user should not enter it.
2. Do not input data that the user can retrieve from system files or calculate from other data. This reduces input errors and data inconsistencies.
3. Do not input constant data. If orders are in batches with the same date, then a user should enter the order date only once for the first order in the batch. If orders are entered online, then the user can retrieve the order date automatically using the current system date.
4. Use codes. Codes are shorter than the data they represent, and coded input can reduce data entry time. Codes are discussed more in Chapter 9.

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CASE IN POINT 8.2: Boolean Toys

Suppose you are a systems analyst studying the order processing system at Boolean Toys, a fast-growing developer of software for preschool children. You know that many data entry users have complained about the input screens. Some users would prefer to rearrange the order of the fields, others would like to change the background color on their screens, and still others want shortcuts that would allow them to avoid a series of introductory screens.

What if Boolean's users could customize their own data entry screens without assistance from the IT staff by using a menu-driven utility program? What would be the pros and cons of such an approach? When should a systems analyst decide a design issue, and when should users be allowed to select what works best for them?

8.5 Source Document and Form Design

No matter how data enters an information system, the quality of the output is only as good as the quality of the input. The term **garbage in, garbage out (GIGO)** is familiar to IT professionals, who know that the best time to avoid problems is when the data is entered. The main objective is to ensure the quality, accuracy, and timeliness of input data. Unfortunately, the dream of a "paperless office" has never been realized. Even with RFID technology and automated data capture, we still enter data on source documents and forms, and instead of a human-computer interface, systems analysts must deal with the challenge of a human-paper interface.

A **source document** collects input data, triggers or authorizes an input action, and provides a record of the original transaction. During the input design stage, the analyst develops source documents that are easy to complete and use for data entry. Source documents generally are paper based but also can be provided online. Either way, the design considerations are the same.

Consider a time when it was a struggle to complete a poorly designed form. There might have been insufficient space, confusing instructions, or poor organization—all symptoms of incorrect **form layout**.

Good form layout makes the form easy to complete and provides enough space, both vertically and horizontally, for users to enter the data. A form should indicate data entry positions clearly using blank lines or boxes and descriptive captions. Also consider using check boxes whenever possible, so users can select choices easily. However, be sure to include an option for any input that does not match a specific check box.

The placement of information on a form also is important. Source documents typically include most of the zones shown in Figure 8-13. The heading zone usually contains the company name or logo and the title and number of the form. The control zone contains codes, identification information, numbers, and dates that are used for storing completed forms. The instruction zone contains instructions for completing the form. The main part of the form, called the body zone, usually takes up at least half of the space on the form and contains captions and areas for entering variable data. If totals are included on the form, they appear in the **totals zone**. Finally, the **authorization zone** contains any required signatures.

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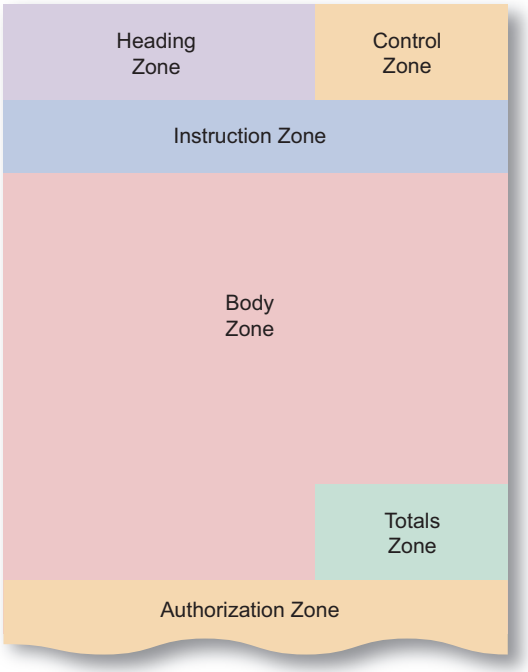


FIGURE 8-13 Source document zones.

Information should flow on a form from left to right and top to bottom to match the way users read documents naturally. That layout makes the form easy to use for the individual who completes the form and for users who enter data into the system using the completed form.

The same user-friendly design principles also apply to printed forms such as invoices and monthly statements, except that heading information usually is preprinted. Column headings should be short but descriptive, avoiding nonstandard abbreviations, with reasonable spacing between columns for better readability.

The order and placement of printed fields should be logical, and totals should be identified clearly. When designing a preprinted form, contact the form's vendor for advice on paper sizes, type styles and sizes, paper and ink colors, field placement, and other important form details. The goal is to design a form that is attractive, readable, and effective.

Layout and design also are important on web-based forms. There are many resources that will help with designing efficient, user-friendly forms. These include websites that must conform to the U.S. Federal Government's accessibility guidelines, which can be found online at http://www.section508.gov.

8.6 Printed Output

Before designing printed output, there are several questions to consider:

- Why is this being delivered as printed output, rather than screen-based information, with an option for users to view, print, or save as needed?
- Who wants the information, why is it needed, and how will it be used?
- What specific information will be included?
- Will the printed output be designed for a specific device?

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- When and how will the information be delivered, and how often must it be updated?
- Do security or confidentiality issues exist? How will they be managed?

The design process should not begin until these questions have been answered. Some information probably was gathered during the systems analysis phase. To gain more understanding, the analyst should meet with users to find out exactly what kind of output *they* are requesting. Prototypes and mock-ups can be used to obtain feedback throughout the design process.

8.6.1 Report Design

Although many organizations strive to reduce the flow of paper and printed reports, few firms have been able to eliminate printed output totally. Because they are portable, printed reports are convenient and even necessary in some situations. Many users find it handy to view screen output and then print the information they need for a discussion or business meeting. Printed output also is used in **turnaround documents**, which are output documents that are later entered back into the same or another information system. In some areas, the telephone or utility bill, for example, might be a turnaround document printed by the company's billing system. When the required portion of the bill is returned with payment, the bill is scanned into the company's accounts receivable system to record the payment accurately.

Designers use a variety of styles, fonts, and images to produce reports that are attractive and user-friendly. Whether printed or viewed on-screen, reports must be easy to read and well organized. Rightly or wrongly, some managers judge an entire project by the quality of the reports they receive.

Database programs such as Microsoft Access include a variety of report design tools, including a Report Wizard, which is a menu-driven feature that designers can use to create reports quickly and easily. Many online web-based database systems also provide similar report design guidelines.

Although the vast majority of reports are designed graphically, some systems still produce one or more **character-based reports** that use a character set with fixed spacing. Printing character-based reports on high-speed impact printers is a fast, inexpensive method for producing large-scale reports, such as payroll or inventory reports, or registration rosters at a school. This is especially true if multiple copies are required.

Users should approve all report designs in advance. The best approach is to prepare a sample report, called a **mock-up**, or prototype, for users to review. The sample should include typical field values and contain enough records to show all the design features. Depending on the type of printed output, a Microsoft Word document can be created, or a report generator used, to create mock-up reports.

8.6.2 Report Design Principles

Printed reports must be attractive, professional, and easy to read. For example, a well-designed report should provide totals and subtotals for numeric fields. In the report shown in Figure 8-14, note that when the value of a control field, such as Store Number, changes, a **control break** occurs. A control break usually causes specific actions, such as printing subtotals for a group of records. That type of detail report is called a **control break report**. To produce a control break report, the records must be arranged, or sorted, in **control field order**.

Good report design requires effort and attention to detail. To produce a well-designed report, the analyst must consider design features such as report headers and footers, page headers and footers, column headings and alignment, column spacing, field order, and grouping of detail lines.

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REPORT HEADERS AND FOOTERS: Every report should have a report header and a report footer. The **report header**, which appears at the beginning of the report, identifies the report and contains the report title, date, and other necessary information. The **report footer**, which appears at the end of the report, can include grand totals for numeric fields and other end-of-report information, as shown in Figure 8-14.

PAGE HEADERS AND FOOTERS: Every page should include a **page header**, which appears at the top of the page and includes the column headings that identify the

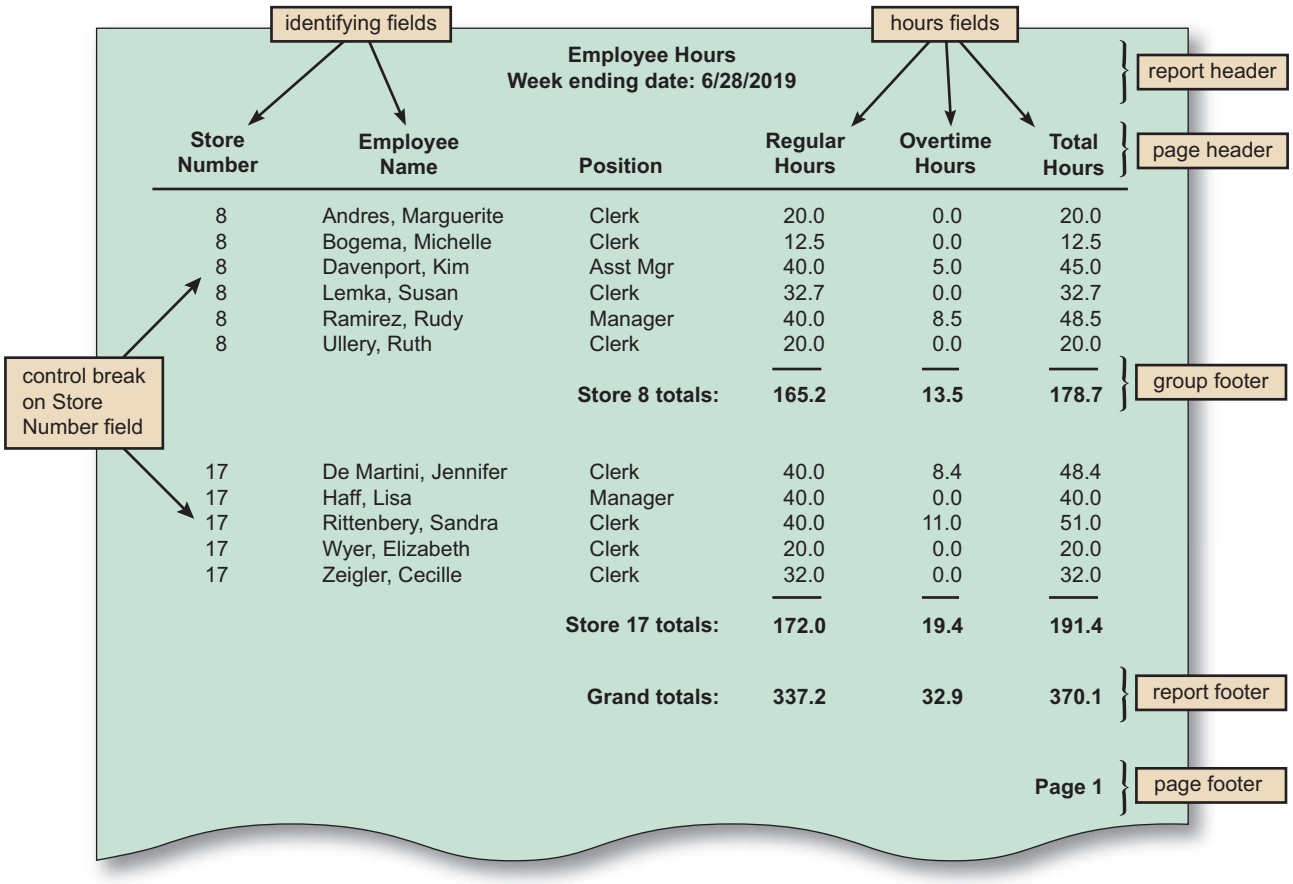
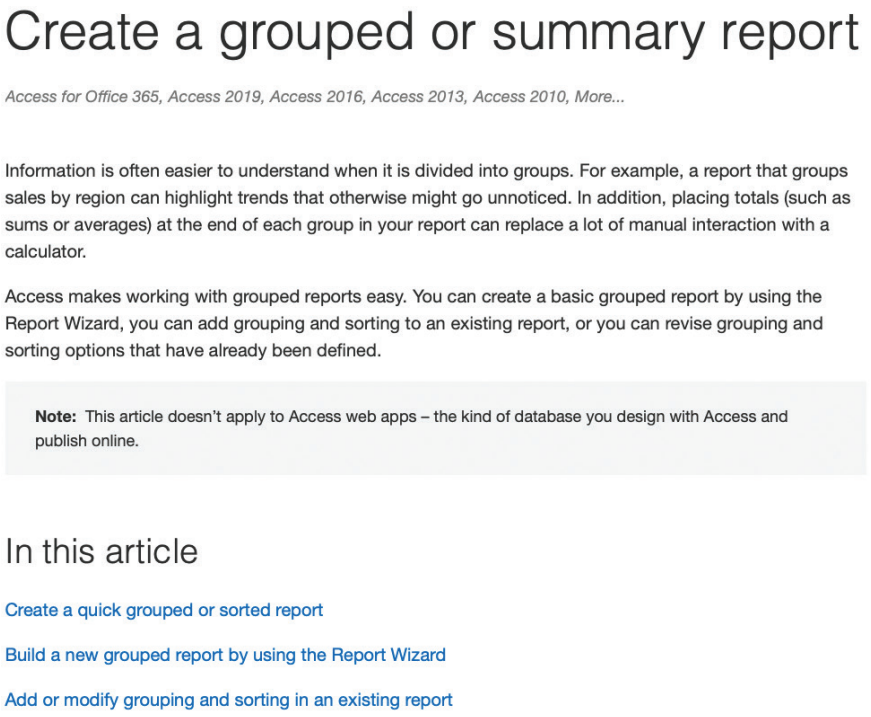


FIGURE 8-14 The Employee Hours report is a detailed report with control breaks, subtotals, and grand totals. Note that a report header identifies the report, a page header contains column headings, a group footer contains subtotals for each store, a report footer contains grand totals, and a page footer identifies the page number.

data. The headings should be short but descriptive. Avoid abbreviations unless the users will understand them clearly. Either a page header or a **page footer**, which appears at the bottom of the page, is used to display the report title and the page number.

Database programs such as Microsoft Access make it easy to create groups and subgroups based on particular fields. The report can also calculate and display totals, averages, record counts, and other data for any group or subgroup. For example, a large company might want to see total sales and number of sales broken down by product within each of the 50 states. The information shown in Figure 8-15 is part of Access' online help that refers to a step-by-step process for creating multilevel grouping.

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Create a grouped or summary report

Access for Office 365, Access 2019, Access 2016, Access 2013, Access 2010, More...

Information is often easier to understand when it is divided into groups. For example, a report that groups sales by region can highlight trends that otherwise might go unnoticed. In addition, placing totals (such as sums or averages) at the end of each group in your report can replace a lot of manual interaction with a calculator.

Access makes working with grouped reports easy. You can create a basic grouped report by using the Report Wizard, you can add grouping and sorting to an existing report, or you can revise grouping and sorting options that have already been defined.

Note: This article doesn't apply to Access web apps – the kind of database you design with Access and publish online.

In this article

Create a quick grouped or sorted report

Build a new grouped report by using the Report Wizard

Add or modify grouping and sorting in an existing report

FIGURE 8-15 Microsoft Access includes an easy-to-use tool for grouping data.
Source: Microsoft Corporation

REPEATING FIELDS: Report design is an art, not a science. User involvement is essential, but users often don't know what they want without seeing samples. For example, consider the issue of repeating fields. The sample report in Figure 8-14 repeats the store number on every row. Is that a good thing? The best advice is to ask users what they think and be guided accordingly. A similar issue exists with regard to the overtime hours column. Is it better to print the zero-overtime data, or only print actual hours, so the data stands out clearly? Again, the best answer is usually the one that works best for users.

CONSISTENT DESIGN: Look and feel are important to users, so reports should be uniform and consistent. When a system produces multiple reports, each report should share common design elements. For example, the date and page numbers should print in the same place on each report page. Abbreviations used in reports also should be consistent. For example, when indicating a numeric value, it is confusing for one report to use #, another *NO*, and a third *NUM*. Items in a report also should be consistent. If one report displays the inventory location as a shelf number column followed by a bin number column, that same layout should be used on all inventory location reports.

8.6.3 Types of Reports

To be useful, a report must include the information that a user needs. From a user's point of view, a report with too little information is of no value. Too much information, however, can make a report confusing and difficult to understand. When designing reports, the essential goal is to match the report to the user's specific information needs. Depending on their job functions, users might need one or more of the reports described in the following sections.

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DETAIL REPORTS: A **detail report** produces one or more lines of output for each record processed. Because it contains one or more lines for each record, a detail report can be quite lengthy. Consider, for example, a large auto parts business. If the firm stocks 3,000 parts, then the detail report would include 3,000 detail lines on approximately 50 printed pages. A user who wants to locate any part in short supply has to examine 3,000 detail lines to find the critical items. A better alternative might be an exception report.

EXCEPTION REPORTS: An **exception report** displays only those records that meet a specific condition or conditions. Exception reports are useful when the user wants information only on records that might require action but does not need to know the details. For example, a credit manager might use an exception report to identify only those customers with past-due accounts, or a customer service manager might want a report on all packages that were not delivered within a specified time period.

SUMMARY REPORTS: Upper-level managers often want to see total figures and do not need supporting details. A sales manager, for example, might want to know total sales for each sales representative but not want a detail report listing every sale made by them. In that case, a **summary report** is appropriate. Similarly, a personnel manager might need to know the total regular and overtime hours worked by employees in each store but might not be interested in the number of hours worked by each employee.

CASE IN POINT 8.3: LAZY EDDIE

Lazy Eddie is a furniture chain specializing in recliners. Their management has asked you to review the large number of printed reports that are distributed to Lazy Eddie's 35 store managers. Management is not sure that the managers actually read or use the reports, even though the store managers say they want them. Store visits have shown many of the reports end up stacked on top of filing cabinets, seemingly untouched.

To determine if store managers really use the printed reports, management has asked you to create a procedure that requires users to review and justify their information needs. You could design a form that asks if the information still is required, and why. You could try to get users to decide if a report is worth the cost of producing it. How do you proceed?

8.7 TECHNOLOGY ISSUES

Unlike early innovations such as the mouse and the inkjet printer, most technology advances today affect both output *and* input. In a very real sense, output and input have become interdependent, as they are in a user interface, and it is difficult to cite examples of changes in one that would not cause, or at least encourage, changes in the other. For example, new touch-screen input technology generates output that must be properly designed and sized for a particular device, which might be a smartphone, a tablet, or a 23-inch desktop monitor.

The following sections discuss output and input technology separately, but interface designers should always be alert to the possible opportunities, or potential problems, of input/output linkage.

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8.7.1 Output Technology

Although business information systems still provide most output as screen displays and printed matter, technology is having an enormous impact on how people communicate and obtain information. This trend is especially important to firms that use information technology to lower their costs, improve employee productivity, and communicate effectively with their customers.

In addition to screen output and printed matter, output can be delivered in many ways. The system requirements document probably identified user output needs. Now, in the systems design phase, the analyst creates the actual forms, reports, documents, and other types of output that might be accessed from workstations, notebooks, tablets, smartphones, and other devices. How the information will be used, stored, and retrieved must also be considered. The following subsections explain various output types and technologies.

INTERNET-BASED INFORMATION DELIVERY: Millions of firms use the Internet to reach new customers and markets around the world. To support the explosive growth in e-commerce, web designers must provide user-friendly screen interfaces that display output and accept input from customers. For example, a business can link its inventory system to its website so the output from the inventory system is displayed as an online catalog. Customers visiting the site can review the items, obtain current prices, and check product availability.

Another example of web-based output is a system that provides customized responses to product or technical questions. When a user enters a product inquiry or requests technical support, the system responds with appropriate information from an on-site knowledge base. Web-based delivery allows users to download a universe of files and documents to support their information needs. For example, the web provides consumers with instant access to brochures, product manuals, and parts lists, while prospective homebuyers can obtain instant quotes on mortgages, insurance, and other financial services.

To reach prospective customers and investors, companies also use a live or prerecorded **webcast**, which is an audio or video media file distributed over the Internet. Radio and TV stations also use this technique to broadcast program material to their audiences.

EMAIL: Email is an essential means of internal and external business communication. Employees send and receive email on local or wide area networks, including the Internet. Companies send new product information to customers via email, and financial services companies use email messages to confirm online stock trades. Employees use email to exchange documents, data, and schedules and to share business-related information they need to perform their jobs. In many firms, email has virtually replaced traditional memos and printed correspondence.

BLOGS: Web-based logs, called **blogs**, are another form of web-based output. Because blogs are journals written from a particular point of view, they not only deliver facts to web readers but also provide opinions. Blogs are useful for posting news, reviewing current events, and promoting products.

INSTANT MESSAGING: This popular form of communication is another way for individuals and companies to communicate effectively over the Internet. Although some users feel that it can be a distraction, others like the constant flow of communication, especially as a team member in a collaborative situation.

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WIRELESS DEVICES: Messages and data can be transmitted to a wide array of mobile devices, including tablet computers, smartphones, and similar wireless products that combine portable computing power, multimedia capability, and Internet access.

DIGITAL AUDIO, IMAGES, AND VIDEO: Sounds, images, and video clips can be captured, stored in digital format, and transmitted as output to users who can reproduce the content.

Audio or video output can be attached to an email message or inserted as a clip in a Microsoft Word document. Businesses also use automated systems to handle voice transactions and provide information to customers. For example, using a telephone keypad, a customer can confirm an airline seat assignment, check a credit card balance, or determine the current price of a mutual fund.

If a picture is worth a thousand words, then digital images and video clips certainly are high-value output types that offer a whole new dimension. For example, an insurance adjuster with a digital camera phone can take a picture, submit the image via a wireless device, and receive immediate authorization to pay a claim on the spot. If images are a valuable form of output, video clips are even better in some situations. For example, video clips provide online virtual tours that allow realtors to show off the best features of homes they are marketing. The user can zoom in or out and rotate the image in any direction.

AUTOMATED FAX SYSTEMS: An **automated fax** or **faxback** system allows a customer to request a fax using email, via the company website, or by telephone. The response is transmitted in a matter of seconds back to the user's fax machine. Although most users prefer to download documents from the web, many established organizations still offer an automated faxback service as another way to provide immediate response 24 hours a day to a certain set of customers. Certain industries in particular, such as drug stores and doctor's offices, insurance companies, and real estate brokers, still rely on fax machines as a primary way of communication.

PODCASTS: A **podcast** is a specially formatted digital audio file that can be downloaded by Internet users from a variety of content providers. Many firms use podcasts as sales and marketing tools and to communicate with their own employees. Using software such as iTunes, users can receive a podcast, launch the file on their computer, and store it on their portable player. Podcasts can include images, sounds, and video.

COMPUTER OUTPUT TO DIGITAL MEDIA: This process is used when many paper documents must be scanned, stored in digital format, and retrieved quickly. For example, if an insurance company stores thousands of paper application forms, special software can treat the documents as data and extract information from a particular column or area on the form. Digital storage media can include magnetic tape, CDs, DVDs, and high-density laser disks.

SPECIALIZED FORMS OF OUTPUT: An incredibly diverse marketplace requires many forms of specialized output and devices. For example:

- Portable, web-connected devices that can run multiple apps, handle multimedia output, and provide powerful, multipurpose communication for users
- Retail point-of-sale terminals that handle computer-based credit card transactions, print receipts, and update inventory records

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- Automatic teller machines (ATMs) that can process bank transactions and print deposit and withdrawal slips
- Special-purpose printers that can produce labels, employee ID cards, driver's licenses, gasoline pump receipts, and, in some states, lottery tickets
- Plotters that can produce high-quality images such as blueprints, maps, and electronic circuit diagrams
- Electronic detection of data embedded in credit cards, bank cards, and employee identification cards

8.7.2 Input Technology

Input technology has changed dramatically in recent years. In addition to traditional devices and methods, there has been a rapid expansion of new hardware and ways to capture and enter data into a system, some of which are shown in Figure 8-16. Businesses are using the new technology to speed up the input process, reduce costs, and capture data in new forms, such as digital signatures.

INPUT TECHNOLOGY		
Traditional	**Evolving**	**Emerging**
Keyboard	Body motion detection	Brain-computer interface (BCI)
Mouse	Advanced voice recognition	Neural networks
Pointing devices	Biological feedback	Artificial intelligence (AI)
Microphone	Embedded magnetic data	Advanced motion sensors
OCR (optical character recognition)	RFID	Two-way satellite interface
MICR (magnetic ink character recognition)	Advanced optical recognition	Virtual environments
Graphic input devices	Physical adaptation devices	3-D technology

FIGURE 8-16 Input devices can be very traditional or based on the latest technology.

Input methods should be cost-efficient, timely, and as simple as possible. Systems analysts study transactions and business operations to determine how and when data should enter the system. Usually, the first decision is whether to use batch or online input methods. Each method has advantages and disadvantages, and the systems analyst must consider the following factors.

BATCH INPUT: Using **batch input**, data entry usually is performed on a specified time schedule, such as daily, weekly, monthly, or longer. For example, batch input occurs when a payroll department collects time cards at the end of the week and enters the data as a **batch**. Another example is a school that enters all grades for the academic term in a batch.

ONLINE INPUT: Although batch input is used in specific situations, most business activity requires **online data entry**. The online method offers major advantages, including the immediate validation and availability of data. A popular online input method is **source data automation**, which combines online data entry and automated

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data capture using input devices such as **radio frequency identification(RFID) tags**, magnetic data strips, or even smartphones. Source data automation is fast and accurate and minimizes human involvement in the translation process.

Many large companies use a combination of source data automation and a powerful communication network to manage global operations instantly. Some common examples of source data automation are as follows:

- Businesses that use point-of-sale (POS) terminals equipped with bar code scanners and magnetic swipe scanners to input credit card data
- Automatic teller machines (ATMs) that read data strips on bank cards
- Factory employees who use magnetic ID cards to clock on and off specific jobs so the company can track production costs accurately
- Hospitals that imprint bar codes on patient identification bracelets and use portable scanners when gathering data on patient treatment and medication
- Retail stores that use portable bar code scanners to log new shipments and update inventory data
- Libraries that use handheld scanners to read optical strips on books

TRADE-OFFS: Although online input offers many advantages, it does have some disadvantages. For example, unless source data automation is used, manual data entry is slower and more expensive than batch input because it is performed at the time the transaction occurs and often done when computer demand is at its highest.

The decision to use batch or online input depends on business requirements. For example, hotel reservations must be entered and processed immediately, but hotels can enter their monthly performance figures in a batch. In fact, some input occurs naturally in batches. A cable TV provider, for example, receives customer payments in batches when the mail arrives.

8.8 Security and Control Issues

A company must do everything in its power to protect its data. This includes not only the firm's own information but that of its customers, employees, and suppliers. Most assets have a value, but corporate data is priceless because without safe, secure, and accurate data, a company cannot function.

The following sections discuss output and input data security and control.

8.8.1 Output Security and Control

Output must be accurate, complete, current, and secure. Companies use various **output control** methods to maintain output integrity and security. For example, every report should include an appropriate title, report number or code, printing date, and time period covered. Reports should have pages that are numbered consecutively, identified as *Page nn of nn*, and the end of the report should be labeled clearly. Control totals and record counts should be reconciled against input totals and counts. Reports should be selected at random for a thorough check of correctness and completeness. All processing errors or interruptions must be logged so they can be analyzed.

Output security protects privacy rights and shields the organization's proprietary data from theft or unauthorized access. To ensure output security, several important

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tasks must be performed. First, limit the number of printed copies and use a tracking procedure to account for each copy. When printed output is distributed from a central location, specific procedures should be used to ensure that the output is delivered to authorized recipients only. That is especially true when reports contain sensitive information, such as payroll data. All sensitive reports should be stored in secure areas. All pages of confidential reports should be labeled appropriately.

As shown in Figure 8-17, it is important to shred sensitive reports, out-of-date reports, and output from aborted print runs. Blank check forms must be stored in a secure location and be inventoried regularly to verify that no forms are missing. If signature stamps are used, they must be stored in a secure location away from the forms storage location.



FIGURE 8-17 To maintain output security, it is important to shred sensitive material.

Gang Liu/Shutterstock.com

In most organizations, the IT department is responsible for coordinating output control and security measures. Systems analysts must be concerned with security issues as they design, implement, and support information systems. Whenever possible, security should be designed into the system by using passwords, shielding sensitive data, and controlling user access. Physical security always will be necessary, especially in the case of printed output that is tangible and can be viewed and handled easily.

Enterprise-wide data access creates a whole new set of security and control issues. Many firms have responded to those concerns by installing diskless workstations. A **diskless workstation** is a network terminal that supports a full-featured user interface but limits the printing or copying of data, except to certain network resources that can be monitored and controlled. This concept would typically preclude the use of portable storage devices, such as USB thumb drives.

8.8.2 Input Security and Control

Input control includes the necessary measures to ensure that input data is correct, complete, and secure. Input control must be the focus during every phase of input design, starting with source documents that promote data accuracy and quality. When a batch input method is used, the computer can produce an input log file that identifies and documents the data entered.

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Every piece of information should be traceable back to the input data that produced it. That means the analyst must provide an audit trail that records the source of each data item and when it entered the system. In addition to recording the original source, an audit trail must show how and when data is accessed or changed, and by whom. All those actions must be logged in an audit trail file and monitored carefully.

A company must have procedures for handling source documents to ensure that data is not lost before it enters the system. All source documents that originate from outside the organization should be logged when they are received. Whenever source documents pass between departments, the transfer should be recorded.

Data security policies and procedures protect data from loss or damage, which is a vital goal in every organization. If the safeguards are not 100% effective, data recovery utilities should be able to restore lost or damaged data. Once data is entered, the company should store source documents in a safe location for some specified length of time. The company should have a **records retention policy** that meets all legal requirements and business needs.

Audit trail files and reports should be stored and saved. Then, if a data file is damaged, the information can be used to reconstruct the lost data. Data security also involves protecting data from unauthorized access. System sign-on procedures should prevent unauthorized individuals from entering the system, and users should change their passwords regularly. Having several levels of access also is advisable. For example, a data entry person might be allowed to *view* a credit limit but not *change* it. Sensitive data can be encrypted, or coded, in a process called **encryption**, so only users with decoding software can read it.

8.9 Emerging Trends

The user interface continues to evolve. The widespread use of mobile devices such as the iPad and other tablets, coupled with the ubiquity of the iPhone and other smartphones, has greatly influenced user interface design. Indeed, key user experience lessons from these devices have been reflected back into the user interface for mainstream operating systems such as Mac OS X and Microsoft Windows.

It is difficult to predict the future, but the introduction of the Apple Watch, Google's Wear OS, Fitbit's fitness trackers, and other wearable devices promises to further shake up user interface design principles. Advanced technology will support the evolution, but the *real* driving force will be user empowerment, which results in customer satisfaction, increased productivity, and bottom-line savings.

8.9.1 Modular Design

In a **modular design**, individual components, called **modules**, are created that connect to a higher-level program or process. In a structured design, each module represents a specific process, which is shown on a DFD and documented in a process description. If an object-oriented design is being used, as described in Chapter 6, code modules represent classes. Modular design is explained in more detail in Chapter 11, which describes systems implementation.

Modules should be designed to perform a single function. Independent modules provide greater flexibility because they can be developed and tested individually and then combined or reused later in the development process. Modular design is especially important in designing large-scale systems because separate teams of analysts and programmers can work on different areas and then integrate the results.

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8.9.2 Responsive Web Design

Today's content is viewed by users on multiple devices: computers, tablets, and smartphones. Each device has its own form factors that can limit the user experience. For example, the physical dimensions of a smartphone preclude the use of wide menus—without forcing the user to scroll horizontally too much.

Responsive web design is an emerging trend that renders web content properly, independently of the device in use. This means the developer only has to focus on essential user interface issues; how the GUI artifacts are presented on the device is handled automatically by the underling framework. Responsive web design addresses various nonfunctional attributes, including usability, performance, and maintainability.

Responsive web design relies on a number of underlying technologies, including CSS3, flexible images, and fluid grids. Page elements are expressed in relative terms (e.g., percentages), rather than absolute terms (e.g., pixels). This allows the content to "flow" properly in the user interface, irrespective of the display device.

8.9.3 Prototyping

Prototyping produces an early, rapidly constructed working version of the proposed information system, called a **prototype**. Prototyping, which involves a repetitive sequence of analysis, design, modeling, and testing, is a common technique that can be used to design anything from a new home to a computer network. For example, engineers use a prototype to evaluate an aircraft design before production begins, as shown in the wind tunnel testing in Figure 8-18.



FIGURE 8-18 Wind tunnel testing is a typical example of prototyping.
Courtesy of NASA

User input and feedback is essential at every stage of the systems development process. Prototyping allows users to examine a model that accurately represents system outputs, inputs, interfaces, and processes. Users can "test-drive" the model in a risk-free environment and either approve it or request changes. In some situations, the prototype evolves into the final version of the information system. In other cases, the prototype is intended only to validate user requirements and is discarded afterward.

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Perhaps the most intense form of prototyping occurs when agile methods are used. As described in Chapter 1, agile methods build a system by creating a series of prototypes and constantly adjusting them to user requirements. As the agile process continues, developers revise, extend, and merge earlier versions into the final product. An agile approach emphasizes continuous feedback, and each incremental step is affected by what was learned in the prior steps.

Systems analysts generally use two prototyping methods: system prototyping and design prototyping.

SYSTEM PROTOTYPING: System prototyping produces a full-featured, working model of the information system. A system prototype that meets all requirements is ready for implementation, as shown in Figure 8-19. Because the model is "on track" for implementation, it is especially important to obtain user feedback and to be sure that the prototype meets all requirements of users and management.

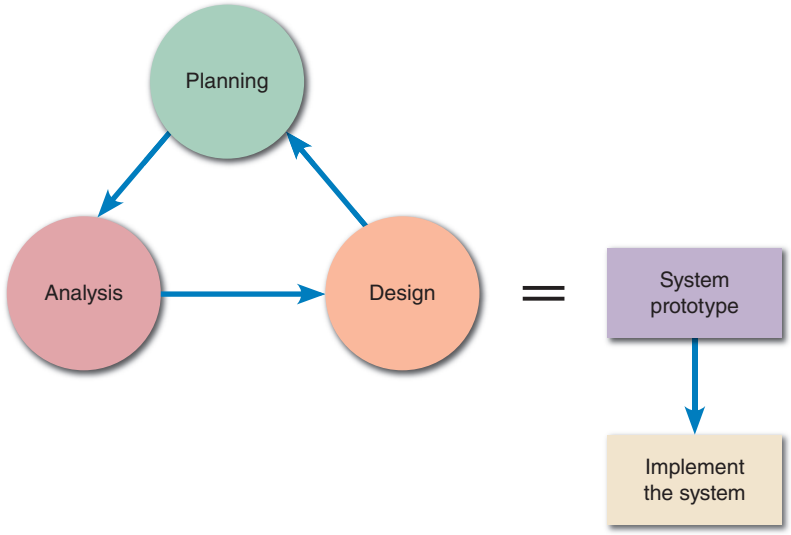


FIGURE 8-19 The end product of system prototyping is a working model of the information system, ready for proper implementation.

DESIGN PROTOTYPING: Systems analysts also use prototyping to verify user requirements, after which the prototype is discarded and implementation continues. The approach is called **design prototyping**, or **throwaway prototyping**. In this case, the prototyping objectives are more limited but no less important. The end product of design prototyping is a user-approved model that documents and benchmarks the features of the finished system. Design prototyping makes it possible to capture user input and approval while continuing to develop the system within the framework of the SDLC. Systems analysts typically use design prototyping as they construct outputs, inputs, and user interfaces.

TRADE-OFFS: Prototyping offers many benefits, including the following:

- Users and systems developers can avoid misunderstandings.
- System developers can create accurate specifications for the finished system based on the prototype.
- Managers can evaluate a working model more effectively than a paper specification.

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- Systems analysts can use a prototype to develop testing and training procedures before the finished system is available.
- Prototyping reduces the risk and potential financial exposure that occur when a finished system fails to support business needs.

Although most systems analysts believe that the advantages of prototyping far outweigh any disadvantages, the following potential problems should be considered:

- The rapid pace of development can create quality problems, which are not discovered until the finished system is operational.
- Other system requirements, such as reliability and maintainability, cannot be tested adequately using a prototype.
- In very complex systems, the prototype can become unwieldy and difficult to manage.
- A client or user might want to adopt the prototype with few to no changes, mistakenly thinking that the prototype will meet their needs though it may need further customization, leading to increased maintenance costs later in the SDLC.

A QUESTION OF ETHICS



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One of the systems analysts on the project team thought that he did a good job of designing the company's tech support webpage, but his supervisor isn't so sure. His supervisor is concerned that the design is very similar to a page used by the company's major competitor, and she asked him whether he had used any HTML code from that site in his design. Although the analyst didn't copy any of the code, he did examine it in his web browser to see how they handled some design issues.

The supervisor asked the analyst to investigate webpage copyright issues and report back to her. In his research, the analyst learned that outright copying would be a copyright violation, but merely viewing other sites to get design ideas would be permissible. What is not so clear is the gray area in the middle. The analyst asked you, as a friend, for your opinion on this question: Even if no actual copying is involved, are there ethical constraints on how far you should go in using the creative work of others? How would you answer?

8.10 Summary

The chapter began with a discussion of user interface design and HCI concepts. A GUI uses visual objects and techniques that allow users to communicate effectively with the system. User-centered design principles include understanding the business, maximizing graphic effectiveness, thinking like a user, using models and prototypes, focusing on usability, inviting feedback, and documenting everything.

When designing the user interface, it should be transparent; create an interface that is easy to learn and use; enhance user productivity; make it easy to obtain help or correct errors; minimize input data problems; provide feedback; create an attractive layout and design; and use familiar terms and images. Control features, such as menu

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bars, toolbars, drop-down list boxes, dialog boxes, toggle buttons, list boxes, option buttons, check boxes, and command buttons can also be added. Controls are placed on a main switchboard, which is like a graphical version of a main menu.

The discussion of input design began with a description of source documents and the various zones in a document, including the heading zone, the control zone, the instruction zone, the body zone, the totals zone, and the authorization zone. The discussion of data entry screen design explained the use of input masks and validation rules to reduce data errors. Input masks are like templates that only permit certain combinations of characters, and data validation rules can provide checks to ensure that inappropriate data is prevented from entering the system. These checks can include data sequence, existence, range and limit, reasonableness, and validity, among others.

The chapter described various types of printed reports, including detail, exception, and summary reports. The features and sections of reports, including control fields, control breaks, report headers and footers, page headers and footers, and group headers and footers were explained. Other types of output, such as web-based information delivery, audio output, instant messaging, podcasts, email, and other specialized forms of output were also discussed.

Batch and online input methods were also described, as were input media and procedures, and input volume. Input methods include data capture and data entry. Data capture, which may be automated, involves identifying and recording source data. Data entry involves converting source data into a computer-readable form and entering it into the system. New technology offers optical and voice recognition systems, biological feedback devices, motion sensors, and a variety of graphical input devices.

Security and control were discussed. Output control includes physical protection of data and reports and control of unauthorized ports or devices that can extract data from the system. Input controls include audit trails, encryption, password security, data security, and the creation of access levels to limit persons authorized to view or use data.

Finally, the emerging trends of modular design, responsive web design, and prototyping were discussed.

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Key Terms

audit trail A record of the source of each data item and when it entered a system. In addition to recording the original source, an audit trail must show how and when data is accessed or changed, and by whom. All these actions must be logged in an audit trail file and monitored carefully.

authorization zone Part of a form that contains any required signatures.

automated fax A system that allows a customer to request a fax using email, the company website, or a telephone. The response is transmitted in a matter of seconds back to the user's fax machine. *See* **faxback**.

batch A group of data, usually inputted into an information system at the same time.

batch control A total used to verify batch input. Batch controls might check data items such as record counts and numeric field totals. For example, before entering a batch of orders, a user might calculate the total number of orders and the sum of all the order quantities. When the batch of orders is entered, the order system also calculates the same two totals. If the system totals do not match the input totals, then a data entry error has occurred.

batch input A process where data entry is performed on a specified time schedule, such as daily, weekly, monthly, or longer. For example, batch input occurs when a payroll department collects time cards at the end of the week and enters the data as a batch.

blog An online journal. The term is a contraction of "web log."

calendar control A calendar control allows the user to select a date that the system will display and store as a field value.

character-based report A report created using a single mono-spaced character set.

check box Used to select one or more choices from a group. A check mark, or an X, represents selected options.

combination check A type of data validation check that is performed on two or more fields to ensure that they are consistent or reasonable when considered together. Even though all the fields involved in a combination check might pass their individual validation checks, the combination of the field values might be inconsistent or unreasonable.

command button Onscreen button that initiates an action such as printing a form or requesting Help.

context-sensitive A feature that is sensitive to the current conditions when it is invoked. For example, context-sensitive help offers assistance for a task in progress.

control break A control break usually causes specific actions to occur, such as printing subtotals for a group of records.

control break report A detail report that focuses on control breaks.

control field order In a control break report, the records are arranged or sorted in the same order as the control fields.

data security Protection of data from loss or damage and recovers data when it is lost or damaged.

data type check A type of data validation check that is used to ensure that a data item fits the required data type. For example, a numeric field must have only numbers or numeric symbols, and an alphabetic field can contain only the characters A through Z or the characters a through z.

data validation rule A mechanism to improve input quality by testing the data and rejecting any entry that fails to meet specified conditions.

default value A value that a system displays automatically.

design prototyping Creating a prototype of user requirements, after which the prototype is discarded and implementation continues. Also called throwaway prototyping.

detail report A detail report produces one or more lines of output for each record processed.

dialog box Allows a user to enter information about a task that a system will perform.

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diskless workstation A network terminal that supports a full-featured user interface but limits the printing or copying of data, except to certain network resources that can be monitored and controlled more easily.

electronic health record (EHR) An electronic record of a patient's health information generated as the patient encounters various health-care providers and shared among multiple facilities and agencies.

encryption A process where data is coded (converted into unreadable characters) so that only those with the required authorization can access the data (usually via decoding software).

exception report A document displaying only those records that meet a specific condition or conditions. Exception reports are useful when the user wants information only on records that might require action but does not need to know the details.

existence check A type of data validation check that is used for mandatory data items. For example, if an employee record requires a Social Security number, an existence check would not allow the user to save the record until he or she enters a suitable value in the SSN field.

faxback *See* **automated fax**.

form filling A very effective method of online data entry where a blank form that duplicates or resembles the source document is completed on the screen. The user enters the data and then moves to the next field.

form layout The physical appearance and placement of data on a form. Form layout makes the form easy to complete and provides enough space, both vertically and horizontally, for users to enter the data.

garbage in, garbage out (GIGO) The concept that the quality of the output is only as good as the quality of the input.

graphical user interface (GUI) The use of graphical objects and techniques allowing users to communicate with a system. A well-designed GUI can help users learn a new system rapidly and work with the system effectively.

hash totals Not meaningful numbers themselves but are useful for comparison purposes. Also known as batch control totals.

human-computer interaction (HCI) A description of the relationship between computers and the people who use them to perform business-related tasks. HCI concepts apply to everything from a PC desktop to the main menu for a global network.

input control The necessary measures to ensure that input data is correct, complete, and secure. A systems analyst must focus on input control during every phase of input design, starting with source documents that promote data accuracy and quality.

input mask Template or pattern that makes it easier for users to enter data. Often used in automated forms to guide an unfamiliar user.

limit check Occurs when a validation check involves a minimum or a maximum value, but not both. Checking that a payment amount is greater than zero, but not specifying a maximum value, is an example of a limit check.

list box An output mechanism that displays a list of choices that the user can select.

menu bar A set of user-selectable software application options, usually located across the top of the screen.

mock-up When designing a report, a sample report is prepared, which is a mock-up, or prototype, for users to review. The sample should include typical field values and contain enough records to show all the design features.

modular design A design that can be broken down into logical blocks. Also known as partitioning, or top-down design.

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module Related program code organized into small units that are easy to understand and maintain. A complex program could have hundreds or even thousands of modules.

natural language A software feature that allows users to type commands or requests in normal English (or other language) phrases.

online data entry A data entry method used for most business activity. The online method offers major advantages, including the immediate validation and availability of data.

option button Radio buttons that represent groups of options. The user can select only one option at a time; a selected option contains a black dot. *See also* **radio button**.

output control Methods to maintain output integrity and security. For example, every report should include an appropriate title, report number or code, printing date, and time period covered. Reports should have pages that are numbered consecutively, identified as Page xx of xx, and the end of the report should be labeled clearly.

output security Output security protects privacy rights and shields the organization's proprietary data from theft or unauthorized access.

page footer Appears at the bottom of the page and is used to display the name of the report and the page number.

page header Appears at the top of the page and includes the column headings that identify the data.

podcast A web-based broadcast that allows a user to receive audio or multimedia files using music player software such as iTunes, and listen to them on a PC or download them to a portable MP3 player or smart phone.

prototype An early, rapidly constructed working version of the proposed information system.

prototyping The method by which a prototype is developed. It involves a repetitive sequence of analysis, design, modeling, and testing. It is a common technique that can be used to design anything from a new home to a computer network.

radio button Buttons that represent groups of options. The user can select only one option at a time; a selected option contains a black dot. *See also* **option button**.

radio frequency identification (RFID) tag An input device used in source data automation.

range check A type of data validation check that tests data items to verify that they fall between a specified minimum and maximum value. The daily hours worked by an employee, for example, must fall within the range of 0 to 24.

reasonableness check A type of data validation check that identifies values that are questionable but not necessarily wrong. For example, input payment values of $0.05 and $5,000,000.00 both pass a simple limit check for a payment value greater than zero, and yet both values could be errors.

records retention policy Rules designed to meet all legal requirements and business needs for keeping records.

report footer Appears at the end of the report, can include grand totals for numeric fields and other end-of-report information.

report header Appears at the beginning of a report and identifies the report as well as the report title, date, and other necessary information.

scroll bar In user interface design, a scroll bar allows the user to move through the available choices for an input field.

sequence check A type of data validation check that is used when the data must be in some predetermined sequence. If the user must enter work orders in numerical sequence, for example, then an out-of-sequence order number indicates an error. If the user must enter transactions chronologically, then a transaction with an out-of-sequence date indicates an error.

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source data automation A popular online input method that combines online data entry and automated data capture using input devices such as magnetic data strips or swipe scanners.

source document A form used to request and collect input data, trigger or authorize an input action, and provide a record of the original transaction. During the input design stage, you develop source documents that are easy to complete and inexpensive.

storyboard Sketches used during prototyping to show the general screen layout and design.

summary report A report used by individuals at higher levels in the organization that includes less detail than reports used by lower-level employees.

switchboard The use of command buttons in a user interface to enable users to navigate a system and select from groups of related tasks.

system prototyping Producing a full-featured, working model of the information system being developed.

throwaway prototyping *See* **design prototyping**.

toggle button A GUI element used to represent on or off status. Clicking the toggle button switches to the other status.

toolbar A GUI element that contains icons or buttons that represent shortcuts for executing common commands.

totals zone If a form has data totals, they will appear in this section of the form.

transparent interface A user interface that users don't really notice—a user-friendly interface that does not distract the user and calls no attention to itself.

turnaround document Output document that is later entered back into the same or another information system. A telephone or utility bill, for example, might be a turnaround document printed by the company's billing system. When the bill is returned with payment, it is scanned into the company's accounts receivable system to record the payment accurately.

usability In user interface design, includes user satisfaction, support for business functions, and system effectiveness.

usability metrics Data that interface designers can obtain by using software that can record and measure user interactions with the system.

user-centered A term that indicates the primary focus is upon the user. In a user-centered system, the distinction blurs between input, output, and the interface itself.

user interface (UI) The mechanism through which the user interacts with the system. The interface can be graphical, textual, aural, or a combination of different modes of interaction.

validity check A type of data validation check that is used for data items that must have certain values. For example, if an inventory system has 20 valid item classes, then any input item that does not match one of the valid classes will fail the check.

webcast A one-way transmission of information or training materials, such as a Webinar session, available on demand or for a specific period to online participants.

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Exercises

Questions

1. Explain Apple's view of user interface design, especially for apps.
2. What is HCI?
3. Why is a transparent interface desirable?
4. What are the seven habits of successful interface designers?
5. How would you rank the 10 guidelines for user interface design in order of importance? Explain your answer.
6. What are the main principles of source document design?
7. What is the difference between a detail report, a summary report, and an exception report?
8. How has input technology changed in recent years?
9. What is output security?
10. What are three emerging trends in user interface design?

Discussion Topics

1. Some systems analysts argue, "Give users what they ask for. If they want lots of reports and reams of data, then that is what you should provide. Otherwise, they will feel that you are trying to tell them how to do their jobs." Others say, "Systems analysts should let users know what information can be obtained from the system. If you listen to users, you'll never get anywhere because they really don't know what they want and don't understand information systems." What do you think of these arguments?
2. Some systems analysts maintain that source documents are unnecessary. They say that all input can be entered directly into the system, without wasting time in an intermediate step. Do you agree? Can you think of any situations where source documents are essential?
3. Suppose your network support company employs 75 technicians who travel constantly and work at customer sites. Your task is to design an information system that provides technical data and information to the field team. What types of output and information delivery would you suggest for the system?
4. A user interface can be quite restrictive. For example, the interface design might not allow a user to exit to a Windows desktop or to log on to the Internet. Should a user interface include such restrictions? Why or why not?
5. How is the increased use of smartphones and tablets, with their smaller screen size, affecting user interface design practices?

Projects

1. Visit the administrative office at your school or a local company. Ask to see examples of input screens. Analyze the design and appearance of each screen and try to identify at least one possible improvement.
2. Search the web to find an especially good example of a user interface that includes guidelines in this chapter. Document your research and discuss it with your class.
3. Review Section 8.2 and the comments about EHR usability. Research the current status of EHR usability and describe all noteworthy developments.
4. Suggest at least two good examples and two bad examples of source document design.
5. Explore the emerging area of wearable computing, such as the Apple Watch, and comment on the impact of these devices on user interface design.

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CHAPTER 9 Data Design

Chapter 9 is the second of three chapters in the systems design phase of the SDLC. During the systems analysis phase, a logical model of the system was created. Now, it must be decided how data will be organized, stored, and managed. These are important issues that affect data quality and consistency. This chapter focuses on the data design skills that are necessary for a systems analyst to construct the physical model of the information system.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" raises the important and timely issue of sharing customer data without their explicit consent.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Explain basic data design concepts, including data structures, DBMSs, and the evolution of the relational database model
2. Explain the main components of a DBMS
3. Define the major characteristics of web-based design
4. Define data design terminology
5. Draw entity-relationship diagrams
6. Apply data normalization
7. Utilize codes to simplify output, input, and data formats
8. Explain data storage tools and techniques, including logical versus physical storage
9. Explain data coding
10. Explain data control measures

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9.1 Data Design Concepts

Systems analysts must understand basic data design concepts, including data structures and the evolution of the relational database model.

9.1.1 Data Structures

A **data structure** is a framework for organizing, storing, and managing data. Data structures consist of files or tables that interact in various ways. Each file or table contains data about people, places, things, or events. For example, one file or table might contain data about customers, and other files or tables might store data about products, orders, suppliers, or employees.

Many older legacy systems utilized file processing because it worked well with mainframe hardware and batch input. Some companies still use this method to handle large volumes of structured data on a regular basis because can be cost-effective in certain situations. For example, consider a credit card company that posts thousands of daily transactions from a TRANSACTIONS file to account balances stored in a CUSTOMERS file, as shown in Figure 9-1. For that relatively simple process, file processing might be an option.

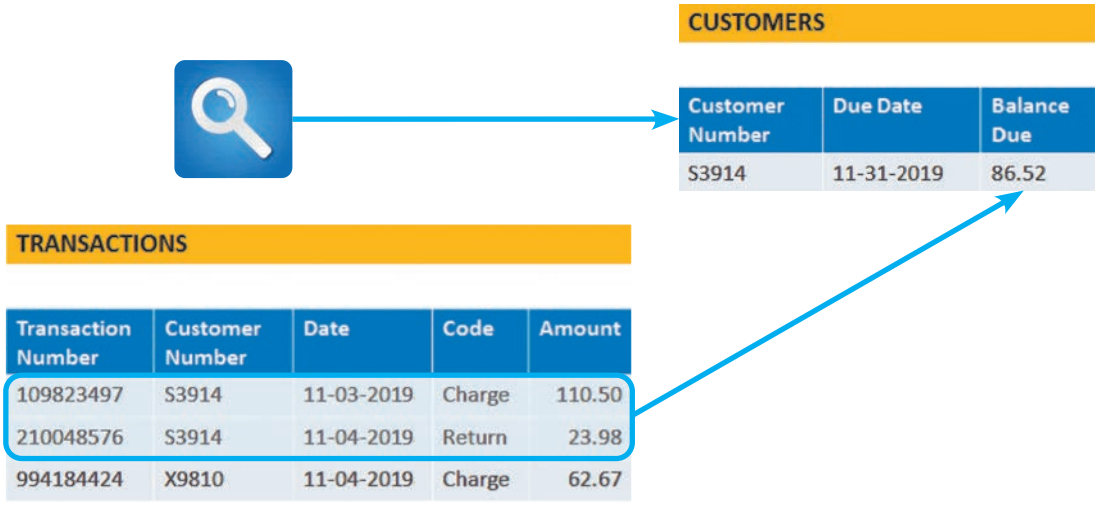


FIGURE 9-1 A credit card company that posts thousands of daily transactions might consider a file processing option.

Over time, the modern relational database became a standard model for systems developers. The following example of an auto service shop will compare the two concepts.

9.1.2 Mario and Danica: A Data Design Example

Figure 9-2 shows an auto shop mechanic at work. Imagine two shops that are very similar but use two different information system designs. Let's call them Mario's Auto Shop and Danica's Auto Shop. Mario uses two file-oriented systems, while Danica uses a database management system.

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FIGURE 9-2 In the example shown here, data about the mechanic, the customer, and the brake job might be stored in a file-oriented system or in a database system.
Lisa F. Young/Shutterstock.com

MARIO'S AUTO SHOP: Mario relies on two **file-oriented systems**, sometimes called file processing systems, to manage his business. The two systems store data in separate files that are not connected or linked. Figure 9-3 shows Mario's file-oriented systems:

- The MECHANIC SYSTEM uses the MECHANIC file to store data about shop employees
- The JOB SYSTEM uses the JOB file to store data about work performed at the shop.

Unfortunately, using two separate systems means that some data is stored in two different places, and the data might or might not be consistent. For example, three data items (Mechanic No, Name, and Pay Rate) are stored in both files. This redundancy is a major disadvantage of file-oriented systems because it threatens data quality and integrity. In fact, Figure 9-3 includes a typical discrepancy: Jim Jones' pay rate is shown as $18.90 in the MECHANIC SYSTEM file and $19.80 in the JOB SYSTEM file.

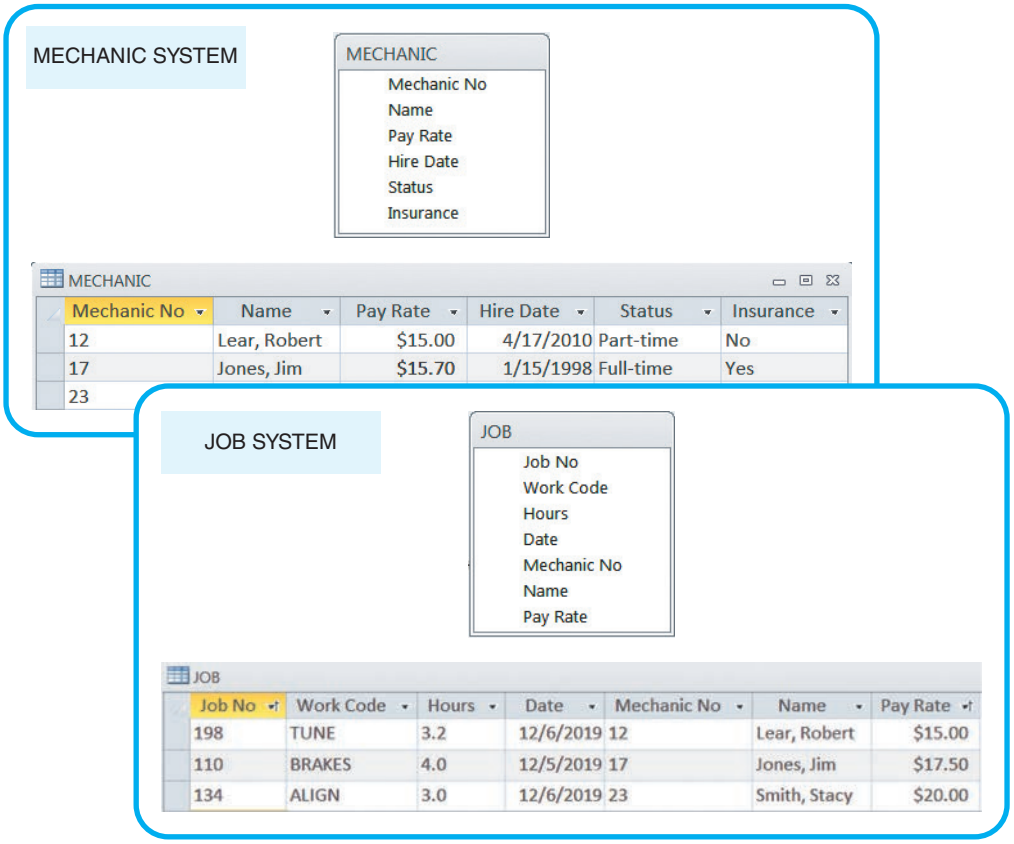
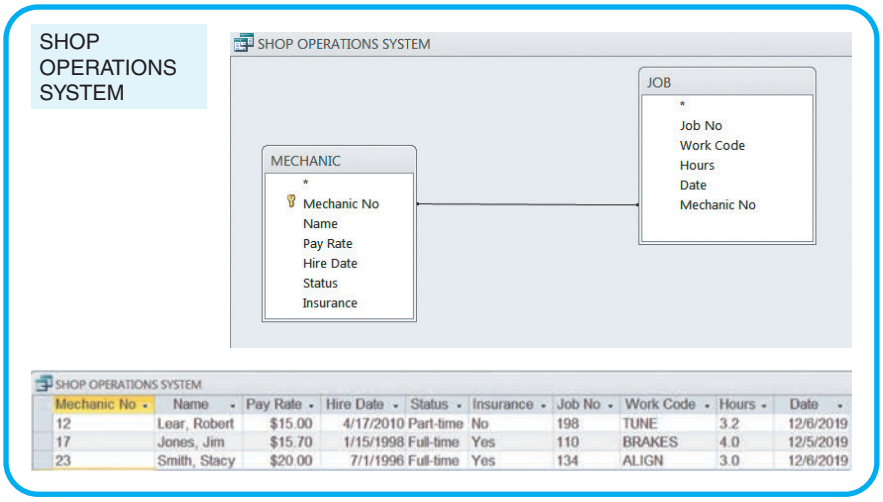


FIGURE 9-3 Mario's shop uses two separate systems, so certain data must be entered twice. This redundancy is inefficient and can produce errors.

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DANICA'S AUTO SHOP: Danica uses a database management system (DBMS) with two separate tables that are joined, so they act like one large table, as shown in Figure 9-4. In Danica's SHOP OPERATIONS SYSTEM, the tables are linked by the Mechanic No field, which is called a *common field* because it connects the tables. Note that except for the common field, no other data items are duplicated. The DBMS design, also called a **relational database** or **relational model**, was introduced in the 1970s and continues to be the dominant approach for organizing, storing, and managing business data.



Mechanic No	Name	Pay Rate	Hire Date	Status	Insurance	Job No	Work Code	Hours	Date
12	Lear, Robert	$15.00	4/17/2010	Part-time	No	198	TUNE	3.2	12/6/2019
17	Jones, Jim	$15.70	1/15/1998	Full-time	Yes	110	BRAKES	4.0	12/5/2019
23	Smith, Stacy	$20.00	7/1/1996	Full-time	Yes	134	ALIGN	3.0	12/6/2019

FIGURE 9-4 Danica's SHOP OPERATIONS SYSTEM uses a database design, which avoids duplication. The data can be viewed as if it were one large table, regardless of where the data is physically stored.

Mario's file-oriented systems show two different pay rates for Jim Jones, most likely because of a data entry error in one of them. That type of error could not occur in Danica's relational database, because an employee's pay rate is stored in only one place. However, DBMSs are not immune to data entry problems, which are discussed in detail later in this chapter.

9.1.3 Database Management Systems

A database provides an overall framework that avoids data redundancy and supports a real-time, dynamic environment. Figure 9-5 shows a company-wide database that supports four separate information systems.

A **database management system (DBMS)** is a collection of tools, features, and interfaces that enables users to add, update, manage, access, and analyze data. From a user's point of view, the main advantage of a DBMS is that it offers timely, interactive, and flexible data access. Specific DBMS advantages include the following:

- *Scalability*. **Scalability** means that a system can be expanded, modified, or downsized easily to meet the rapidly changing needs of a business enterprise.



FIGURE 9-5 In this example, a sales database can support four separate business systems.

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For example, if a company decides to add data about secondary suppliers of material it uses, a new table can be added to the relational database and linked with a common field.

- *Economy of scale*. Database design allows better utilization of hardware. If a company maintains an enterprise-wide database, processing is less expensive using powerful servers and communication networks. The inherent efficiency of high-volume processing on larger computers is called **economy of scale**.
- *Enterprise-wide application*. A DBMS is typically managed by a person called a **database administrator (DBA)**. The DBA assesses overall requirements and maintains the database for the benefit of the entire organization rather than a single department or user. Database systems can support enterprise-wide applications more effectively than file processing systems.
- *Stronger standards*. Effective database administration helps ensure that standards for data names, formats, and documentation are followed uniformly throughout the organization.
- *Better security*. The DBA can define authorization procedures to ensure that only legitimate users can access the database and can allow different users to have different levels of access. Most DBMSs provide sophisticated security support.
- *Data independence*. Systems that interact with a DBMS are relatively independent of how the physical data is maintained. That design provides the DBA flexibility to alter data structures without modifying information systems that use the data.

Although the trend is toward enterprise-wide database design, many companies still use a combination of centralized DBMSs and smaller, department-level database systems. This is because most large businesses view data as a company-wide resource that must be accessible to users throughout the company. At the same time, other factors encourage a decentralized design, including network expense; a reluctance to move away from smaller, more flexible systems; and a realization that enterprise-wide DBMSs can be highly complex and expensive to maintain. The compromise, in many cases, is a client/server design, where processing is shared among several computers. Client/server systems are described in detail in Chapter 10. As with many design decisions, the best solution depends on the organization's needs and particular circumstances.

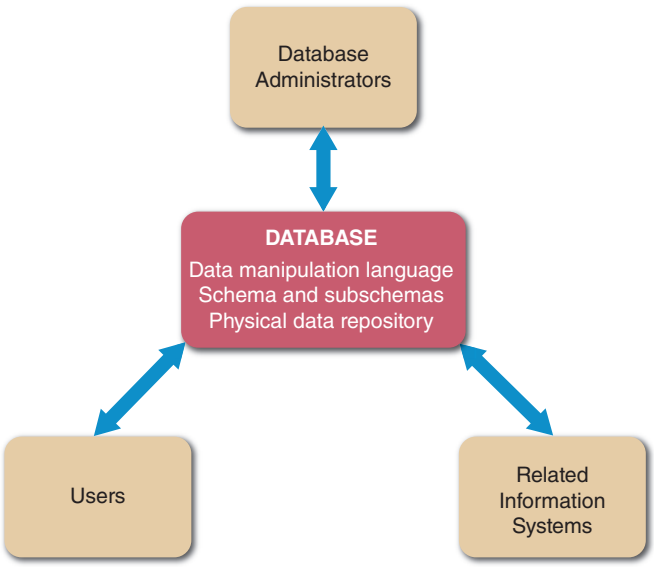


FIGURE 9-6 In addition to interfaces for users, database administrators, and related information systems, a DBMS also has a data manipulation language, a schema and subschemas, and a physical data repository.

9.2 DBMS Components

A DBMS provides an interface between a database and users who need to access the data. Although users are concerned primarily with an easy-to-use interface and support for their business requirements, a systems analyst must understand all of the components of a DBMS. In addition to interfaces for users, DBAs, and related systems, a DBMS also has a data manipulation language, a schema and subschemas, and a physical data repository, as shown in Figure 9-6.

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9.2.1 Interfaces for Users, Database Administrators, and Related Systems

When users, DBAs, and related information systems request data and services, the DBMS processes the request, manipulates the data, and provides a response. A **data manipulation language (DML)** controls database operations, including storing, retrieving, updating, and deleting data. Most commercial DBMSs, such as Oracle and IBM's DB2, use a DML. Some database products, such as Microsoft Access, also provide an easy-to-use graphical environment that enables users to control operations with menu-driven commands.

USERS: Users typically work with predefined queries and switchboard commands but also use query languages to access stored data. A **query language** allows a user to specify a task without specifying how the task will be accomplished. Some query languages use natural language commands that resemble ordinary English sentences. With a **query by example (QBE)** language, the user provides an example of the data requested. Many database programs also use **Structured Query Language (SQL)**, which is a language that allows client workstations to communicate with servers and mainframe computers. Figure 9-7 shows a QBE request for all Lime Squeeze or Blue Candy 2019 Ford Fusions with a power moonroof. The QBE request generates the SQL commands shown at the bottom of Figure 9-7.

DATABASE ADMINISTRATORS: A DBA is responsible for DBMS management and support. DBAs are concerned with data security and integrity, preventing unauthorized access, providing backup and recovery, audit trails, maintaining the database, and supporting user needs. Most DBMSs provide utility programs to assist the DBA in creating and updating data structures, collecting and reporting patterns of database usage, and detecting and reporting database irregularities.

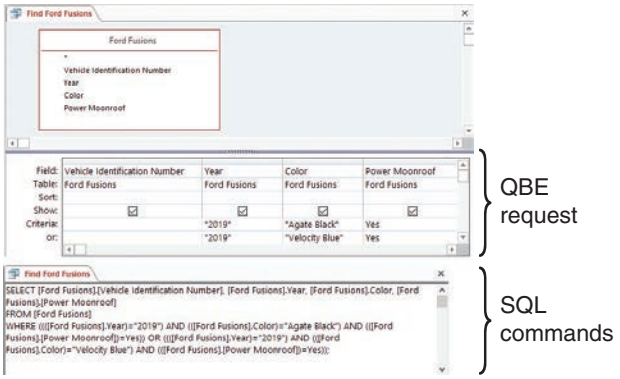


FIGURE 9-7 Using QBE, a user can display all 2019 Ford Fusions that have a power moonroof and are either Lime Squeeze or Blue Candy color.

RELATED INFORMATION SYSTEMS: A DBMS can support several related information systems that provide input to, and require specific data from, the DBMS. Unlike a user interface, no human intervention is required for two-way communication between the DBMS and the related systems.

9.2.2 Schema

The complete definition of a database, including descriptions of all fields, tables, and relationships, is called a **schema**. One or more subschemas can also be defined. A **subschema** is a view of the database used by one or more systems or users. A subschema defines only those portions of the database that a particular system or user needs or is allowed to access. For example, to protect individual privacy, the project management system should not be permitted to retrieve employee pay rates. In that case, the project management system subschema would not include the pay rate field. Database designers also use subschemas to restrict the level of access permitted. For example, specific users, systems, or locations might be permitted to create, retrieve, update, or delete data, depending on their needs and the company's security policies.

9.2.3 Physical Data Repository

Chapter 5 discussed a data dictionary, which describes all data elements included in the logical design. At this stage of the systems development process, the data

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dictionary is transformed into a physical data repository, which also contains the schema and subschemas. The physical repository might be centralized, or it might be distributed at several locations. In addition, the stored data might be managed by a single DBMS, or several systems. To resolve potential database connectivity and access problems, companies use ODBC-compliant software that enables communication among various systems and DBMSs. **Open database connectivity (ODBC)** is an industry-standard protocol that makes it possible for software from different vendors to interact and exchange data. ODBC uses SQL statements that the DBMS understands and can execute, similar to the ones shown in Figure 9-7. Another common standard is called **java database connectivity (JDBC)**. JDBC enables Java applications to exchange data with any database that uses SQL statements and is JDBC-compliant.

Physical design issues are described in Chapter 10, which discusses system architecture, and in Chapter 11, which discusses system implementation and data conversion.

9.3 Web-Based Design

Figure 9-8 lists some major characteristics of web-based design. In a web-based design, the Internet serves as the front end, or interface, for the DBMS. Internet technology provides enormous power and flexibility because the related information system is not tied to any specific combination of hardware and software. Access to the database requires only a web browser and an Internet connection. Web-based systems are popular because they offer ease of access, cost-effectiveness, and worldwide connectivity—all of which are vital to companies that must compete in a global economy.

CHARACTERISTIC	EXPLANATION
Global access	The Internet enables worldwide access, using existing infrastructure and standard telecommunications protocols.
Ease of use	Web browsers provide a familiar interface that is user-friendly and easily learned.
Multiple platforms	Web-based design is not dependent on a specific combination of hardware or software. All that is required is a browser and an Internet connection.
Cost effectiveness	Initial investment is relatively low because the Internet serves as the communication network. Users require only a browser, and web-based systems do not require powerful workstations. Flexibility is high because numerous outsourcing options exist for development, hosting, maintenance, and system support.
Security issues	Security is a universal issue, but Internet connectivity raises special concerns. These can be addressed with a combination of good design, software that can protect the system and detect intrusion, stringent rules for passwords and user identification, and vigilant users and managers.
Adaptability issues	The Internet offers many advantages in terms of access, connectivity, and flexibility. Migrating a traditional database design to the web, however, can require design modification, additional software, and some added expense.

FIGURE 9-8 Web-based design characteristics include global access, ease of use, multiple platforms, cost-effectiveness, security issues, and adaptability issues. In a web-based design, the Internet serves as the front end, or interface, to the database management system. Access to the database requires only a web browser and an Internet connection.

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To access data in a web-based system, the database must be connected to the Internet or intranet. The database and the Internet speak two different languages, however. Databases are created and managed by using various languages and commands that have nothing to do with HTML, which is the language of the web. The objective is to connect the database to the web and enable data to be viewed and updated.

To bridge the gap, it is necessary to use **middleware**, which is a software that integrates different applications and allows them to exchange data. Middleware can interpret client requests in HTML form and translate the requests into commands that the database can execute. When the database responds to the commands, middleware translates the results into HTML pages that can be displayed by the user's browser, as shown in Figure 9-9. Note that the four steps in the process can take place using the Internet or a company intranet as the communications channel. Middleware is discussed in more detail in Chapter 10.

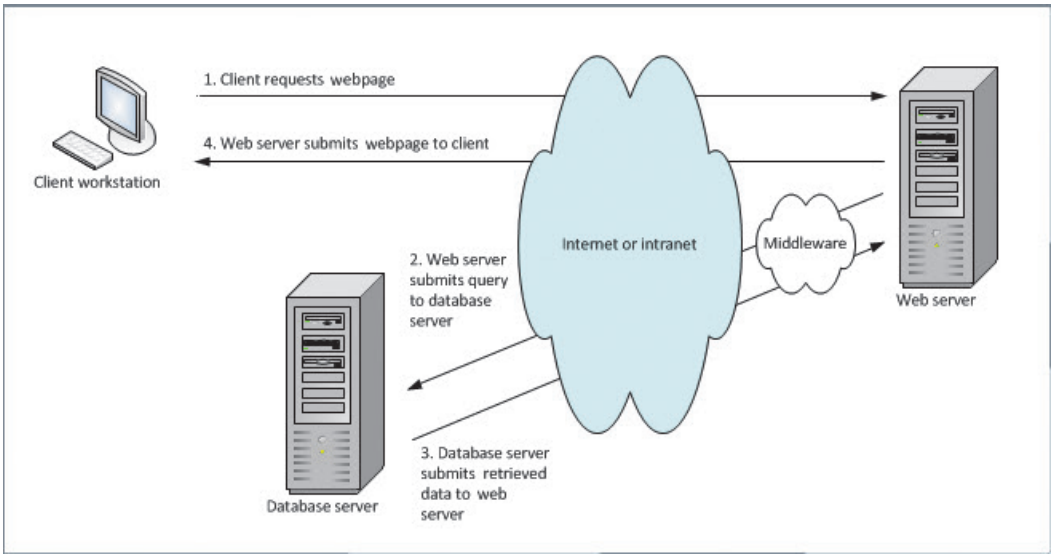


FIGURE 9-9 When a client workstation requests a web page (1), the web server uses middleware to generate a data query to the database server (2). The database server responds (3), and the middleware translates the retrieved data into an HTML page that can be sent by the web server and displayed by the user's browser (4).

Web-based data must be secure, yet easily accessible to authorized users. To achieve this goal, well-designed systems provide security at three levels: the database itself, the web server, and the telecommunication links that connect the components of the system. Data security is discussed in more detail in Section 9.9 and in Chapter 12.

9.4 Data Design Terms

Using the concepts discussed in the previous sections, a systems analyst can select a design approach and begin to construct the system. The first step is to understand data design terminology.

9.4.1 Definitions

Data design terms include entity, table, file, field, record, tuple, and key field. These terms are explained in the following sections.

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ENTITY: An **entity** is a person, a place, a thing, or an event for which data is collected and maintained. For example, an online sales system may include entities named CUSTOMER, ORDER, PRODUCT, and SUPPLIER. When DFDs were prepared during the systems analysis phase, various entities and data stores were identified. Now the relationships among the entities will be considered.

TABLE OR FILE: Data is organized into tables or files. A **table**, or **file**, contains a set of related records that store data about a specific entity. Tables and files are shown as two-dimensional structures that consist of vertical columns and horizontal rows. Each column represents a field, or characteristic of the entity, and each row represents a record, which is an individual instance, or occurrence of the entity. For example, if a company has 10,000 customers, the CUSTOMER table will include 10,000 records, each representing a specific customer.

Although they can have different meanings in a specific context, the terms *table* and *file* often can be used interchangeably.

FIELD: A **field**, also called an **attribute**, is a single characteristic or fact about an entity. For example, a CUSTOMER entity might include the Customer ID, First Name, Last Name, Address, City, State, Postal Code, and Email Address.

A **common field** is an attribute that appears in more than one entity. Common fields can be used to link entities in various types of relationships.

RECORD: A **record**, also called a **tuple** (rhymes with couple), is a set of related fields that describes one instance, or occurrence, of an entity, such as one customer, one order, or one product. A record might have one or dozens of fields, depending on what information is needed.

9.4.2 Key Fields

During the systems design phase, **key fields** are used to organize, access, and maintain data structures. The four types of keys are primary keys, candidate keys, foreign keys, and secondary keys.

PRIMARY KEY: A **primary key** is a field or combination of fields that uniquely and minimally identifies a particular member of an entity. For example, in a customer table, the customer number is a unique primary key because no two customers can have the same customer number. That key also is minimal because it contains no information beyond what is needed to identify the customer. In a CUSTOMER table, a Customer ID might be used as a unique primary key. Customer ID is an example of a primary key based on a single field.

A primary key also can be composed of two or more fields. For example, if a student registers for three courses, his or her student number will appear in three records in the registration system. If one of those courses has 20 students, 20 separate records will exist for that course number—one record for each student who registered.

In the registration file, neither the student number nor the course ID is unique, so neither field can be a primary key. To identify a specific student in a specific course, the primary key must be a combination of student number and course ID. In that case, the primary key is called a **combination key**. A combination key also can be called a **composite key**, **concatenated key**, or **multivalued key**.

Figure 9-10 shows four different tables: STUDENT, ADVISOR, COURSE, and GRADE. Three of these tables have single-field primary keys. Note that in the

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GRADE table, however, the primary key is a combination of two fields: STUDENT NUMBER and COURSE NUMBER.

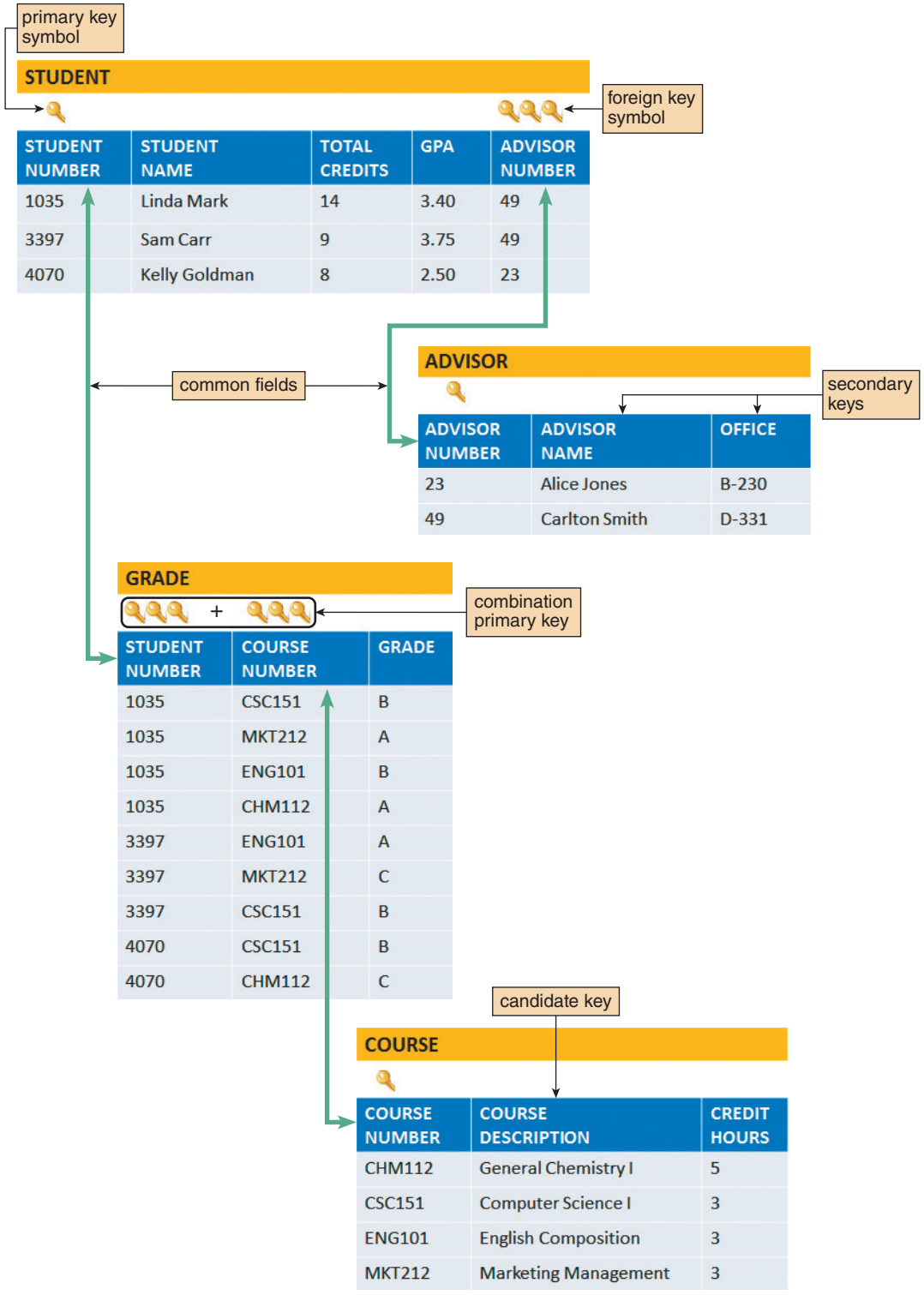


FIGURE 9-10 Examples of common fields, primary keys, candidate keys, foreign keys, and secondary keys.

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CANDIDATE KEY: Sometimes there is a choice of fields or field combinations to use as the primary key. Any field that can serve as a primary key is called a **candidate key**. For example, if every employee has a unique employee number, then it could be used as a primary key. Note that an employee's Social Security number would not be a good choice for a candidate key: Contrary to popular belief, Social Security numbers are not unique. Because only one field can be designated as a primary key, the field that contains the least amount of data and is the easiest to use should be selected. Any field that is not a primary key or a candidate key is called a **nonkey field**.

The primary keys shown in Figure 9-10 also are candidate keys. Another candidate key is the COURSE DESCRIPTION field in the COURSE table. What about the OFFICE field in the ADVISOR table? It could not be a candidate key because more than one advisor might share the same office.

FOREIGN KEY: Recall that a common field exists in more than one table and can be used to form a relationship, or link, between the tables. For example, in Figure 9-10, the ADVISOR NUMBER field appears in both the STUDENT table and the ADVISOR table and joins the tables together. Note that ADVISOR NUMBER is a primary key in the ADVISOR table, where it uniquely identifies each advisor, and is a foreign key in the STUDENT table. A **foreign key** is a field in one table that must match a primary key value in another table in order to establish the relationship between the two tables.

Unlike a primary key, a foreign key need not be unique. For example, Carlton Smith has advisor number 49. The value 49 must be a unique value in the ADVISOR table because it is the primary key, but 49 can appear any number of times in the STUDENT table, where the advisor number serves as a foreign key.

Figure 9-10 also shows how two foreign keys can serve as a composite primary key in another table. Consider the GRADE table at the bottom of the figure. The two fields that form the primary key for the GRADE table are both foreign keys: the STUDENT NUMBER field, which must match a student number in the STUDENT table, and the COURSE NUMBER field, which must match one of the course IDs in the COURSE table.

How can these two foreign keys serve as a primary key in the GRADE table? Note that student numbers and course IDs can appear any number of times in the table, but the *combination* of a specific student and a specific course occurs only once. For example, student 1035 appears four times and course CSC151 appears three times—but there is only *one* combined instance of student 1035 *and* course CSC151. Because the combination of the specific student (1035) and the specific course (CSC151) is unique, it ensures that the grade (B) will be assigned to the proper student in the proper course.

SECONDARY KEY: A **secondary key** is a field or combination of fields that can be used to access or retrieve records. Secondary key values are not unique. For example, to access records for only those customers in a specific postal code, the postal code field would be used as a secondary key. Secondary keys also can be used to sort or display records in a certain order. For example, the GPA field in a STUDENT file could be used to display records for all students in grade point order.

The need for a secondary key arises because a table can have only one primary key. In a CUSTOMER file, the CUSTOMER NUMBER is the primary key, so it must be unique. The customer's name might be known, but not the customer's number. For example, to access a customer named James Morgan without knowing his customer number, the table is searched using the CUSTOMER NAME field as a secondary key. The records for all customers named James Morgan are retrieved and then the correct record is selected.

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In Figure 9-10, student name and advisor names are identified as secondary keys, but other fields also could be used. For example, to find all students who have a particular advisor, the ADVISOR NUMBER field in the STUDENT table could be used as a secondary key.

9.4.3 Referential Integrity

Validity checks can help avoid data input errors. One type of validity check, called **referential integrity**, is a set of rules that avoids data inconsistency and quality problems. In a relational database, referential integrity means that a foreign key value cannot be entered in one table unless it matches an existing primary key in another table. For example, referential integrity would prevent a customer order from being entered in an order table unless that customer already exists in the customer table. Without referential integrity, there might be an order called an **orphan**, because it had no related customer.

In the example shown in Figure 9-10, referential integrity will not allow a user to enter an advisor number (foreign key value) in the STUDENT table unless a valid advisor number (primary key value) already exists in the ADVISOR table.

Referential integrity can also prevent the deletion of a record if the record has a primary key that matches foreign keys in another table. For example, suppose that an advisor resigns to accept a position at another school. The advisor cannot be deleted from the ADVISOR table while records in the STUDENT table still refer to that advisor number. Otherwise, the STUDENT records would be orphans. To avoid the problem, students must be reassigned to other advisors by changing the value in the ADVISOR NUMBER field; then the advisor record can be deleted.

When creating a relational database, referential integrity can be built into the design. Figure 9-11 shows a Microsoft Access screen that identifies a common field and allows the user to enforce referential integrity rules.

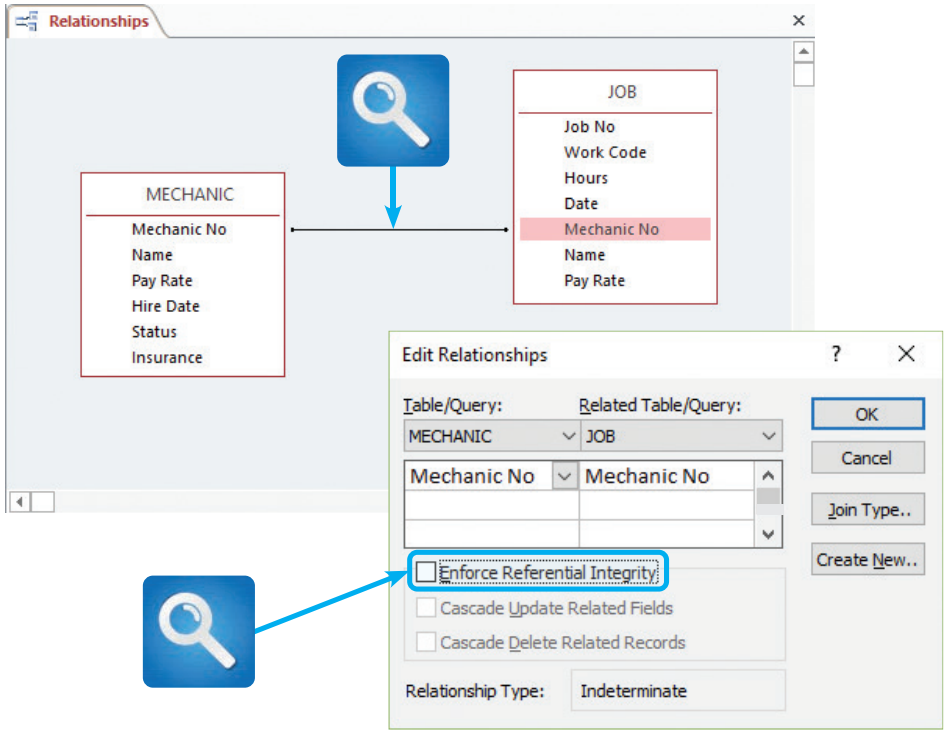


FIGURE 9-11 Microsoft Access allows a user to specify that referential integrity rules will be enforced in a relational database design.

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9.5 Entity-Relationship Diagrams

Recall that an entity is a person, a place, a thing, or an event for which data is collected and maintained. For example, entities might be customers, sales regions, products, or orders. An information system must recognize the relationships among entities. For example, a CUSTOMER entity can have several instances of an ORDER entity, and an EMPLOYEE entity can have one instance, or none, of a SPOUSE entity.

An **entity-relationship diagram (ERD)** is a model that shows the logical relationships and interaction among system entities. An ERD provides an overall view of the system and a blueprint for creating the physical data structures.

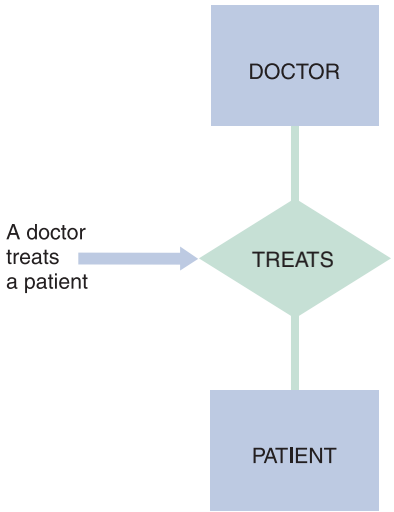


FIGURE 9-12 In an entity-relationship diagram, entities are labeled with singular nouns and relationships are labeled with verbs. The relationship is interpreted as a simple English sentence.

9.5.1 Drawing an ERD

The first step is to list the entities that were identified during the systems analysis phase and to consider the nature of the relationships that link them. At this stage, a simplified method can be used to show the relationships between entities.

Although there are different ways to draw ERDs, a popular method is to represent entities as rectangles and relationships as diamond shapes. The entity rectangles are labeled with singular nouns, and the relationship diamonds are labeled with verbs, usually in a top-to-bottom and left-to-right fashion. For example, in Figure 9-12, a DOCTOR entity *treats* a PATIENT entity. Unlike data flow diagrams, ERDs depict relationships, not data or information flows.

9.5.2 Types of Relationships

Three types of relationships can exist between entities: one-to-one, one-to-many, and many-to-many.

A **one-to-one relationship**, abbreviated **1:1**, exists when exactly one of the second entity occurs for each instance of the first entity. Figure 9-13 shows examples of several 1:1 relationships. A number 1 is placed alongside each of the two connecting lines to indicate the 1:1 relationship.

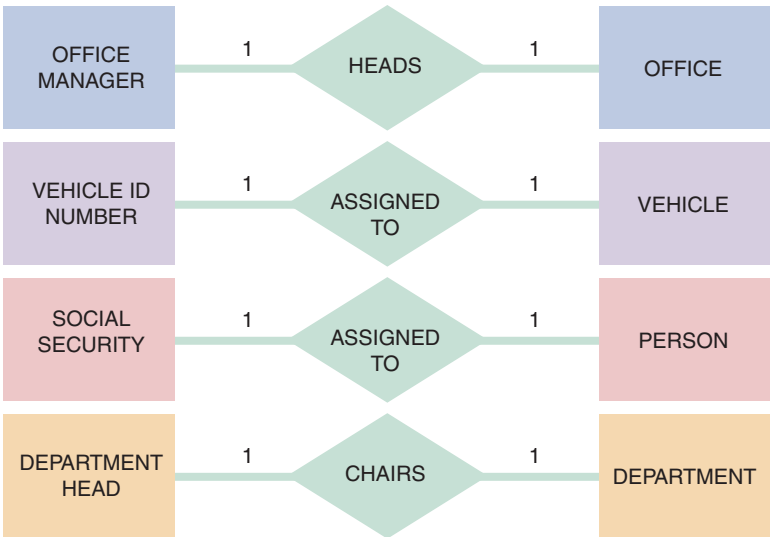


FIGURE 9-13 Examples of one-to-one (1:1) relationships.

A **one-to-many relationship**, abbreviated **1:M**, exists when one occurrence of the first entity can relate to many instances of the second entity, but each instance of the second entity can associate with only one instance of the first entity. For example, the relationship between DEPARTMENT and EMPLOYEE is one-to-many: One department can have many employees, but each employee works in only one department at a time. Figure 9-14 shows several 1:M relationships. The line connecting the *many* entity is labeled with the letter M, and the number 1 labels the other connecting line. How many is *many*? The first 1:M relationship shown in Figure 9-14 shows the entities INDIVIDUAL and

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AUTOMOBILE. One individual might own five automobiles, or one, or none. Thus, *many* can mean any number, including zero.

A **many-to-many relationship**, abbreviated **M:N**, exists when one instance of the first entity can relate to many instances of the second entity, and one instance of the second entity can relate to many instances of the first entity. The relationship between STUDENT and CLASS, for example, is many-to-many—one student can take many classes, and one class can have many students enrolled. Figure 9-15 shows several M:N entity relationships. One of the connecting lines is labeled with the letter M, and the letter N labels the other connection.

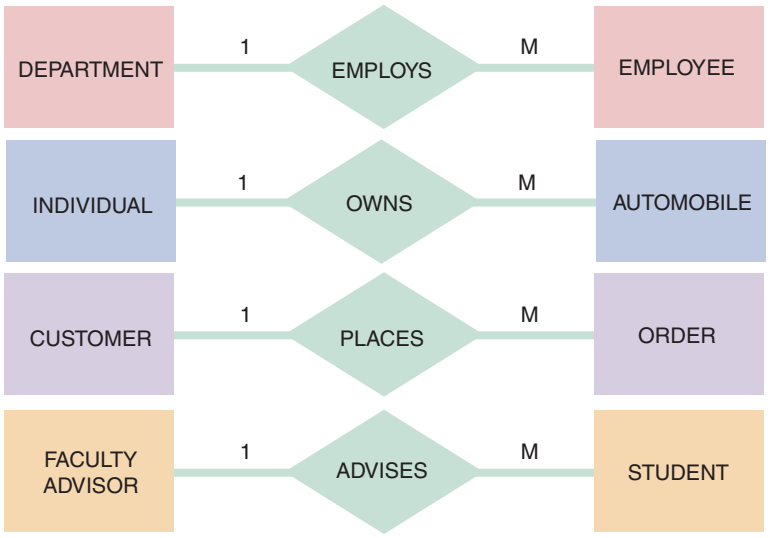


FIGURE 9-14 Examples of one-to-many (1:M) relationships.

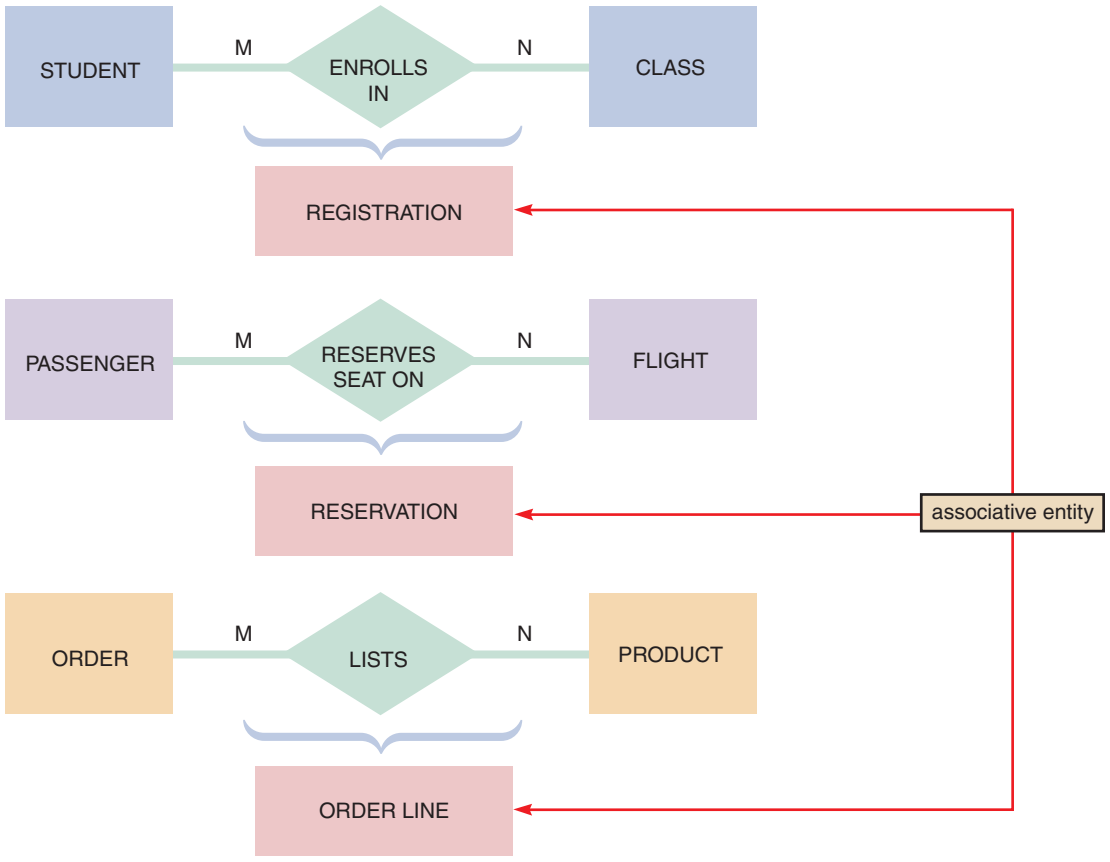


FIGURE 9-15 Examples of many-to-many (M:N) relationships. Notice that the event or transaction that links the two entities is an associative entry with its own set of attributes and characteristics.

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Note that an M:N relationship is different from 1:1 or 1:M relationships because the event or transaction that links the two entities is actually a third entity, called an **associative entity**, that has its own characteristics. In the first example in Figure 9-15, the ENROLLS IN symbol represents a REGISTRATION entity that records each instance of a specific student enrolling in a specific course. Similarly, the RESERVES SEAT ON symbol represents a RESERVATION entity that records each instance of a specific passenger reserving a seat on a specific flight. In the third example, the LISTS symbol represents an ORDER LINE entity that records each instance of a specific product listed in a specific customer order.

Figure 9-16 shows an ERD for a sales system. Note the various entities and relationships shown in the figure, including the associative entity named ORDER LINE. The detailed nature of these relationships is called cardinality. An analyst must understand cardinality in order to create a data design that accurately reflects all relationships among system entities.

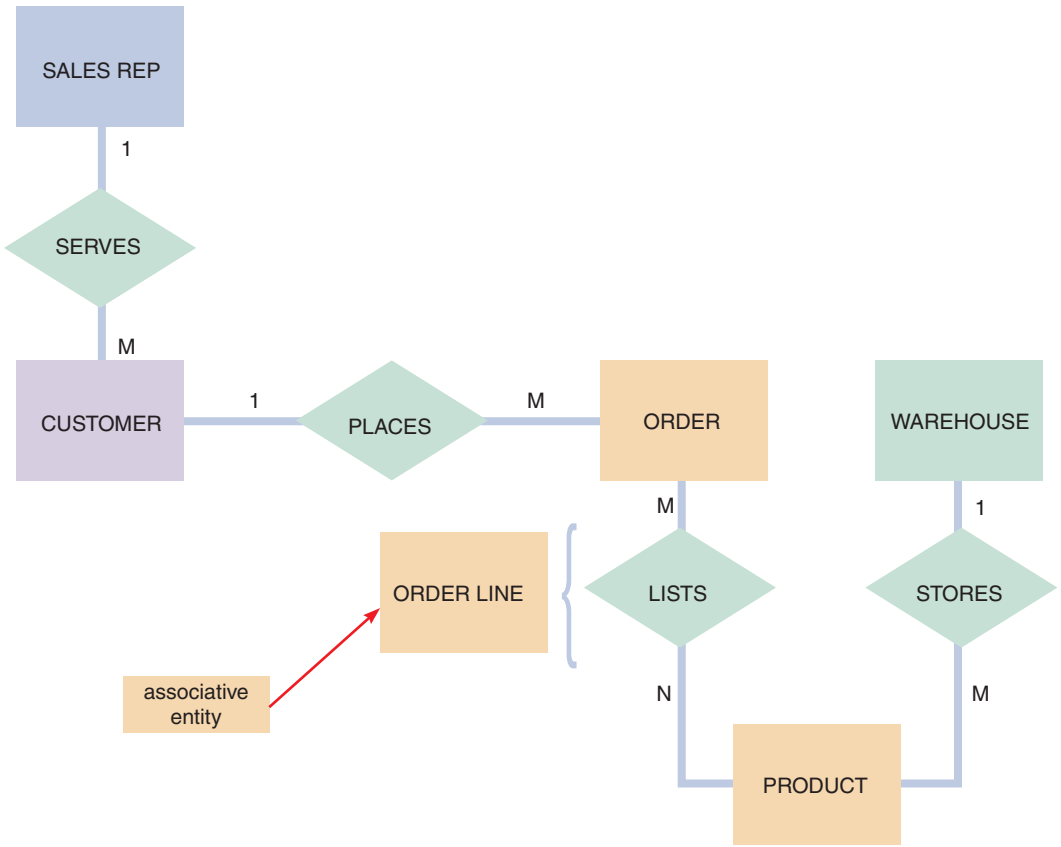


FIGURE 9-16 An entity-relationship diagram for SALES REP, CUSTOMER, ORDER, PRODUCT, and WAREHOUSE. Notice that the ORDER and PRODUCT entities are joined by an associative entity named ORDER LINE.

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9.5.3 Cardinality

After an analyst draws an initial ERD, he or she must define the relationships in more detail by using a technique called cardinality. **Cardinality** describes the numeric relationship between two entities and shows how instances of one entity relate to instances of another entity. For example, consider the relationship between two entities: CUSTOMER and ORDER. One customer can have one order, many orders, or none, but each order must have one and only one customer. An analyst can model this interaction by adding **cardinality notation**, which uses special symbols to represent the relationship.

A common method of cardinality notation is called **crow's foot notation** because of the shapes, which include circles, bars, and symbols that indicate various possibilities. A single bar indicates one, a double bar indicates one and only one, a circle indicates zero, and a crow's foot indicates many. Figure 9-17 shows various cardinality symbols, their meanings, and the UML representations of the relationships. As described in Chapter 4, the **Unified Modeling Language (UML)** is a widely used method of visualizing and documenting software systems design.

In Figure 9-18, four examples of cardinality notation are shown. In the first example, one and only one CUSTOMER can place anywhere from zero to many of the ORDER entity. In the second example, one and only one ORDER can include one ITEM ORDERED or many. In the third example, one and only one EMPLOYEE can have one SPOUSE or none. In the fourth example, one EMPLOYEE, or many employees, or none, can be assigned to one PROJECT, or many projects, or none.

Most CASE products support the drawing of ERDs from entities in the data repository. Figure 9-19 shows part of a library system ERD drawn using the Visible Analyst CASE tool. Note that crow's foot notation is used to show the nature of the relationships, which are described in both directions.

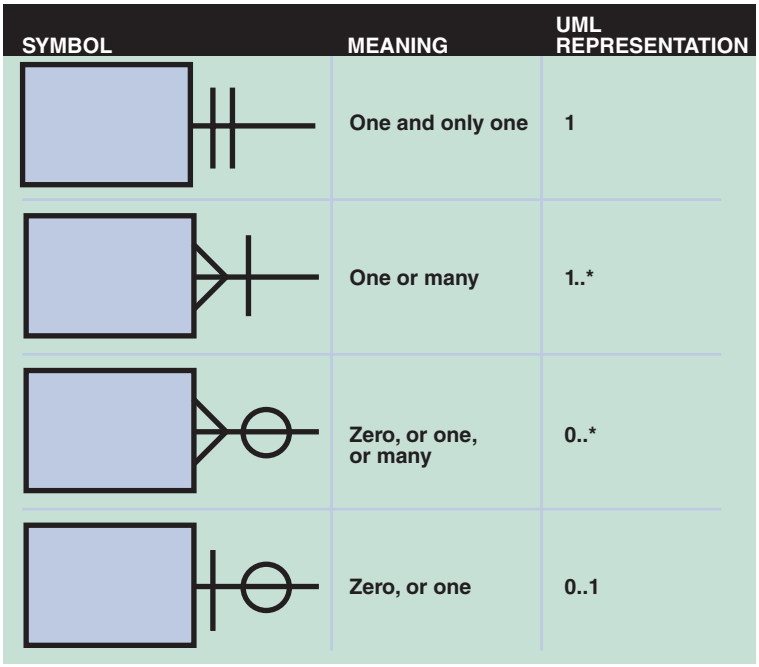


FIGURE 9-17 Crow's foot notation is a common method of indicating cardinality. The four examples show how various symbols can be used to describe the relationships between entities.

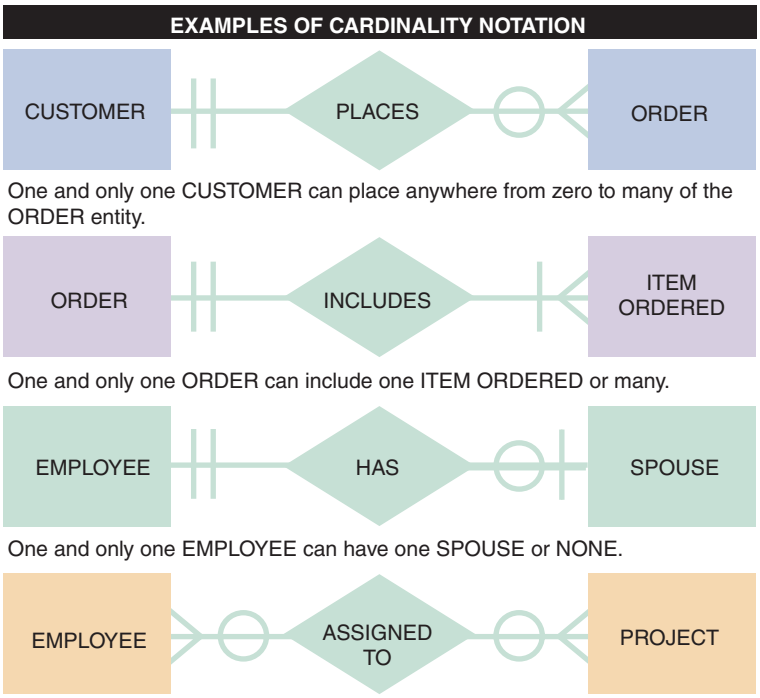


FIGURE 9-18 In the first example of cardinality notation, one and only one CUSTOMER can place anywhere from zero to many of the ORDER entity. In the second example, one and only one ORDER can include one ITEM ORDERED or many. In the third example, one and only one EMPLOYEE can have one SPOUSE or none. In the fourth example, one EMPLOYEE, or many employees, or none, can be assigned to one PROJECT, or many projects, or none.

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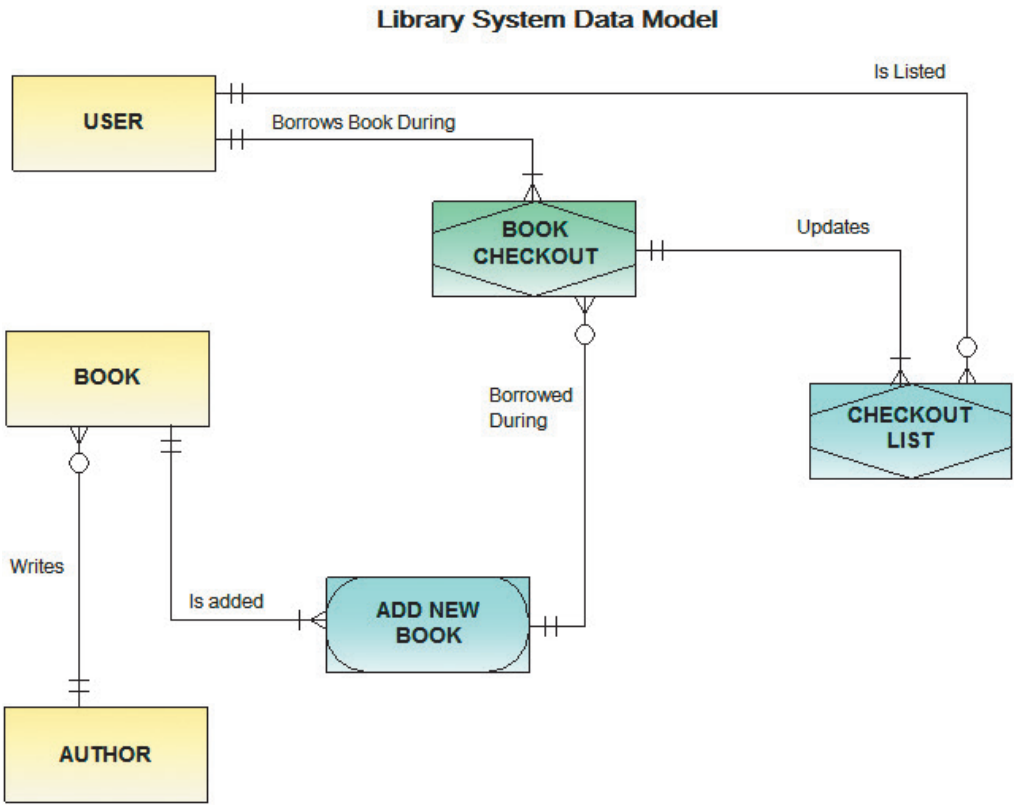


FIGURE 9-19 An ERD for a library system drawn with Visible Analyst. Notice that crow's foot notation has been used and relationships are described in both directions.

CASE IN POINT 9.1: TopText Publishing

TopText Publishing is a textbook publishing company with a headquarters location, a warehouse, and three sales offices that each has a sales manager and sales reps. TopText sells to schools, colleges, and individual customers. Many authors write more than one book for TopText, and more than one author writes some books. TopText maintains an active list of more than 100 books, each identified by a universal code called an ISBN. How would you draw an ERD for the TopText information system, including cardinality notation?

9.6 Data Normalization

Normalization is the process of creating table designs by assigning specific fields or attributes to each table in the database. A **table design** specifies the fields and identifies the primary key in a particular table or file. Working with a set of initial table designs, normalization is used to develop an overall database design that is simple, flexible, and free of data redundancy. Normalization involves applying a set of rules that can help identify and correct inherent problems and complexities in table designs. The concept of normalization is based on the work of Edgar Codd, a British computer scientist, who formulated the basic principles of relational database design.

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The normalization process typically involves four stages: unnormalized design, first normal form, second normal form, and third normal form. The three normal forms constitute a progression in which third normal form represents the best design. Most business-related databases must be designed in third normal form. Note that normal forms beyond 3NF exist, but they rarely are used in business-oriented systems.

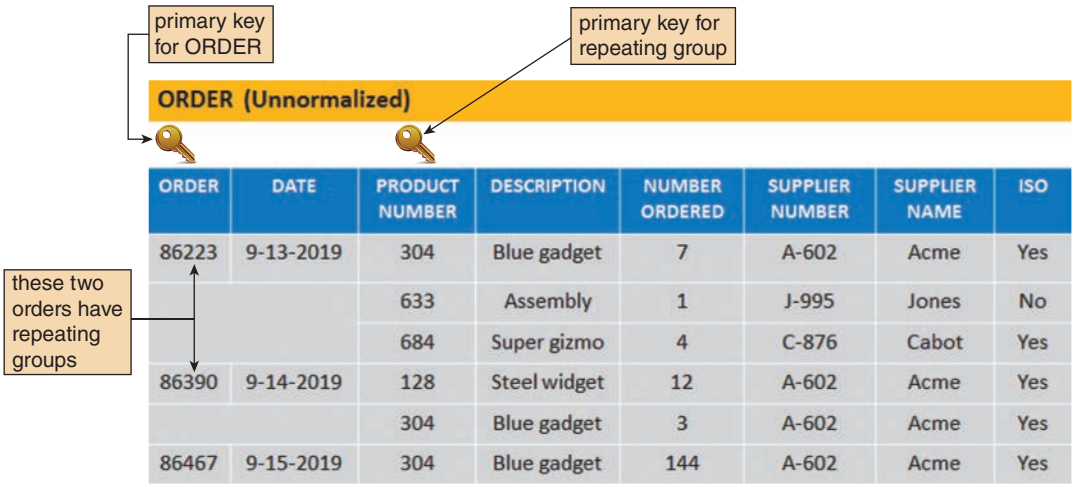
9.6.1 Standard Notation Format

Designing tables is easier if a **standard notation format** is used to show a table's structure, fields, and primary key. The standard notation format in the following examples of an ORDER system starts with the name of the table, followed by a parenthetical expression that contains the field names separated by commas. The primary key field(s) is/are underlined, like this:

NAME (FIELD 1, FIELD 2, FIELD 3)

During data design, the analyst must be able to recognize a repeating group of fields. A **repeating group** is a set of one or more fields that can occur any number of times in a single record, with each occurrence having different values.

A typical example of a repeating group is shown in Figure 9-20. If a company used written source documents to record orders, they might look like this. As Figure 9-20 shows, two orders contain multiple items, which constitute repeating groups within the same order number. Note that in addition to the order number and date, the records with multiple products contain repetitions of the product number, description, number ordered, supplier number, supplier name, and ISO status. A repeating group can be thought of as a set of child (subsidiary) records contained within the parent (main) record.



ORDER (Unnormalized)

ORDER	DATE	PRODUCT NUMBER	DESCRIPTION	NUMBER ORDERED	SUPPLIER NUMBER	SUPPLIER NAME	ISO
86223	9-13-2019	304	Blue gadget	7	A-602	Acme	Yes
		633	Assembly	1	J-995	Jones	No
		684	Super gizmo	4	C-876	Cabot	Yes
86390	9-14-2019	128	Steel widget	12	A-602	Acme	Yes
		304	Blue gadget	3	A-602	Acme	Yes
86467	9-15-2019	304	Blue gadget	144	A-602	Acme	Yes

FIGURE 9-20 In the ORDER table design, two orders have repeating groups that contain several products. ORDER is the primary key for the ORDER table, and PRODUCT NUMBER serves as a primary key for the repeating group. Because it contains repeating groups, the ORDER table is unnormalized.

A table design that contains a repeating group is called **unnormalized**. The standard notation method for representing an unnormalized design is to enclose the repeating group of fields within a second set of parentheses. An example of an unnormalized table looks like this:

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NAME (FIELD 1, FIELD 2, FIELD 3, (REPEATING FIELD 1, REPEATING FIELD 2))

Now review the unnormalized ORDER table design shown in Figure 9-20. Following the notation guidelines, the design can be described as follows:

ORDER (ORDER, DATE, (PRODUCT NUMBER, DESCRIPTION, NUMBER ORDERED, SUPPLIER NUMBER, SUPPLIER NAME, ISO))

The notation indicates that the ORDER table design contains eight fields, which are listed within the outer parentheses. The ORDER field is underlined to show that it is the primary key. The PRODUCT NUMBER, DESCRIPTION, NUMBER ORDERED, SUPPLIER NUMBER, SUPPLIER NAME, and ISO and NUMBER ORDERED fields are enclosed within an inner set of parentheses to indicate that they are fields within a repeating group. Note that PRODUCT NUMBER also is underlined because it acts as the primary key of the repeating group. If a customer orders three different products in one order, then six fields must be repeated for each product, as shown in Figure 9-20.

9.6.2 First Normal Form

A table is in **first normal form (1NF)** if it does not contain a repeating group. To convert an unnormalized design to 1NF, the table's primary key must be expanded to include the primary key of the repeating group.

For example, in the ORDER table shown in Figure 9-20, the repeating group consists of six fields: PRODUCT NUMBER, DESCRIPTION, NUMBER ORDERED, SUPPLIER NUMBER, SUPPLIER NAME, and ISO. Of the three fields, only PRODUCT NUMBER can be a primary key because it uniquely identifies each instance of the repeating group. The DESCRIPTION cannot be a primary key because it might or might not be unique. For example, a company might sell a large number of parts with the same descriptive name, such as *washer*, relying on a coded part number to identify uniquely each washer size.

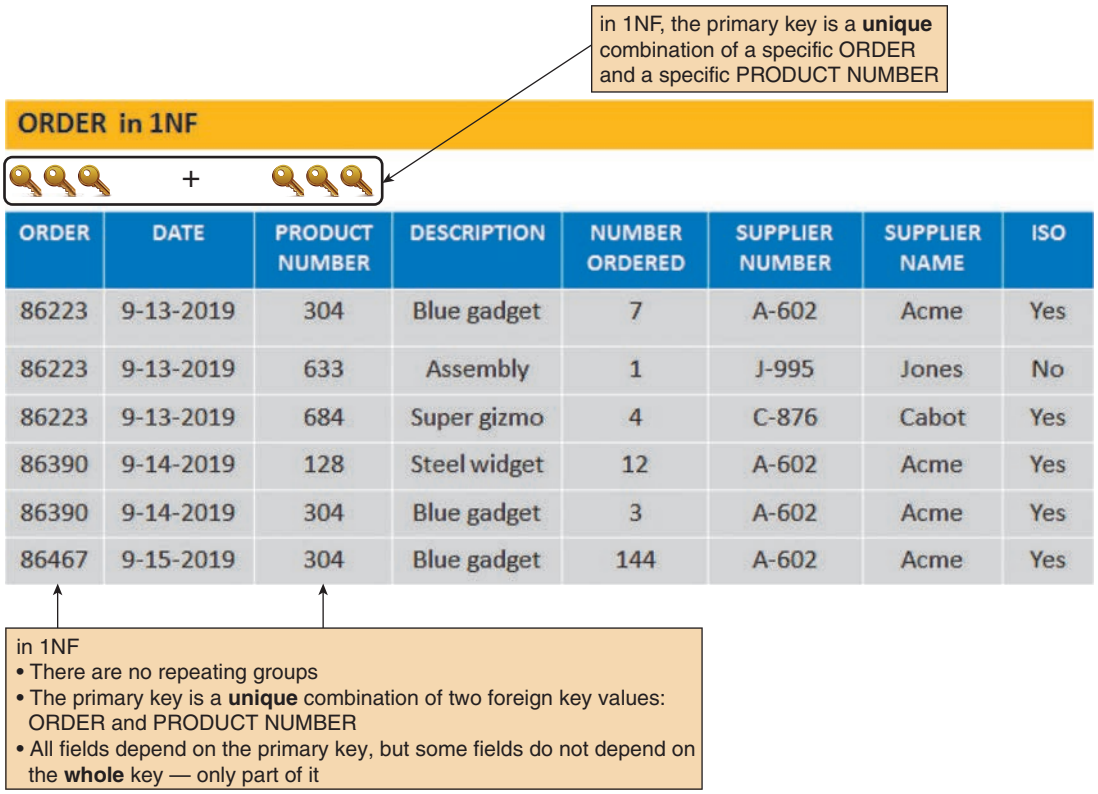
When the primary key of the ORDER table is expanded to include PRODUCT NUMBER, the repeating group is eliminated, and the ORDER table is now in 1NF, as shown:

ORDER (ORDER, DATE, PRODUCT NUMBER, DESCRIPTION, NUMBER ORDERED, SUPPLIER NUMBER, SUPPLIER NAME, ISO)

Figure 9-21 shows the ORDER table in 1NF. Note that when the repeating group is eliminated, additional records emerge—one for each combination of a specific order and a specific product. The result is more records but a greatly simplified design. In the new version, the repeating group for order number 86223 has become three separate records, and the repeating group for order number 86390 has become two separate records. Therefore, when a table is in 1NF, each record stores data about a single instance of a specific order and a specific product.

Also note that the 1NF design shown in Figure 9-21 has a combination primary key. The primary key of the 1NF design cannot be the ORDER field alone, because the order number does not uniquely identify each product in a multiple-item order. Similarly, PRODUCT NUMBER cannot be the primary key, because it appears more than once if several orders include the same product. Because each record must reflect a specific product in a specific order, *both* fields are needed, ORDER and PRODUCT NUMBER, to identify a single record uniquely. Therefore, the primary key is the *combination* of two fields: ORDER and PRODUCT NUMBER.

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ORDER	DATE	PRODUCT NUMBER	DESCRIPTION	NUMBER ORDERED	SUPPLIER NUMBER	SUPPLIER NAME	ISO
86223	9-13-2019	304	Blue gadget	7	A-602	Acme	Yes
86223	9-13-2019	633	Assembly	1	J-995	Jones	No
86223	9-13-2019	684	Super gizmo	4	C-876	Cabot	Yes
86390	9-14-2019	128	Steel widget	12	A-602	Acme	Yes
86390	9-14-2019	304	Blue gadget	3	A-602	Acme	Yes
86467	9-15-2019	304	Blue gadget	144	A-602	Acme	Yes

FIGURE 9-21 The ORDER table as it appears in 1NF. The repeating groups have been eliminated. Notice that the repeating group for order 86223 has become three separate records, and the repeating group for order 86390 has become two separate records. The 1NF primary key is a combination of ORDER and PRODUCT NUMBER, which uniquely identifies each record.

9.6.3 Second Normal Form

To understand second normal form (2NF), the concept of functional dependence must be understood. For example, *Field A* is **functionally dependent** on *Field B* if the value of *Field A* depends on *Field B*. For example, in Figure 9-21, the DATE value is functionally dependent on the ORDER, because for a specific order number, there can be only one date. In contrast, a product description is *not* dependent on the order number. For a particular order number, there might be several product descriptions—one for each item ordered.

A table design is in **second normal form (2NF)** if it is in 1NF *and* if all fields that are not part of the primary key are functionally dependent on the *entire* primary key. If any field in a 1NF table depends on only one of the fields in a combination primary key, then the table is not in 2NF.

Note that if a 1NF design has a primary key that consists of only one field, the problem of partial dependence does not arise—because the entire primary key is a single field. Therefore, a 1NF table with a single-field primary key is automatically in 2NF.

Now reexamine the 1NF design for the ORDER table shown in Figure 9-21:

ORDER (ORDER, DATE, PRODUCT NUMBER, DESCRIPTION, NUMBER ORDERED, SUPPLIER NUMBER, SUPPLIER NAME, ISO)

Recall that the primary key is the combination of the order number and the product number. The NUMBER ORDERED field depends on the *entire* primary key because NUMBER ORDERED refers to a specific product number *and* a specific order number. In contrast, the DATE field depends on the order number, which is only

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a part of the primary key. Similarly, the DESCRIPTION field depends on the product number, which also is only a part of the primary key. Because some fields are not dependent on the *entire* primary key, the design is not in 2NF.

A standard process exists for converting a table from 1NF to 2NF. The objective is to break the original table into two or more new tables and reassign the fields so that each nonkey field will depend on the entire primary key in its table. To accomplish this, the following steps should be followed:

1. Create and name a separate table for each field in the existing primary key. For example, in Figure 9-21, the ORDER table's primary key has two fields, ORDER and PRODUCT NUMBER, so two tables must be created. The ellipsis (. . .) indicates that fields will be assigned later. The result is:

   ORDER (ORDER, . . .)
   PRODUCT (PRODUCT NUMBER, . . .)

2. Create a new table for each possible combination of the original primary key fields. In the Figure 9-21 example, a new table would be created with a combination primary key of ORDER and PRODUCT NUMBER. This table describes individual lines in an order, so it is named ORDER LINE, as shown:

   ORDER LINE (ORDER, PRODUCT NUMBER)

3. Study the three tables and place each field with its appropriate primary key, which is the minimal key on which it functionally depends. When all the fields have been placed, remove any table that did not have any additional fields assigned to it. The remaining tables are the 2NF version of the original table. The three tables can be shown as:

   ORDER (ORDER, DATE)
   PRODUCT (PRODUCT NUMBER, DESCRIPTION, SUPPLIER NUMBER, SUPPLIER NAME, ISO)
   ORDER LINE (ORDER, PRODUCT NUMBER)

Figure 9-22 shows the 2NF table designs. By following the steps, the original 1NF table has been converted into three 2NF tables.

Why is it important to move from 1NF to 2NF? Four kinds of problems are found with 1NF designs that do not exist in 2NF:

1. Consider the work necessary to change a particular product's description. Suppose 500 current orders exist for product number 304. Changing the product description involves modifying 500 records for product number 304. Updating all 500 records would be cumbersome and expensive.
2. 1NF tables can contain inconsistent data. Because someone must enter the product description in each record, nothing prevents product number 304 from having different product descriptions in different records. In fact, if product number 304 appears in a large number of order records, some of the matching product descriptions might be inaccurate or improperly spelled. Even the presence or absence of a hyphen in the orders for *all-purpose gadget* would create consistency problems. If a data entry person must enter a term such as *IO1Queue Controller* numerous times, it certainly is possible that some inconsistency will result.
3. Adding a new product is a problem. Because the primary key must include an order number and a product number, values are needed for both fields in order to add a record. What value should be used for the order number when no

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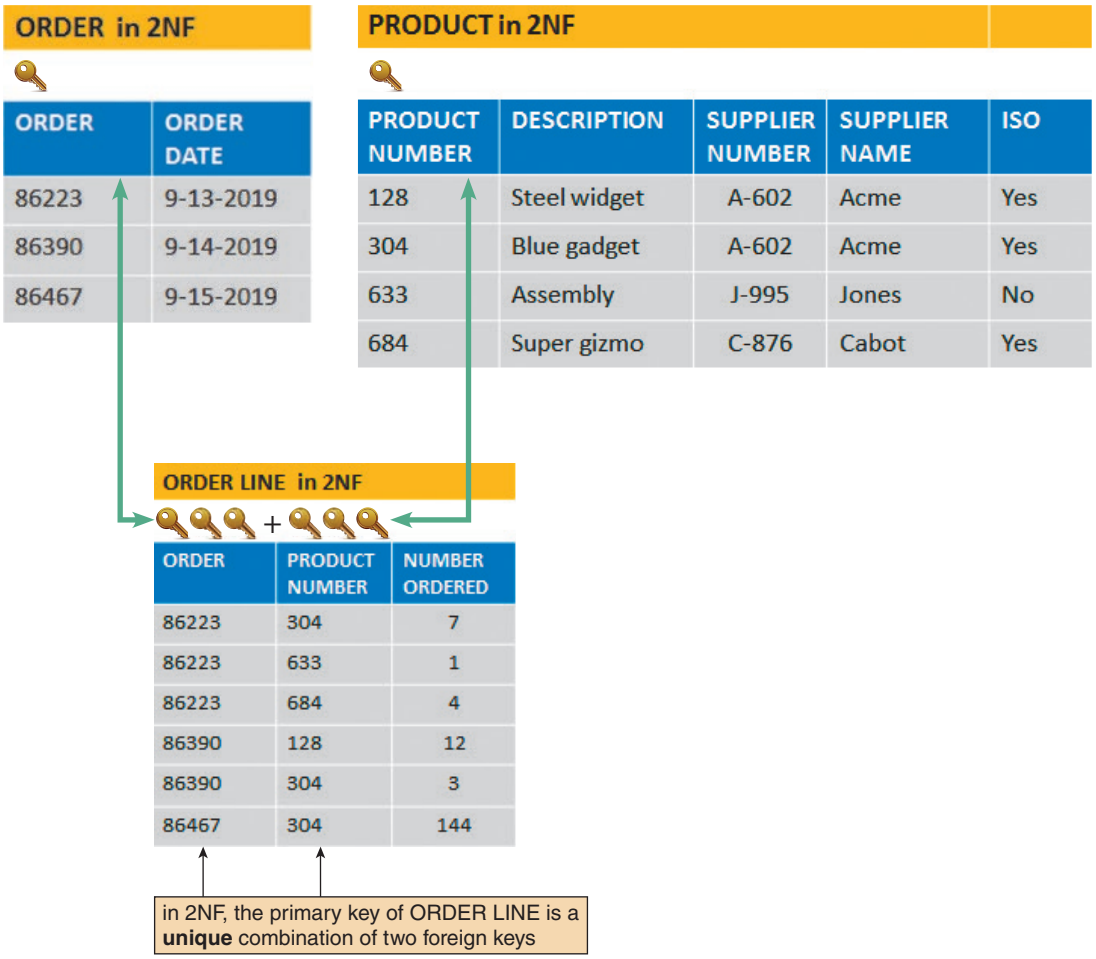


FIGURE 9-22 ORDER, PRODUCT, and ORDER LINE tables in 2NF. All fields are functionally dependent on the primary key.

customer has ordered the product? A dummy order number could be used and later replaced with a real order number when the product is ordered to solve the problem, but that solution also creates difficulties.

4. Deleting a product is a problem. If all the related records are deleted once an order is filled and paid for, what happens if the only record that contains product number 633 is deleted? The information about that product number and its description is lost.

Has the 2NF design eliminated all potential problems? To change a product description, now just one PRODUCT record needs to be changed. Multiple, inconsistent values for the product description are impossible because the description appears in only one location. To add a new product, a new PRODUCT record is created, instead of creating a dummy order record. When the last ORDER LINE record for a particular product number is removed, that product number and its description is not lost because the PRODUCT record still exists. The four potential problems are eliminated, and the three 2NF designs are superior to both the original unnormalized table and the 1NF design.

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9.6.4 Third Normal Form

A popular rule of thumb is that a design is in 3NF if every nonkey field depends on *the key*, *the whole key*, and *nothing but the key*. A 3NF design avoids redundancy and data integrity problems that still can exist in 2NF designs.

Continuing the ORDER example, now review the PRODUCT table design in Figure 9-23:

PRODUCT (PRODUCT NUMBER, DESCRIPTION, SUPPLIER NUMBER, SUPPLIER NAME, ISO)

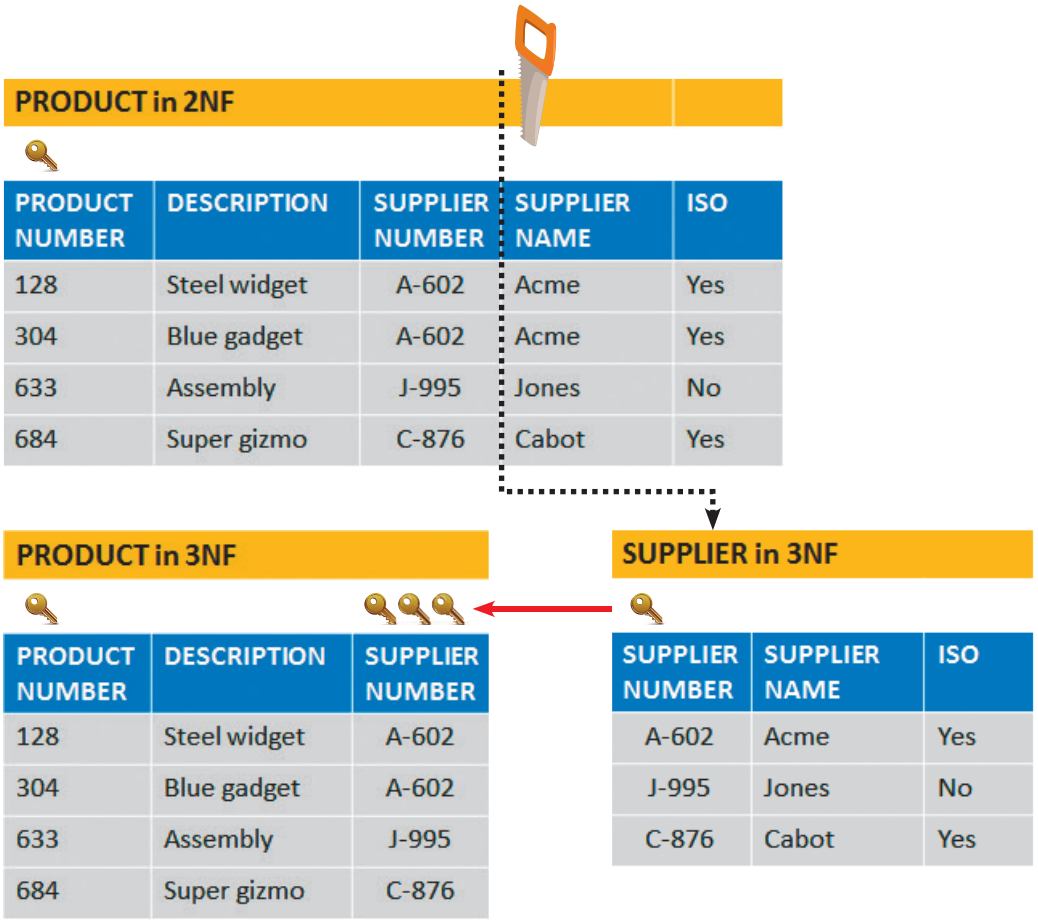


FIGURE 9-23 When the PRODUCT table is transformed from 2NF to 3NF, the result is two separate tables: PRODUCT and SUPPLIER. Note that in 3NF, all fields depend on the key alone.

The PRODUCT table is in 1NF because it has no repeating groups. The table also is in 2NF because the primary key is a single field. But the table still has four potential problems:

1. To change a supplier name, every record in which that name appears must be changed. With hundreds, or even thousands of records, the process would be slow, expensive, and subject to input errors.
2. The 2NF design allows a supplier to have a different name or ISO status in different records.

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3. Because the supplier name is included in the ORDER table, a dummy ORDER record must be created to add a new supplier who has not yet been received any orders.
4. If all the orders for a supplier are deleted, that supplier's number and name will be lost.

Those potential problems are caused because the design is not in 3NF. A table design is in **third normal form (3NF)** if it is in 2NF and if no nonkey field is dependent on another nonkey field. Remember that a nonkey field is a field that is not a candidate key for the primary key.

The PRODUCT table at the top of Figure 9-23 is not in 3NF because two nonkey fields, SUPPLIER NAME and ISO, both depend on another nonkey field, SUPPLIER NUMBER.

To convert the table to 3NF, all fields from the 2NF table that depend on another nonkey field must be removed and placed in a new table that uses the nonkey field as a primary key. In the PRODUCT example, SUPPLIER NAME and ISO must be removed and placed into a new table that uses SUPPLIER NUMBER as the primary key. As shown in Figure 9-23, 3NF divides the 2NF version into two separate 3NF tables:

PRODUCT (PRODUCT NUMBER, DESCRIPTION, SUPPLIER NUMBER)
SUPPLIER (SUPPLIER NUMBER, SUPPLIER NAME, ISO)

CASE IN POINT 9.2: CyberToys

You handle administrative support for CyberToys, a small chain that sells computer hardware and software and specializes in personal service. The company has four stores located at malls and is planning more. Each store has a manager, a technician, and between one and four sales reps.

The owners want to create a personnel records database, and they asked you to review a table that they had designed. They suggested fields for store number, location, store telephone, manager name, and manager home telephone. They also want fields for technician name and technician home telephone and fields for up to four sales rep names and sales rep home telephones.

Draw their suggested design and analyze it using the normalization concepts you learned in the chapter. What do you think of their design and why? What would you propose?

9.6.5 Two Real-World Examples

A good way to learn about normalization is to apply the rules to a representative situation. This section presents two different scenarios: first a school and then a technical service company. If a step-by-step process is followed, data designs can be created that are efficient, maintainable, and error-resistant.

EXAMPLE 1: Crossroads College: Consider the familiar situation in Figure 9-24, which depicts several entities in the Crossroads College advising system: ADVISOR, COURSE, and STUDENT. The relationships among the three entities are shown in the ERD in Figure 9-25. The following sections discuss normalization rules for these three entities.



FIGURE 9-24 A faculty advisor, who represents an entity, can advise many students, each of whom can register for one or many courses.
Monkey Business Images/Shutterstock.com

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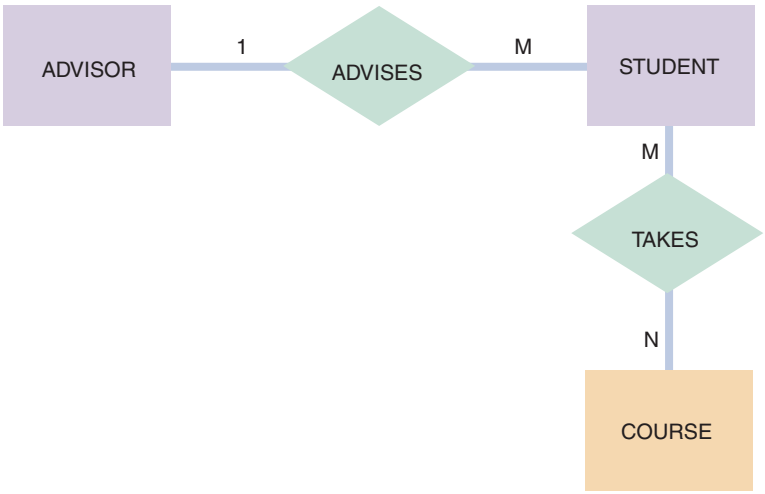


FIGURE 9-25 An initial entity-relationship diagram for ADVISOR, STUDENT, and COURSE.

Before the normalization process is started, it is noted that the STUDENT table contains fields that relate to the ADVISOR and COURSE entities, so a decision is made to begin with the initial design for the STUDENT table, which is shown in Figure 9-26. Note that the table design includes the student number, student name, total credits taken, grade point average (GPA), advisor number, advisor name, and, for every course the student has taken, the course number, course description, number of credits, and grade received.

The STUDENT table in Figure 9-26 is unnormalized because it has a repeating group. The STUDENT table design can be written as:

STUDENT (STUDENT NUMBER, STUDENT NAME, TOTAL CREDITS, GPA, ADVISOR NUMBER, ADVISOR NAME, OFFICE, (COURSE NUMBER, CREDIT HOURS, GRADE))

To convert the STUDENT record to 1NF, the primary key must be expanded to include the key of the repeating group, producing:

STUDENT (STUDENT NUMBER, STUDENT NAME, TOTAL CREDITS, GPA, ADVISOR NUMBER, ADVISOR NAME, OFFICE, COURSE NUMBER, CREDIT HOURS, GRADE)

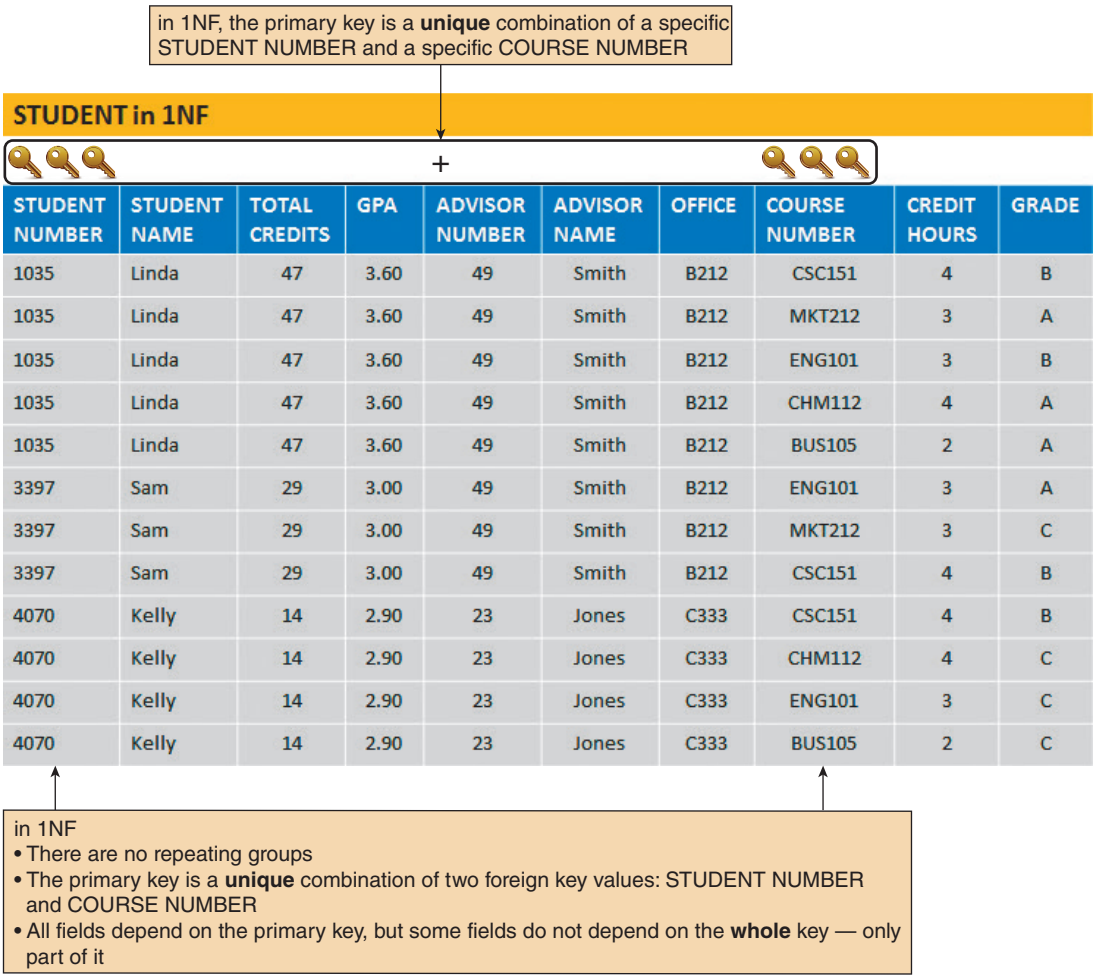
STUDENT (Unnormalized)

STUDENT NUMBER	STUDENT NAME	TOTAL CREDITS	GPA	ADVISOR NUMBER	ADVISOR NAME	OFFICE	COURSE NUMBER	CREDIT HOURS	GRADE
1035	Linda	47	3.60	49	Smith	B212	CSC151	4	B
							MKT212	3	A
							ENG101	3	B
							CHM112	4	A
							BUS105	2	A
3397	Sam	29	3.00	49	Smith	B212	ENG101	3	A
							MKT212	3	C
							CSC151	4	B
4070	Kelly	14	2.90	23	Jones	C333	CSC151	4	B
							CHM112	4	C
							ENG101	3	C
							BUS105	2	C

FIGURE 9-26 The STUDENT table is unnormalized because it contains a repeating group that represents the course each student has taken.

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Figure 9-27 shows the 1NF version of the sample STUDENT data. Do any of the fields in the 1NF STUDENT table depend on only a portion of the primary key? The student name, total credits, GPA, advisor number, and advisor name all relate only to the student number and have no relationship to the course number. The course description depends on the course number but not on the student number. Only the GRADE field depends on the entire primary key.



STUDENT NUMBER	STUDENT NAME	TOTAL CREDITS	GPA	ADVISOR NUMBER	ADVISOR NAME	OFFICE	COURSE NUMBER	CREDIT HOURS	GRADE
1035	Linda	47	3.60	49	Smith	B212	CSC151	4	B
1035	Linda	47	3.60	49	Smith	B212	MKT212	3	A
1035	Linda	47	3.60	49	Smith	B212	ENG101	3	B
1035	Linda	47	3.60	49	Smith	B212	CHM112	4	A
1035	Linda	47	3.60	49	Smith	B212	BUS105	2	A
3397	Sam	29	3.00	49	Smith	B212	ENG101	3	A
3397	Sam	29	3.00	49	Smith	B212	MKT212	3	C
3397	Sam	29	3.00	49	Smith	B212	CSC151	4	B
4070	Kelly	14	2.90	23	Jones	C333	CSC151	4	B
4070	Kelly	14	2.90	23	Jones	C333	CHM112	4	C
4070	Kelly	14	2.90	23	Jones	C333	ENG101	3	C
4070	Kelly	14	2.90	23	Jones	C333	BUS105	2	C

FIGURE 9-27 The student table in 1NF. Notice that the primary key has been expanded to include STUDENT NUMBER and COURSE NUMBER.

Following the 1NF–2NF conversion process described earlier, a new table would be created for each field and combination of fields in the primary key, and the other fields would be placed with their appropriate key. The result is:

STUDENT (STUDENT NUMBER, STUDENT NAME, TOTAL CREDITS, GPA, ADVISOR NUMBER, ADVISOR NAME, OFFICE)
COURSE (COURSE NUMBER, CREDIT HOURS)
GRADE (STUDENT NUMBER, COURSE NUMBER, GRADE)

The original 1NF STUDENT table has now been converted into three tables, all in 2NF. In each table, every nonkey field depends on the entire primary key.

Figure 9-28 shows the 2NF STUDENT, COURSE, and GRADE designs and sample data. Are all three tables STUDENT in 3NF? The COURSE and GRADE

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tables are in 3NF. STUDENT is not in 3NF, however, because the ADVISOR NAME and OFFICE fields depend on the ADVISOR NUMBER field, which is not part of the STUDENT primary key. To convert STUDENT to 3NF, the ADVISOR NAME and OFFICE fields are removed from the STUDENT table and placed into a table with ADVISOR NUMBER as the primary key.

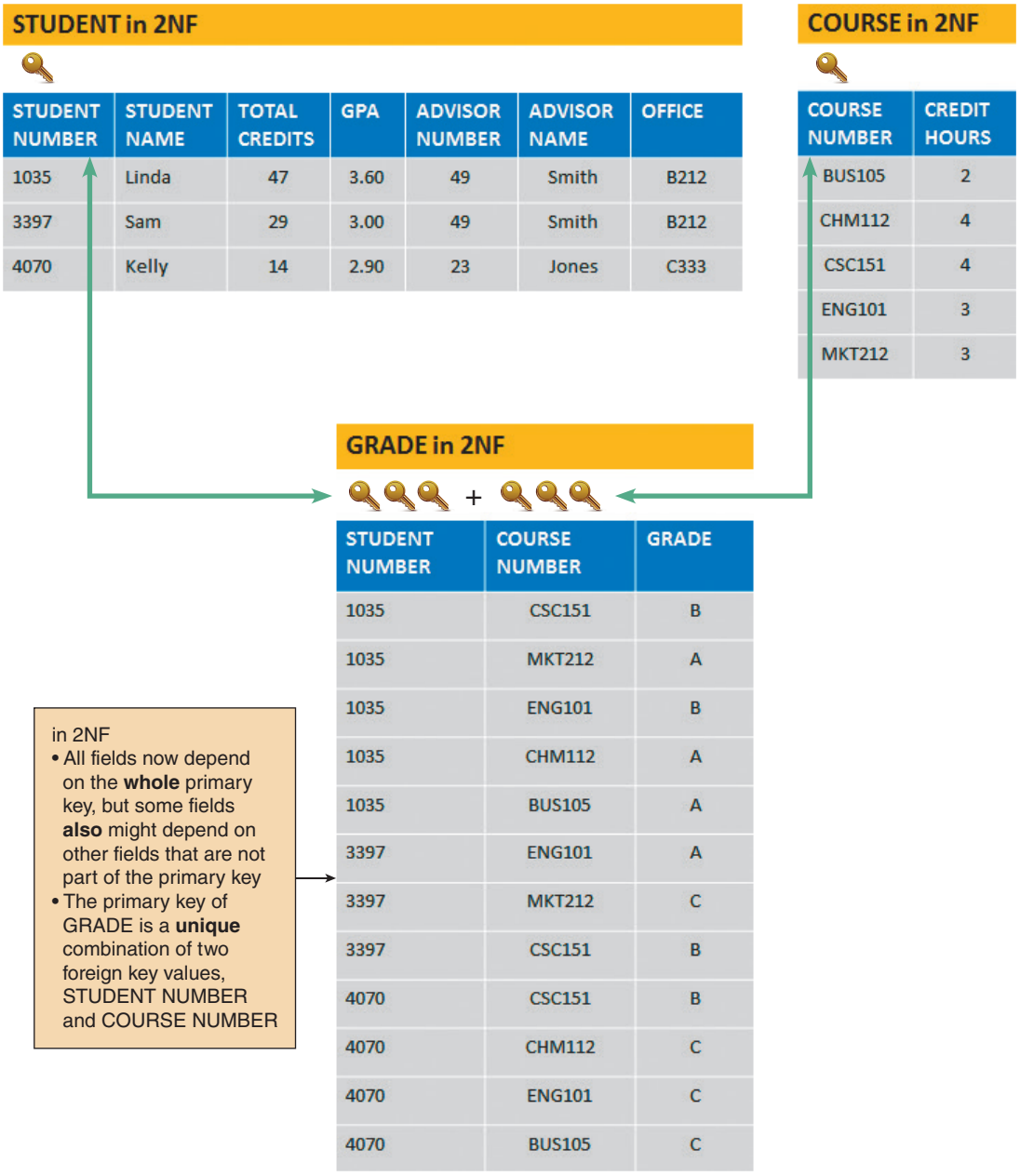


FIGURE 9-28 The STUDENT, COURSE, and GRADE tables in 2NF. Notice that all fields are functionally dependent on the entire primary key of their respective tables.

Figure 9-29 shows the 3NF versions of the sample data for STUDENT, ADVISOR, COURSE, and GRADE. The final 3NF design is:

STUDENT (STUDENT NUMBER, STUDENT NAME, TOTAL CREDITS, GPA, ADVISOR NUMBER)

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ADVISOR (ADVISOR NUMBER, ADVISOR NAME, OFFICE)
COURSE (COURSE NUMBER, CREDIT HOURS)
GRADE (STUDENT NUMBER, COURSE NUMBER, GRADE)

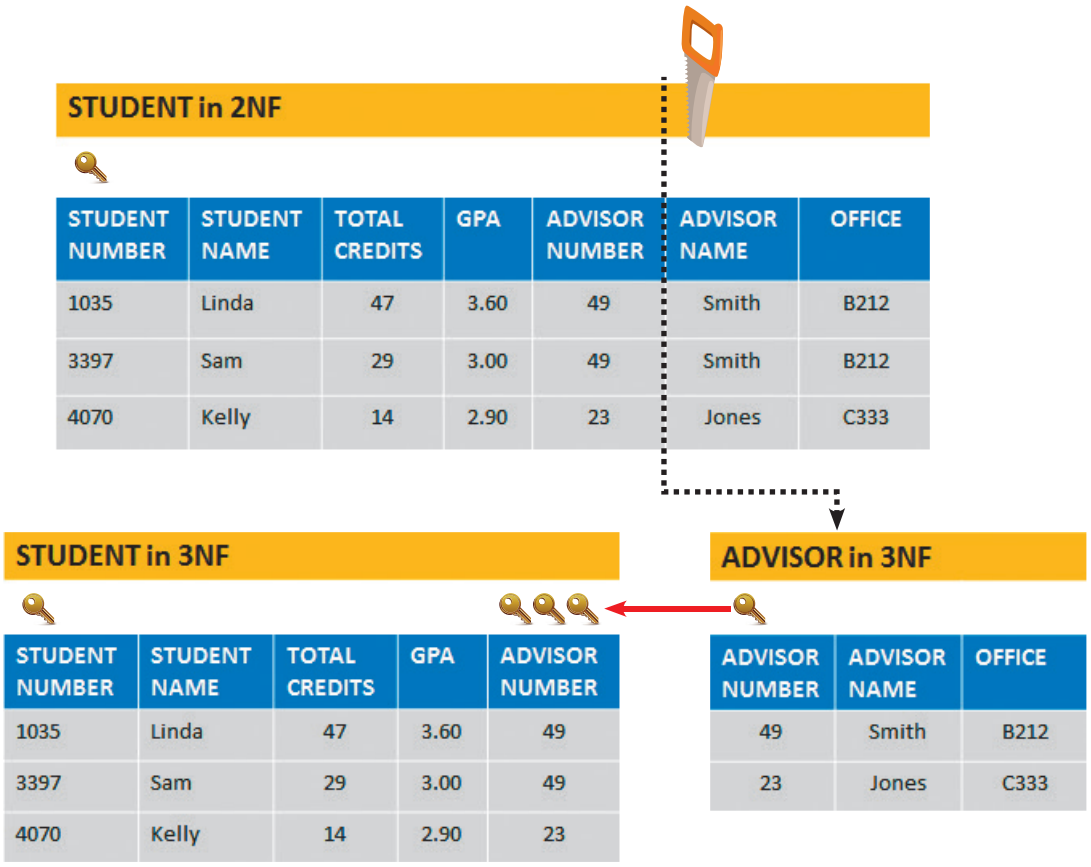


FIGURE 9-29 STUDENT, ADVISOR, COURSE, and GRADE tables in 3NF. When the STUDENT table is transformed from 2NF to 3NF, the result is two tables: STUDENT and ADVISOR.

Figure 9-30 shows the complete ERD after normalization. Now there are four entities: STUDENT, ADVISOR, COURSE, and GRADE (which is an associative entity). Note how Figure 9-25, which was drawn before GRADE was identified as an entity, shows that the M:N relationship between STUDENT and COURSE has been converted into two 1:M relationships: one relationship between STUDENT and GRADE and the other relationship between COURSE and GRADE.

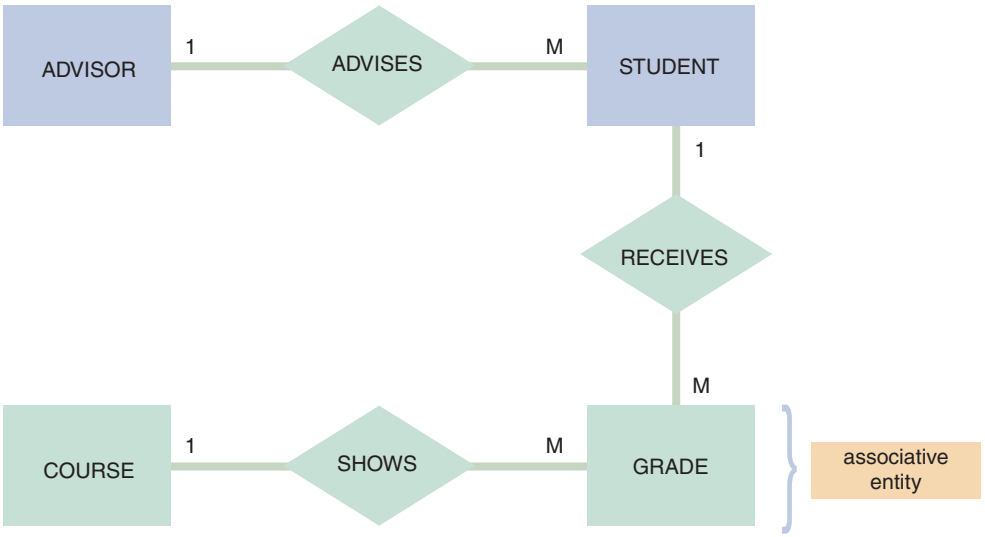


FIGURE 9-30 The entity-relationship diagram for STUDENT, ADVISOR, and COURSE after normalization. The GRADE entry was identified during the normalization process. GRADE is an associative entity that links the STUDENT and COURSE tables.

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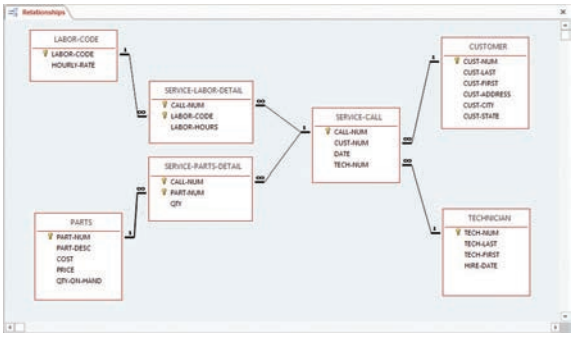


FIGURE 9-31 A relational database design for a computer service company uses common fields to link the tables and form an overall data structure. Notice the one-to-many notation symbols and the primary keys, which are indicated with gold-colored key symbols.

To create 3NF designs, the nature of first, second, and third normal forms must be understood. A systems analyst will encounter designs that are much more complex than the examples in this chapter.

EXAMPLE 2: Magic Maintenance: Magic Maintenance provides on-site service for electronic equipment. Figure 9-31 shows the overall database design that such a firm might use. The figure contains examples of many concepts described earlier. The database consists of seven separate tables, all joined by common fields, so they form an integral data structure.

Figure 9-32 shows even more detail, including sample data, primary keys, and common fields. Note that the entities include customers, technicians, service calls,

LABOR-CODE

LABOR-CODE	HOURLY-RATE
A	$35.00
B	$45.00
C	$55.00
D	$65.00

CUSTOMER

CUST-NUM	CUST-LAST	CUST-FIRST	CUST-ADDRESS	CUST-CITY	CUST-STATE
1456	Jones	Albert	43 Oak Drive	Denver	CO
1933	Valdez	Trini	1011 Hilltop Road	Charlotte	NC
2836	Gonzalez	Juan	678 8th Street	Seattle	WA
6321	Belli	Mary	101 Main Street	San Jacinto	CA
8760	Sansone	Jackie	9 Blueberry Court	Boston	MA
8848	McSorley	John	321 Smith Lane	Hudson	FL

SERVICE-LABOR-DETAIL

CALL-NUM	LABOR-CODE	LABOR-HOURS
10796	A	1.5
10796	C	2.0
10798	B	5.0
10799	C	1.5
10799	D	1.5
10801	A	2.5

SERVICE-CALL

CALL-NUM	CUST-NUM	DATE	TECH-NUM
10796	1456	12/12/2019	04
10797	2836	12/13/2019	17
10798	8848	12/13/2019	04
10799	1456	12/15/2019	21
10800	6321	12/16/2019	21
10801	1456	12/16/2019	09

SERVICE-PARTS-DETAIL

CALL-NUM	PART-NUM	QTY
10796	DD-9192	4
10796	SS-1111	2
10797	AB-6784	6
10799	AB-6784	1
10799	XC-3133	15
10800	SS-1024	8

TECHNICIAN

TECH-NUM	TECH-LAST	TECH-FIRST	HIRE-DATE
04	Robison	Gerry	6/1/2008
09	Whitfield	David	8/1/2001
17	Kaplan	Carl	1/1/1993
20	Choud	Leland	12/1/2003
21	Johnson	Marie	10/1/2014

PARTS

PART-NUM	PART-DESC	COST	PRICE	QTY-ON-HAND
AB-6784	METER	$98.50	$125.00	33
DD-9192	DISC	$1.30	$1.69	220
SS-1024	COVER	$16.00	$19.79	78
SS-1099	EMBLEM	$38.00	$50.00	41
SS-1111	JUMPER	$12.50	$15.00	3
XC-3133	CABLE	$6.75	$7.99	77

Primary Keys
Common fields

FIGURE 9-32 Sample data, primary keys, and common fields for the database shown in Figure 9-31. The design is in 3NF. Notice that all nonkey fields functionally depend on a primary key alone.

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and parts. Other tables store data about labor and parts that are used on specific service calls. Also note that all tables use a single field as a primary key, except the SERVICE-LABOR-DETAIL and SERVICE-PARTS-DETAIL tables, where the primary key requires a combination of two fields to uniquely identify each record.

9.7 Codes

A **code** is a set of letters or numbers that represents a data item. Codes can be used to simplify output, input, and data formats.

9.7.1 Overview of Codes

Because codes can represent data, they are encountered constantly in everyday life. Student numbers, for example, are unique codes to identify students in a school registration system. Three students with the name John Turner might be enrolled at the same school, but *only* one is student number 268960.

A postal code is another common example. A nine-digit postal code contains a lot of information. For example, the first digit identifies 1 of 10 main geographical areas in the United States. The combination of the next three digits identifies a major city or major distribution point. The fifth digit identifies an individual post office, an area within a city, or a specific delivery unit. The last four digits identify a post office box or a specific street address.

For example, consider the zip code 32901-6975 shown in Figure 9-33. This is called the "5+4" zip code format. The first digit, 3, indicates a broad geographical area in the southeastern United States. The next two digits, 29, indicate the area east of Orlando in Florida. The next two digits, 01, represent the city of Melbourne, Florida. The last four digits represent the specific location of the Florida institute of Technology: 150 W. University Blvd.

Codes can be used in many ways. Because codes are shorter than the data they represent, they save storage space and costs, reduce data transmission time, and decrease data entry time. Codes also can be used to reveal or conceal information. The last two digits of a seven-digit part number, for example, might represent the supplier number or the maximum discount that a salesperson can offer.

Finally, codes can reduce data input errors in situations when the coded data is easier to remember and enter than the original source data, when only certain valid codes are allowed, and when something within the code itself can provide immediate verification that the entry is correct.

Broad geographical location in southeastern US	FL Orlando East	Melbourne	Florida Tech 150 W. University Blvd.
3	**29**	**01**	**6975**

FIGURE 9-33 A zip code is an example of a significant digit code that uses groups and subgroups to store data. This example is for the zip code 32901-6975, which is the location of the Florida Institute of Technology in Melbourne, Florida.

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9.7.2 Types of Codes

Companies use many different coding methods. Because information system users must work with coded data, the codes should be easy to learn and apply. If it is planned to create new codes or change existing ones, comments and feedback from users should be obtained. The following section describes seven common coding methods.

1. **Sequence codes** are numbers or letters assigned in a specific order. Sequence codes contain no additional information other than an indication of order of entry into the system. For example, a human resource system issues consecutive employee numbers to identify employees. Because the codes are assigned in the order in which employees are hired, the code can be used to see that employee number 584 was hired after employee number 433. The code, however, does not indicate the starting date of either person's employment.
2. **Block sequence codes** use blocks of numbers for different classifications. College course numbers usually are assigned using a block sequence code. 100-level courses, such as Chemistry 110 and Mathematics 125, are freshman-level courses, whereas course numbers in the 200s indicate sophomore-level courses. Within a particular block, the sequence of numbers can have some additional meaning, such as when English 151 is the prerequisite for English 152.
3. **Alphabetic codes** use alphabet letters to distinguish one item from another based on a category, an abbreviation, or an easy-to-remember value, called a mnemonic code. Many classification codes fit more than one of the following definitions:
   a. **Category codes** identify a group of related items. For example, a local department store uses a two-character category code to identify the department in which a product is sold: GN for gardening supplies, HW for hardware, and EL for electronics.
   b. **Abbreviation codes** are alphabetic abbreviations. For example, standard state codes include NY for New York, ME for Maine, and MN for Minnesota. Some abbreviation codes are called **mnemonic codes** because they use a specific combination of letters that are easy to remember. Many three-character airport codes such as those pictured in Figure 9-34 are mnemonic codes, such as ATL for Atlanta and MIA for Miami. However, some airport codes are not mnemonic, such as ORD (Chicago O'Hare) or MCO (Orlando).



FIGURE 9-34 Abbreviations for some of the world's busiest airports.
BLANKartist/Shutterstock.com

4. **Significant digit codes** distinguish items by using a series of subgroups of digits. Postal codes, for example, are significant digit codes. Other such codes include inventory location codes that consist of a two-digit warehouse code, followed by a one-digit floor number code, a two-digit section code, a one-digit aisle number, and a two-digit bin number code. Figure 9-35 illustrates the inventory location code 11205327. What looks like a large eight-digit number is actually five separate numbers, each of which has significance.

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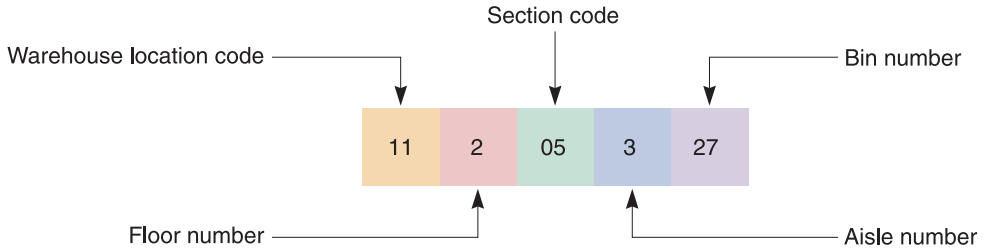


FIGURE 9-35 Sample of a code that uses significant digits to pinpoint the location of an inventory item.

5. **Derivation codes** combine data from different item attributes, or characteristics. Most magazine subscription codes are derivation codes. For example, one popular magazine uses a subscriber's five-digit postal code, followed by the first, third, and fourth letters of the subscriber's last name, the last two digits of the subscriber's house number, and the first, third, and fourth letters of the subscriber's street name. A sample is shown in Figure 9-36.

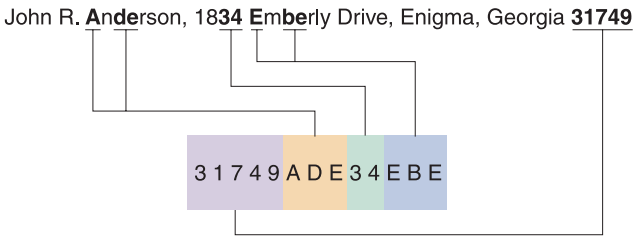


FIGURE 9-36 A magazine subscriber code is derived from various parts of the name and address.

6. **Cipher codes** use a keyword to encode a number. A retail store, for example, might use a 10-letter word, such as CAMPGROUND, to code wholesale prices, where the letter C represents 1, A represents 2, and so on. Thus, the code, GRAND, indicates that the store paid $562.90 for the item.
7. **Action codes** indicate what action is to be taken with an associated item. For example, a student records program might prompt a user to enter or click an action code such as D (to display a record), A (to add a record), and X (to exit the program).

9.7.3 Designing Codes

Here are some code design suggestions:

- *Keep codes concise*. Do not create codes that are longer than necessary. For example, if a code is needed to identify each of 250 customers, a six-digit code is not needed.
- *Allow for expansion*. A coding scheme must allow for reasonable growth in the number of assigned codes. For example, if the company currently has eight warehouses, do not use a one-digit code for the warehouse number. If two more warehouses are added, the code must be increased to two digits or changed to a character code in order to identify each location. The rule also applies to using a single letter as a character code because more than 26 data items might be needed in the future. Of course, more characters can be added, which is just what the airline industry has done. Most airlines now use six-character codes that allow millions of combinations.
- *Keep codes stable*. Changes in codes can cause consistency problems and require data updates. During the changeover period, all the stored occurrences of a particular code and all documents containing the old code will have to change as users switch to the new code. Usually, both the old and new codes are used for an interim period, and special procedures are required to handle the two codes. For example, when telephone area codes change, either area code (old or new) can be used for a certain time period.

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- *Make codes unique*. Codes used for identification purposes must be unique to have meaning. If the code HW can indicate hardware or houseware, the code is not very useful.
- *Use sortable codes*. If products with three-digit codes in the 100s or the 300s are of one type, while products with codes in the 200s are a different type, a simple sort will not group all the products of one type together. In addition, be careful that single-digit character codes will sort properly with double-digit codes—in some cases a leading zero must be added (01, 02, 03, etc.) to ensure that codes sort correctly.
- *Use a simple structure*. Do not code some part numbers with two letters, a hyphen, and one digit, and others with one letter, a hyphen, and two digits. Avoid allowing both letters and numbers to occupy the same positions within a code because some of those are easily confused. This situation might be a good place to use an input mask to assure that the correct data type is entered.
- *Avoid confusion*. It is easy to confuse the number zero (0) and the uppercase letter O, or the number one (1) with the lowercase letter L (l) or uppercase letter I. For example, the five-character code 5Z081 easily can be misread as 5ZO8I, or 52081.
- *Make codes meaningful*. Codes should be easy to remember, user-friendly, convenient, and easy to interpret. Using SW as a code for the southwest sales region, for example, has far more meaning than the code 14. Using ENG as the code for the English department is easier to interpret and remember than either XVA or 132.
- *Use a code for a single purpose*. Do not use a code to classify unrelated attributes. For example, if a single code is used to identify the combination of an employee's department *and* the employee's insurance plan type, users will have difficulty identifying all the subscribers of a particular plan, or all the workers in a particular department, or both. A separate code for each separate characteristic makes much more sense.
- *Keep codes consistent*. For example, if the payroll system already is using two-digit codes for departments, do not create a new, different coding scheme for the personnel system. If the two systems already are using different coding schemes, try to establish a consistent coding scheme.

CASE IN POINT 9.3: MADERA TOOLS

Madera Tools operates a small business that specializes in hard-to-find woodworking tools. The firm advertises in various woodworking magazines and currently accepts mail and telephone orders. Madera is planning a website that will be the firm's primary sales channel. The site will feature an online catalog, powerful search capabilities, and links to woodworking information and resources.

Madera has asked you, an IT consultant, whether a set of codes would be advantageous. What codes would you suggest? Provide at least two choices for a customer code and at least two choices for a product code. Be sure to describe your choices and provide some specific examples. Also include an explanation of why you selected these particular codes and what advantages they might offer.

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9.8 Data Storage and Access

Data storage and access involve strategic business tools, such as data warehousing and data mining software, as well as logical and physical storage issues, selection of data storage formats, and special considerations regarding storage of date fields.

9.8.1 Tools and Techniques

Companies use data warehousing and data mining as strategic tools to help manage the huge quantities of data they need for business operations and decisions. A large number of software vendors compete for business in this fast-growing IT sector.

DATA WAREHOUSING: Large firms maintain many databases, which might or might not be linked together into an overall structure. To provide rapid access to this information, companies use software packages that organize and store data in special configurations called data warehouses. A **data warehouse** is an integrated collection of data that can include seemingly unrelated information, no matter where it is stored in the company. Because it can link various information systems and databases, a data warehouse provides an enterprise-wide view to support management analysis and decision making.

A data warehouse allows users to specify certain dimensions, or characteristics. By selecting values for each characteristic, a user can obtain multidimensional information from the stored data. For example, in a typical company, most data is generated by transaction-based systems, such as order processing systems, inventory systems, and payroll systems. If a user wants to identify the customer on sales order 34071, he or she can retrieve the data easily from the order processing system by entering an order number.

On the other hand, suppose that a user wants to see June 2019 sales results for the sales rep assigned to Jo-Mar Industries. The data is stored in two different systems with different databases: the sales information system and the human resources information system, as shown in Figure 9-37. Without a data warehouse, it would be difficult for a user to extract data that spans several information systems and time frames. Rather than accessing separate systems, a data warehouse stores transaction data in a format that allows users to retrieve and analyze the data easily.

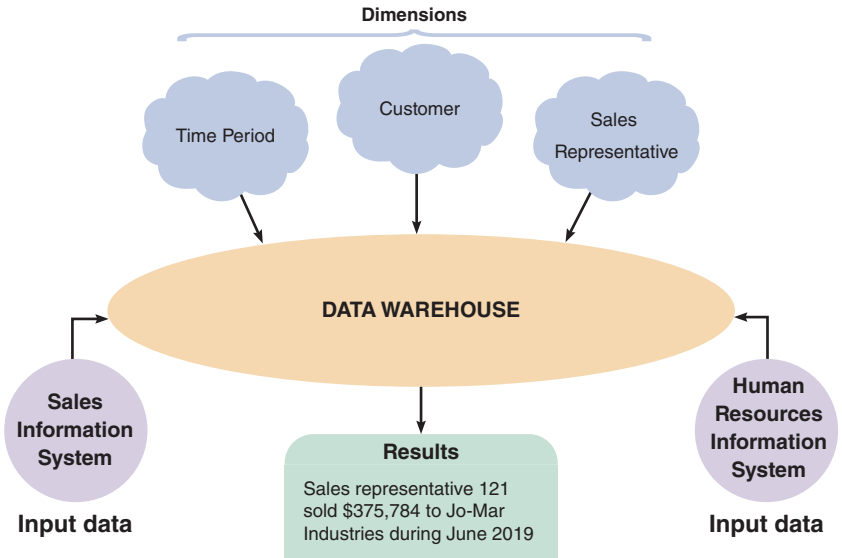


FIGURE 9-37 A data warehouse stores data from several systems. By selecting data dimensions, a user can retrieve specific information without having to know how or where the data is stored.

While a data warehouse typically spans the entire enterprise, many firms prefer to use a **data mart**, which is designed to serve the needs of a specific department, such as sales, marketing, or finance. Each data mart includes only the data that users in that department require to perform their jobs. There are pros and cons to both approaches, and the best solution usually depends on the specific situation.

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Regardless of the overall approach, storing large quantities of data is like building a house—it doesn't just happen. A well-constructed data warehouse needs an architecture that includes detailed planning and specifications.

DATA MINING: **Data mining** software looks for meaningful data patterns and relationships. For example, data mining software could help a consumer products firm identify potential customers based on their prior purchases. Information about customer behavior is valuable, but data mining also raises serious ethical and privacy issues, such as the example in the Question of Ethics feature in this chapter.

The enormous growth in e-commerce has focused attention on data mining as a marketing tool. In an article called "Data Mining on the Web" that appeared in the January 2000 issue of *New Architect*, a web-based magazine, Dan R. Greening noted that web hosts typically possess a lot of information about visitors, but most of it is of little value. His article mentions that smart marketers and business analysts are using data mining techniques, which he describes as "machine learning algorithms that find buried patterns in databases, and report or act on those findings." He concludes by saying that "the great advantage of web marketing is that you can measure visitor interactions more effectively than in brick-and-mortar stores or direct mail. Data mining works best when you have clear, measurable goals." Some of the goals he suggests are as follows:

- Increase the number of pages viewed per session.
- Increase the number of referred customers.
- Reduce **clicks to close**, which means average page views to accomplish a purchase or obtain desired information.
- Increase checkouts per visit.
- Increase average profit per checkout.

This type of data gathering is sometimes called **clickstream storage**. Armed with this information, a skillful web designer could build a profile of typical new customers, returning customers, and customers who browse but do not buy. Although this information would be very valuable to the retailer, clickstream storage could raise serious legal and privacy issues if an unscrupulous firm sought to link a customer's web behavior to a specific name or email address and then sell or otherwise misuse the information.

Because it can detect patterns and trends in large amounts of data, data mining is a valuable tool for managers. There is a well-known story about a chain of supermarkets that performed a detailed affinity analysis of purchases and found that beer and diapers were often purchased together. It is unclear whether or not this story is true, but without attempting to explain this correlation, the obvious tactic for a retailer would be to display these items in the same area of the store. This data mining technique relies on association rule learning and is often called **market basket analysis**.

9.8.2 Logical Versus Physical Storage

It is important to understand the difference between logical storage and physical storage. **Logical storage** refers to data that a user can view, understand, and access, regardless of how or where that information actually is organized or stored. In contrast, **physical storage** is strictly hardware related because it involves the process of reading and writing binary data to physical media such as a hard drive, CD/DVD, or network-based storage device. For example, portions of a document might be stored in different physical locations on a hard drive, but the user sees the document as a single logical entity on the computer screen.

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Logical storage consists of alphabetic and numeric **characters**, such as the letter *A* or the number 9. As described earlier in this chapter, a set of related characters forms a field, which describes a single characteristic, or attribute, of a person, a place, a thing, or an event. A field also is called a **data element** or a **data item**.

When designing fields, space should be provided for the largest values that can be anticipated, without allocating unnecessarily large storage capacities that will not be used. For example, suppose a customer order entry system is being designed for a firm with 800 customers. It would be a mistake to limit the customer number field to three or even four characters. Instead, a five-character field with leading zeros that could store customer numbers from *00001* to *99999* should be considered.

A mix of alphabetic and numeric characters can also be considered, which many people find easier to view and use. Alphabetic characters expand the storage capacity because there are 26 possible values for each character position. Most airlines now use six alphabetic characters as a record locator, which has over 300 million possible values.

A **logical record** is a set of field values that describes a single person, place, thing, or event. For example, a logical customer record contains specific field values for a single customer, including the customer number, name, address, telephone number, credit limit, and so on. Application programs see a logical record as a group of related fields, regardless of how or where the data is stored physically.

The term *record* usually refers to a logical record. Whenever an application program issues a read or write command, the operating system supplies one logical record to the program or accepts one logical record from the program. The physical data might be stored on one or more servers, in the same building or thousands of miles away, but all the application program sees is the logical record—the physical storage location is irrelevant.

9.8.3 Data Coding

Computers represent data as **bits** (short for *binary digits*) that have only two possible values: 1 and 0. A computer understands a group of bits as a digital code that can be transmitted, received, and stored. Computers use various data coding and storage schemes, such as EBCDIC, ASCII, and binary. A more recent coding standard called Unicode also is popular. Also, the storage of dates raises some design issues that must be considered.

EBCDIC, ASCII, AND BINARY: **EBCDIC** (pronounced EB-see-dik), which stands for Extended Binary Coded Decimal Interchange Code, is a coding method used on mainframe computers and high-capacity servers. **ASCII** (pronounced ASK-ee), which stands for American Standard Code for Information Interchange, is a coding method used on most personal computers. EBCDIC and ASCII both require eight bits, or one **byte**, for each character. For example, the name Ann requires 3 bytes of storage, the number *12,345* requires 5 bytes of storage, and the number *1,234,567,890* requires 10 bytes of storage.

Compared with character-based formats, a **binary storage format** offers a more efficient storage method because it represents numbers as actual binary values, rather than as coded numeric digits. For example, an integer format uses only 16 bits, or two bytes, to represent the number *12,345* in binary form. A long integer format uses 32 bits, or four bytes, to represent the number *1,234,567,890* in binary form.

UNICODE: **Unicode** is a more recent coding standard that uses two bytes per character, rather than one. This expanded scheme enables Unicode to represent more

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than 65,000 unique, multilingual characters. Why is this important? Consider the challenge of running a multinational information system or developing a program that will be sold in Asia, Europe, and North America. Because it supports virtually all languages, Unicode has become a global standard.

Traditionally, domestic software firms developed a product in English and then translated the program into one or more languages. This process was expensive, slow, and error-prone. In contrast, Unicode creates translatable content right from the start. Today, most popular operating systems support Unicode, and the Unicode Consortium maintains standards and support, as shown in Figure 9-38.

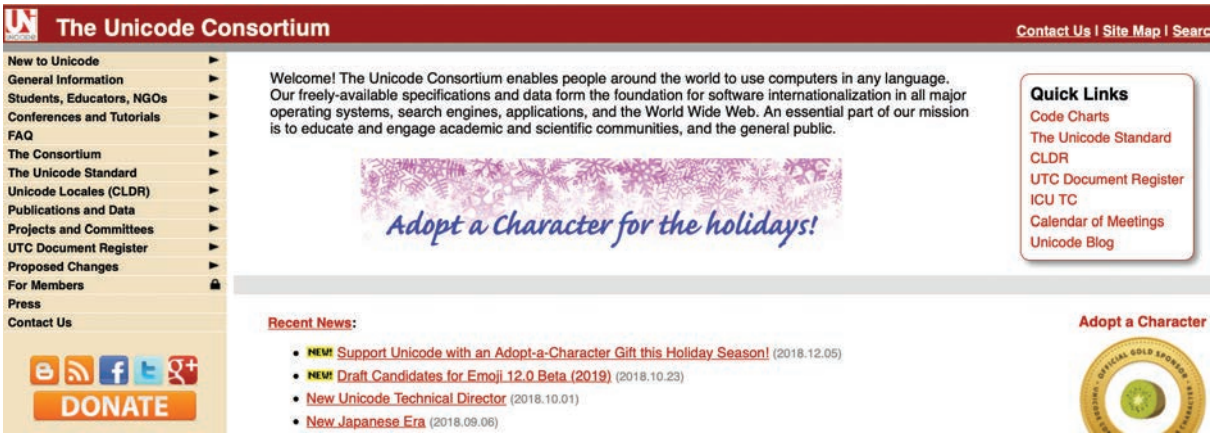


FIGURE 9-38 Unicode is an international coding format that represents characters as integers, using 16 bits (two bytes) per character. The Unicode Consortium maintains standards and support for Unicode.

Source: Unicode Consortium

STORING DATES: What is the best way to store dates? The answer depends on how the dates will be displayed and whether they will be used in calculations.

At the beginning of the twenty-first century, many firms that used only two digits to represent the year were faced with a major problem called the **Y2K issue**. Based on that experience, most date formats now are based on the model established by the **International Organization for Standardization (ISO)**, which requires a format of four digits for the year, two for the month, and two for the day (YYYYMMDD). A date stored in that format can be sorted easily and used in comparisons. If a date in ISO form is larger than another date in the same form, then the first date is later. For example, 20150504 (May 4, 2015) is later than 20130927 (September 27, 2013).

But what if dates must be used in calculations? For example, if a manufacturing order placed on June 23 takes three weeks to complete, when will the order be ready? If a payment due on August 13 is not paid until April 27 of the following year, exactly how late is the payment and how much interest is owed? In these situations, it is easier to use absolute dates.

An **absolute date** is the total number of days from some specific base date. To calculate the number of days between two absolute dates, one date is subtracted from the other. For example, if the base date is January 1, 1900, then May 4, 2015, has an absolute date of 42128. Similarly, September 27, 2013, has an absolute date value of 41544. If the earlier date value is subtracted from the later one, the result is 584 days. A spreadsheet can be used to determine and display absolute dates easily, as shown in Figure 9-39.

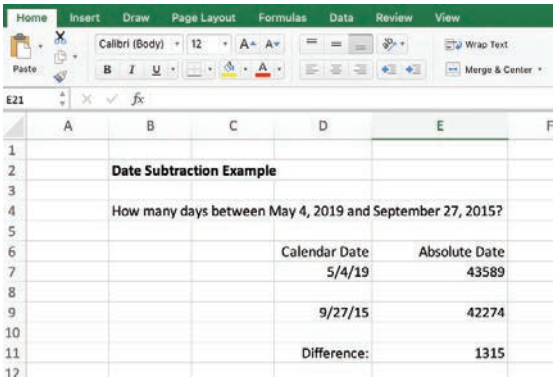


FIGURE 9-39 Microsoft Excel uses absolute dates in calculations. In this example, May 4, 2019, is displayed as 43589, and September 27, 2015, is displayed as 42274. The difference between the dates is 1315 days.

Scott Tilley

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9.9 Data Control

Just as it is important to secure the physical part of the system, as shown in Figure 9-40, file and database control must include all measures necessary to ensure that data storage is correct, complete, and secure. File and database control is also related to input and output techniques discussed earlier.



FIGURE 9-40 In addition to network monitoring, system security includes access codes, data encryption, passwords, and audit trails.
Gorodenkoff/Shutterstock.com

A well-designed DBMS must provide built-in control and security features, including subschemas, passwords, encryption, audit trail files, and backup and recovery procedures to maintain data. The analyst's main responsibility is to ensure that the DBMS features are used properly.

Earlier in this chapter, it was explained that a subschema can be used to provide a limited view of the database to a specific user or level of users. Limiting access to files and databases is the most common way of protecting stored data. Users must furnish a proper user ID and password to access a file or database. Different privileges, also called **permissions**, can be associated with different users, so some employees can be limited to read-only access, while other users might be allowed to update or delete data. For highly sensitive data, additional access codes can be established that restrict specific records or fields within records. Stored data also can be encrypted to prevent unauthorized access. **Encryption** is the process of converting readable data into unreadable characters to prevent unauthorized access to the data.

All system files and databases must be backed up regularly and a series of **backup** copies must be retained for a specified period of time. In the event of a file catastrophe, **recovery procedures** can be used to restore the file or database to its current state at the time of the last backup. **Audit log files**, which record details of all accesses and changes to the file or database, can be used to recover changes made since the last backup. **Audit fields**, which are special fields within data records to provide additional control or security information, can also be included. Typical audit fields include the date the record was created or modified, the name of the user who performed the action, and the number of times the record has been accessed.

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A QUESTION OF ETHICS



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Tip Top Toys is a relatively small division of Worldwide Enterprises. Worldwide has nine other divisions, which include insurance, health-care products, and financial planning services, to name a few.

The corporate marketing director for Worldwide has requested Tip Top's customer shopping data to target people who might be likely to purchase items or services from other Worldwide divisions. The database manager is not totally comfortable with this and pointed out Tip Top's web privacy policy, which states "Tip Top Toys, a division of Worldwide Enterprises, will not share personal data with other companies without a customer's consent."

The marketing director replied that the statement only applies to outside companies—not other Worldwide divisions. He said he checked with the corporate legal department, and they agreed. The database manager replied, "Even if it is legally OK, it's not the *right* thing to do. Many people take our statement to mean that their data does not leave Tip Top. At the very least, we should give customers a choice, and share the data only with their consent."

Do you agree with the marketing director? Why or why not?

9.10 Summary

This chapter continued the study of the systems design phase of the SDLC. It was explained that files and tables contain data about people, places, things, or events that affect the information system. File-oriented systems, also called file processing systems, manage data stored in separate.

A database consists of linked tables that form an overall data structure. A DBMS is a collection of tools, features, and interfaces that enable users to add, update, manage, access, and analyze data in a database.

DBMS designs are more powerful and flexible than traditional file-oriented systems. A database environment offers scalability, support for organization-wide access, economy of scale, data sharing among user groups, balancing of conflicting user requirements, enforcement of standards, controlled redundancy, effective security, flexibility, better programmer productivity, and data independence. Large-scale databases are complex and require extensive security and backup/recovery features.

DBMS components include interfaces for users, DBAs, and related systems; a DML; a schema; and a physical data repository. Other data management techniques include data warehousing, which stores data in an easily accessible form for user access, and data mining, which looks for meaningful patterns and relationships among data. Data mining also includes clickstream storage, which records how users interact with a site, and market basket analysis, which can identify product relationships and consumer buying patterns.

In a web-based design, the Internet serves as the front end, or interface, for the DBMS. Access to the database requires only a web browser client and an Internet connection. Middleware can interpret client requests in HTML form and translate

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the requests into commands that the database can execute. Web-based data must be secure, yet easily accessible to authorized users. To achieve this goal, well-designed systems provide security at three levels: the database itself, the web server, and the telecommunication links that connect the components of the system

In an information system, an entity is a person, a place, a thing, or an event for which data is collected and maintained. A field, or attribute, is a single characteristic of an entity. A record, or tuple, is a set of related fields that describes one instance of an entity. Data is stored in files (in a file-oriented system) and tables (in a database environment).

A primary key is the field or field combination that uniquely and minimally identifies a specific record; a candidate key is any field that could serve as a primary key. A foreign key is a field or field combination that must match the primary key of another file or table. A secondary key is a field or field combination used as the basis for sorting or retrieving records.

An ERD is a graphic representation of all system entities and the relationships among them. The ERD is based on entities and data stores in DFDs prepared during the systems analysis phase. The three basic relationships represented in an ERD are one-to-one (1:1), one-to-many (1:M), and many-to-many (M:N). In a M:N relationship, the two entities are linked by an associative entity.

The relationship between two entities also is referred to as cardinality. A common form of cardinality notation is called crow's foot notation, which uses various symbols to describe the characteristics of the relationship.

Normalization is a process for avoiding problems in data design. A 1NF record has no repeating groups. A record is in 2NF if it is in 1NF and all nonkey fields depend on the entire primary key. A record is in 3NF if it is in 2NF and if no field depends on a nonkey field.

Data design tasks include creating an initial ERD; assigning data elements to an entity; normalizing all table designs; and completing the data dictionary entries for files, records, and data elements.

A code is a set of letters or numbers used to represent data in a system. Using codes can speed up data entry, reduce data storage space, and reduce transmission time. Codes also can be used to reveal or to conceal information. The main types of codes are sequence codes, block sequence codes, classification codes, alphabetic codes (e.g., category codes, abbreviation codes, and mnemonic codes), significant digit codes, derivation codes, cipher codes, and action codes.

Logical storage is information seen through a user's eyes, regardless of how or where that information actually is organized or stored. Physical storage is hardware related and involves reading and writing binary data to physical media. A logical record is a related set of field values that describes a single person, place, thing, or event. Data storage formats include EBCDIC, ASCII, binary, and Unicode. Dates can be stored in several formats, including ISO and absolute format.

File and database control measures include limiting access to the data, data encryption, backup/recovery procedures, audit trail files, and internal audit fields.

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Key Terms

1:1 A type of entity relationship. A one-to-one relationship, abbreviated 1:1, exists when exactly one of the second entity occurs for each instance of the first entity.

1:M A type of entity relationship. A one-to-many relationship, abbreviated 1:M, exists when one occurrence of the first entity can be related to many occurrences of the second entity, but each occurrence of the second entity can be associated with only one occurrence of the first entity.

abbreviation code Alphabetic abbreviation. For example, standard state codes include NY for New York, ME for Maine, and MN for Minnesota.

absolute date The total number of days from some specific base date. To calculate the number of days between two absolute dates, subtract one date from the other. For example, using a base date of January 1, 1900, September 27, 2012, has an absolute date value of 41179 and July 13, 2011, has an absolute date of 40737. If the earlier date value is subtracted from the later one, the result is 442 days.

action code Indicates what action is to be taken with an associated item. For example, a student records program might prompt a user to enter or click an action code such as D (to display the student's record), A (to add a record), and X (to exit the program).

alphabetic code Uses alphabet letters to distinguish one item from another based on a category, an abbreviation, or an easy-to-remember value, called a mnemonic code.

ASCII Stands for American Standard Code for Information Interchange, a data storage coding method used on most personal computers and workstations.

associative entity An entity that has its own set of attributes and characteristics. Associative entities are used to link between many-to-many (M:N) relationships.

attribute A single characteristic or fact about an entity. An attribute, or field, is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of an attribute. In object-oriented analysis, an attribute is part of a class diagram that describes the characteristics of objects in the class. Also known as a data element.

audit fields Special fields within data records to provide additional control or security information. Typical audit fields include the date the record was created or modified, the name of the user who performed the action, and the number of times the record has been accessed.

audit log files Record details of all accesses and changes to a file or database and can be used to recover changes made since the last backup.

backup The process of saving a series of file or data copies to be retained for a specified period of time. Data can be backed up continuously, or at prescribed intervals.

binary storage format A format that offers efficient storage of numeric data. For example, when numeric data types are specified using Microsoft Access, there are a variety of storage formats choices, including integer and long integer, among others.

bit The smallest unit of data is one binary digit.

block sequence code Cipher that uses blocks of numbers for different classifications.

byte A group of eight bits is called a byte, or a character. A set of bytes forms a field, which is an individual fact about a person, a place, a thing, or an event.

candidate key Sometimes it is possible to have a choice of fields or field combinations to use as the primary key. Any field that could serve as a primary key is called a candidate key.

cardinality A concept that describes how instances of one entity relate to instances of another entity. Described in ERDs by notation that indicates combinations that include zero or one-to-many, one-to-one, and many-to-many.

cardinality notation Code that shows relationships between entities.

category codes Ciphers that identify a group of related items. For example, a local department store may use a two-character category code to identify the department in which a product is sold.

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character A group of eight bits is called a character, or a byte. A set of bytes forms a field, which is an individual fact about a person, a place, a thing, or an event.

cipher codes Use of a keyword to encode a number. A retail store, for example, may use a 10-letter word, such as CAMPGROUND, to code wholesale prices, where the letter C represents 1, A represents 2, and so on. Thus, the code, GRAND, would indicate that the store paid $562.90 for the item.

clicks to close The average number of page views to accomplish a purchase or obtain desired information.

clickstream storage Recording web visitor behavior and traffic trends for later data mining. use.

code A set of letters or numbers that represents a data item. Codes can be used to simplify output, input, and data formats.

combination key A type of data validation check that is performed on two or more fields to ensure that they are consistent or reasonable when considered together. Even though all the fields involved in a combination check might pass their individual validation checks, the combination of the field values might be inconsistent or unreasonable.

common field An attribute that appears in more than one entity. Common fields can be used to link entities in various types of relationships.

composite key Sometimes it is necessary for a primary key to consist of a combination of fields. In that case, the primary key is called a combination key, composite key, concatenated key, or multivalued key.

concatenated key *See* **composite key**.

crow's foot notation A type of cardinality notation. It is called crow's foot notation because of the shapes, which include circles, bars, and symbols, that indicate various possibilities. A single bar indicates one, a double bar indicates one and only one, a circle indicates zero, and a crow's foot indicates many.

data element A single characteristic or fact about an entity. A data element, field, or attribute is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of a data element. The term *data item* is also used.

data item *See* **data element**.

data manipulation language (DML) A DML controls database operations, including storing, retrieving, updating, and deleting data. Most commercial DBMSs, such as Oracle and IBM's DB2, use a DML.

data mart A specialized database designed to serve the needs of a specific department, such as sales, marketing, or finance. Each data mart includes only the data that users in that department require to perform their jobs.

data mining Looking for meaningful patterns and relationships among data. For example, data mining software could help a consumer products firm identify potential customers based on their prior purchases.

data structure A meaningful combination of related data elements that is included in a data flow or retained in a data store. A framework for organizing and storing data.

data warehouse An integrated collection of data that can support management analysis and decision making.

database administrator (DBA) Someone who manages a DBMS. The DBA assesses overall requirements and maintains the database for the benefit of the entire organization rather than a single department or user.

database management system (DBMS) A collection of tools, features, and interfaces that enables users to add, update, manage, access, and analyze data in a database.

derivation code Combining data from different item attributes, or characteristics, to build the code. Most magazine subscription codes are derivation codes.

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EBCDIC Stands for Extended Binary Coded Decimal Interchange Code, a coding method used on mainframe computers and some high-capacity servers.

economy of scale The inherent efficiency of high-volume processing on larger computers. Database design allows better utilization of hardware. If a company maintains an enterprise-wide database, processing is less expensive using a powerful mainframe server instead of using several smaller computers.

encryption A process where data is coded (converted into unreadable characters) so that only those with the required authorization can access the data (usually via decoding software)

entity A person, a place, a thing, or an event for which data is collected and maintained. For example, an online sales system may include entities named CUSTOMER, ORDER, PRODUCT, and SUPPLIER.

entity-relationship diagram (ERD) A graphical model of the information system that depicts the relationships among system entities.

field A single characteristic or fact about an entity. A field, or attribute, is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of a field. The terms *data element*, *data item*, and *field* are used interchangeably.

file Each file or table contains data about people, places, things, or events that interact with the information system.

file-oriented system A file-oriented system, also called a file processing system, stores and manages data in one or more separate files.

first normal form (1NF) A record is said to be in 1NF if it does not contain a repeating group (a set of data items that can occur any number of times in a single record).

foreign key A field in one table that must match a primary key value in another table in order to establish the relationship between the two tables.

functionally dependent Functional dependence is an important concept for understanding the 2NF. The field X is said to be functionally dependent on the field Y if the value of X depends on the value of Y. For example, an order date is dependent on an order number; for a particular order number, there is only one value for the order date. In contrast, the product description is not dependent on the order number. For a particular order number, there might be several product descriptions, one for each item ordered.

International Organization for Standardization (ISO) A network of national standards institutes from over a hundred countries working in partnership with international organizations, governments, industries, and business and consumer representatives. The ISO acts as a bridge between public and private sectors.

java database connectivity (JDBC) A standard that enables Java applications to exchange data with any database that uses SQL statements and is ODBC-compliant.

key fields Used during the systems design phase to organize, access, and maintain data structures. The four types of key fields are primary keys, candidate keys, foreign keys, and secondary keys.

logical record A logical record contains field values that describe a single person, place, thing, or event. Application programs *see* a logical record as a set of fields, regardless of how or where the data is stored physically.

logical storage Refers to information as seen through a user's eyes, regardless of how or where that information is organized or stored.

M:N A type of entity relationship. A many-to-many relationship, abbreviated M:N, exists when one instance of the first entity can be related to many instances of the second entity, and one instance of the second entity can be related to many instances of the first entity.

many-to-many relationship *See* **M:N**.

market basket analysis A type of analysis that can detect patterns and trends in large amounts of data.

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middleware Software that connects dissimilar applications and enables them to communicate and exchange data. For example, middleware can link a departmental database to a web server that can be accessed by client computers via the Internet or a company intranet.

mnemonic code Ciphers using a specific combination of letters that are easy to remember. Many three-character airport codes are mnemonic codes. For example, LAX represents Los Angeles.

multivalued key Sometimes it is necessary for a primary key to consist of a combination of fields. In that case, the primary key is called a combination key, composite key, concatenated key, or multivalued key.

nonkey field Any field that is not a primary key or a candidate key is called a nonkey field.

normalization A process by which analysts identify and correct inherent problems and complexities in their record designs.

one-to-many relationship *See* **1:M**.

one-to-one relationship *See* **1:1**.

open database connectivity (ODBC) An industry-standard protocol that makes it possible for software from different vendors to interact and exchange data.

orphan An unassociated or unrelated record or field. An orphan could be created if a customer order was entered in an order table where that customer did not already exist in the customer table. Referential integrity would prevent the creation of this orphan.

permissions User-specific privileges that determine the type of access a user has to a database, file, or directory. Also called user rights.

physical storage Information storage mechanism that is strictly hardware related, because it involves the process of reading and writing binary data to physical media, such as a hard drive, flash drive, or DVD.

primary key A field or combination of fields that uniquely and minimally identifies a particular member of an entity. For example, in a customer table the customer number is a unique primary key because no two customers can have the same customer number. That key also is minimal because it contains no information beyond what is needed to identify the customer.

query by example (QBE) A language allows the user to provide an example of the data requested.

query language Allows a user to specify a task without specifying how the task will be accomplished. Some query languages use natural language commands that resemble ordinary English sentences

record A set of related fields that describes one instance, or member of an entity, such as one customer, one order, or one product. A record might have one or dozens of fields, depending on what information is needed. Also called a tuple.

recovery procedure Process for restoring data and restarting a system after an interruption. Recovery procedures can be used to restore a file or database to its current state at the time of the last backup.

referential integrity A type of validity check. Referential integrity is a set of rules that avoids data inconsistency and quality problems.

relational database A database in which tables are related by common fields, creating a unified data structure that provides improved data quality and access.

relational model A model used in relational databases. The relational model was introduced during the 1970s and became popular because it was flexible and powerful.

repeating group A set of one or more fields that can occur any number of times in a single record, with each occurrence having different values.

scalability A characteristic implying the system can be expanded, modified, or downsized easily to meet the rapidly changing needs of a business enterprise.

schema The complete definition of a database, including descriptions of all fields, records, and relationships.

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second normal form (2NF) A record design is in 2NF if it is in 1NF and if all fields that are not part of the primary key are dependent on the entire primary key. If any field in a 1NF record depends on only one of the fields in a combination primary key, then the record is not in 2NF. A 1NF record with a primary key that is a single field is automatically in 2NF.

secondary key A field or combination of fields that can be used to access or retrieve records. Secondary key values are not unique. For example, to access records for only those customers in a specific postal code, the postal code field could be used as a secondary key.

sequence code Numbers or letters assigned in a specific order. Sequence codes contain no additional information other than an indication of order of entry into a system.

significant digit code Cipher that distinguishes items by using a series of subgroups of digits. U.S. Postal Service zip codes, for example, are significant digit codes.

standard notation format A representation that makes designing tables easier as it clearly shows a table's structure, fields, and primary key.

Structured Query Language (SQL) A query language that allows PC users to communicate with servers and mainframe computers.

subschema A view of the database used by one or more systems or users. A subschema defines only those portions of the database that a particular system or user needs or is allowed to access.

table Each file or table contains data about people, places, things, or events that interact with the information system.

table design Specifies the fields and identifies the primary key in a particular table or file.

third normal form (3NF) A record design is in 3NF if it is in 2NF and if no nonkey field is dependent on another nonkey field. A nonkey field is a field that is not a candidate key for the primary key.

tuple A tuple (rhymes with couple), or record, is a set of related fields that describes one instance, or member of an entity, such as one customer, one order, or one product. A tuple might have one or dozens of fields, depending on what information is needed.

Unicode A relatively recent coding method that represents characters as integers. Unlike EBCDIC and ASCII, which use eight bits for each character, Unicode requires 16 bits per character, which allows it to represent more than 65,000 unique characters.

Unified Modeling Language (UML) A widely used method of visualizing and documenting software systems design. UML uses object-oriented design concepts, but it is independent of any specific programming language and can be used to describe business processes and requirements generally.

unnormalized A record that contains a repeating group, which means that a single record has multiple occurrences of a particular field, with each occurrence having different values.

Y2K issue A problem faced by many firms in the year 2000 because their computer systems used only two digits to represent the year; most dates now use a four-digit format for the year (YYYYMMDD).

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Exercises

Questions

1. What is a data structure?
2. Briefly describe the components of a DBMS.
3. List the major characteristics of web-based design.
4. Explain primary key, candidate key, secondary key, and foreign key.
5. What are ERDs and how are they used?
6. How do you convert an unnormalized design to 1NF? In your answer, refer to specific pages and figures in this chapter.
7. How are codes used in data design?
8. What is data warehousing and data mining?
9. How would a specific date, such as March 15, 2019, be represented as an absolute date?
10. How are permissions used to control access to data?

Discussion Topics

1. In the auto shop examples in Section 9.1.2, what are some problems that might arise in Mario's system? Why won't Danica run into the same problems? Provide specific examples in your answer.
2. Many large organizations have had their database system hacked and customer data stolen. How should the security for the database be different than security for the rest of the system? Does it make a difference for web-based data designs? If so, how?
3. Suggest three typical business situations where referential integrity avoids data problems.
4. We use lots of codes in our personal and business lives. How many can you name?
5. Are there ethical issues to consider when planning a database? For example, should sensitive personal data (such as medical information) be stored in the same DBMS that manages employee salary and benefits data? Why or why not?

Projects

1. Consider an automobile dealership with three locations. Data fields exist for stock number, vehicle identification number, make, model, year, color, and invoice cost. Identify the possible candidate keys, the likely primary key, a probable foreign key, and potential secondary keys.
2. Visit the bookstore at your school or in your area. Interview the manager or store employees to learn more about the business and the entities that are involved in bookstore operations. Remember that an entity is a person, a place, a thing, or an event that affects an information system. Draw an ERD, including cardinality, which describes the bookstore's operations.
3. Cludadwy Chairs sells a patented seat that spectators can take to youth soccer games. The seat folds so it is small enough to fit in the glove box of most vehicles. The company operates a factory in Kansas and also contracts its manufacturing projects to small firms in Canada and Mexico.

   An unusual problem has occurred for this small multinational company: People are getting confused about dates in internal memos, purchase orders, and email. When the company's database was originally designed, the designer was not aware that the format for dates in Canada and Mexico was different from the format used in the United States. For example, in Canada and Mexico, the notation 7/1/19 indicates January 7, 2019, whereas in the United States the same notation indicates July 1, 2019. Although it seems like a small point, the date confusion has resulted in several order cancellations.

   Cludadwy Chairs has asked for your advice. You could suggest writing a simple program to convert the dates automatically or design a switchboard command that would allow users to select a date

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format as data is entered. You realize, however, that Cludadwy Chairs might want to do business in other countries in the future. What would be the best course of action? Should the company adapt to the standard of each country, or should it maintain a single international format? What are the arguments for each option?

4. Use Microsoft Access or similar database software to create a DBMS for the imaginary company called TopText Publishing, which is described in Case in Point 9.1. Add several sample records to each table and report to the class on your progress.
5. Search the Internet to find information about date formats. Determine whether the date format used in the United States is the most common format.

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CHAPTER 10 System Architecture

Chapter 10 is the final chapter in the systems design phase of the SDLC. This chapter describes system architecture, which translates the logical design of an information system into a physical blueprint. Designing the system architecture requires consideration of servers, clients, processing methods, networks, and related issues.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" explores the trade-offs between the potential benefits of installing tracking software on users' computers to improve the system's response to common usage patterns versus the ethical issues related to invasion of privacy by constant monitoring of employees' online activity.

LEARNING OBJECTIVES

***When you finish this chapter, you should be able to*:**

1. Provide a checklist of issues to consider when selecting a system architecture
2. Trace the evolution of system architecture from mainframes to current designs
3. Explain client/server architecture
4. Describe the impact of the Internet on system architecture
5. Compare in-house e-commerce development with packaged solutions and service providers
6. Explain online and batch processing
7. Describe network models, including hierarchical, bus, ring, star, and mesh topologies
8. Explain network devices, including routers, gateways, and proxy servers
9. Describe wireless networking, including wireless standards, topologies, and trends
10. Explain the final activities in the systems design phase

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10.1 Architecture Checklist
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10.2 The Evolution of System Architecture
10.3 Client/Server Architecture
10.4 The Impact of the Internet
10.5 E-Commerce Architecture
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10.6 Processing Methods
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10.1 Architecture Checklist

At this point in the SDLC, the objective is to determine an overall architecture to implement the information system. **System architecture** translates the logical design of an information system into a physical structure that includes hardware, software, network support, processing methods, and security. The end product of the systems design phase is the system design specification. If this document is approved, the next step is systems implementation.

Just as an architect begins a project with a list of the owner's requirements, a systems analyst must consider several issues that will affect the architecture choice. This is done with an overall architecture checklist:

- Corporate organization and culture
- Enterprise resource planning (ERP)
- Initial and total cost of ownership (TCO)
- Scalability
- Web integration
- Legacy system interface requirements
- Processing options
- Security issues
- Corporate portals

10.1.1 Corporate Organization and Culture

To be successful, an information system must perform well in a company's organization and culture. For example, consider two large bicycle brands, Green Bikes and Blue Bikes. Each firm has three operating divisions: an Asian subsidiary that manufactures the bicycles, a factory in Los Angeles that produces bike accessories and clothing, and a plant in Canada that makes bike carriers, racks, and custom trailers.

On the surface, the two firms are similar, but they have very different organizations and corporate cultures. Green Bikes is highly centralized and oversees day-to-day operations from its Los Angeles office. Blue Bikes also has a Los Angeles executive office but allows its three business units to operate separately, with minimal corporate oversight. Both firms are successful, and it is unlikely that their managerial styles will change anytime soon.

Suppose both firms asked a consultant to suggest an IT architecture that would boost productivity and reduce costs. How might corporate organization and culture issues affect the consultant's recommendation? There is no easy answer to that question. The best approach probably would be to study day-to-day business functions, talk to users at all levels, and focus on operational feasibility issues, just as was done earlier in the development process.

10.1.2 Enterprise Resource Planning (ERP)

Many companies use **enterprise resource planning (ERP)** software to establish a company-wide strategy for using IT that includes a specific architecture, standards for data, processing, network, and user interface design. A main advantage of ERP is that it describes a specific hardware and software environment, also called a **platform**, which ensures connectivity and easy integration of future systems, including in-house software and commercial packages.

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Many companies are extending internal ERP systems to their suppliers and customers, using a concept called **supply chain management (SCM)**. For example, in a totally integrated supply chain system, a customer order could cause a manufacturing system to schedule a work order, which in turn triggers a call for more parts from one or more suppliers. In a dynamic, highly competitive economy, SCM can help companies achieve faster response, better customer service, and lower operating costs.

Oracle is an example of a company offering ERP solutions. As shown in Figure 10-1, Oracle's ERP products are cloud-based services that support employee collaboration, provide access to information from mobile devices, and deliver data analytics capabilities to gain insight into business processes.

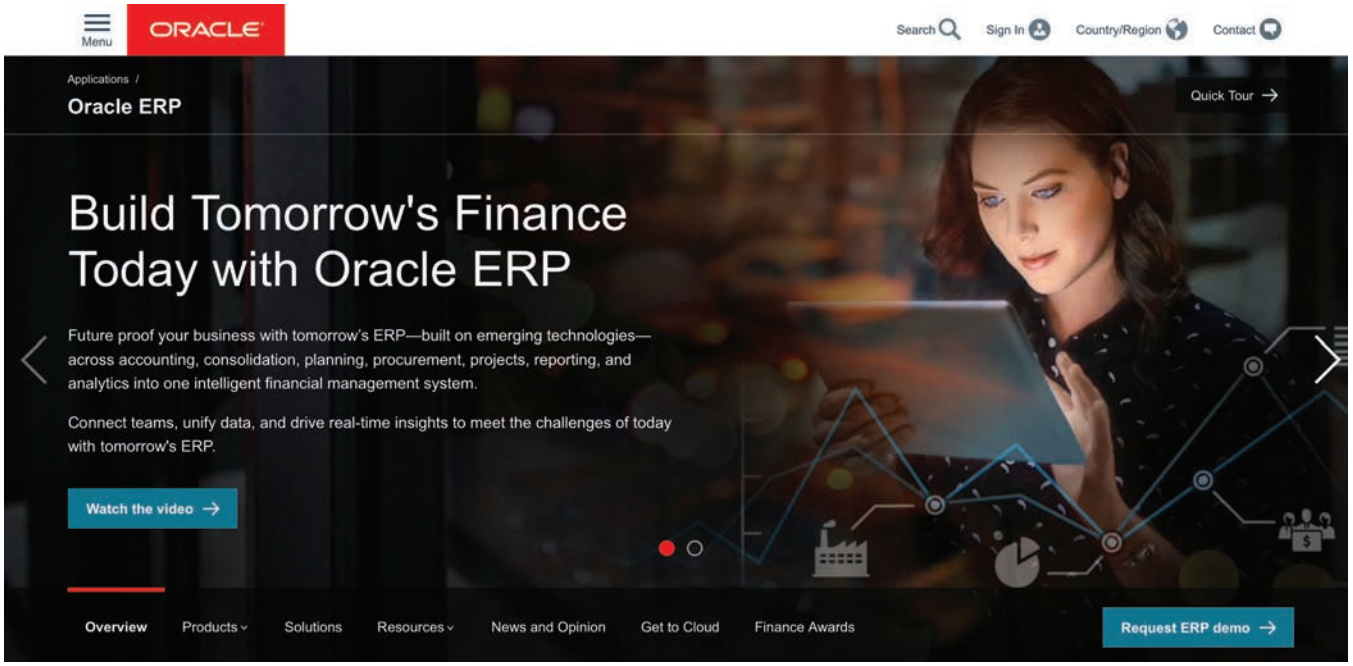


FIGURE 10-1 Oracle offers ERP solutions as a cloud-based service.
Source: Oracle Corporation

10.1.3 Initial Cost and TCO

The importance of considering economic feasibility and TCO during systems planning and analysis was discussed earlier. TCO includes tangible purchases, fees, and contracts called *hard* costs. However, additional *soft* costs of management, support, training, and downtime are just as important but more difficult to measure.

A TCO analysis should address the following questions:

- If in-house development was selected as the best alternative initially, is it still the best choice? Is the necessary technical expertise available, and does the original cost estimate appear realistic?
- If a specific package was chosen initially, is it still the best choice? Are newer versions or competitive products available? Have any changes occurred in pricing or support?
- Have any new types of outsourcing become available?
- Have any economic, governmental, or regulatory events occurred that could affect the proposed project?

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- Have any significant technical developments occurred that could affect the proposed project?
- Have any major assumptions changed since the company made the build versus buy decision?
- Are there any merger or acquisition issues to consider, whereby the company might require compatibility with a specific environment?
- Have any new trends occurred in the marketplace? Are new products or technologies on the verge of being introduced?
- Have the original TCO estimates been updated? If so, are there any significant differences?

The answers to these questions might affect the initial cost and TCO for the proposed system. The system requirements and alternatives should be reviewed now, before proceeding to design the system architecture.

10.1.4 Scalability

A network is composed of individual nodes. A **node** represents a physical device, wired or wireless, that can send, receive, or manage network data. For example, nodes can be servers, computers, shared printers, mass storage devices, wireless access points, or tablets.

Scalability, sometimes also called **extensibility**, refers to a system's ability to expand, change, or downsize to meet the changing needs of a business enterprise. Scalability is especially important in implementing systems that are volume related, such as transaction processing systems. A scalable system is necessary to support a dynamic, growing business. For example, a scalable network could handle anywhere from a few dozen nodes to thousands of nodes, and a scalable DBMS could support the acquisition of an entire new sales division. When investing large amounts of money in a project, management is especially concerned about scalability issues that could affect the system's life expectancy.

10.1.5 Web Integration

An information system includes **applications**, which are programs that handle the input, manage the processing logic, and provide the required output. The systems analyst must know if a new application will be part of an e-commerce strategy and the degree of integration with other web-based components. As mentioned earlier, a **web-centric** architecture follows Internet design protocols and enables a company to integrate the new application into its e-commerce strategy. Even where e-commerce is not involved, a web-centric application can run on the Internet or a company intranet or extranet. A web-based application avoids many of the connectivity and compatibility problems that typically arise when different hardware environments are involved. In a web-based environment, a firm's external business partners can use standard web browsers to import and export data.

10.1.6 Legacy Systems

A new system might have to interface with one or more **legacy systems**, which are older systems that use outdated technology but still are functional. For example, a new marketing information system might need to report sales data to a server-based accounting system and obtain product cost data from a legacy manufacturing system.

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Interfacing a new system with a legacy system involves analysis of data formats and compatibility. In some cases, a company will need to convert legacy file data, which can be an expensive and time-consuming process. Middleware, which is discussed later in this chapter, might be needed to pass data between new systems and legacy systems. Finally, to select the best architecture, the analyst must know if the new application eventually will replace the legacy system or will coexist with it.

10.1.7 Processing Options

In planning the architecture, designers also must consider how the system will process data: online or in batches. For example, a high-capacity transaction processing system, such as an order entry system, requires more network, processing, and data storage resources than a monthly billing system that handles data in batches. Also, if the system must operate online, 24 hours a day and seven days a week (24/7), provision must be made for backup and speedy recovery in the event of system failure.

The characteristics of online and batch processing methods are described later in this chapter, with examples of each type.

10.1.8 Security Issues

From the simple password protection shown in Figure 10-2 to complex intrusion detection systems, security threats and defenses are a major concern to a systems analyst. As the physical design is translated into specific hardware and software, the analyst must consider security issues and determine how the company will address them. Security is especially important when data or processing is performed at remote locations, rather than at a centralized facility. In mission-critical systems, security issues will have a major impact on system architecture and design.



FIGURE 10-2 User IDs and passwords are traditional elements of system security.
JMiks/Shutterstock.com

Web-based systems introduce additional security concerns, as critical data must be protected in the Internet environment. Also, firms that use e-commerce applications must assure customers that their personal data is safe and secure. The lamentable number of high-profile security breaches in large corporations in recent years suggests that security issues should play an even larger role in system architecture considerations. System security concepts and strategies are discussed in detail in Chapter 12.

10.1.9 Corporate Portals

Depending on the system, the planned architecture might include a corporate portal. A **portal** is an entrance to a multifunction website. After entering a portal, a user can navigate to a destination using various tools and features provided by the portal designer. A **corporate portal** can provide access for customers, employees, suppliers, and the public. A well-designed portal can integrate with various other systems and provide a consistent look and feel across multiple organizational divisions.

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CASE IN POINT 10.1: ABC Systems

You are a systems analyst at ABC Systems, a fast-growing IT consulting firm, that provides a wide range of services to companies that want to establish e-commerce operations. During the past 18 months, ABC acquired two smaller firms and set up a new division that specializes in SCM. Aligning ABC's internal systems was quite a challenge, and top management was not especially happy with the integration cost or the timetable. To avoid future problems, you have decided to suggest an ERP strategy, and you plan to present your views at the staff meeting tomorrow. ABC's management team is very informal and prefers a loose, flexible style of management. How will you persuade them that ERP is the way to go?

10.2 The Evolution of System Architecture

Every business information system must carry out three main functions:

- Manage applications that perform the processing logic
- Handle data storage and access
- Provide an interface that allows users to interact with the system

Depending on the architecture, the three functions are performed on a server, on a client, or are divided between the server and the client. During system design, the analyst must determine where the functions will be carried out and ascertain the advantages and disadvantages of each design approach.

10.2.1 Mainframe Architecture

A **server** is a computer that supplies data, processing services, or other support to one or more computers, called **clients**. The earliest servers were mainframe computers, and a system design where the server performs *all* the processing sometimes is described as **mainframe architecture**. Although the actual server does not have to be a mainframe, the term *mainframe architecture* typically describes a multiuser environment where the server is significantly more powerful than the clients. A systems analyst should know the history of mainframe architecture to understand the server's role in modern system design.

In the 1960s, mainframe architecture was the *only* choice. In addition to centralized data processing, the earliest systems performed all data input and output at a central location, often called a **data processing center**. Physical data was delivered or transmitted in some manner to the data processing center, where it was entered into the system. Users in the organization had no input or output capability, except for printed reports that were distributed by a corporate IT department.

As network technology advanced, companies installed terminals at remote locations, so that users could enter and access data from anywhere in the organization, regardless of where the centralized computer was located. A terminal included a keyboard and display screen to handle input and output but lacked independent processing capability. In a centralized design, as shown in Figure 10-3, the remote user's keystrokes are transmitted from his or her terminal to the mainframe, which responds by sending screen output back to the user's screen.

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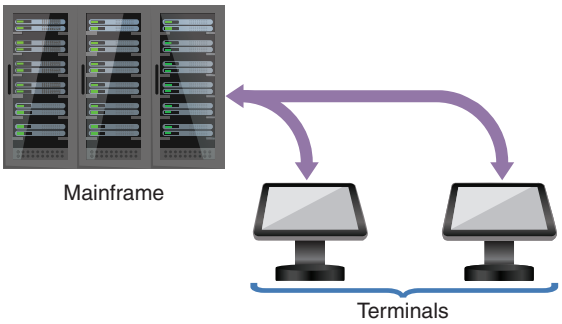


FIGURE 10-3 In a centralized design, the remote user's keystrokes are transmitted to the mainframe, which responds by sending screen output back to the user's screen.

Today, mainframe architecture still is used in industries that require large amounts of processing that can be done at a central location. For example, a bank might use mainframe servers to update customer balances each night. In a blend of old and new technology, many organizations are moving some of their data processing off their mainframes and into the cloud. Indeed, a mainframe can be used to implement part of a cloud computing infrastructure.

10.2.2 Impact of the Personal Computer

When PC technology exploded in the 1990s, powerful microcomputers quickly appeared on corporate desktops. Users found that they could run their own word processing, spreadsheet, and database applications, without assistance from the IT group, in a mode called **stand-alone** computing. Before long, companies linked the stand-alone computers into networks that enabled the user clients to exchange data and perform local processing.

When an individual user works in stand-alone mode, the workstation performs all the functions of a server by storing, accessing, and processing data, as well as providing a user interface. Although stand-alone PCs improved employee productivity and allowed users to perform tasks that previously required IT department assistance, stand-alone computing could be inefficient and expensive. Even worse, maintaining data on individual workstations raised major concerns about data security, integrity, and consistency. Without a central storage location, it was impossible to protect and back up valuable business data, and companies were exposed to enormous risks. In some cases, users who were frustrated by a lack of support and services from the IT department created and managed their own databases. In addition to security concerns, this led to data inconsistency and unreliability.

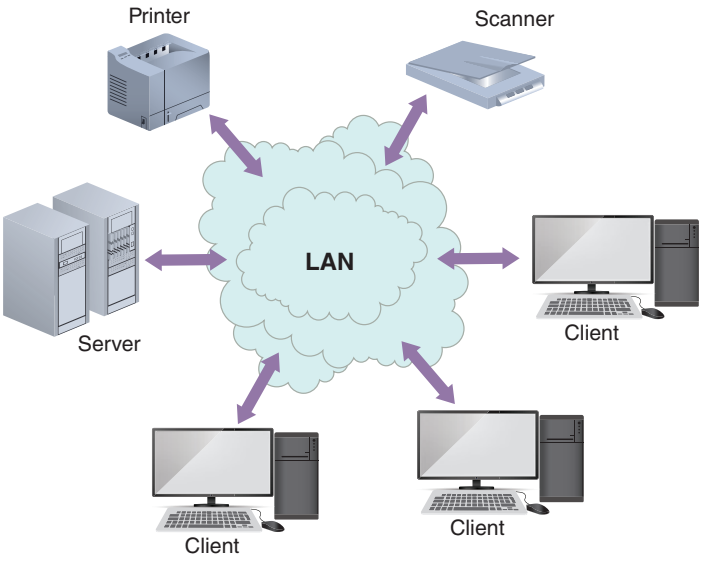


FIGURE 10-4 A LAN allows sharing of data and hardware, such as printers and scanners.

10.2.3 Network Evolution

As technology became available, companies resolved the problems of stand-alone computing by joining clients into a **local area network (LAN)** that allows sharing of data and hardware resources, as shown in Figure 10-4 . One or more LANs, in turn, can connect to a centralized server. Further advances in technology made it possible to create powerful networks that could use satellite links, high-speed fiber-optic lines, or the Internet to share data.

A **wide area network (WAN)** spans long distances and can connect LANs that are continents apart, as shown in Figure 10-5 . When a user accesses data on a LAN or WAN, the network is **transparent** because users see the data as if it were stored on their own workstation. Company-wide systems that connect one or more LANs or WANs are called **distributed systems**. The capabilities of a distributed system depend on the power and capacity of the underlying data

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communication network. Compared to mainframe architecture, distributed systems increase concerns about data security and integrity because many individual clients require access to perform processing.

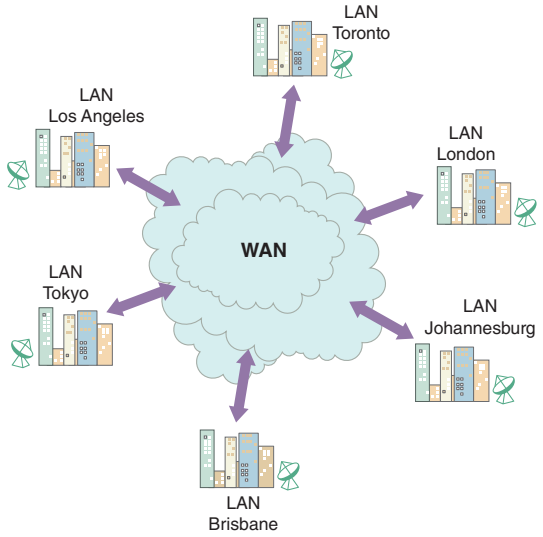


FIGURE 10-5 A WAN can connect many LANs and link users who are continents apart.

10.3 Client/Server Architecture

Today's interconnected world requires an information architecture that spans the entire enterprise. Whether it's a departmental network or a multinational corporation, a systems analyst works with a distributed computing strategy called **client/server architecture**.

The term client/server generally refers to systems that divide processing between one or more networked clients and a central server. In a typical client/server system, the client handles the entire user interface, including data entry, data query, and screen presentation logic. The server stores the data and provides data access and database management functions. Application logic is divided in some manner between the server and the clients.

In a client/server interaction, the client submits a request for information from the server, which carries out the operation and responds to the client. As shown in Figure 10-6, the data file is not transferred from the server to the client—only the request and the result are transmitted across the network. To fulfill a request from a client, the server might contact other servers for data or processing support, but that process is transparent to the client.

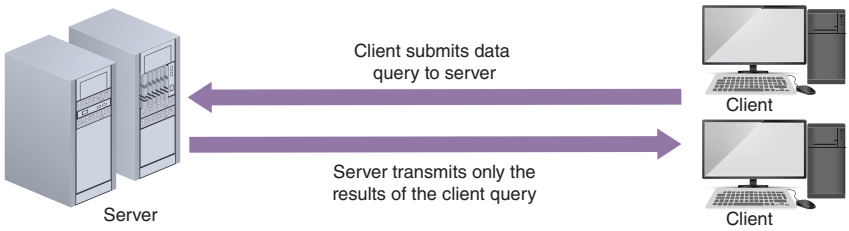


FIGURE 10-6 In a client/server design, data is stored and usually processed on the server.

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Figure 10-7 lists some major differences between client/server and traditional mainframe systems. Many early client/server systems did not produce expected savings because few clear standards existed, and development costs often were higher than anticipated. Implementation was expensive because clients needed powerful hardware and software to handle shared processing tasks. In addition, many companies had an installed base of data, called **legacy data**, which was difficult to access and transport to a client/server environment.

Comparison of Client/Server and Mainframe Systems

Characteristics	Client/Server	Mainframe
Basic architecture	Very flexible	Very rigid
Application development	Flexible Fast Object-oriented	Highly structured Slow Traditional
User environment	PC-based GUI Empowers the user Improves productivity	Uses terminals Text interface Constrains the user Limited options
Security and control features	Decentralized Difficult to control	Centralized Easier to control
Processing options	Can be shared and configured in any form desired	Extensive and programmable
Data storage options	Can be distributed to place data closer to users	All data is stored centrally
Hardware/software integration	Very flexible Multivendor model	Very rigid Single proprietary vendor

FIGURE 10-7 Comparison of the characteristics of client/server and mainframe systems.

As large-scale networks grew more powerful, client/server systems became more cost-effective. Many companies invested in client/server systems to achieve a unique combination of computing power, flexibility, and support for changing business operations. Today, client/server architecture remains a popular form of systems design, using Internet protocols and network models such as the ones described later in this chapter. As businesses form new alliances with customers and suppliers, the client/server concept continues to expand to include clients and servers outside the organization. Service-oriented architecture (SOA) is an example of a networked system where a service can be a client and a server simultaneously, and it can exist outside of corporate boundaries.

Cloud computing is seen by some observers as an entirely new concept. Others see it as the ultimate form of client/server architecture, where Internet-based computing becomes the *server* part of client/server and handles processing tasks, while the Internet itself becomes the platform that replaces traditional networks. The bottom line is that it doesn't matter whether cloud computing is part of a client/server evolution or a whole new way of thinking about computing. Either way, successful systems must support business requirements, and system architecture is an important step in the systems development process.

10.3.1 The Client's Role

The client/server relationship must specify how the processing will be divided between the client and the server. A **fat client**, also called a **thick client**, design locates all or

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most of the application processing logic at the client. A **thin client** design locates all or most of the processing logic at the server.

In the late 1990s, Sun Microsystems (now part of Oracle) was a strong advocate of thin-client computing, which was also referred to as **net-centric computing**. The thin client was a Java-powered terminal, which communicated using standard Internet protocols with powerful servers. Thin clients were expected to provide lower TCO, since maintenance was centralized. However, many users rebelled at the limited functionality provided by thin clients (e.g., no Microsoft Office) and the latency problems inherent in network access to remote applications and data. In the end, fat clients (e.g., regular PCs) remained popular, even with all their management issues and higher TCO.

Today's laptop computers, tablets, and smartphones are so powerful that the allure of thin clients has mostly passed, with the exception of access to the cloud for large datasets and specialized processing needs. The app ecosystem has also changed the TCO equation in favor of powerful computing for clients at the edge of the system architecture.

10.3.2 Client/Server Tiers

Early client/server designs were called two-tier designs. In a **two-tier design**, the user interface resides on the client, all data resides on the server, and the application logic can run either on the server or on the client or be divided between the client and the server.

Another form of client/server design, called a three-tier design, has become more popular. In a **three-tier design**, the user interface runs on the client and the data is stored on the server, just as with a two-tier design. A three-tier design also has a middle layer between the client and server that processes the client requests and translates them into data access commands that can be understood and carried out by the server, as shown in Figure 10-8 . The middle layer can be considered an **application server**, because it provides the **application logic**, or **business logic**, required by the system. Three-tier designs also are called ***n*-tier designs**, to indicate that some designs use more than one intermediate layer.

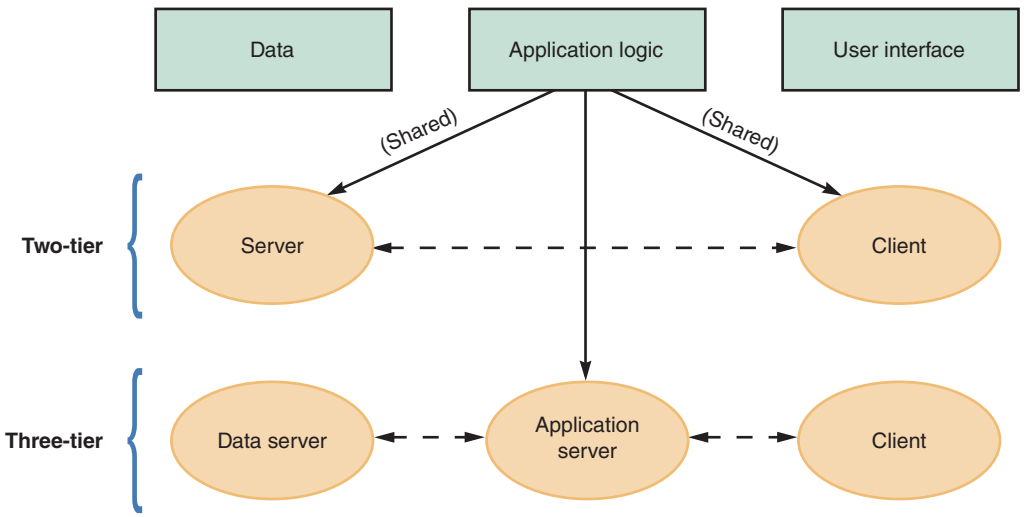


FIGURE 10-8 Characteristics of two-tier versus three-tier client/server design.

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The advantage of the application logic layer is that a three-tier design may enhance overall performance by reducing the data server's workload. The separate application logic layer also relieves clients of complex processing tasks. Because it can run on a server that is much more powerful than the typical client workstations, the middle layer is more efficient and cost-effective in large-scale systems. Figure 10-9 shows where the data, the application logic, and the user interface are located on various architectures. In a client/server system, the tiers communicate using software called middleware, as described in the following section.

Architecture		Data	Application Logic	User Interface
Central data processing center	Server	X	X	X
	Client			
Central server with remote terminals	Server	X	X	
	Client			X
Stand-alone client	Server			
	Client	X	X	X
Two-tier client/server	Server	X	X	
	Client		X	X
Three-tier client/server	Data server	X		
	Application server		X	
	Client			X

FIGURE 10-9 The location of the data, the application logic, and the user interface depend on the type of architecture.

10.3.3 Middleware

In a multitier system, special software called **middleware** enables the tiers to communicate and pass data back and forth. Middleware is sometimes called **glueware** because it is used to connect two or more software components in a federated system architecture. Middleware plays an important role in integrating legacy systems and web-based and/or cloud-based applications. Middleware can also be seen as representing the slash in the term *client/server*.

10.3.4 Cost-Benefit Issues

To support business requirements, information systems need to be scalable, powerful, and flexible. For most companies, client/server systems offer the best combination of features to meet those needs. Whether a business is expanding or downsizing, client/server systems enable the firm to scale the system in a rapidly changing environment. As the size of the business changes, it is easier to adjust the number of clients and the processing functions they perform than it is to alter the capability of a large-scale central server.

Client/server computing also allows companies to transfer applications from expensive mainframes to less-expensive client platforms, sometimes moving heavy-weight processing needs to the cloud. In addition, using common languages such as SQL, clients and servers can communicate across multiple platforms. That difference is important because many businesses have substantial investments in a variety of hardware and software environments.

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Finally, client/server systems can influence network load and improve response times. For example, consider a user at a company headquarters who wants information about total sales figures. In a client/server system, the server locates the data, performs the necessary processing, and responds immediately to the client's request. The data retrieval and processing functions are transparent to the client because they are done on the server, not the client.

10.3.5 Performance Issues

While it provides many advantages, client/server architecture does involve performance issues that relate to the separation of server-based data and networked clients that must access the data.

Consider the difference between client/server design and a centralized environment, where a server-based program issues a command that is executed by the server's own CPU. Processing speed is enhanced because program instructions and data both travel on an internal system bus, which moves data more efficiently than an external network.

In contrast to the centralized system, a client/server design separates applications and data. Networked clients submit data requests to the server, which responds by sending data back to the clients. When the number of clients and the demand for services increases beyond a certain level, network capacity becomes a constraint and system performance declines dramatically.

According to IBM, the performance characteristics of a client/server system are not the same as a centralized processing environment. Client/server response times increase gradually as more requests are made, but then rise dramatically when the system nears its capacity. This point is called the **knee of the curve**, because it marks a sharp decline in the system's speed and efficiency. To deliver and maintain acceptable performance, system developers must anticipate the number of users, network traffic, server size and location, and design a client/server architecture that can support current and future business needs.

To enhance performance, client/server systems must be designed so the client contacts the server only when necessary and makes as few trips as possible. This is one of the goals of the **HTTP/2** protocol used between a server and a web browser.

Another issue that affects client/server performance is data storage. Just as processing can be done at various places, data can be stored in more than one location using a **distributed database management system (DDBMS)**. Using a DDBMS offers several advantages: Data stored closer to users can reduce network traffic; the system is scalable, so new data sites can be added without reworking the system design; and with data stored in various locations, the system is less likely to experience a catastrophic failure. A potential disadvantage of distributed data storage involves data security: It can be more difficult to maintain controls and standards when data is stored in various locations. In addition, the architecture of a DDBMS is more complex and difficult to manage. From a system design standpoint, the challenge is that companies often want it both ways—they want the control that comes with centralization *and* the flexibility associated with decentralization.

10.4 The Impact of the Internet

The Internet has had an enormous impact on system architecture. The Internet has become more than a communication channel—many IT observers see it as a fundamentally different environment for system development.

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10.4.1 Internet-Based Architecture

Recall that in a traditional client/server system, the client handles the user interface, as shown in Figure 10-9 , and the server (or servers in a multitier system) handles the data and application logic. In a sense, part of the system runs on the client, part on the server. In contrast, in an Internet-based architecture, in addition to data and application logic, the entire user interface is provided by the web server in the form of HTML documents that are displayed by the client's browser. Shifting the responsibility for the interface from the client to the server simplifies data transmission and results in lower hardware cost and complexity.

The advantages of Internet-based architecture have changed fundamental ideas about how computer systems should be designed, and we are moving rapidly to a total online environment. At the same time, millions of people are using web-based collaboration and social networking applications to accomplish tasks that used to be done in person, over the phone, or by more traditional Internet channels.

10.4.2 Cloud Computing

Cloud computing refers to the cloud symbol that often is used to represent the Internet. The cloud computing concept envisions a *cloud* of remote computers that provide a total online software and data environment that is hosted by third parties. For example, a user's computer does not perform all the processing or computing tasks—the cloud does some or all of it. This concept is in contrast to today's computing model, which is based on networks that strategically distribute processing and data across the enterprise. In a sense, the cloud of computers acts as one giant computer that performs tasks for users.

Figure 10-10 shows users connected to the cloud, which performs the computing work. Instead of requiring specific hardware and software on the user's computer, cloud computing spreads the workload to powerful remote systems that are part of the cloud. The user appears to be working on a local system, but all computing is actually performed in the cloud. No software updates or system maintenance are required of the user.

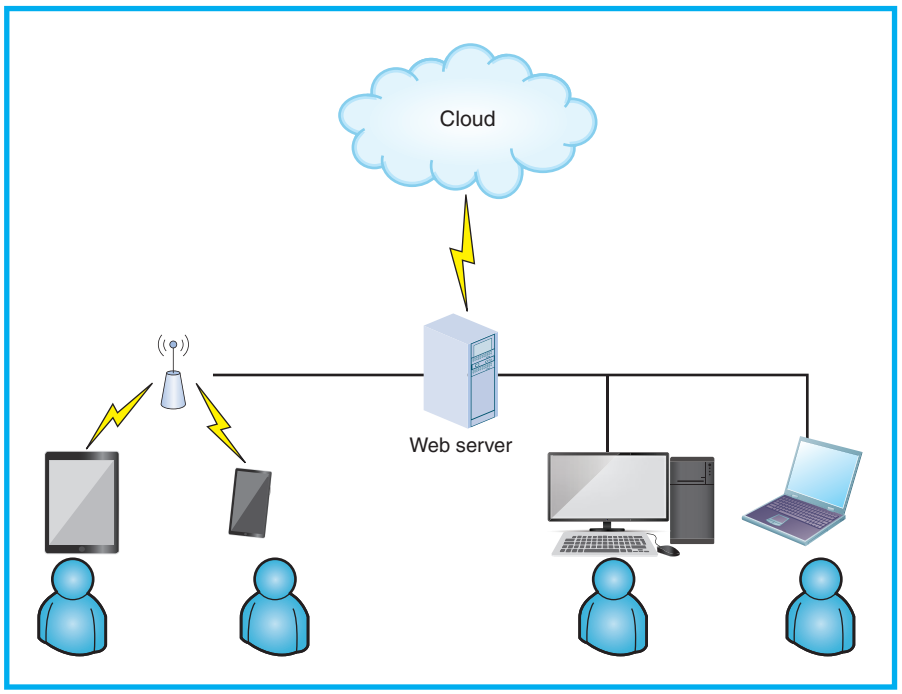


FIGURE 10-10 Cloud computing.

Cloud computing effectively eliminates compatibility issues, because the Internet itself is the platform. This architecture also provides **scaling on demand**, which matches resources to needs at any given time. For example, during peak loads, additional cloud servers might come online automatically to support the workload.

Cloud computing is an ideal platform for powerful Software as a Service (SaaS) applications. As described in Chapter 7, SaaS is a popular deployment

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method where software is not purchased but is paid for as a service, much like one pays for electricity or cable TV each month. In this architecture, service providers can easily make updates and changes to services without involving the users.

Even though cloud computing has tremendous advantages, some concerns exist. First, cloud computing may require more **bandwidth** (the amount of data that can be transferred in a fixed time period) than traditional client/server networks. Second, because cloud computing is Internet-based, if a user's Internet connection becomes unavailable, the user will be unable to access any cloud-based services. In addition, there are security concerns associated with sending large amounts of data over the Internet, as well as concerns about storing it securely. Finally, there is the issue of control. Because a service provider hosts the resources and manages data storage and access, the provider has complete control of the system. Many firms are wary of handing over control of mission-critical data and systems to a third-party provider. This is particularly true when the cloud provider's servers are physically located in another jurisdiction or country.

Future technology advances will make cloud computing even more feasible, desirable, and secure. As the IT industry moves toward a web-based architecture, cloud computing is being marketed aggressively and growing rapidly. It has become a cornerstone of enterprise system architecture and will continue to be for the foreseeable future.

10.4.3 Web 2.0

The shift to Internet-based collaboration has been so powerful and compelling that it has been named Web 2.0. Web 2.0 is not a reference to a more technically advanced version of the current web. Rather, Web 2.0 envisions a second generation of the web that will enable people to collaborate, interact, and share information more dynamically. Some view Web 2.0 as a stepping stone toward the **semantic web**, called Web 3.0 by some, where the documents shared on the Internet have semantics (meaning) and not just syntax (HTML markup).

Social networking sites, such as Facebook, Twitter, and LinkedIn, are seeing explosive growth in the Web 2.0 environment. Another form of social collaboration is called a wiki. A **wiki** is a web-based repository of information that anyone can access, contribute to, or modify. In a sense, a wiki represents the collective knowledge of a group of people. One of the best-known wikis is *Wikipedia.org*, but smaller-scale wikis are growing rapidly at businesses, schools, and other organizations that want to compile and share information.

One of the goals of Web 2.0 is to enhance creativity, interaction, and shared ideas. In this regard, the Web 2.0 concept resembles the agile development process and the open-source software movement. Web 2.0 communities and services are based on a body of data created by users. As users collaborate, new layers of information are added in an overall environment known as the **Internet operating system**. These layers can contain text, audio, images, and video clips that are shared with the user community.

10.5 E-Commerce Architecture

The huge expansion of online commerce is reshaping the IT landscape. Internet business solutions must be efficient, reliable, and cost-effective. When planning an e-commerce architecture, analysts can examine in-house development, packaged solutions, and service providers. The following sections discuss these options.

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10.5.1 In-House Solutions

Chapter 7 described how to analyze advantages and disadvantages of in-house development versus purchasing a software package. The same basic principles apply to system design.

If a decision is made to proceed with an in-house solution, there must be an overall plan to help achieve the project's goals. Figure 10-11 offers guidelines for companies developing e-commerce strategies. An in-house solution usually requires a greater initial investment but provides more flexibility for a company that must adapt quickly in a dynamic e-commerce environment. By working in-house, a company has more freedom to integrate with customers and suppliers and is less dependent on vendor-specific solutions.

Guidelines for In-house E-commerce Site Development
Analyze the company's business needs and develop a clear statement of your goals. Consider the experience of other companies with similar projects.
Obtain input from users who understand the business and technology issues involved in the project. Plan for future growth, but aim for ease of use.
Determine whether the IT staff has the necessary skills and experience to implement the project. Consider training, additional resources, and the use of consultants if necessary.
Consider integration requirements for existing legacy systems or enterprise resource planning. Select a physical infrastructure carefully, so it will support the application, now and later.
Develop the project in modular form so users can test and approve the functional elements as you go along.
Connect the application to existing in-house systems and verify interactivity.
Test every aspect of the site exhaustively. Consider a preliminary rollout to a pilot group to obtain feedback before a full launch.

FIGURE 10-11 Guidelines for companies developing e-commerce strategies.

For smaller companies, the decision about in-house web development is even more critical, because this approach will require financial resources and management attention that many small companies might be unable or unwilling to commit. An in-house strategy, however, can provide valuable benefits, including the following:

- A unique website, with a look and feel consistent with the company's other marketing efforts
- Complete control over the organization of the site, the number of pages, and the size of the files
- A scalable structure to handle increases in sales and product offerings in the future
- More flexibility to modify and manage the site as the company changes
- The opportunity to integrate the firm's web-based business systems with its other information systems, creating the potential for more savings and better customer service

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Whether a firm uses an in-house or a packaged design, the decision about web hosting is a separate issue. Although internal hosting has some advantages, such as greater control and security, the expense would be much greater, especially for a small- to medium-sized firm.

10.5.2 Packaged Solutions

If a small company is reluctant to take on the challenge and complexity of developing an Internet commerce site in-house, an alternative can be a packaged solution. This is true even for medium- to large-sized firms. Many vendors, including IBM and Microsoft, offer turnkey systems for companies that want to get an e-business up and running quickly, as shown in Figure 10-12 . For large-scale systems that must integrate with existing applications, packaged solutions might be less attractive.

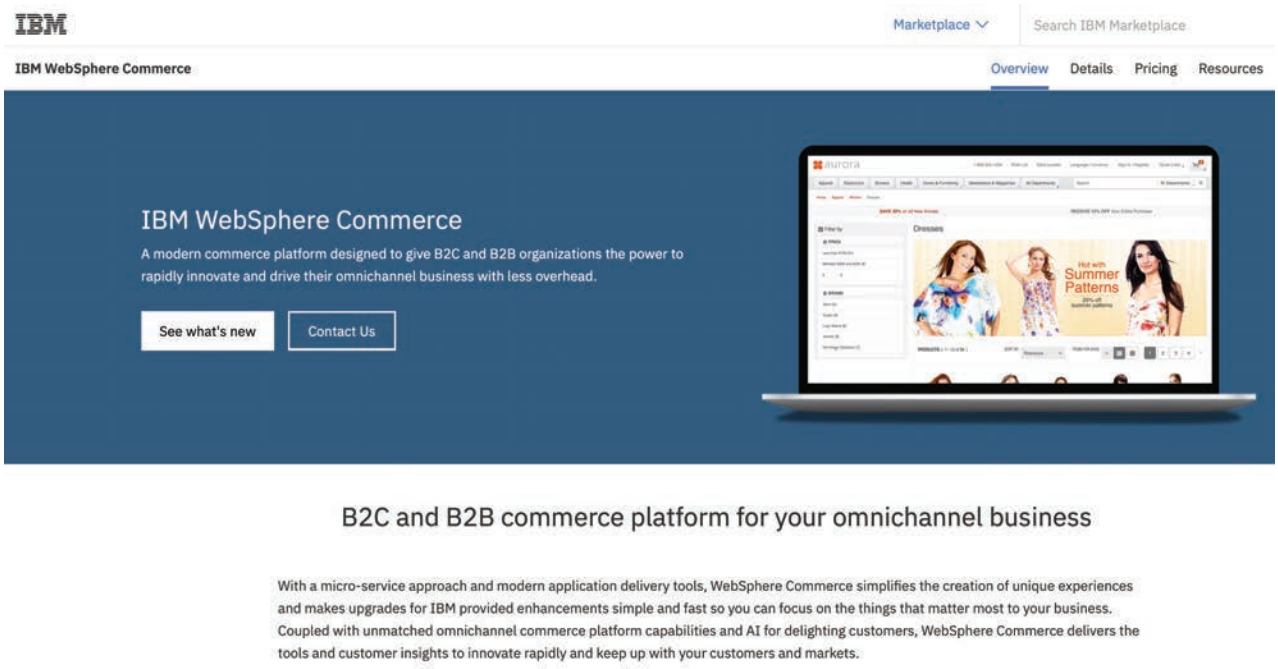


FIGURE 10-12 IBM WebSphere Commerce offers software solutions for companies that want to get an e-business up and running quickly.
Source: IBM Corporation

10.5.3 Service Providers

Another alternative is to use an application service provider (ASP). As explained in Chapter 7, an ASP provides applications, or access to applications, by charging a usage or subscription fee. Today, many ASPs offer full-scale Internet business services for companies that decide to outsource those functions.

A systems analyst confronts a bewildering array of products and strategies when implementing Internet-based systems. A good starting point might be to consider the experience of other companies in the same industry. Many firms offer the names of clients and customers, along with their success stories. Although this information may not be reliable, it can provide valuable knowledge regarding a vendor's products and services.

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CASE IN POINT 10.2: Small Potatoes

Small Potatoes is a family-operated seed business that has grown rapidly. It specializes in supplying home gardeners with the finest seeds and gardening supplies. Until now, the firm has done all its business by placing ads in gardening and health magazines and taking orders using a toll-free telephone number.

Now, the family has decided to establish a website and sell online, but there is some disagreement about the best way to proceed. Some say it would be better to develop the site on their own, and one of the employees, who is a recent computer science graduate, believes she can handle the task. Others feel it would be better to outsource the site and focus on the business itself. Suppose the family asked for your opinion. What would you say? What additional questions would you ask?

10.6 Processing Methods

In selecting an architecture, the systems analyst must determine which transactions will be handled online, and what functions, if any, can be carried out using a batch processing method.

10.6.1 Online Processing

Early computer systems were designed to handle data records as a group, or *batch*. Fewer systems use that model today. However, even the most advanced online systems must perform maintenance, post large quantities of data during off-hours when network traffic is low, and carry out housekeeping tasks just as their legacy computer ancestors did. This section discusses the online processing capability that is at the core of powerful, modern systems, and the following section describes the evolution of batch processing.

An **online system** handles transactions when and where they occur and provides output directly to users. Because it is interactive, online processing avoids delays and allows a constant dialog between the user and the system.

An airline reservations system is a familiar example of online processing. When online customers visit the airline's website, they can enter their origin, destination, travel dates, and travel times. The system searches a database and responds by displaying available flights, times, and prices. The customer can make a reservation, enter a name, address, credit card information, and other required data, and the system creates the reservation, assigns a seat, and updates the flight database immediately.

Online processing also can be used with file-oriented systems. Figure 10-13 shows what happens when a customer uses an ATM to inquire about an account balance. After the ATM verifies the customer's card and password, the customer enters the request (Step 1). Then, the system accesses the account master file using the account number as the primary key and retrieves the customer's record (Step 2). The system verifies the account number and displays the balance (Step 3). Data is retrieved and the system transmits the current balance to the ATM, which prints it for the customer.

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Online processing systems have four typical characteristics:

1. The system processes transactions completely when and where they occur.
2. Users interact directly with the information system.
3. Users can access data randomly.
4. The information system must be available whenever necessary to support business functions.

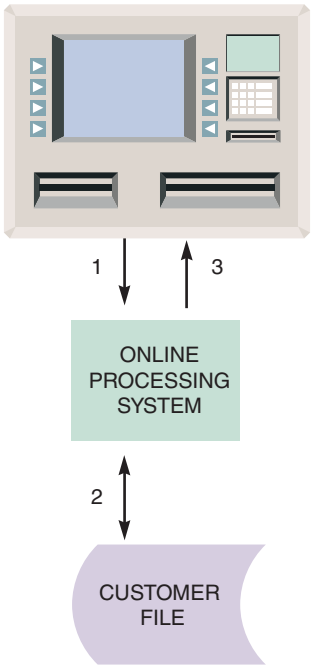


FIGURE 10-13 When a customer requests a balance, the ATM system verifies the account number, submits the query, retrieves the current balance, and displays the balance on the ATM screen.

10.6.2 Batch Processing

Batch processing means that data is managed in groups or batches. That was an acceptable choice in the 1960s, and for most firms, it was the *only* choice. Today, all businesses need real-time information to operate, and batch processing is not always desirable. However, batch methods can be efficient and convenient in some situations.

For example, batch processing can be used for large amounts of data that must be processed on a routine schedule, such as weekly paychecks, daily credit card transaction updates, or closing stock data that must be calculated and published in the following day's news media. The advantages of batch methods include the following:

- Tasks can be planned and run on a predetermined schedule, without user involvement.
- Batch programs that require major network resources can run at times when costs, and impact on other traffic, will be lowest.
- A batch method is well suited to address security, audit, and privacy concerns, because it runs in a relatively controlled environment.

10.6.3 Example

The diagram in Figure 10-14 shows how a **point-of-sale (POS)** terminal, such as that used in a supermarket, might trigger a series of online and batch processing events. Note that the system uses online processing to handle data entry and inventory updates, while reports and accounting entries are performed in a batch. A company would choose a mix of online and batch processing when it makes good business sense. Consider the following scenario in a typical retail store:

- During business hours, a salesperson enters a sale on a POS terminal, which is part of an online system that handles daily sales transactions and maintains an up-to-date inventory file.
- When the salesperson enters the transaction, online processing occurs. The system performs calculations, updates the inventory file, and produces output on the POS terminal in the form of a screen display and a printed receipt. At the same time, each sales transaction creates input data for day-end batch processing.

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- When the store closes, the system uses the sales transactions to produce the daily sales report, perform the related accounting entries, and analyze the data to identify slow- or fast-moving items, sales trends, and related issues—such as store discounts for the next day.

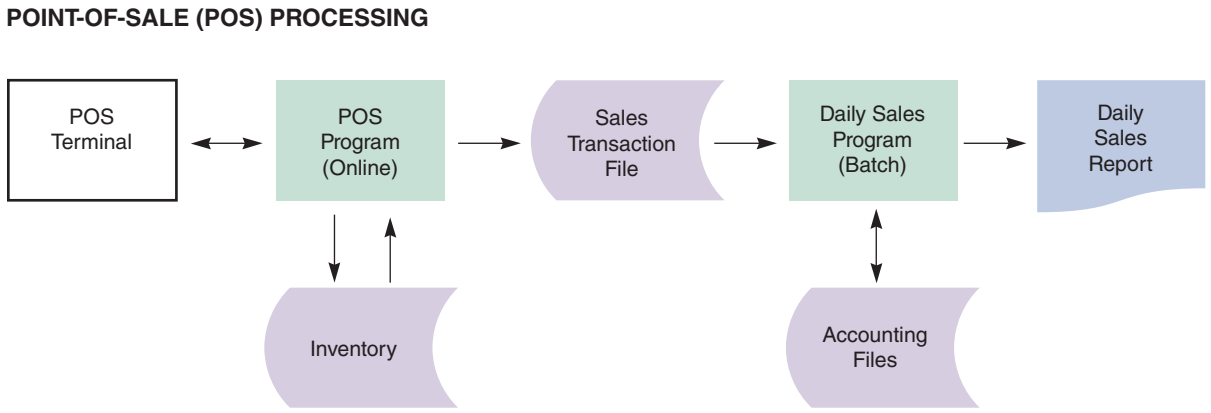


FIGURE 10-14 Many retailers use a combination of online and batch processing. When a salesperson enters the sale on the POS terminal, the online system retrieves data from the item file, updates the quantity in stock, and produces a sales transaction record. At the end of the day, a batch processing program produces a daily sales report and updates the accounting system.

Online or batch processing are totally different but can work well together. In this scenario, an online system handles POS processing, which must be done as it occurs, while a batch method provides routine, overnight processing and marketing analysis. Online processing allows the data to be entered and validated immediately, so the information always is up to date. However, a heavy volume of online transactions can be expensive for smaller firms, and data backup and recovery also add to IT costs. In contrast, when used properly, batch processing can be cost-effective and less vulnerable to system disruption.

10.7 Network Models

A network allows the sharing of hardware, software, and data resources in order to reduce expenses and provide more capability to users. When planning a network design, the systems analyst must consider network terms and concepts, including the OSI model, network modeling tools, network topology, network protocols, and wireless networks, which are covered in this section. Other important issues, such as network performance and security, are covered in Chapter 12.

10.7.1 The OSI Model

The discussion of system architecture earlier in this chapter already introduced basic network terms such as client, server, LAN, WAN, client/server architecture, tiers, middleware, and cloud computing. To fully understand how networks are configured, the **Open Systems Interconnection (OSI) model** should also be understood. The OSI model describes how data moves from an application on one computer to an application on another networked computer. The OSI model consists of seven layers, and each layer performs a specific function. The OSI model provides physical design standards that assure seamless network connectivity, regardless of the specific hardware environment.

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10.7.2 Network Topology

The way a network is configured is called the **network topology**. Topology can refer to a physical or a logical view of the network. For example, **physical topology** describes the actual network cabling and connections, while **logical topology** describes the way the components interact. It is important to understand the distinction, because a specific physical topology might be able to support more than one logical topology. For example, it is not uncommon to run cabling in a certain pattern because of physical installation and cost issues but to use a different pattern for the logical topology.

Computers may be physically arranged in a circular shape, but that might or might not reflect the network topology. The examples shown in Figures 10-15 to 10-19 represent a logical topology, as seen by network users, who may not know or care about the physical cabling pattern.

LAN and WAN networks typically are arranged in four patterns: hierarchical, bus, ring, and star. The concepts are the same regardless of the size of the network, but the physical implementation is different for a large-scale WAN that spans an entire business enterprise compared with a small LAN in a single department. These four common topologies are described in the following sections.

HIERARCHICAL NETWORK: In a **hierarchical network**, as shown in Figure 10-15, one or more powerful servers control the entire network. Departmental servers control lower levels of processing and network devices. An example of a hierarchical network might be a retail clothing chain, with a central computer that stores data about sales activity and inventory levels and local computers that handle store-level operations. The stores transmit data to the central computer, which analyzes sales trends, determines optimum stock levels, and coordinates a SCM system. In this situation, a hierarchical network might be used, because it mirrors the actual operational flow in the organization.

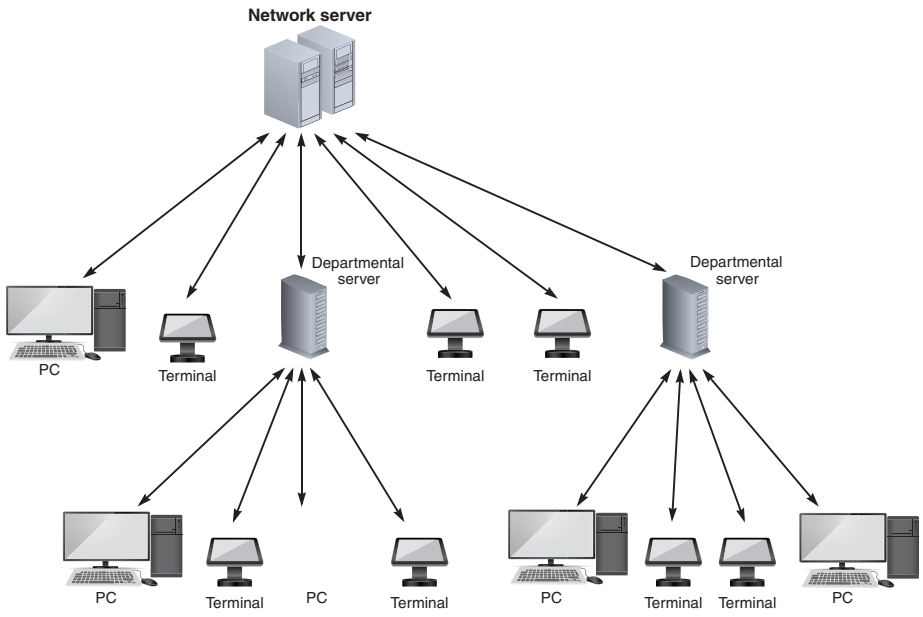


FIGURE 10-15 A hierarchical network with a single server that controls the network.

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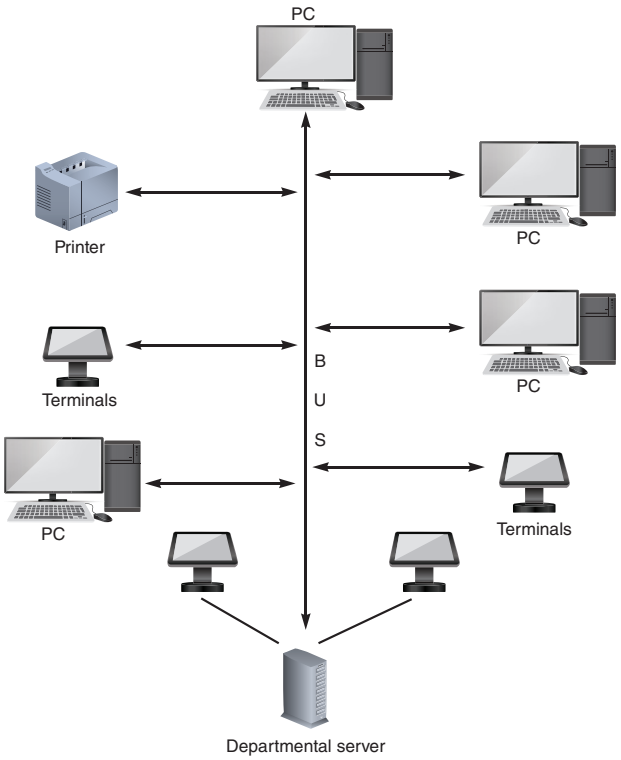


FIGURE 10-16 A bus network with all the devices connected to a single communication path.

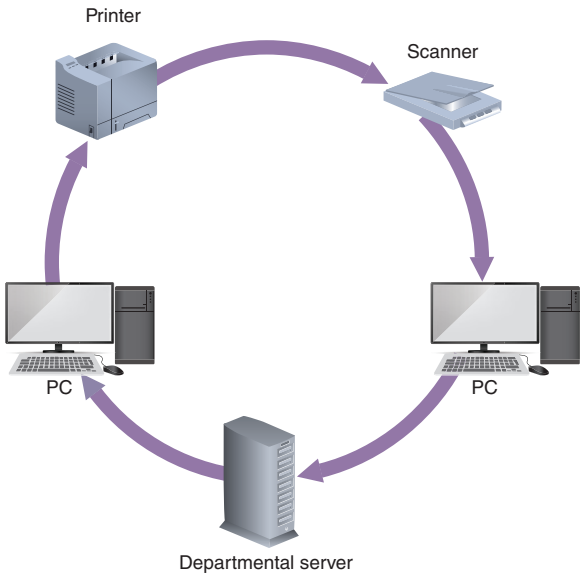


FIGURE 10-17 A ring network with a set of computers that sends and receives data flowing in one direction.

One disadvantage of a hierarchical network is that if a business adds additional processing levels, the network becomes more complex and expensive to operate and maintain. Hierarchical networks were often used in traditional mainframe-based systems but are less common today.

BUS NETWORK: In a **bus network**, as shown in Figure 10-16 , a single communication path connects the central server, departmental servers, workstations, and peripheral devices. Information is transmitted in either direction between networked devices, and all messages travel over the same central bus. Bus networks require less cabling than other topologies, because only a single cable is used. Devices can also be attached or detached from the network at any point without disturbing the rest of the network. In addition, a failure in one workstation on the network does not necessarily affect other workstations on the network.

One major disadvantage of a bus network is that if the central bus becomes damaged or defective, the entire network shuts down. Another disadvantage is that overall performance declines as more users and devices are added, because all message traffic must flow along the central bus. This does not occur in the treelike structure of a hierarchical network or the hub-and-spoke design of a star network, where network paths are more isolated and independent.

The bus network is one of the oldest LAN topologies and is a simple way to connect multiple workstations. Before the proliferation of star networks, bus networks were very common. They share characteristics of hardware bus networks. Today, the bus design is less popular, but some firms have retained bus networks to avoid the expense of new wiring and hardware.

RING NETWORK: Although ring networks are still around, they are somewhat outdated. IBM was a leader in ring network technology when they introduced their token ring LAN, and large companies who use IBM mainframe equipment still deploy the ring network design. A **ring network**, as shown in Figure 10-17 , resembles a circle where the data flows in only one direction from one device to the next. In function, a ring network can be thought of as a bus network with the ends connected. One disadvantage of a ring network is that if a network device (e.g., a PC or a server) fails, the devices downstream from the failed device cannot communicate with the network.

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STAR NETWORK: Because of its speed and versatility, the star network is a popular LAN topology. A **star network** has a central networking device called a **switch**, which manages the network and acts as a communications conduit for all network traffic. In the past, a device known as a **hub** was used to connect star networks, but a switch offers advanced technology and much better performance. A hub or switch functions like a familiar multisocket power strip but with network devices such as servers, workstations, and printers plugged in rather than electrical appliances. The hub broadcasts network traffic, called **data frames**, to all connected devices. In contrast, a switch enhances network performance by sending traffic only to specific network devices that need to receive the data.

A star configuration, as shown in Figure 10-18, provides a high degree of network control, because all traffic flows into and out of the switch. An inherent disadvantage of the star design is that the entire network is dependent on the switch. However, in most large star networks, backup switches are available immediately in case of hardware failure.

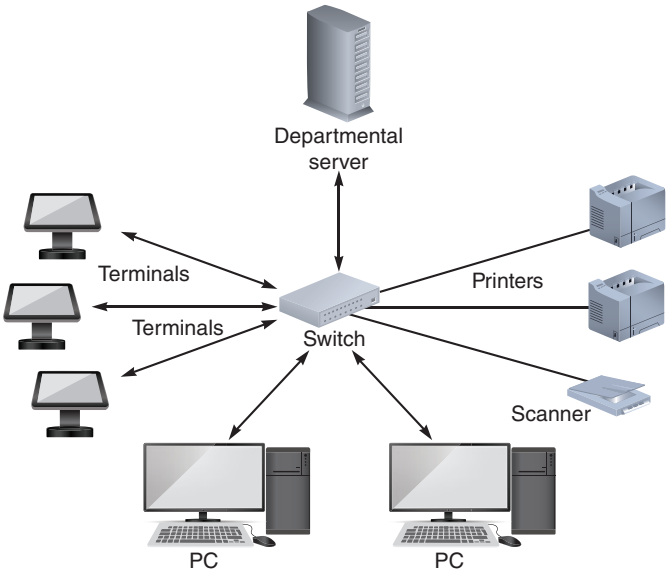


FIGURE 10-18 A star network with a switch, departmental server, and connected computers and devices.

MESH NETWORK: In the **mesh network** shown in Figure 10-19 , each node connects to every other node. While this design is extremely reliable, it also is very expensive to install and maintain. A mesh network resembles the Internet in that a message can travel on more than one path. Originally developed for military applications, the primary advantage of a mesh network is redundancy, because multiple paths provide backup if communication problems arise or some nodes become inoperable.

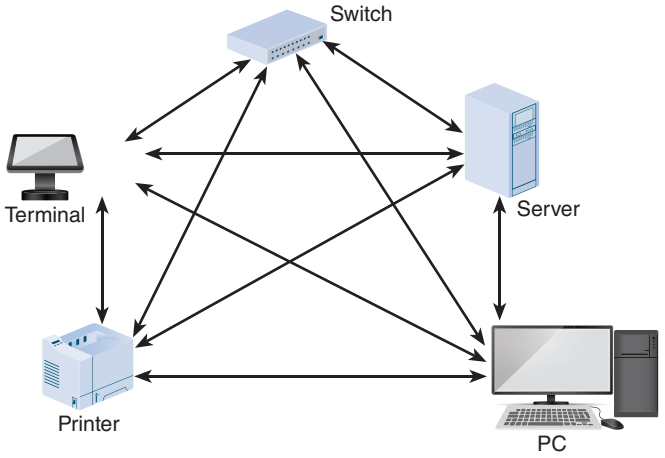


FIGURE 10-19 A mesh network is used in situations where a high degree of redundancy is needed, such as military applications. The redundant design provides alternate data paths but is expensive to install and maintain.

10.7.3 Network Devices

Networks such as LANs or WANs can be interconnected using devices called routers. A **router** is a device that connects network segments, determines the most efficient data path, and guides the flow of data.

Using a router, any network topology can connect to a larger, dissimilar network, such as the Internet. This connection is called a **gateway**. The example in Figure 10-20 shows a star topology, where a switch connects nodes in the LAN and the router links the network to the Internet. A device called a **proxy server** provides Internet connectivity for internal LAN users. The vast majority of business networks use routers to integrate the overall network architecture.

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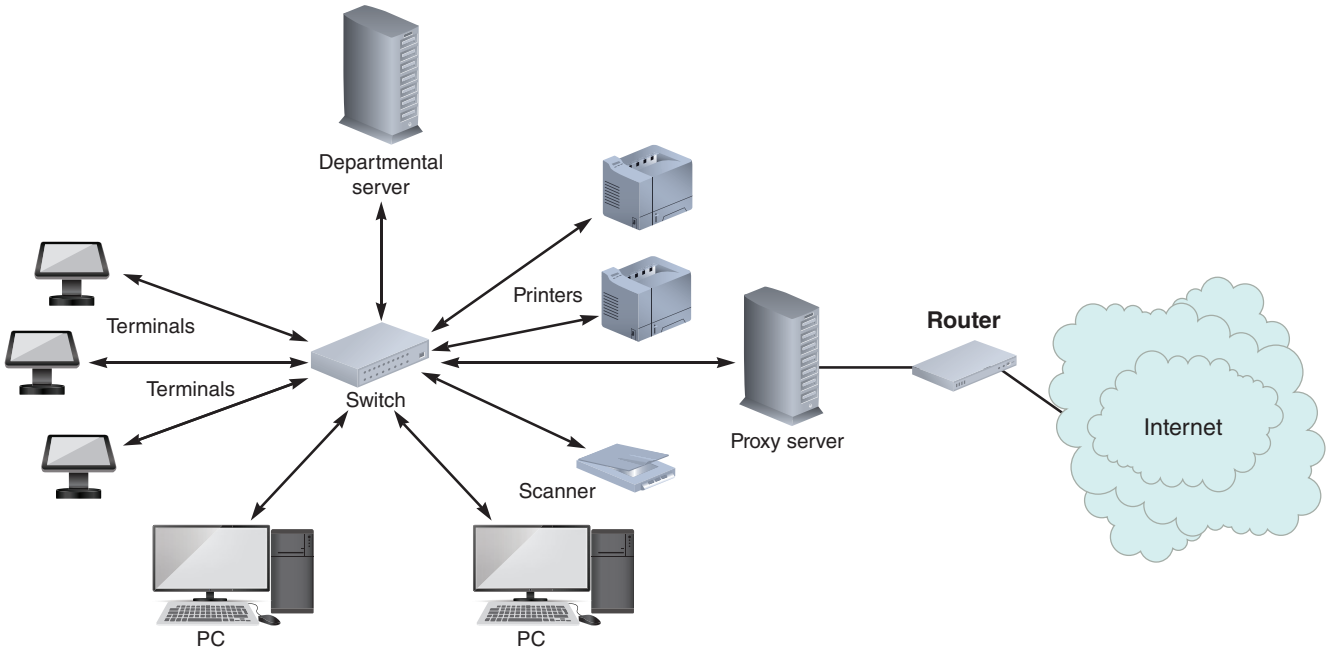


FIGURE 10-20 Routers can be used to create gateways between different network topologies and large, dissimilar networks such as the Internet.

10.8 Wireless Networks

Although a wired LAN provides enormous flexibility, the cabling cost can be substantial, as well as the inevitable wiring changes that occur in a dynamic organization. Many companies find wireless technology to be an attractive alternative. A **wireless local area network (WLAN)** is relatively inexpensive to install and is well suited to workgroups and users who are not anchored to a specific desk or location. Most notebook computers and other mobile devices are equipped with built-in wireless capability, and it is relatively simple to add this feature to existing desktop computers and workstations in order to set up a wireless network.

Like their wired counterparts, wireless networks have certain standards and topologies, which are discussed in the following sections.

10.8.1 Standards

Wireless networks are based on various standards and protocols that still are evolving. The most popular of these is called IEEE **802.11**, which is a family of standards developed by the **Institute of Electrical and Electronics Engineers (IEEE)** for wireless LANs.

Current wireless networks are based on variations of the original 802.11 standard. Several versions, or amendments, were intended to improve bandwidth, range, and security. The IEEE 802.11 set of standards changes very rapidly, in large part due to pressure from consumer groups and industry leaders moving toward ever-faster wireless networks. Wireless network speed is measured in **megabits per second (Mbps)** or **gigabits per second (Gbps)**.

For example, when the **802.11b** standard was introduced in 1999, the average speed was 11 Mbps. Later versions, such as **802.11g** and **802.11n**, increased bandwidth to 54 Mbps and 450 Mbps, respectively, and were widely accepted by the

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IT industry. Current standards, such as **802.11ac**, can theoretically reach speeds of nearly 7 Gbps. The increased speed is accomplished using **multiple input/multiple output (MIMO)** technology to boost performance. MIMO relies on multiple data paths, also called **multipath design**, to increase bandwidth and range.

If wireless capacity continues to expand and security issues can be overcome, WLANs could replace wired networks in many situations. Wireless security is discussed in detail in Chapter 12.

10.8.2 Topologies

Like wired networks, wireless networks also can be arranged in different topologies. The two most common network topologies available for IEEE 802.11 WLANs are the Basic Service Set and the Extended Service Set. Figure 10-21 shows simplified models of these topologies.

The **Basic Service Set (BSS)**, also called the **infrastructure mode**, is shown at the top of Figure 10-21. In this configuration, a central wireless device, called an **access point** or **wireless access point (WAP)**, is used to serve all wireless clients. The access point is similar to a hub in the LAN star topology, except it provides network services to wireless clients instead of wired clients. Because access points use a single communications medium, the air, they broadcast all traffic to all clients, just as a hub would do in a wired network. Typically, the access point itself is connected to a wired network, so wireless clients can access the wired network.

The second wireless topology is the **Extended Service Set (ESS)**, as shown at the bottom of Figure 10-21. An ESS is made up of two or more BSS networks. Thus, using an ESS topology, wireless access can be expanded over a larger area. Each access point provides wireless services over a limited range. As a client moves away from one access point and closer to another, a process called **roaming** automatically allows the client to associate with the stronger access point, allowing for undisrupted service.

10.8.3 Trends

Wireless technology has brought explosive change to the IT industry and will continue to affect businesses, individuals, and society. Even in the ever-changing world of IT, it would be difficult to find a more dynamic area than wireless technology.

With the growing popularity of 802.11, many firms offer networking products, services, and information. One of the most significant groups is the **Wi-Fi Alliance**, which maintains a website at *www.wi-fi.org*. According to the site, the Alliance is a nonprofit international association formed in 1999 to certify interoperability of wireless network products based on IEEE 802.11 specifications. Products that meet the requirements are certified as **wireless fidelity (Wi-Fi)** compatible. The stated goal of the Wi-Fi Alliance is to enhance the user experience through product interoperability.

Even though they have many advantages, wireless networks also have limitations and disadvantages. For example, devices that use the 2.4 GHz band can pick up interference from appliances such as microwave ovens and cordless telephones that use the same band. More important, wireless networks pose major security concerns because wireless transmissions are much more susceptible to interception and intrusion than wired networks. These issues are discussed in detail in Chapter 12.

In addition to Wi-Fi, another form of wireless transmission called **Bluetooth** is very popular for short-distance wireless communication that does not require high power. Examples of Bluetooth devices include wireless keyboards, mice, printers, cell phone headsets, and digital cameras, among others. People with Bluetooth-equipped phones or tablets can even beam information to each other and exchange digital notes.

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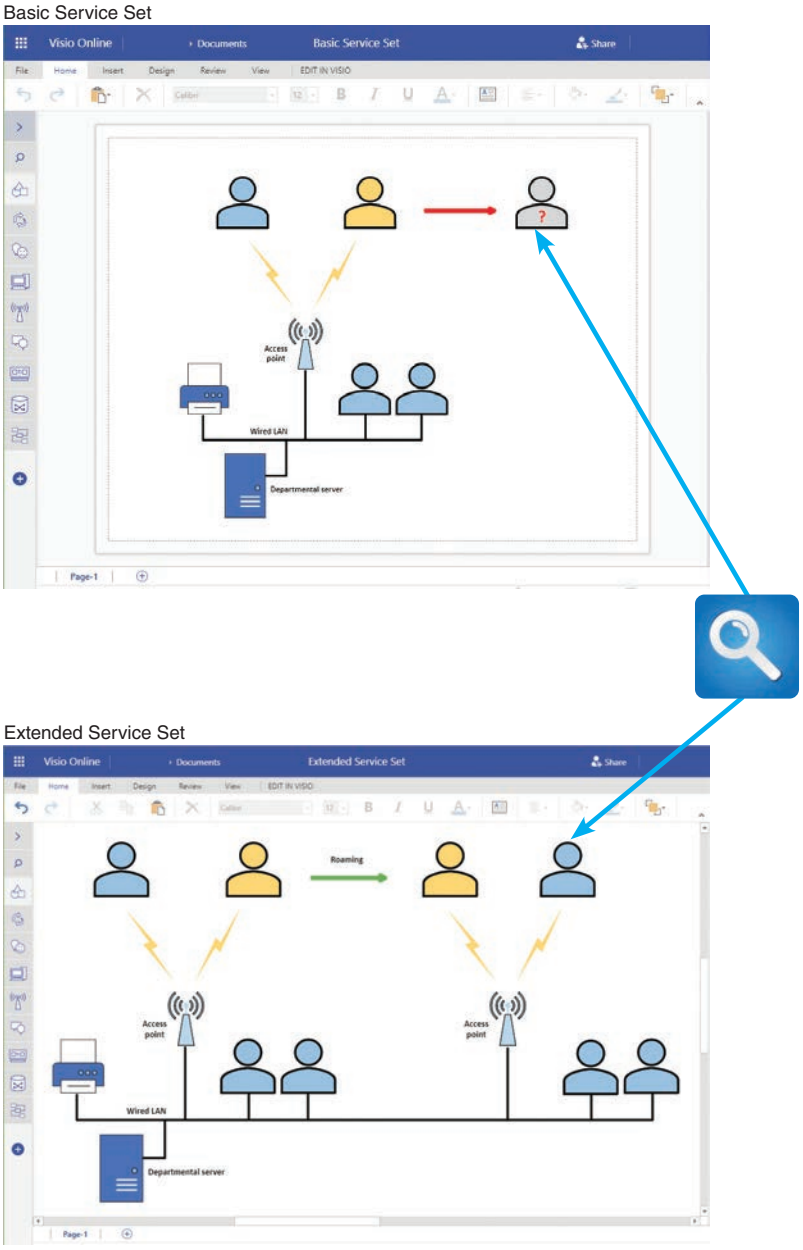


FIGURE 10-21 The user in the upper screen has moved out of the BSS coverage area and cannot communicate. In the lower screen, the user roams into another ESS coverage area and the transition is seamless.

CASE IN POINT 10.3: SPIDER IT SERVICES

Spider IT Services specializes in custom network design and installation. Firms hire Spider to do an overall analysis of their network needs, including a detailed cost-benefit study. Recently, a problem arose. One of Spider's clients complained that the relatively new network was too slow and lacked sufficient capacity. Reviewing the case, Spider's top management realized that the rapidly growing client had simply outgrown the network much earlier than anticipated. How could this problem have been avoided?

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10.9 Systems Design Completion

System architecture marks the end of the systems design phase of the SDLC. Recall that in the systems analysis phase, all functional primitives were identified and documented with process descriptions. The objective then was to identify the system's functions and determine *what* each logical module would do, without attempting to determine *how* that function would be carried out. Moving from analysis to design tasks, the development process continued with consideration of output and user interface design, data design, and system architecture issues. Now, based on a clear definition of system requirements and design, software applications can be developed, documented, and tested as part of the systems implementation phase of the SDLC, which is described in Chapter 11.

Developers must also consider system management and support tools that can monitor system performance, deal with fault management, handle backup, and provide for disaster recovery. These topics are covered in detail in Chapter 12.

The final activities in the systems design phase are preparing a system design specification, obtaining user approval, and delivering a presentation to management.

10.9.1 System Design Specification

The **system design specification** is a document that presents the complete design for the new information system, along with detailed costs, staffing, and scheduling for completing the next SDLC phase—systems implementation.

The system design specification is the baseline against which the operational system will be measured. Unlike the system requirements document, which is written for users to understand, the system design specification is oriented toward the programmers who will use it to create the necessary programs. Some sections of the system requirements document are repeated in the system design specification, such as process descriptions, data dictionary entries, and data flow diagrams.

The system design specification varies in length, so it should be organized carefully. One typically includes a cover page, a detailed table of contents, and an index. The contents of the system design specification depend on company standards and the complexity of the system. A typical system design specification includes the following sections.

1. *Management summary*. This is a brief overview of the project for company managers and executives. It outlines the development efforts to date, provides a current status report, summarizes project costs, reviews the benefits of the new system, presents the systems implementation schedule, and highlights any issues that management will need to address.
2. *System components*. This section contains the complete design for the new system, including the user interface, outputs, inputs, files, databases, and network specifications. Source documents, report and screen layouts, DFDs, and all other relevant documentation should be included. In addition, the requirements for all support processing, such as backup and recovery, start-up processing, and file retention should be included. If the purchase of a software package is part of the strategy, include any interface information required between the package and the system being developed. If a CASE design tool is used, design diagrams and most other documentation can be produced directly from the tool.
3. *System environment*. This section describes the constraints, or conditions, affecting the system, including any requirements that involve operations, hardware, systems software, or security. Examples of operational constraints include

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transaction volumes that must be supported, data storage requirements, processing schedules, reporting deadlines, and online response times.

4. *Implementation requirements*. In this section, start-up processing, initial data entry or acquisition, user training requirements, and software test plans are specified.
5. *Time and cost estimates*. This section provides detailed schedules, cost estimates, and staffing requirements for the systems development phase and revised projections for the remainder of the SDLC. Total costs-to-date for the project and a comparison of those costs with prior estimates are also presented.
6. *Additional material*. Other material can be included at the end of the system design specification. In this section, documents from earlier phases can be inserted if they would be helpful to readers.

10.9.2 User Approval

Users must review and approve the interface design, report and menu designs, data entry screens, source documents, and other areas of the system that affect them. The review and approval process continues throughout the systems design phase. When the design for a report is complete, the systems analyst should meet with users to review the prototype, adjust the design if necessary, and obtain written approval. Chapter 8 contains guidelines and suggestions about report design.

Securing approvals from users throughout the design phase is very important. That approach ensures that a major task of obtaining approvals is not left to the end, it keeps the users involved with the system's development, and it provides feedback about whether or not the project is on target. Some sections of the system design specification might not interest users, but anything that does affect them should be approved as early as possible.

Other IT department members also need to review the system design specification. IT management will be concerned with staffing, costs, hardware and systems software requirements, network impact, and the effect on the operating environment when the new system is added. The programming team will want to get ready for its role, and the operations group will be interested in processing support, report distribution, network loads, integration with other systems, and any hardware or software issues for which they need to prepare. As always, a systems analyst must be a good communicator to keep people up to date, obtain their input and suggestions, and obtain necessary approvals.

When the system design specification is complete, the document is distributed to a target group of users, IT department personnel, and company management. It should be distributed at least one week before a presentation to allow the recipients enough time to review the material.

10.9.3 Presentations

Usually, the systems analyst will give several presentations at the end of the systems design phase. The presentations offer an opportunity to explain the system, answer questions, consider comments, and secure final approval.

The first presentation is to the other systems analysts, programmers, and technical support staff members who will be involved in future project phases or operational support for the system. Because of the audience, the presentation is technically oriented.

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The next presentation is to department managers and users from departments affected by the system. As in the first presentation, the primary objective is to obtain support and approval for the systems design. This is not a technical presentation; it is aimed at user interaction with the system and management's interest in budgets, schedules, staffing, and impact on the production environment.

The final presentation is delivered to management. By the time this presentation is delivered, all necessary approvals should have been obtained from prior presentations, and the users and IT department should be onboard. Just like the management presentation at the end of the systems analysis phase, this presentation has a key objective: to obtain management's approval and support for the next development step—systems implementation—including a solid commitment for financial and other resources needed.

Based on the presentation and the data submitted, management might reach one of three decisions: proceed with systems development, perform additional work on the systems design phase, or terminate the project.

A QUESTION OF ETHICS



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The new accounting system is operational, but feedback from users has been negative. The most common complaint is that the system is not user-friendly. Some people in the IT department think that more user training would solve the problem. However, the IT manager is opposed to a fresh round of training. "Let's just set up the network to monitor the users' keystrokes and mouse clicks, and see what the patterns are," he suggested. "We can analyze the data and come up with tips and suggestions that would make the system easier to use."

Your initial reaction is that the IT manager is wrong for two reasons. First, you believe that monitoring would not be an effective method to learn what users really want. In your view, that should have been done in the system requirements phase. Second, you are bothered by an ethical question: Even though the proposed monitoring would involve company business, the company network, and company time, you feel that many users would resent the unannounced monitoring and might feel that their performance or other computing activities were being appraised without their knowledge.

The IT manager has asked to you to write up a recommendation. What will you say about the ethical question that troubles you?

10.10 Summary

An information system combines hardware, software, data, procedures, and people into a system architecture. The architecture translates the system's logical design into a physical structure that includes hardware, software, and processing methods. The software consists of application programs, also called applications, which handle the input, manage the processing logic, and provide the required output.

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Before selecting a system architecture, the analyst must consider ERP, initial cost and TCO, scalability, web integration, legacy interface requirements, processing options, security issues, and corporate portals.

ERP establishes an enterprise-wide strategy for IT resources and specific standards for data, processing, network, and user interface design. Companies can extend ERP systems to suppliers and customers in a process called SCM. A systems analyst must assess initial cost and TCO and ensure that the design is scalable. Scalability means that a system can be expanded, modified, or downsized easily to meet business needs. The analyst also must consider if the system will be web-centric and follow Internet design protocols and if it must interface with existing systems, called legacy systems. System security is an important concern throughout the design process, especially for e-commerce applications that involve credit card and personal data. Processing options affect system design and resources required. The planned architecture can include a corporate portal that is an entrance to a multifunction website. Corporate portals can provide access for customers, employees, suppliers, and others.

A system architecture requires servers and clients. Servers are computers that supply data, processing services, or other support to one or more computers called clients. In mainframe architecture, the server performs all processing, and terminals communicate with the centralized system. Clients can be connected in distributed systems to form LANs or WANs.

Client/server architecture divides processing between one or more clients and a central server. In a typical client/server system, the client handles the entire user interface, including data entry, data query, and screen presentation logic. The server stores the data and provides data access and database management functions. Application logic is divided in some manner between the server and the clients. In a typical client/server interaction, the client submits a request for information from the server, which carries out the operation and responds to the client. Compared to file server designs, client/server systems are more scalable and flexible.

A fat, or thick, client design places all or most of the application processing logic at the client. A thin client design places all or most of the processing logic at the server. Compared with maintaining a central server, TCO for fat clients can be higher than for thin clients because of initial hardware and software requirements and the ongoing expense of maintaining and updating remote client computers. However, the fat client design may be simpler to develop, because the architecture resembles traditional file server designs where all processing is performed at the client.

Client/server designs can be two-tier or three-tier (also called *n*-tier). In a two-tier design, the user interface resides on the client, all data resides on the server, and the application logic can run either on the server or on the client or be divided between the client and the server. In a three-tier design, the user interface runs on the client and the data is stored on the server, just as with a two-tier design. A three-tier design also has a middle layer between the client and server that processes the client requests and translates them into data access commands that can be understood and carried out by the server. The middle layer is called an application server, because it provides the application logic or business logic. Middleware is software that connects dissimilar applications and enables them to communicate and pass data. In planning the system design, a systems analyst also must consider cost-benefit and performance issues.

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The Internet has had an enormous impact on system architecture. In implementing a design, an analyst should consider e-commerce architecture, the availability of packaged solutions, and service providers. The analyst also should understand the concepts of cloud computing and Web 2.0, which are shaping the future of Internet computing. Cloud computing uses a cloud symbol to represent the Internet. The cloud, which is transparent to users, provides a hardware-independent environment where remote servers handle all processing and computing functions, and the Internet itself replaces traditional networks. Web 2.0 refers to a new generation of the web that encourages people to collaborate, interact, and share information more dynamically. Web 2.0 is fueling the explosive growth of social networking and group-based communications.

The most prevalent processing method today is online processing. Users interact directly with online systems that continuously process their transactions when and where they occur and continuously update files and databases. In contrast, batch systems process transactions in groups and execute them on a predetermined schedule. Many online systems also use batch processing to perform routine tasks, such as handling reports and accounting entries.

Networks allow the sharing of hardware, software, and data resources in order to reduce expenses and provide more capability to users. The network is represented by a seven-layer model called the OSI model.

The way a network is configured is called the network topology. Networks typically are arranged in five patterns: hierarchical, bus, ring, star, and mesh. A single mainframe computer usually controls a hierarchical network, a bus network connects workstations in a single-line communication path, a ring network connects workstations in a circular communication path, a star network connects workstations to a central computer or networking device called a switch, and a mesh network connects every network node to every other node. Wireless networks, or WLANs, based on IEEE 802.11 standards, have seen explosive growth, especially in situations where the flexibility of wireless is important. The IEEE 802.11ac standard uses MIMO, or multipath technology, which has increased wireless network speed and range. WLANs have two major topologies: BSS and ESS. Although wireless networks are very popular, they do have some limitations and disadvantages, including interference and security concerns.

The system design specification presents the complete systems design for an information system and is the basis for the presentations that complete the systems design phase. Following the presentations, the project either progresses to the systems development phase, requires additional systems design work, or is terminated.

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Key Terms

802.11 A family of wireless network specifications developed by the IEEE.

802.11ac An IEEE wireless network specification, approved in 2014, that uses expanded MIMO technology to achieve theoretical speeds of nearly 7 Gbps while increasing the wireless range and is backward compatible with 802.11a, b, g, and n.

802.11b An IEEE wireless network specification introduced in 1999 based on a frequency of 2.4 GHz and maximum bandwidth of 11 Mbps. Replaced by 802.11g.

802.11g An IEEE wireless network specification introduced in 2003 based on a frequency of 2.4 GHz and maximum bandwidth of 54 Mbps; compatible with and replaced 802.11b, and has been superseded by the 802.11n standard.

802.11n An IEEE wireless network specification adopted in 2009 that uses MIMO technology to achieve speeds of 200+ Mbps while increasing the wireless range and is backward compatible with 802.11a, b, and g.

access point A central wireless device that provides network services to wireless clients.

application Part of the information system, an application handles the input, manages the processing logic, and provides the required output.

application logic The underlying business rules or logic for an application.

application server A computer acting as "middlemen" between customers and an organization's databases and applications. Often used to facilitate complex business transactions.

bandwidth The amount of data that the system can handle in a fixed time period. Bandwidth requirements are expressed in bits per second (bps).

Basic Service Set (BSS) A wireless network configuration in which a central wireless device called an access point is used to serve all wireless clients; also called infrastructure mode.

Bluetooth A form of wireless transmission very popular for short-distance wireless communication that does not require high power.

bus network A computer network where a single communication path connects the mainframe computer, server, workstations, and peripheral devices. Information is transmitted in either direction from any workstation to another workstation, and any message can be directed to a specific device.

business logic Rules reflecting the operational requirements of the business that determine how a system handles data and produces useful information. Examples include adding the proper amount of sales tax to invoices, calculating customer balances and finance charges, and determining whether a customer is eligible for a volume-based discount.

client Workstation that users interact within a client/server design. These workstations, or computers, are supplied data, processing services, or other support from other computers, called servers.

client/server architecture Generally refers to systems that divide processing between one or more networked clients and a central server. In a typical client/ server system, the client handles the entire user interface, including data entry, data query, and screen presentation logic. The server stores the data and provides data access and database management functions. Application logic is divided in some manner between the server and the clients.

corporate portal A website that provides various tools and features for an organization's customers, employees, suppliers, and the public.

data frames Traffic on a computer network.

data processing center A central location where physical data was delivered or transmitted in some manner and entered into the system. Users in the organization had no input or output capability, except for printed reports that were distributed by a corporate IT department.

distributed database management system (DDBMS) A system for managing data stored at more than one location. Using a DDBMS offers several advantages: Data stored closer to users can reduce network

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traffic; the system is scalable, so new data sites can be added without reworking the system design; and with data stored in various locations, the system is less likely to experience a catastrophic failure. A potential disadvantage of distributed data storage involves data security. It can be more difficult to maintain controls and standards when data is stored in various locations.

distributed system Company-wide systems that are connected by one or more LANs or WANs. The capabilities of a distributed system depend on the power and capacity of the underlying data communication network.

enterprise resource planning (ERP) A process that establishes an enterprise-wide strategy for IT resources. ERP defines a specific architecture, including standards for data, processing, network, and user interface design.

Extended Service Set (ESS) A wireless network configuration made up of two or more BSS networks, which allows wireless clients to roam from BSS to BSS.

extensibility Refers to a system's ability to expand, change, or downsize easily to meet the changing needs of a business enterprise. Also known as scalability.

fat client A network design that locates all or most of the application processing logic at the client. Also called a thick client design.

gateway (1) In business processing modeling notation, a fork in the process, allowing the flow to go one way or another. (2) A router or other network device used to connect to a larger, dissimilar type of network, such as the Internet.

gigabits per second (Gbps) A bandwidth or throughput measurement.

glueware *See* **middleware**.

hierarchical network A network design where one computer (typically a mainframe) controls the entire network. Satellite computers or servers control lower levels of processing and network devices.

HTTP/2 The second major version of the network protocol used by the web. Released as a standard in 2015.

hub The center of a star network. Switches in modern networks have largely replaced hubs.

infrastructure mode A wireless network configuration in which a central wireless device called an access point is used to serve all wireless clients; also called BSS.

Institute of Electrical and Electronics Engineers (IEEE) A professional organization that establishes standards for telecommunications.

Internet operating system Part of the Web 2.0 model, an online computing environment created by online communities and services, based on layers of shared information that can contain text, sound bytes, images, and video clips.

knee of the curve A performance characteristic of a client/server computing environment. Client/server response times tend to increase gradually and then rise dramatically as the system nears its capacity. The point where response times increase dramatically.

legacy data The data associated with an older, less technologically advanced legacy system.

legacy system Term used to describe older systems that are typically less technologically advanced than currently available systems.

local area network (LAN) A network design that allows the sharing of data and hardware, such as printers and scanners. Advances in data communication technology have made it possible to create powerful networks that use satellite links, high-speed fiber-optic lines, or the Internet to share data.

logical topology A view of a network that describes the way the components interact, rather than the actual network cabling and connections.

mainframe architecture A system design where the server performs all the processing.

megabits per second (Mbps) A bandwidth or throughput measurement.

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mesh network A network design in which each node connects to every other node. While this design is very reliable, it is also expensive to install and maintain.

middleware Software that connects dissimilar applications and enables them to communicate and exchange data. For example, middleware can link a departmental database to a Web server that can be accessed by client computers via the Internet or a company intranet. *See also* **glueware**.

multipath design A network design that relies on multiple data paths to increase bandwidth and range, using MIMO technology.

multiple input/multiple output (MIMO) A wireless networking technology incorporated in the IEEE 802.11n and 802.11ac standards that uses multiple data streams and multiple antennas to achieve higher transmission speeds and substantially increase wireless range over earlier standards.

net-centric computing A distributed environment where applications and data are downloaded from servers and exchanged with peers across a network on an as-needed basis.

network topology The way a network is configured. LAN and WAN networks typically are arranged in one of four common patterns: hierarchical, bus, star, and ring.

node A physical device, wired or wireless, that can send, receive, or manage network data.

***n*-tier design** A multilevel design or architecture. For example, three-tier designs also are called *n*-tier designs, to indicate that some designs use more than one intermediate layer.

online system Handling transactions when and where they occur and providing output directly to users. Because it is interactive, online processing avoids delays and allows a constant dialog between the user and the system.

Open Systems Interconnection (OSI) model Describes how data actually moves from an application on one computer to an application on another networked computer. The OSI consists of seven layers, and each layer performs a specific function.

physical topology The connection structure of an actual network's cabling.

platform A specific hardware and software configuration that supports IT business goals such as hardware connectivity and easy integration of future applications. Also called an environment.

point-of-sale (POS) The part of an information system that handles daily sales transactions and maintains the online inventory file.

portal An entrance to a multifunction website. After entering a portal, a user can navigate to a destination, using various tools and features provided by the portal designer.

proxy server A networking device that provides Internet connectivity for internal LAN users.

ring network A network resembling a circle of computers that communicate with each other. A ring network often is used when processing is performed at local sites rather than at a central location.

roaming A process that allows wireless clients to move from one access point to another, automatically associating with the stronger access point and allowing for uninterrupted service.

router A device that connects network segments, determines the most efficient data path, and guides the flow of data.

scalability A characteristic implying the system can be expanded, modified, or downsized to meet the rapidly changing needs of a business enterprise.

scaling on demand The ability to match network resources to needs at any given time; a feature of cloud computing. For example, during peak loads, additional cloud servers might come on line automatically to support increased workloads.

semantic web An evolution of the web where the documents shared on the Internet have semantics (meaning) and not just syntax (HTML markup). Sometimes called Web 3.0.

server Computer in a client/server design that supplies data, processing, and services to client workstations.

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stand-alone When personal computers first appeared in large numbers in the 1990, users found that they could run their own word processing, spreadsheet, and database applications, without assistance from the IT group, in a mode called stand-alone computing.

star network A network design with a central device and one or more workstations connected to it in a way that forms a star pattern.

supply chain management (SCM) The coordination, integration, and management of materials, information, and finances as they move from suppliers to customers, both within and between companies. In a totally integrated supply chain, a customer order could cause a production planning system to schedule a work order, which in turn could trigger a call for certain parts from one or more suppliers.

switch Central networking device in a star network, which manages the network and acts as a conduit for all network traffic.

system architecture A translation of the logical design of an information system into a physical structure that includes hardware, software, network support, and processing methods.

system design specification A document that presents the complete design for the new information system, along with detailed costs, staffing, and scheduling for completing the next SDLC phase, systems implementation. Also called the technical design specification or the detailed design specification.

thick client A system design that locates most or all of the application processing logic at the client. Also called a fat client design.

thin client A system design that locates most or all of the processing logic at the server.

three-tier design In a three-tier design, the user interface runs on the client and the data is stored on the server, just as in a two-tier design. A three-tier design also has a middle layer between the client and server that processes the client requests and translates them into data access commands that can be understood and carried out by the server.

transparent A network is transparent if a user sees the data as if it were stored on his or her own workstation.

two-tier design A network design where the user interface resides on the client, all data resides on the server, and the application logic can run either on the server or on the client or be divided between the client and the server.

web-centric A strategy or approach that emphasizes a high degree of integration with other web-based components. A web-centric architecture follows Internet design protocols and enables a company to integrate the new application into its e-commerce strategy.

wide area network (WAN) A network spanning long distances that can link users who are continents apart.

Wi-Fi Alliance A nonprofit international association formed in 1999 to certify interoperability of wireless network products based on IEEE 802.11 specifications.

wiki A web-based repository of information that anyone can access, contribute to, or modify.

Wi-Max IEEE 802.16 specifications, which are expected to enable wireless multimedia applications with a range of up to 30 miles.

wireless access point (WAP) A central wireless device that provides network services to wireless clients. Also called an access point.

wireless fidelity (Wi-Fi) Family of popular IEEE LAN wireless networking standards, also known as 802.11, including 802.11a, b, g, and n. 802.11n is the most recent standard. 802.11ac and 802.11ad are proposed new standards.

wireless local area network (WLAN) A wireless network that is relatively inexpensive to install and is well suited to workgroups and users who are not anchored to a specific desk or location.

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Exercises

Questions

1. If you had to rank the items in the architecture checklist, from most important to least important, what would your list look like?
2. What are the three functions that every business information system must carry out, irrespective of system architecture?
3. What is client/server architecture?
4. What has been the impact of the Internet on system architecture?
5. What are the differences between in-house e-commerce development with packaged solutions and service providers?
6. What are the advantages of online and batch processing, respectively?
7. Explain the five main network models.
8. What functions do routers, gateways, and proxy servers serve in a network?
9. What role do standards play in wireless networking?
10. List the sections of a system design specification and describe the contents.

Discussion Topics

1. How is the proliferation of mobile devices that are locally powerful, use apps instead of full-fledged applications, and rely on wireless network connectivity changing system architecture design considerations?
2. E-commerce has seen explosive growth in recent years. What are the most important reasons for this trend? Will it continue? Why or why not?
3. Is batch processing still relevant? Why or why not?
4. What are the main differences between the BSS and ESS wireless topologies?
5. One manager states, "When a new system is proposed, I want a written report, not an oral presentation, which is like a sales pitch. I only want to see the facts about costs, benefits, and schedules." Do you agree with that point of view?

Projects

1. Visit the IT department at your school or a local company to learn about the network they use. Describe the network and draw a sketch of the configuration.
2. Prepare a 10-minute talk explaining Web 2.0 and cloud computing to a college class. Using the text and your own Internet research, briefly describe the five most important points you will include in your presentation.
3. Perform research on the Internet to identify a service provider that offers web-based business solutions, and write a report describing the firm and its services.
4. Perform research on the Internet to learn about emerging trends in wireless networking and typical costs involved in the installation of a wireless LAN.
5. Examine the role wireless networks are having in the developing world. Why are some places bypassing LANs and physical cabling altogether and moving to a wireless system architecture? What are the advantages and disadvantages of this?

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PHASE 4 SYSTEMS IMPLEMENTATION

DELIVERABLE
A functioning information system

Systems implementation is the fourth of five phases in the systems development life cycle. In the previous phase, systems design, a physical model of the system was developed. The output of that phase, the systems design specification, is used as input to the systems implementation phase, where a completely functioning information system is created.

Successful systems implementation requires considerable effort. After all, without a working system delivered to the customer, all other phases of the SDLC have little meaning. In software engineering, the construction phase is often jokingly referred to as "a small matter of programming"—but of course it's no small matter at all.

Chapter 11 focuses on managing systems implementation throughout the useful life of the system. This includes quality assurance, application development (structured, object-oriented, and agile), coding, testing, documentation, and system installation.

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CHAPTER

Managing Systems Implementation

Chapter 11 describes the systems implementation phase of the SDLC. Managing systems implementation involves paying constant attention to quality assurance throughout the activities of application development, coding, testing, documentation, and installation. The system design specification serves as a blueprint for constructing the new system. The initial task is application development, which requires systems analysts and programmers to work together to construct the necessary programs and code modules. Before a changeover, the system must be tested and documented carefully, users must be trained, and existing data must be converted. After the new system is operational, a formal evaluation of the results takes place as part of a final report to management.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. The "Question of Ethics" concerns with an issue that all testers have to deal: when to stop testing. In the example, there is an ethical question raised about whether or not a 90% pass rate is sufficient to ship the product, assuming the remaining bugs will be fixed once the system is operational.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Explain quality assurance and three techniques to help improve the finished product
2. Outline application development
3. Apply structured development
4. Apply object-oriented development
5. Apply agile development
6. Explain coding
7. Explain unit, integration, and system testing
8. Differentiate between program, system, operations, and user documentation
9. Explain the role of online documentation
10. Describe the five tasks involved in system installation

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11.2 Application Development
11.3 Structured Development
11.4 Object-Oriented Development
11.5 Agile Development
11.6 Coding
11.7 Testing
Case in Point 11.1: Your Move, Inc.
11.8 Documentation
11.9 Installation
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Case in Point 11.3: Yorktown Industries
A Question of Ethics
11.10 Summary
Key Terms
Exercises

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11.1 Quality Assurance

In today's competitive business environment, companies are intensely concerned with the quality of their products and services. A successful organization must improve quality in every area, including its information systems. Top management must provide the leadership, encouragement, and support needed for high-quality IT resources.

No matter how carefully a system is designed and implemented, problems can occur. Rigorous testing can detect errors during implementation, but it is much less expensive to correct mistakes earlier in the development process. The main objective of **quality assurance (QA)** is to avoid problems or to identify them as soon as possible. Poor quality can result from inaccurate requirements, design problems, coding errors, faulty documentation, and ineffective testing.

To improve the finished product, software systems developers should consider best practices in software engineering, systems engineering, and internationally recognized quality standards.

11.1.1 Software Engineering

Software engineering is the disciplined application of engineering principles to the creation of complex, long-lived applications. It is an amalgam of people, process, and technology. Software engineering is broader than just development. It includes five technical activity areas: requirements, design, construction, testing, and maintenance and evolution. It is supported by nontechnical activities such as cost and effort estimation, project management, and **process improvement**.

The website for the Software Engineering Institute (SEI) at Carnegie Mellon University is shown in Figure 11-1. SEI is a leader in software engineering and provides quality standards and suggested procedures for software developers and systems analysts. SEI's primary objective is to find better, faster, and less-expensive methods of software development. To achieve that goal, SEI designed an influential set of software development standards called the **Capability Maturity Model (CMM)®**, which has been used successfully by thousands of organizations around the globe. The purpose of the model is to improve software quality, reduce development time, and cut costs. The five maturity levels of the software CMM are shown in Figure 11-2.

After the original software CMM was released and updated, other CMMs were introduced. Eventually the SEI established a new model, called **Capability Maturity Model Integration (CMMI)®**, that integrates software and systems development into a much larger framework. The CMMI tracks an organization's processes, using five maturity levels, from Level 1, which is referred to as unpredictable, poorly controlled, and reactive, to Level 5, in which the optimal result is process improvement.

11.1.2 Systems Engineering

Systems engineering not only builds upon software engineering but also includes other parts of the overall system, such as hardware, networks, and interfaces. Trade organizations such as INCOSE and the IEEE Systems Council provide guidance on best practices and emerging technologies in systems engineering. As shown in Figure 11-3, systems analysts can benefit from a holistic approach to large-scale problem solving by adopting a broader perspective.

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FIGURE 11-1 The Software Engineering Institute at Carnegie Mellon University has had profound influence on software engineering research and practice.
Source: Carnegie Mellon University

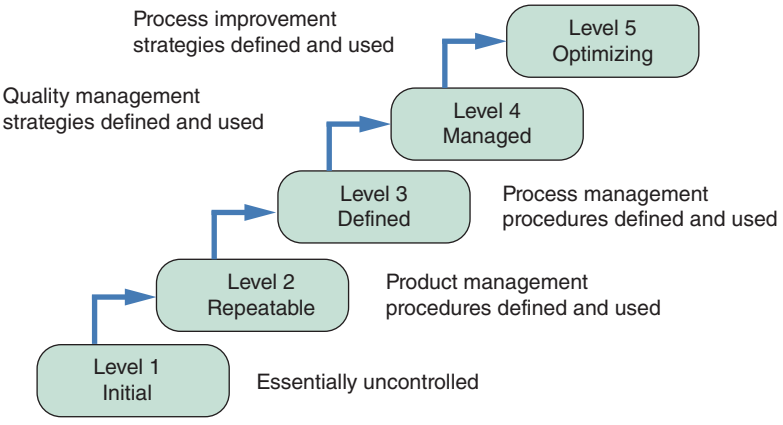


FIGURE 11-2 The CMM has five maturity levels, from Level 1 (initial), which is essentially uncontrolled development, to Level 5 (optimizing), in which process improvement strategies are defined and used.
Source: Scott Tilley

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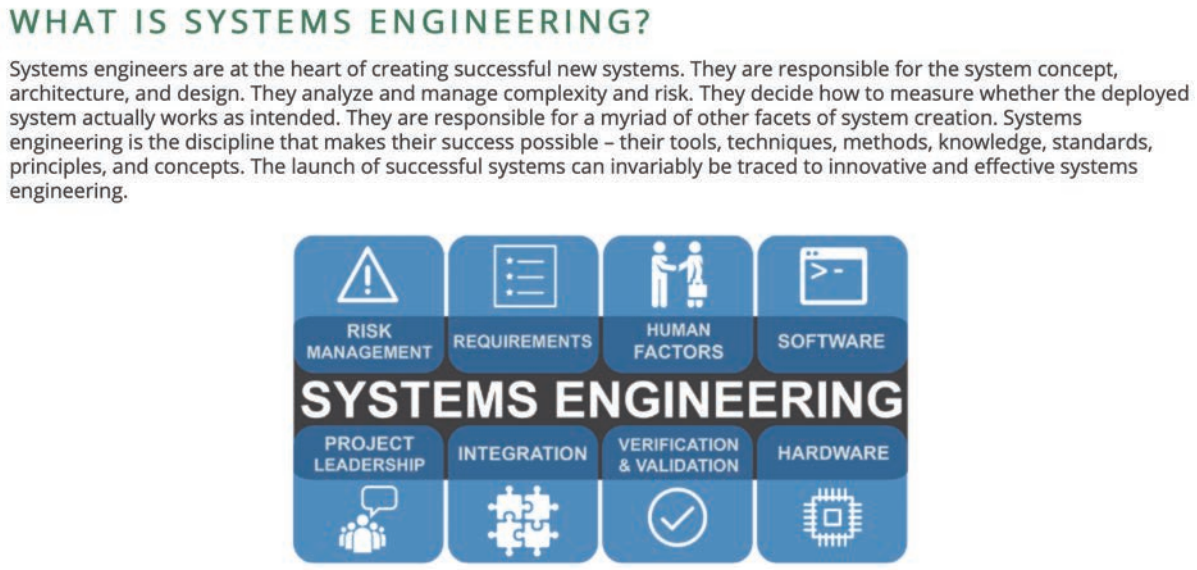


FIGURE 11-3 INCOSE's view of systems engineering.
Source: INCOSE - International Council on Systems Engineering

11.1.3 International Organization for Standardization

What do automobiles, water, and software have in common? Along with thousands of other products and services, they are all covered by standards from the International Organization for Standardization (ISO), which was discussed in Chapter 9.

ISO standards include everything from internationally recognized symbols, such as those shown in Figure 11-4 to the ISBN numbering system that identifies this text. In addition, ISO seeks to offer a global consensus of what constitutes good management practices that can help firms deliver consistently high-quality products and services—including software.

Because software is so important to a company's success, many firms seek assurance that software systems, either purchased or developed in-house, will meet rigid quality standards. In 2014, ISO updated a set of guidelines, called ISO 9000-3:2014, that provided a QA framework for developing and maintaining software.

A company can specify ISO standards when it purchases software from a supplier or use ISO guidelines for in-house software development to ensure that the final result measures up to ISO standards. ISO requires a specific development plan, which outlines a step-by-step process for transforming user requirements into a finished product. ISO standards can be quite detailed. For example, ISO requires that a software supplier document all testing and maintain records of test results. If problems are found, they must be resolved, and any modules affected must be retested. Additionally, software and hardware specifications of all test equipment must be documented and included in the test records.



FIGURE 11-4 ISO symbols include internationally recognized symbols.
bytedust/Shutterstock.com

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11.2 Application Development

Application development is the process of constructing the programs and code modules that serve as the building blocks of the information system. In Chapter 1, it was explained that structured analysis, object-oriented (O-O) analysis, and agile methods are three popular development options. Regardless of the method, the objective is to translate the design into program and code modules that will function properly.

Regardless of whether structured analysis, O-O design, or agile methods are used, even a modest-sized project might have hundreds or even thousands of modules. For this reason, application development can become quite complex and difficult to manage. At this stage, project management is especially important to control schedules and budgets.

Users and managers are looking forward to the new system, and it is very important to set realistic schedules, meet project deadlines, control costs, and maintain quality. To achieve these goals, the systems analyst or project manager should use project management tools and techniques similar to those described in Chapter 3 to monitor and control the development effort.

11.2.1 Review the System Design

At this point, it is helpful to review the tasks involved in the creation of the system design:

- Chapter 4 focused on requirements modeling and how to use functional decomposition diagrams (FDDs) to break complex business operations down into smaller units, or functions.
- Chapter 5 focused on structured data and process modeling, and data flow diagrams (DFDs). The development of process descriptions for functional primitive processes that documented the business logic and processing requirements was also discussed.
- Chapter 6 focused on an O-O model of the new system that included use case diagrams, class diagrams, sequence diagrams, state transition diagrams, and activity diagrams.
- Chapter 7 focused on selecting a development strategy.
- Chapter 8 focused on designing the user interface.
- Chapter 9 focused on data design issues, analyzing relationships between system entities, and constructing entity-relationship diagrams (ERDs).
- Chapter 10 focused on overall system architecture considerations.

Taken together, this set of tasks produced an overall design and a plan for physical implementation.

11.2.2 Application Development Tasks

If traditional structured or O-O methods were used during system design, the process of translating the design into a functioning application can begin. If an agile development method was selected, development begins with planning the project, followed by laying the groundwork, assembling the team, and preparing to interact with the customers.

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TRADITIONAL METHODS: Building a new system requires careful planning. After an overall strategy is established, individual modules must be designed, coded, tested, and documented. A **module** consists of related program code organized into small units that are easy to understand and maintain. After the modules are developed and tested individually, more testing takes place, along with thorough documentation of the entire system, as shown in Figure 11-5.

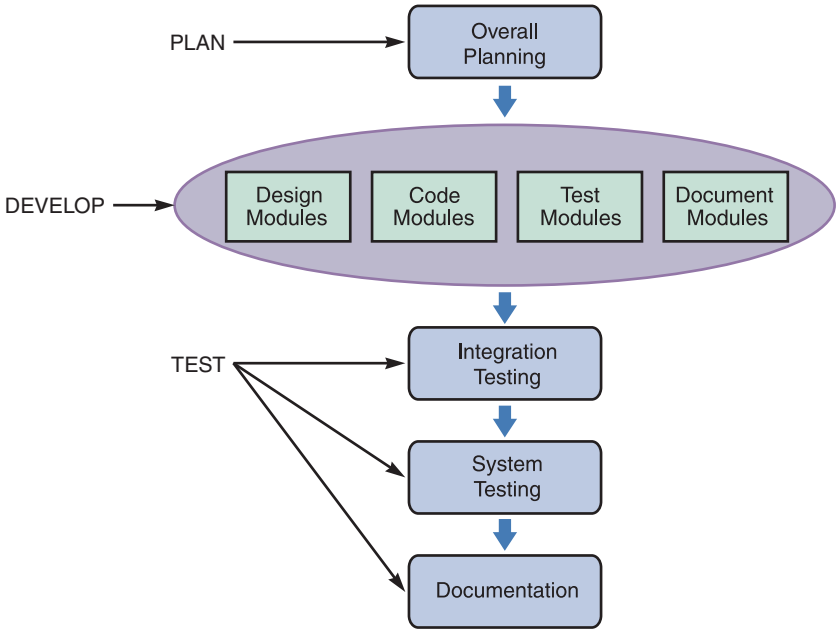


FIGURE 11-5 The main steps in traditional application development.

When program modules are created using structured or O-O methods, the process starts by reviewing requirements documentation from prior SDLC phases and creating a set of program designs. If a documentation file was built early in the development process and updated regularly, there is a valuable repository of information. The documentation centerpiece is the system design specification, accompanied by diagrams, source documents, screen layouts, report designs, data dictionary entries, and user comments. If a CASE tool was used during the systems analysis and design process, the analyst's job will be much easier. At this point, coding and testing tasks begin. Although programmers typically perform the actual coding, IT managers usually assign systems analysts to work with them as a team.

AGILE METHODS: If an agile approach is decided upon, intense communication and collaboration will now begin between the IT team and the users or customers. The objective is to create the system through an iterative process of planning, designing, coding, and testing. Agile projects use various iterative and incremental models, including Extreme Programming (XP) as shown in Figure 11-6. Agile development and XP are discussed more later in this chapter.

11.2.3 Systems Development Tools

Each systems development approach has its own set of tools that has worked well for that method. For example, structured development relies heavily on DFDs and structure charts; O-O methods use a variety of UML diagrams, including use case, class,

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sequence, and transition state diagrams; and agile methods tend to use spiral or other iterative models such as the example shown in Figure 11-6.

System developers also can use multipurpose tools to help them translate the system logic into properly functioning program modules. These generic tools include ERDs, flowcharts, pseudocode, decision tables, and decision trees.

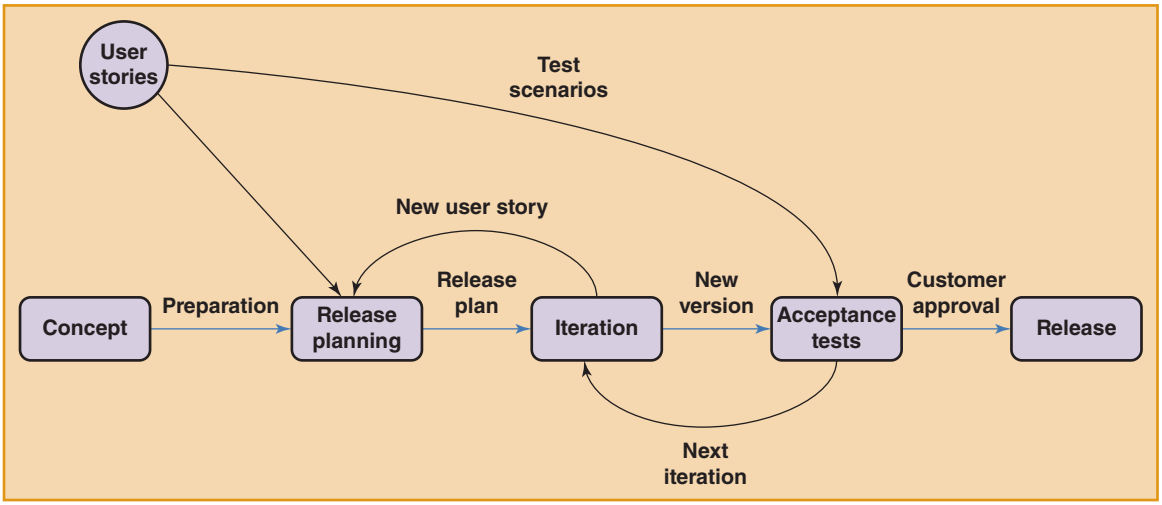


FIGURE 11-6 Simplified model of an XP project. Note the emphasis on iteration and testing.

ENTITY-RELATIONSHIP DIAGRAMS: During data design (Chapter 9), the use of ERDs to show the interaction among system entities and objects was described. An ERD is a useful tool regardless of which methodology used, because the various relationships (one-to-one, one-to-many, and many-to-many) must be understood and implemented in the application development process.

FLOWCHARTS: As described in Chapter 5, flowcharts can be used to represent program logic and are very useful in visualizing a modular design. A **flowchart** represents logical rules and interaction graphically, using a series of symbols connected by arrows. Using flowcharts, programmers can break large systems into subsystems and modules that are easier to understand and code.

PSEUDOCODE: **Pseudocode** is a technique for representing program logic. Pseudocode is similar to structured English, which was explained in Chapter 5. Pseudocode is not language-specific, so it can be used to describe a software module in plain English without requiring strict syntax rules. Using pseudocode, a systems analyst or a programmer can describe program actions that can be implemented in any programming language. Figure 11-7 illustrates an example of pseudocode that documents a sales promotion policy.

DECISION TABLES AND DECISION TREES: As explained in Chapter 5, decision tables and decision trees can be used to model business logic for an information system. In addition to being used as modeling tools, analysts and programmers can use decision tables and decision trees during system development, as code modules that implement the logical rules are developed. Figure 11-8 shows an example of a decision tree that documents the sales promotion policy shown in Figure 11-7. Note that the decision tree accurately reflects the sales promotion policy, which has three separate conditions and four possible outcomes.

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SAMPLE OF A SALES PROMOTION POLICY

- Preferred customers who order more than $1,000 are entitled to a 5% discount, and an additional 5% discount if they used our charge card.
- Preferred customers who do not order more than $1,000 receive a $25 bonus coupon.
- All other customers receive a $5 bonus coupon.

PSEUDOCODE VERSION OF THE SALES PROMOTION POLICY

```
IF customer is a preferred customer, and
        IF customer orders more than $1,000 then
                Apply a 5% discount, and
                IF customer uses our charge card, then
                        Apply an additional 5% discount
        ELSE
                        Award a $25 bonus coupon
ELSE
        Award a $5 bonus coupon
```

FIGURE 11-7 Sample of a sales promotion policy with logical rules (top) and a pseudocode version of the same policy (bottom). Note the alignment and indentation of the logic statements in the pseudocode.

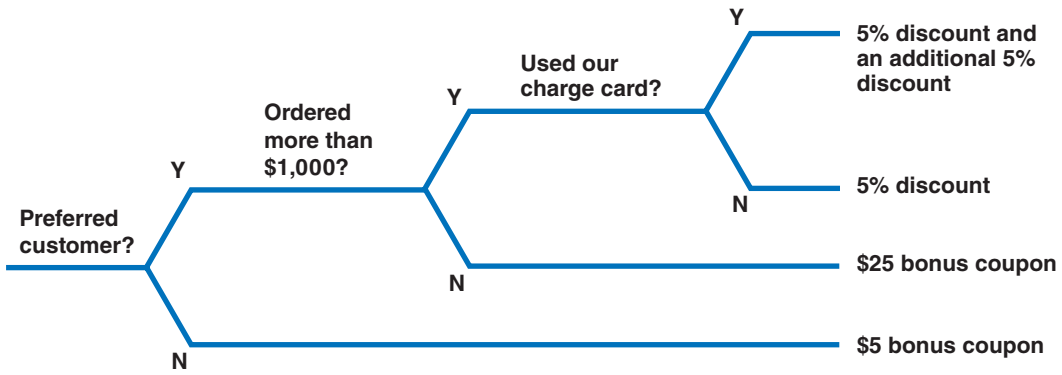


FIGURE 11-8 Sample decision tree that reflects the sales promotion policy in Figure 11-7. Like a decision table, a decision tree shows the action to be taken based on certain properties.

11.3 Structured Development

Structured application development usually involves a **top-down approach**, which proceeds from a general design to a detailed structure. After a systems analyst documents the system's requirements, he or she breaks the system down into subsystems and modules in a process called **partitioning**. This approach also is called **modular design** and is similar to constructing a leveled set of DFDs. By assigning modules to different programmers, several development areas can proceed at the same time. As explained in Chapter 3, project management software can be used to monitor work on each module, forecast overall development time, estimate required human and technical resources, and calculate a critical path for the project.

Because all the modules must work together properly, an analyst must proceed carefully, with constant input from programmers and IT management to achieve a sound, well-integrated structure. The analyst also must ensure that integration capability is built into each design and thoroughly tested.

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11.3.1 Structure Charts

Structure charts show the program modules and the relationships among them. A **structure chart** consists of rectangles that represent the program modules, with arrows and other symbols that provide additional information. Typically, a higher-level module, called a **control module**, directs lower-level modules, called **subordinate modules**. In a structure chart, symbols represent various actions or conditions. Structure chart symbols represent modules, data couples, control couples, conditions, and loops.

MODULE: A rectangle represents a module, as shown in Figure 11-9. In the figure, vertical lines at the edges of a rectangle indicate that module 1.3 is a library module. A **library module** is reusable code and can be invoked from more than one point in the chart.

DATA COUPLE: An arrow with an empty circle represents a data couple. A **data couple** shows data that one module passes to another. In the data couple example shown in Figure 11-10, the Look Up Customer Name module exchanges data with the Maintain Customer Data module.

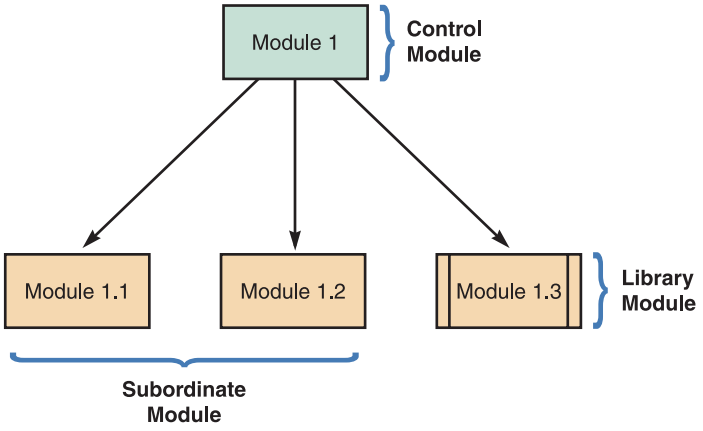


FIGURE 11-9 An example of structure chart modules.

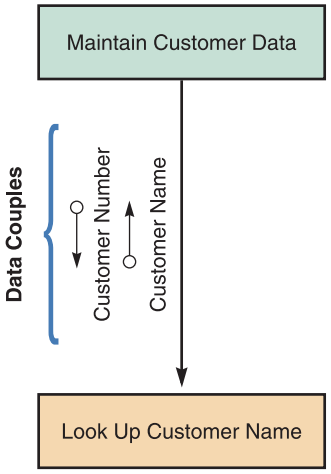


FIGURE 11-10 An example of a structure chart data couple.

CONTROL COUPLE: An arrow with a filled circle represents a control couple. A **control couple** shows a message, also called a **status flag**, that one module sends to another. In the example shown in Figure 11-11, the Update Customer File module sends an Account Overdue flag back to the Maintain Customer Data module. A module uses a flag to signal a specific condition or action to another module.

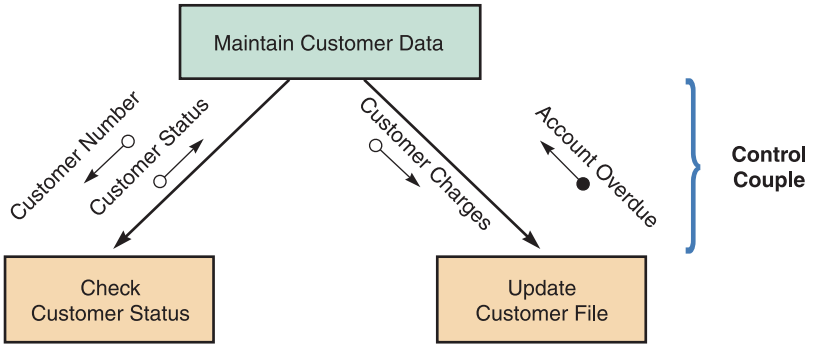


FIGURE 11-11 An example of a structure chart control couple.

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CONDITION: A line with a diamond on one end represents a condition. A **condition** line indicates that a control module determines which subordinate modules will be invoked, depending on a specific condition. In the example shown in Figure 11-12, Sort Inventory Parts is a control module with a condition line that triggers one of the three subordinate modules.

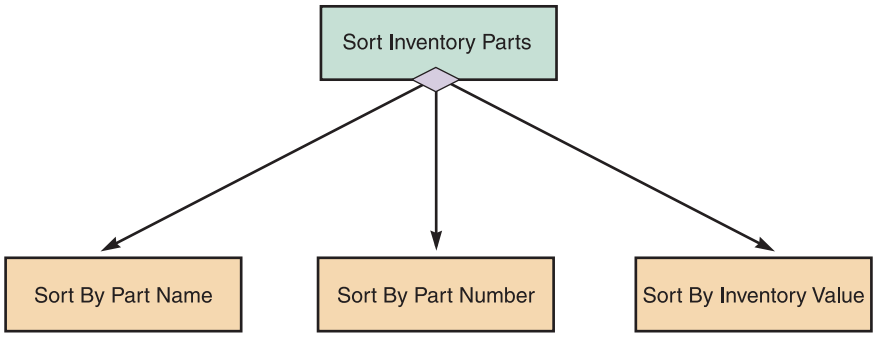


FIGURE 11-12 The diagram shows a control module that triggers three subordinate modules.

LOOP: A curved arrow represents a loop. A **loop** indicates that one or more modules are repeated. In the example shown in Figure 11-13, the Get Student Grades and Calculate GPA modules are repeated.

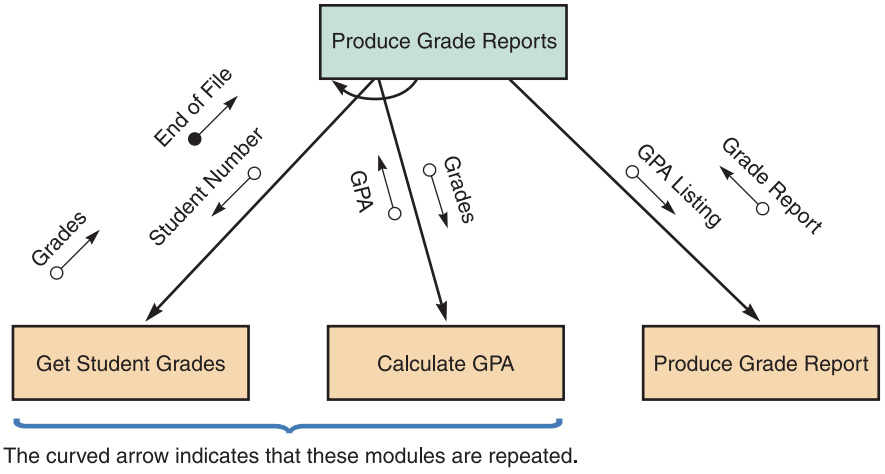


FIGURE 11-13 The diagram shows a structure chart loop with two repeating modules.

11.3.2 Cohesion and Coupling

Cohesion and coupling are important tools for evaluating the overall design. As explained in the following sections, it is desirable to have modules that are highly cohesive and loosely coupled. Otherwise, system maintenance becomes more costly due to difficulties in making changes to the system's structure.

Cohesion measures a module's scope and processing characteristics. A module that performs a single function or task has a high degree of cohesion, which is desirable. Because it focuses on a single task, a cohesive module is much easier to code and reuse. For example, a module named Verify Customer Number is more cohesive than a module named Calculate and Print Statements. If the word *and* is found in a module name, this implies that more than one task is involved.

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If a module must perform multiple tasks, more complex coding is required and the module will be more difficult to create and maintain. To make a module more cohesive, split it into separate units, each with a single function. For example, by splitting the module Check Customer Number and Credit Limit in Figure 11-14 into two separate modules, Check Customer Number and Check Customer Credit Limit, cohesion is greatly improved.

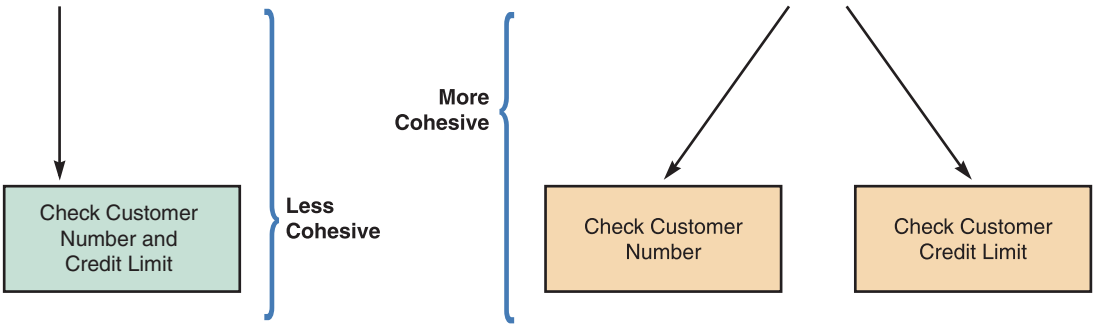


FIGURE 11-14 Two examples of cohesion. Note that the single module on the left is less cohesive than the two modules on the right.

Coupling describes the degree of interdependence among modules. Modules that are independent are **loosely coupled**, which is desirable. Loosely coupled modules are easier to maintain and modify, because the logic in one module does not affect other modules. If a programmer needs to update a loosely coupled module, he or she can accomplish the task in a single location. If modules are **tightly coupled**, one module is linked to internal logic contained in another module. For example, Module A might refer to an internal variable contained in Module B. In that case, a logic error in the Module B will affect the processing in Module A. For that reason, passing a status flag down as a message from a control module is generally regarded as poor design. It is better to have subordinate modules handle processing tasks as independently as possible, to avoid a cascade effect of logic errors in the control module.

In Figure 11-15, the tightly coupled example on the left shows that the subordinate module Calculate Current Charges depends on a status flag sent down from the control module Update Customer Balance. It would be preferable to have the modules loosely coupled and logically independent. In the example on the right, a status flag is not needed because the subordinate module Apply Discount handles discount processing independently. Any logic errors are confined to a single location: the Apply Discount module.

11.3.3 Drawing a Structure Chart

If a structured analysis method was used during system design, the structure charts will be based on the DFDs created during data and process modeling.

Typically, three steps are followed when creating a structure chart. DFDs are reviewed to identify the processes and methods, identify the program modules and determine control-subordinate relationships, and add symbols for couples and loops. Afterward, the structure chart is analyzed to ensure that it is consistent with the system documentation.

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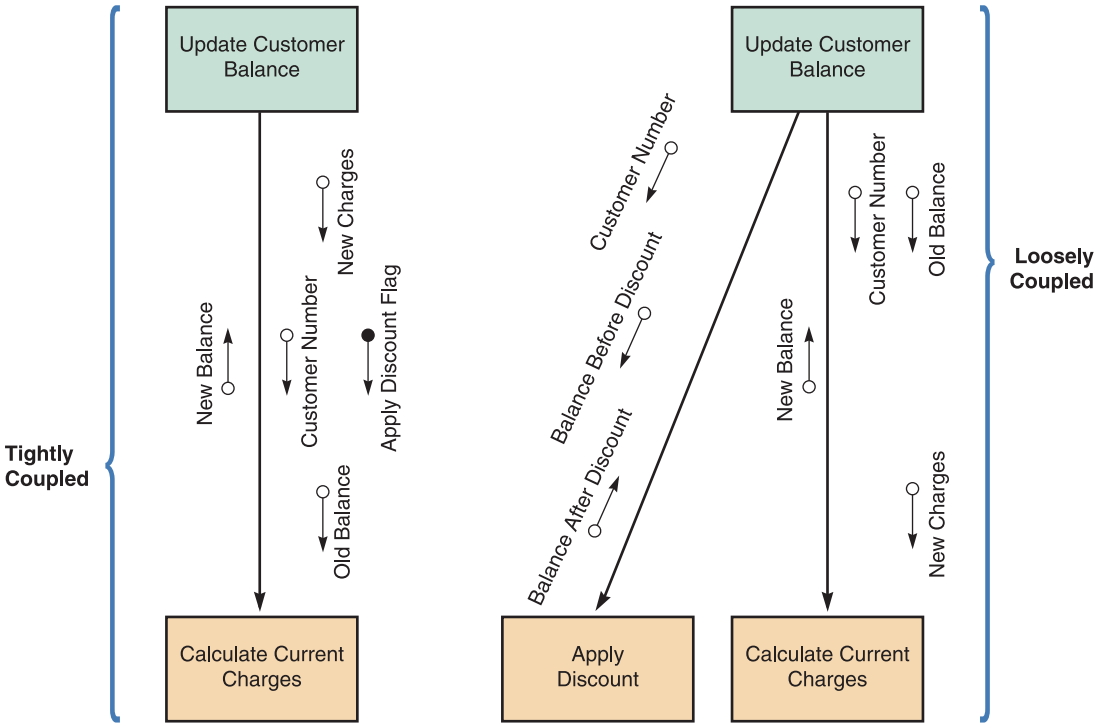


FIGURE 11-15 An example of tightly coupled and loosely coupled structure charts.

STEP 1. REVIEW THE DFDS: The first step is to review all DFDs for accuracy and completeness, especially if changes have occurred since the systems analysis phase. If object models also were developed, they should be analyzed to identify the objects, the methods that each object must perform, and the relationships among the objects. A method is similar to a functional primitive and requires code to implement the necessary actions.

STEP 2. IDENTIFY MODULES AND RELATIONSHIPS: Working from the logical model, functional primitives or object methods are transformed into program modules. When analyzing a set of DFDs, remember that each DFD level represents a processing level. If DFDs are being used, one works way down from the context diagram to the lower-level diagrams, identifying control modules and subordinate modules, until the functional primitives are reached. If more cohesion is desired, processes can be divided into smaller modules that handle a single task. Figure 11-16 shows a structure chart based on the order system from Chapter 5. Note how the three-level structure chart relates to the three DFD levels.

STEP 3. ADD COUPLES, LOOPS, AND CONDITIONS: Next, couples, loops, and conditions are added to the structure chart. If DFDs are being used, the data flows and the data dictionary can be reviewed to identify the data elements that pass from one module to another. In addition to adding the data couples, control couples are added where a module is sending a control parameter, or flag, to another module. Loops and condition lines that indicate repetitive or alternative processing steps are also added, as shown in Figure 11-16. If an object model was developed, the class diagrams and object relationship diagrams can be reviewed to be sure that the interaction among the objects is fully understood.

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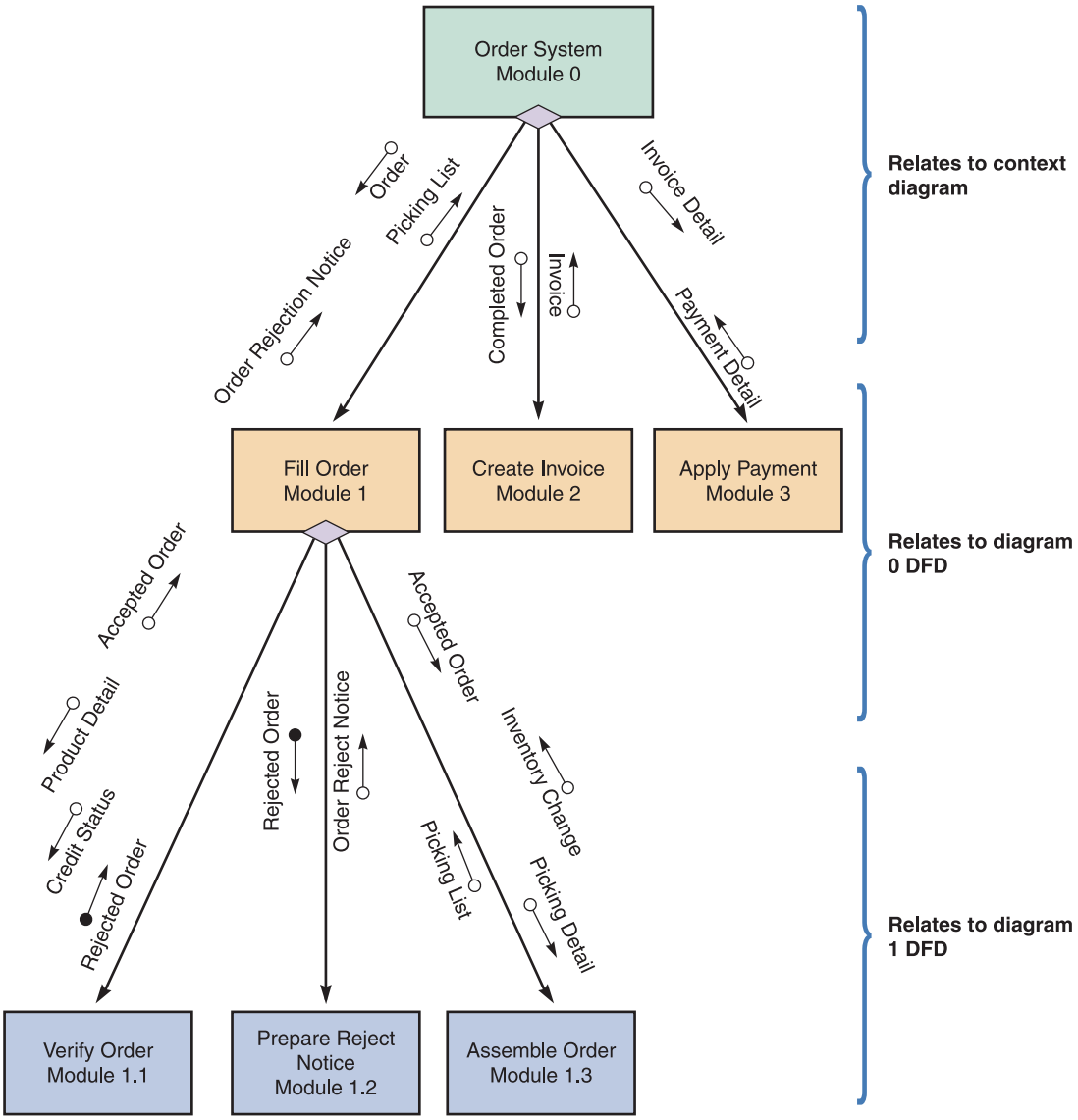


FIGURE 11-16 A structure chart based on the order system DFDs in Chapter 5. The three-level structure chart relates to the three DFD levels.

At this point, the structure chart is ready for careful analysis. Each process, data element, or object method should be checked to ensure that the chart reflects all previous documentation and that the logic is correct. All modules should be strongly cohesive and loosely coupled. Often, several versions of the chart must be drawn. Some CASE tools can help analyze the chart and identify problem areas.

11.4 Object-Oriented Development

O-O methods were described in Chapter 6. O-O analysis makes it easier to translate an object model directly into an O-O programming language. This process is called **object-oriented development (OOD)**. Although many structured design concepts also apply to O-O methodology, there are some differences.

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11.4.1 Characteristics of Object-Oriented Development

When implementing a structured design, a structure chart is used to describe the interaction between program modules, as explained earlier. In contrast, when implementing an O-O design, relationships between objects already exist. Because object interaction is defined during the O-O analysis process, the object model itself represents the application's structure.

As Chapter 6 explains, objects contain both data and program logic called methods. Individual object instances belong to classes of objects with similar characteristics. The relationship and interaction among classes are described using a class diagram, such as the one shown in Figure 11-17. A class diagram includes the class **attributes**, which describe the characteristics of objects in the class, and **methods**, which represent program logic. For example, the Customer class describes customer objects. Customer attributes include Number, Name, Address, and so on. Methods for the Customer class include Place order, Modify order, and Pay invoice, among others. The Customer class can exchange messages with the Order class.

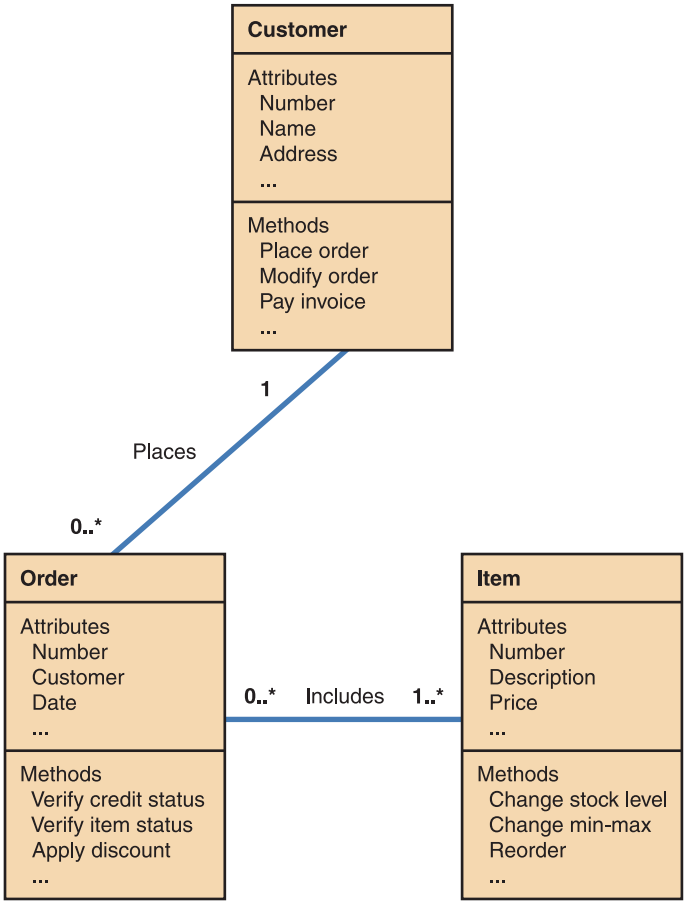


FIGURE 11-17 A simplified class diagram for a customer order processing system.

In addition to class diagrams, programmers get an overview of object interaction by using object relationship diagrams that were developed during the O-O analysis process. For example, Figure 11-18 shows an object relationship diagram for a fitness center. Note that the model shows the objects and how they interact to perform business functions and transactions.

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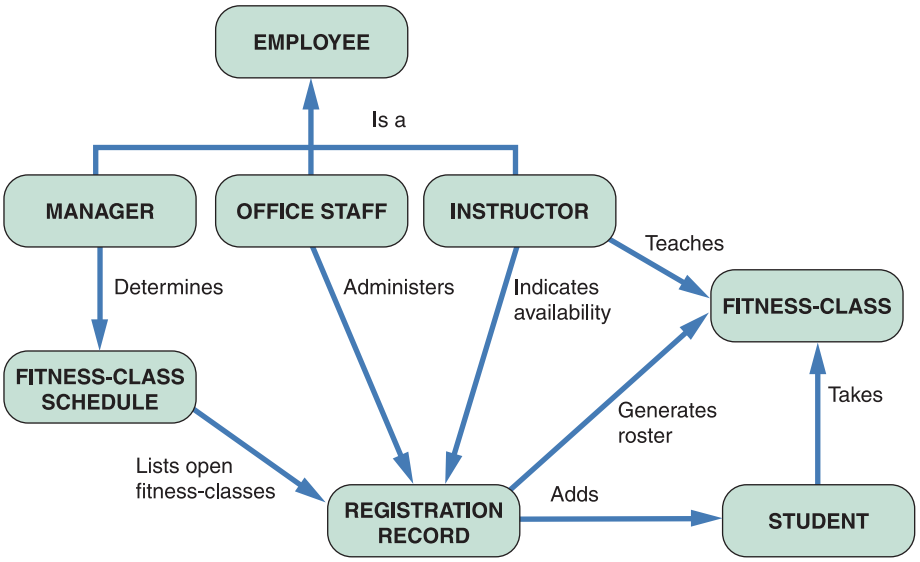


FIGURE 11-18 An object-relationship diagram for a fitness center.

Properly implemented, object-oriented development can speed up projects, reduce costs, and improve overall quality. However, these results are not always achieved. Organizations sometimes have unrealistic expectations and do not spend enough time learning about, preparing for, and implementing the OOD process. For example, no one would build a bridge without an analysis of needs, supporting data, and a detailed blueprint—and the bridge would not be opened for traffic until it had been carefully inspected and checked to ensure that all specifications were met. O-O software developers sometimes forget that the basic rules of architecture also apply to their projects.

In summary, to secure the potential benefits of OOD, systems analysts must carefully analyze, design, implement, test, and document their O-O projects.

11.4.2 Implementation of Object-Oriented Designs

When a programmer translates an O-O design into an application, he or she analyzes the classes, attributes, methods, and messages that are documented in the object model. During this process, the programmer makes necessary revisions and updates to class diagrams, sequence diagrams, state transition diagrams, and activity diagrams.

The programmer's main objective is to translate object methods into program code modules and determine what event or message will trigger the execution of each module. To accomplish the task, the programmer analyzes sequence diagrams and state transition diagrams that show the events and messages that trigger changes to an object. O-O applications are called event-driven, because each event, transaction, or message triggers a corresponding action. The programmer can represent the program steps in pseudocode initially or use CASE tools and code generators to create O-O code directly from the object model.

11.4.3 Object-Oriented Cohesion and Coupling

The principles of cohesion and coupling also apply to O-O application development. Classes should be as loosely coupled (independent of other classes) as possible. In addition, an object's methods also should be loosely coupled (independent of other

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methods) and highly cohesive (perform closely related actions). By following these principles, classes and objects are easier to understand and edit. O-O programmers who ignore cohesion and coupling concepts may end up creating a web of code that is difficult to maintain. When code is scattered in various places, editing becomes complicated and expensive.

11.5 Agile Development

As stated in Chapter 1, agile development is a distinctly different systems development method. It shares many of the steps found in traditional development but uses a highly iterative process. The development team is in constant communication with the primary user, who is called the **customer**, shaping and forming the system to match the customer's specifications. Agile development is aptly named because it is based on a quick and nimble development process that easily adapts to change. Agile development focuses on small teams, intense communication, and rapid development iterations. The four key values of agile software development are shown in Figure 11-19.

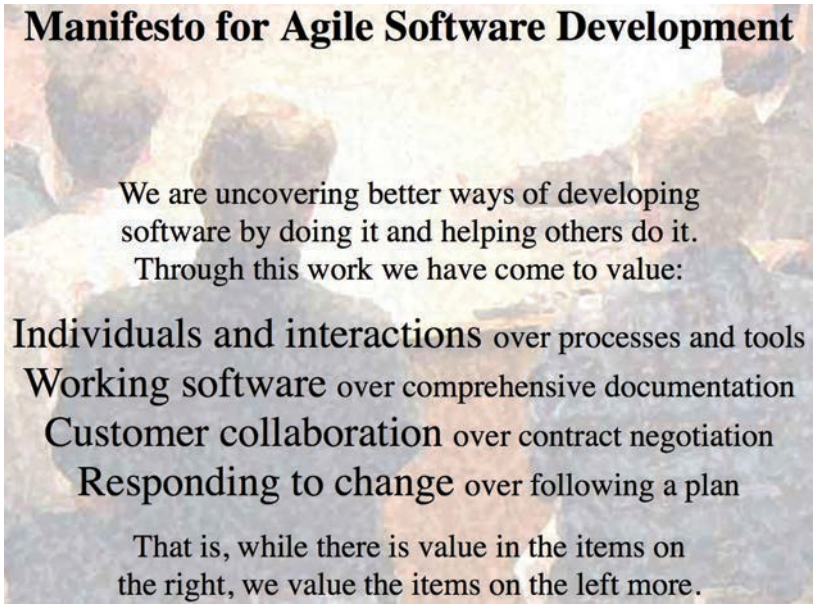


FIGURE 11-19 The manifesto for agile software development.
Source: Agile Software Development

Programmers can use popular agile-friendly languages such as Python, Ruby, and Perl. However, agile methods do not require a specific programming language, and programmers also use various O-O languages such as Java, C++, C#, and others.

As with traditional methodologies, agile development has both positive and negative characteristics. Today, agile methodology is very popular for software projects. Its supporters boast that it speeds up software development and delivers precisely what the customer wants, when the customer wants it, while fostering teamwork and empowering employees. However, there are drawbacks to this adaptive rather than predictive method. Critics of agile development often claim that because it focuses on quick iterations and fast releases, it lacks discipline and produces systems of questionable quality. In addition, agile methodology generally does not work as well for larger projects because of their complexity and the lack of focus on a well-defined end product.

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Before implementing agile development, the proposed system and development methods should be examined carefully. As experienced IT professionals know, a one-size-fits-all solution does not exist. For more information on agile methods, refer to the discussion of systems development methods in Chapter 1 and agile methods such as Scrum in Chapter 4.

11.5.1 Extreme Programming

XP is an agile development method. It is an iterative approach, as shown in Figure 11-20, where a team of users and developers immerse themselves in systems development. XP supporters emphasize values such as simplicity, communication, feedback, respect, and courage. Success requires strong commitment to the process, corporate support, and dedicated team members.



The Values of Extreme Programming

Extreme Programming (XP) is based on values. The rules we just examined are the natural extension and consequence of maximizing our values. XP isn't really a set of rules but rather a way to work in harmony with your personal and corporate values. Start with XP's values listed here then add your own by reflecting them in the changes you make to the rules.

Simplicity: We will do what is needed and asked for, but no more. This will maximize the value created for the investment made to date. We will take small simple steps to our goal and mitigate failures as they happen. We will create something we are proud of and maintain it long term for reasonable costs.

Communication: Everyone is part of the team and we communicate face to face daily. We will work together on everything from requirements to code. We will create the best solution to our problem that we can together.

Feedback: We will take every iteration commitment seriously by delivering working software. We demonstrate our software early and often then listen carefully and make any changes needed. We will talk about the project and adapt our process to it, not the other way around.

Respect: Everyone gives and feels the respect they deserve as a valued team member. Everyone contributes value even if it's simply enthusiasm. Developers respect the expertise of the customers and vice versa. Management respects our right to accept responsibility and receive authority over our own work.

Courage: We will tell the truth about progress and estimates. We don't document excuses for failure because we plan to succeed. We don't fear anything because no one ever works alone. We will adapt to changes when ever they happen.

FIGURE 11-20 The five core values of XP.
Source: ©2009, Don Wells

XP uses a concept called **pair programming**. In pair programming, two programmers work on the same task on the same computer; one drives (programs) while the other navigates (watches). The onlooker examines the code strategically to see the *forest* while the driver is concerned with the individual *trees* immediately in front of him or her. The two discuss their ideas continuously throughout the process.

Another important concept in XP is that unit tests are designed *before* code is written. This **test-driven development (TDD)** focuses on end results from the beginning and prevents programmers from straying from their goals. Because of the magnitude and intensity of the multicycle process, agile testing relies heavily on automated testing methods.

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11.5.2 User Stories

Suppose that a customer has requested a sales tracking system. The first step in an agile process, like any other development method, would be to define the system requirements. The customer begins by meeting with programmers and providing user stories. A **user story** is a short, simple requirements definition. Programmers review user stories to determine the project's requirements, priorities, and scope. Here are three user story examples:

- *As the sales manager, I want to identify fast- or slow-moving items so I can manage our inventory more effectively.*
- *As a store manager, I need enough lead time to replenish my stock, so I don't run out of hot items.*
- *As a sales representative, I want to offer the best selection of fast-selling items and clear out the old stock that is not moving.*

User stories do not deal with technical details and are so short that they are often written on index cards. Each user story is given a priority by the customer, so the requirements can be ranked. In addition, programmers assign a score to each user story that indicates the estimated difficulty of implementation. This information helps the team form a plan and assign its resources. Projects are often composed of many user stories, which taken together form *epics*, from which programmers can estimate the scope, time requirements, and difficulty of the project. In addition to the user stories, frequent face-to-face meetings with customers provide a higher level of detail as the project progresses.

11.5.3 Iterations and Releases

The team must also develop a **release plan**, which specifies when user stories will be implemented and the timing of the releases. Releases are relatively frequent, and each system release is like a prototype that can be tested and modified as needed.

User stories are implemented in a series of iteration cycles. An **iteration cycle** includes planning, designing, coding, and testing of one or more features based on user stories. At the beginning of each iteration cycle, which is often two weeks long, the team holds an **iteration planning meeting** to break down the user stories into specific tasks that are assigned to team members. As new user stories or features are added, the team reviews and modifies the release plan.

As with any development process, success is determined by the customer's approval. The programming team regularly meets with the customer, who tests prototype releases as they become available. This process usually results in additional user stories, and changes are implemented in the next iteration cycle. As the project's code changes during each iteration, obsolete code is removed and remaining code is restructured to keep the system up to date. The iteration cycles continue until all user stories have been implemented, tested, and accepted.

11.6 Coding

Coding is the process of turning program logic into specific instructions that the computer system can execute. Working from a specific design, a programmer uses a programming language to transform program logic into code statements. An individual programmer might create a small program, while larger programs typically are divided into modules that several individuals or groups can work on simultaneously.

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Each developer has their favorite programming environment and standards to make coding easier. Visual Basic, Java, and Python are examples of commonly used programming languages, and many commercial packages use a proprietary set of commands. As the trend toward Internet-based and mobile applications continues, HTML/XML, JavaScript, Swift, and other web-centric languages will be used extensively.

To simplify the integration of system components and reduce code development time, many programmers use an **integrated development environment (IDE)**. IDEs can make it easier to program interactive software products by providing built-in tools and advanced features, such as real-time error detection, syntax hints, highlighted code, class browsers, and version control. Apple Xcode and Microsoft .NET are popular IDEs. In addition to these commercial packages, programmers can use open-source IDEs such as Eclipse.

Earlier chapters explained that systems analysts use application generators, report writers, screen generators, fourth-generation languages, and other CASE tools that produce code directly from program design specifications. Some commercial applications can generate editable program code directly from macros, keystrokes, or mouse actions. For example, IBM's Rational toolset can generate code fragments based on UML design documents. This can help with QA.

11.7 Testing

After coding, a programmer must test each program to make sure it functions correctly. Later, programs are tested in groups, and finally the development team must test the entire system. The first step is to compile the program using a CASE tool or a language compiler. This process detects **syntax errors**, which are language grammar errors. The programmer corrects the errors until the program executes properly.

Next, the programmer desk checks the program. **Desk checking** is the process of reviewing the program code to spot **logic errors**, which produce incorrect results. This process can be performed by the person who wrote the program or by other programmers. Many organizations require a more formal type of desk checking called a **structured walk-through**, or **code review**.

Typically, a group of three to five IT staff members participates in code review. The group usually consists of project team members and might include other programmers and analysts who did not work on the project. The objective is to have a peer group identify errors, apply quality standards, and verify that the program meets the requirements of the system design specification. Errors found during a structured walk-through are easier to fix while coding is still in the developmental stages.

In addition to analyzing logic and program code, the project team usually holds a session with users called a **design walk-through**, to review the interface with a cross section of people who will work with the new system and ensure that all necessary features have been included. This is a continuation of the modeling and prototyping effort that began early in the systems development process.

The next step in application development is to initiate a sequence of unit testing, integration testing, and system testing, as shown in Figure 11-21.

11.7.1 Unit Testing

The testing of an individual program or module is called **unit testing**. The objective is to identify and eliminate execution errors that could cause the program to terminate abnormally and logic errors that could have been missed during desk checking.

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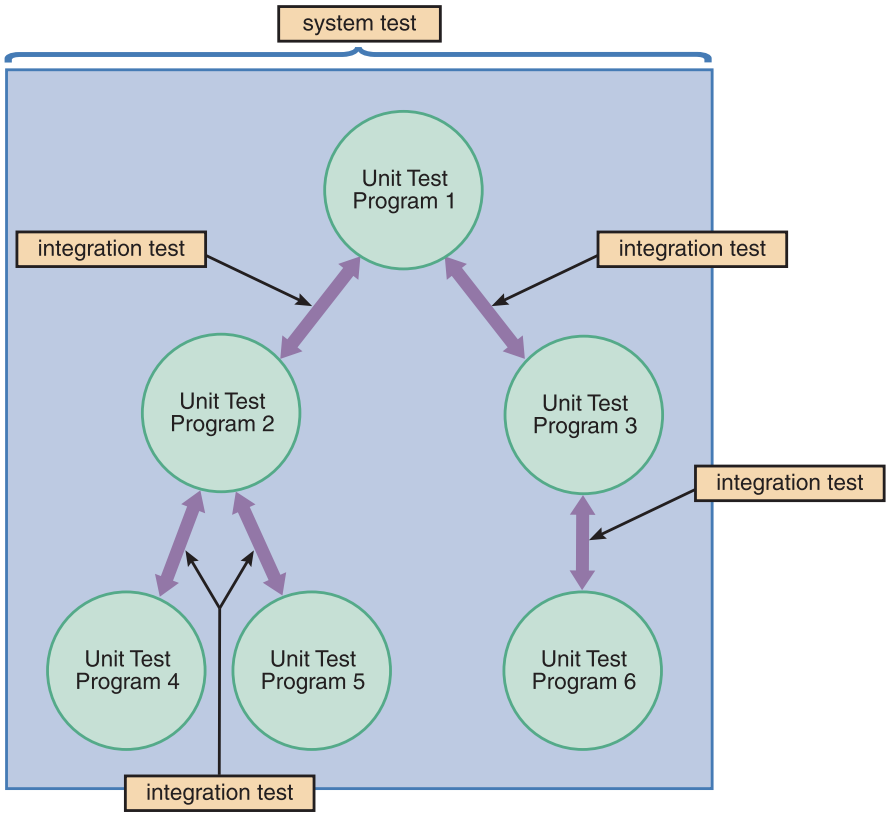


FIGURE 11-21 The first step in testing is unit testing, followed by integration testing and then system testing.

Test data should contain both correct data and erroneous data and should test all possible situations that could occur. For example, for a field that allows a range of numeric values, the test data should contain minimum values, maximum values, values outside the acceptable range, and alphanumeric characters. During testing, programmers can use software tools to determine the location and potential causes of program errors.

During unit testing, programmers must test programs that interact with other programs and files individually, before they are integrated into the system. This requires a technique called stub testing. In **stub testing**, the programmer simulates each program outcome or result and displays a message to indicate whether or not the program executed successfully. Each stub represents an entry or exit point that will be linked later to another program or data file.

To obtain an independent analysis, someone other than the programmer who wrote the program usually creates the test data and reviews the results. Systems analysts frequently create test data during the systems design phase as part of an overall test plan. A **test plan** consists of detailed procedures that specify how and when the testing will be performed, who will participate, and what test data will be used. A comprehensive test plan should include scenarios for every possible situation the program could encounter.

Regardless of who creates the test plan, the project manager or a designated analyst also reviews the final test results. Some organizations also require users to approve final unit test results.

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11.7.2 Integration Testing

Testing two or more programs that depend on each other is called **integration testing**. For example, consider an information system with a program that checks and validates customer credit status and a separate program that updates data in the customer master file. The output from the validation program becomes input to the master file update program. Testing the programs independently does not guarantee that the data passed between them is correct. Only by performing integration testing for this pair of programs can one ensure that the programs work together properly. Figure 11-21 shows integration testing for several groups of programs. Note that a program can have membership in two or more groups.

Systems analysts usually develop the data they use in integration testing. As is the case with all forms of testing, integration test data must consider both normal and unusual situations. For example, integration testing might include passing typical records between two programs, followed by blank records, to simulate an unusual event or an operational problem. Test data that simulates actual conditions should be used because the interface that links the programs is being tested. A testing sequence should not move to the integration test stage unless it has performed properly in all unit tests.

11.7.3 System Testing

After completing integration testing, **system testing** is performed, which involves the entire information system, as shown in Figure 11-21. A system test includes all likely processing situations and is intended to assure users, developers, and managers that the program meets all specifications and that all necessary features have been included.

During a system test, users enter data, including samples of actual, or live, data, perform queries, and produce reports to simulate actual operating conditions. All processing options and outputs are verified by users and the IT project development team to ensure that the system functions correctly. Commercial software packages must undergo system testing similar to that of in-house developed systems, although unit and integration testing usually are not performed. Regardless of how the system was developed, system testing has the following major objectives:

- Perform a final test of all programs
- Verify that the system will handle all input data properly, both valid and invalid
- Ensure that the IT staff has the documentation and instructions needed to operate the system properly and that backup and restart capabilities of the system are adequate (the details of creating this sort of documentation are discussed later in this chapter)
- Demonstrate that users can interact with the system successfully
- Verify that all system components are integrated properly and that actual processing situations will be handled correctly
- Confirm that the information system can handle predicted volumes of data in a timely and efficient manner

Successful completion of system testing is the key to user and management approval, which is why system tests sometimes are called **acceptance tests**. Final acceptance tests, however, are performed during systems installation and evaluation with actual user data, as described later in this chapter.

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How much testing is necessary depends on the situation and requires good judgment and input from other IT staff members, users, and management. Unfortunately, IT project managers often are pressured to finish testing quickly and hand the system over to users. Common reasons for premature or rushed testing are demands from users, tight systems development budgets, and demands from top management to finish projects early. Those pressures hinder the testing process and often have detrimental effects on the final product's quality.

Testing can be a cost-effective means of providing a quality product. Every error caught during testing eliminates potential expenses and operational problems. No system, however, is 100% error-free. Often, errors go undetected until the system becomes operational. Errors that affect the integrity or accuracy of data must be corrected immediately. Minor errors, such as typographical errors in the user interface, can be corrected later.

Some users want a system that is a completely finished product, while others realize that minor changes can be treated as maintenance items after the system is operational. In the final analysis, a decision must be made whether or not to postpone system installation if problems are discovered. If conflicting views exist, management will decide whether or not to install the system after a full discussion of the options.

CASE IN POINT 11.1: Your Move, Inc.

You work at Your Move, Inc., a large retailer specializing in games of all kinds. The company is in the final stages of developing a new inventory management system, and the IT manager wants you to handle the testing.

"Be sure you put lots of errors into the test data," she said. "Users are bound to make mistakes, and we need to design built-in safeguards that will catch the mistakes, and either fix them automatically or alert the user to the problem."

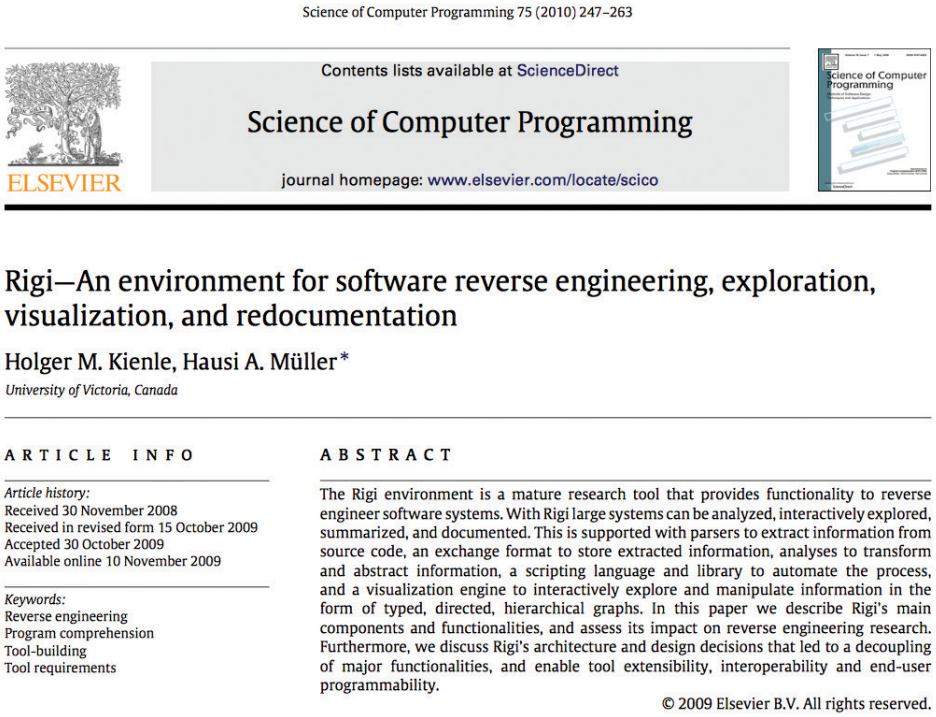
Of course, this comment makes a lot of sense, but you've never done this before, and you wonder how to proceed. Should you try to invent every possible data error? How will you know that you've thought of every situation that could occur? Consider the problem, develop an approach, and write up your plan in a brief memo.

11.8 Documentation

Documentation describes an information system and helps the users, managers, and IT staff who must interact with it. Accurate documentation can reduce system downtime, cut costs, and speed up maintenance tasks. Figure 11-22 shows an example of the Rigi research environment that can automate the documentation process and help software developers generate accurate, comprehensive reference material through detailed source code analysis.

Documentation is essential for successful system operation and maintenance. In addition to supporting a system's users, accurate documentation is essential for IT staff members who must modify the system, add a new feature, or perform maintenance. Documentation includes program documentation, system documentation, operations documentation, and user documentation.

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Rigi—An environment for software reverse engineering, exploration, visualization, and redocumentation

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ABSTRACT

The Rigi environment is a mature research tool that provides functionality to reverse engineer software systems. With Rigi large systems can be analyzed, interactively explored, summarized, and documented. This is supported with parsers to extract information from source code, an exchange format to store extracted information, analyses to transform and abstract information, a scripting language and library to automate the process, and a visualization engine to interactively explore and manipulate information in the form of typed, directed, hierarchical graphs. In this paper we describe Rigi's main components and functionalities, and assess its impact on reverse engineering research. Furthermore, we discuss Rigi's architecture and design decisions that led to a decoupling of major functionalities, and enable tool extensibility, interoperability and end-user programmability.

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FIGURE 11-22 Rigi is a research environment that uses reverse engineering technology to provide software redocumentation capabilities to support program understanding.
Source: ©2009, Elsevier

11.8.1 Program Documentation

Program documentation describes the inputs, outputs, and processing logic for all program modules. The program documentation process starts in the systems analysis phase and continues during systems implementation. Analysts prepare overall documentation, such as process descriptions and report layouts, early in the SDLC. This documentation guides programmers, who construct modules that are well supported by internal and external comments and descriptions that can be understood and maintained easily. A systems analyst usually verifies that program documentation is complete and accurate.

System developers also use **defect tracking software**, sometimes called **bug tracking software**, to document and track program defects, code changes, and replacement code, called **patches**.

11.8.2 System Documentation

System documentation describes the system's functions and how they are implemented. System documentation includes data dictionary entries, DFDs, object models, screen layouts, source documents, and the systems request that initiated the project. System documentation is a necessary reference material for the programmers and analysts who must support and maintain the system.

Most of the system documentation is prepared during the systems analysis and systems design phases. During the systems implementation phase, an analyst must review prior documentation to verify that it is complete, accurate, and up to date, including any changes made during the implementation process. For example, if a screen or report has been modified, the analyst must update the documentation. Updates to the system documentation should be made in a timely manner to prevent oversights.

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11.8.3 Operations Documentation

If the information system environment involves a mainframe or centralized servers, the analyst must prepare documentation for the IT group that supports centralized operations. A mainframe installation might require the scheduling of batch jobs and the distribution of printed reports. In this type of environment, the IT operations staff serves as the first point of contact when users experience problems with the system.

Operations documentation contains all the information needed for processing and distributing online and printed output. Typical operations documentation includes the following information:

- Program, systems analyst, programmer, and system identification
- Scheduling information for printed output, such as report run frequency and deadlines
- Input files and where they originate; output files and destinations
- Email and report distribution lists
- Special forms required, including online forms
- Error and informational messages to operators and restart procedures
- Special instructions, such as security requirements

Operations documentation should be clear, concise, and available online if possible. If the IT department has an operations group, the documentation should be reviewed with them, early and often, to identify any problems. By keeping the operations group informed at every phase of the SDLC, operations documentation can be developed as the project progresses.

11.8.4 User Documentation

User documentation consists of instructions and information to users who will interact with the system and includes user manuals, help screens, and online tutorials. Programmers or systems analysts usually create program documentation and system documentation. To produce effective and clear user documentation—and hence have a successful project—someone with expert skills in this area doing the development is needed, just as someone with expert skills developing the software is needed. The skill set required to develop documentation usually is not the same as that to develop a system. This is particularly true in the world of online documentation, which needs to coordinate with print documentation and intranet and Internet information. Technical writing requires specialized skills, and competent technical writers are valuable members of the IT team.

Just as a system cannot be thrown together in several days, documentation cannot be added at the end of the project. While this has always been true of traditional user documentation, this is an even more critical issue now that online help and context-sensitive help are often used. Context-sensitive help is part of the program and it has to be tested too.

Systems analysts usually are responsible for preparing documentation to help users learn the system. In larger companies, a technical support team that includes technical writers might assist in the preparation of user documentation and training materials. Regardless of the delivery method, user documentation must be clear, understandable, and readily accessible to users at all levels.

User documentation includes the following:

- A system overview that clearly describes all major system features, capabilities, and limitations

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- Description of source document content, preparation, processing, and samples
- Overview of menu and data entry screen options, contents, and processing instructions
- Examples of reports that are produced regularly or available at the user's request, including samples
- Security and audit trail information
- Explanation of responsibility for specific input, output, or processing requirements
- Procedures for requesting changes and reporting problems
- Examples of exceptions and error situations
- Frequently asked questions (FAQs)
- Explanation of how to get help and procedures for updating the user manual

11.8.5 Online Documentation

Most users now prefer **online documentation**, which provides immediate help when they have questions or encounter problems. Many users are accustomed to context-sensitive help screens, hints and tips, hypertext, on-screen demos, and other user-friendly features commonly found in popular software packages; they expect the same kind of support for in-house developed software.

If the system will include online documentation, that fact needs to be identified as one of the system requirements. If someone other than the analysts who are developing the system will create the documentation, that person or group needs to be involved as early as possible to become familiar with the software and begin developing the required documentation and support material. In addition, system developers must determine whether the documentation will be available from within the program or as a separate entity in the form of a tutorial, slide presentation, reference manual, or website. If necessary, links should be created within the program that will take the user to the appropriate documentation.

Effective online documentation is an important productivity tool because it empowers users and reduces the time that IT staff members must spend in providing telephone, email, or face-to-face assistance. Interactive tutorials are especially popular with users who like to learn by doing, and visual impact is very important. The use of YouTube as a host for tutorial videos has become commonplace. For example, Figure 11-23 shows LearnCode.academy, which is a popular YouTube channel offering free web development and website design tutorials.

In addition to program-based assistance, the Internet offers an entirely new level of comprehensive, immediate support. Many programs include links to websites, intranet sites, and Internet-based technical support. For example, the Cisco Systems website shown in Figure 11-24 offers a wide range of support services and social media links that allow Cisco users to collaborate and share their knowledge.

Although online documentation is essential, written documentation material also is valuable, especially in training users and for reference purposes. Systems analysts or technical writers usually prepare the manual, but many companies invite users to review the material and participate in the development process.

No matter what form of user documentation the system requires, keep in mind that it can take a good deal of time to develop. The time between finishing software coding and the time when a complete package—including documentation—can be released to users is entirely dependent on how well the documentation is planned in advance. If

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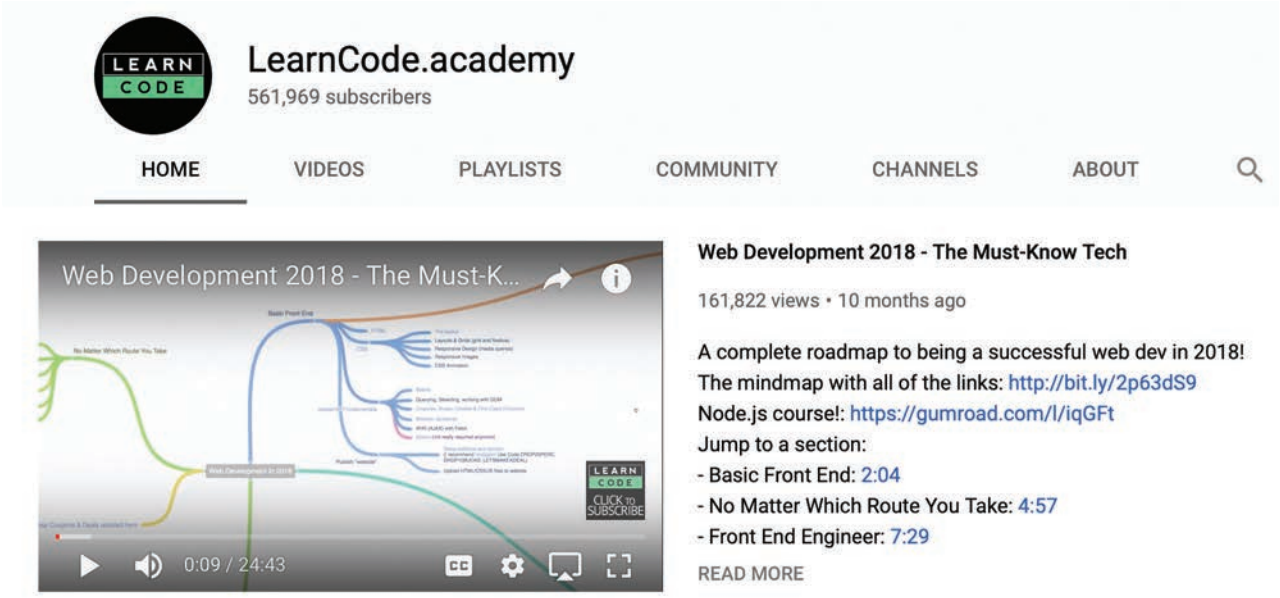


FIGURE 11-23 LearnCode.academy is a popular YouTube channel offering free web development tutorials, website design tutorials, and more.

Source: Learn Code

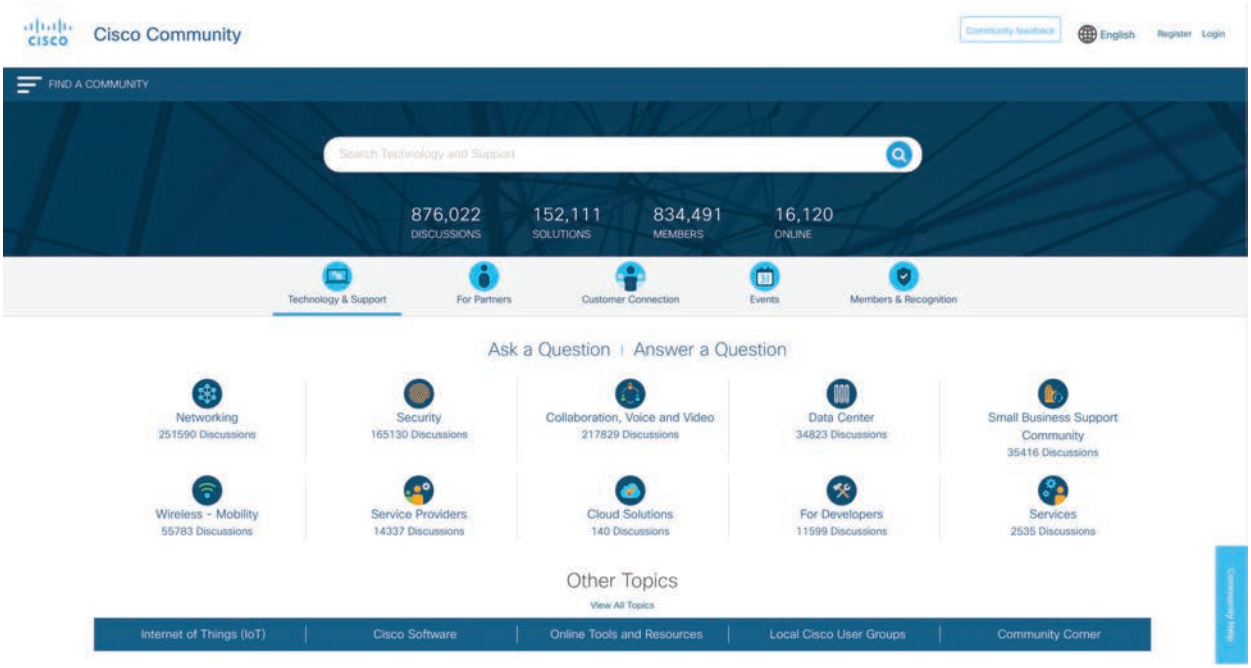


FIGURE 11-24 The Cisco Support Community invites users to contribute valuable experience and documentation using social media.

Source: Cisco Support Community

the completion of the project includes providing user documentation, this issue needs to be addressed from the very beginning of the project. Determining what the user documentation requirements are and ascertaining who will complete the documents are critical to a timely release of the project.

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Neglecting user documentation issues until after all the program is complete often leads to one of two things: (1) the documentation will be thrown together quickly just to get it out the door on time, and it more than likely will be inadequate; or (2) it will be done correctly, and the product release will be delayed considerably.

User training typically is scheduled when the system is installed. The training sessions offer an ideal opportunity to distribute the user manual and explain the procedures for updating it in the future. Training for users, managers, and IT staff is described later in this chapter.

11.9 Installation

After system testing is complete, the results are presented to management. The test results should be described, the status of all required documentation updated, and input from users who participated in system testing summarized. Detailed time schedules, cost estimates, and staffing requirements for making the system fully operational should also be provided. If system testing produced no technical, economical, or operational problems, management determines a schedule for system installation.

The following system installation tasks are performed for every information systems project, whether the application is developed in-house or purchased as a commercial package:

- Prepare a separate operational and test environment
- Perform system changeover
- Perform data conversion
- Provide training for users, managers, and IT staff
- Carry out post-implementation tasks

11.9.1 Operational and Test Environments

Recall that an environment, or platform, is a specific combination of hardware and software. The environment for the actual system operation is called the **operational environment** or **production environment**. The environment that analysts and programmers use to develop and maintain programs is called the **test environment**. A separate test environment is necessary to maintain system security and integrity and protect the operational environment. Typically, the test environment resides on a limited-access workstation or server located in the IT department.

Access to the operational environment is limited to users and must strictly be controlled. Systems analysts and programmers should not have access to the operational environment except to correct a system problem or to make authorized modifications or enhancements. Otherwise, IT department members have no reason to access the day-to-day operational system.

The test environment for an information system contains copies of all programs, procedures, and test data files. Before making any changes to an operational system, the analyst must verify them in the test environment and obtain user approval. Figure 11-25 shows the differences between test environments and operational environments.

An effective testing process is essential to ensuring product quality. Every experienced systems analyst can tell a story about an apparently innocent program change that was introduced without being tested properly. In those stories, the

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innocent change invariably ends up causing some unexpected and unwanted changes to the program. After any modification, the same acceptance tests that were run when the system was developed should be repeated. By restricting access to the operational area and performing all tests in a separate environment, the system can be protected and problems that could damage data or interrupt operations avoided.

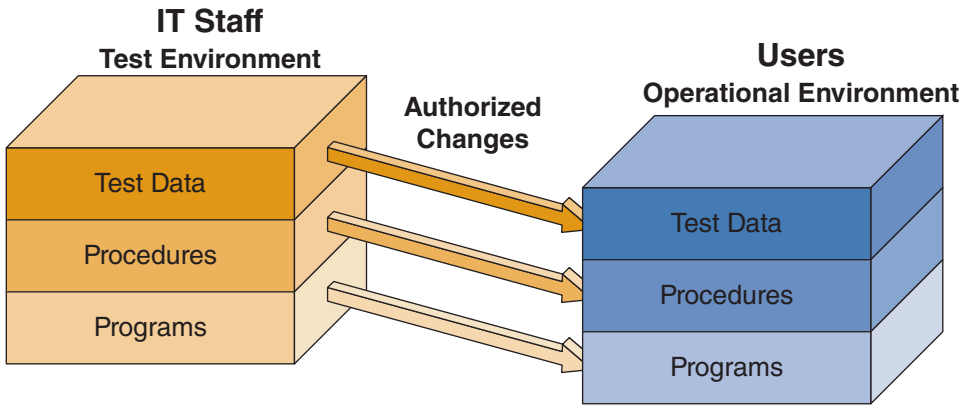


FIGURE 11-25 The test environment versus the operational environment. Note that access to the test environment is limited to IT staff, while the operational environment is restricted to users.

The operational environment includes hardware and software configurations and settings, system utilities, telecommunications resources, and any other components that might affect system performance. Because network capability is critically important in a client/server environment, connectivity, specifications, and performance must be verified before installing any applications. All communications features in the test environment should be checked carefully and then checked again after loading the applications into the operational environment. The documentation should identify all network specifications and settings, including technical and operational requirements for communications hardware and software. If network resources must be built or upgraded to support the new system, the platform must be tested rigorously before system installation begins.

11.9.2 System Changeover

System changeover is the process of putting the new information system online and retiring the old system. Changeover can be rapid or slow, depending on the method. The four changeover methods are direct cutover, parallel operation, pilot operation, and phased operation. Direct cutover is similar to throwing a switch that instantly changes over from the old system to the new. Parallel operation requires that both systems run simultaneously for a specified period, which is the slowest method. The other methods, pilot and phased operation, fall somewhere between direct cutover and parallel operation. Figure 11-26 illustrates the four system changeover methods.

DIRECT CUTOVER: The direct cutover approach causes the changeover from the old system to the new system to occur immediately when the new system becomes operational. Direct cutover usually is the least expensive changeover method because the IT group has to operate and maintain only one system at a time.

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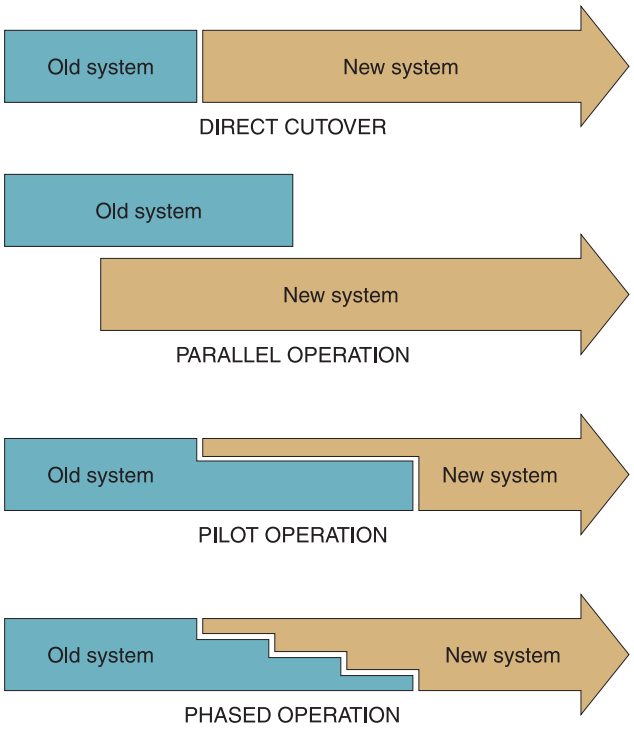


FIGURE 11-26 The four system changeover methods.

Direct cutover, however, involves more risk than other changeover methods. Regardless of how thoroughly and carefully testing and training is conducted, some difficulties can arise when the system goes into operation. Problems can result from data situations that were not tested or anticipated or from errors caused by users or operators. A system also can encounter difficulties because live data typically occurs in much larger volumes than test data.

Although initial implementation problems are a concern with all four changeover methods, they are most significant when the direct cutover approach is used. Detecting minor errors also is more difficult with direct cutover because users cannot verify current output by comparing it to output from the old system. Major errors can cause a system process to terminate abnormally, and with the direct cutover method, reverting to the old system as a backup option is not possible.

Companies often choose the direct cutover method for implementing commercial software packages because they feel that commercial packages involve less risk of total system failure. Commercial software is certainly not risk-free, but the software vendor usually maintains an extensive knowledge base and can supply reliable, prompt fixes for most problems.

For systems developed in-house, most organizations use direct cutover only for noncritical situations. Direct cutover might be the only choice, however, if the operating environment cannot support both the old and new systems or if the old and new systems are incompatible.

Timing is very important when using a direct cutover strategy. Most systems operate on weekly, monthly, quarterly, and yearly cycles. For example, consider a payroll system that produces output on a weekly basis. Some employees are paid twice a month, however, so the system also operates semimonthly. Monthly, quarterly, and annual reports also require the system to produce output at the end of every month, quarter,

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and year. When a cyclical information system is implemented in the middle of any cycle, complete processing for the full cycle requires information from both the old and the new systems. To minimize the need to require information from two different systems, cyclical information systems usually are converted using the direct cutover method at the beginning of a quarter, calendar year, or fiscal year.

PARALLEL OPERATION: The **parallel operation** changeover method requires that both the old and the new information systems operate fully for a specified period. Data is input into both systems, and output generated by the new system is compared with the equivalent output from the old system. When users, management, and the IT group are satisfied that the new system operates correctly, the old system is terminated.

The most obvious advantage of parallel operation is lower risk. If the new system does not work correctly, the company can use the old system as a backup until appropriate changes are made. It is much easier to verify that the new system is working properly under parallel operation than under direct cutover, because the output from both systems is compared and verified during parallel operation.

Parallel operation, however, does have some disadvantages. First, it is the costliest changeover method. Because both the old and the new systems are in full operation, the company pays for both systems during the parallel period. Users must work in both systems and the company might need temporary employees to handle the extra workload. In addition, running both systems might place a burden on the operating environment and cause processing delays.

Parallel operation is not practical if the old and new systems are incompatible technically or if the operating environment cannot support both systems. Parallel operation also is inappropriate when the two systems perform different functions or if the new system involves a new method of business operations.

PILOT OPERATION: The **pilot operation** changeover method involves implementing the complete new system at a selected location of the company. A new sales reporting system, for instance, might be implemented in only one branch office, or a new payroll system might be installed in only one department. In these examples, the group that uses the new system first is called the **pilot site**. During pilot operation, the old system continues to operate for the entire organization, including the pilot site. After the system proves successful at the pilot site, it is implemented in the rest of the organization, usually using the direct cutover method. Therefore, pilot operation is a combination of parallel operation and direct cutover methods.

Restricting the implementation to a pilot site reduces the risk of system failure, compared with a direct cutover method. Operating both systems for only the pilot site is less expensive than a parallel operation for the entire company. In addition, if a parallel approach to complete the implementation is used later on, the changeover period can be much shorter if the system proves successful at the pilot site.

PHASED OPERATION: The **phased operation** changeover method allows the new system to be implemented in stages, or modules. For example, instead of implementing a new manufacturing system all at once, the materials management subsystem is installed first, then the production control subsystem, then the job cost subsystem, and so on. Each subsystem can be implemented by using any of the other three changeover methods.

Analysts sometimes confuse phased and pilot operation methods. Both methods combine direct cutover and parallel operation to reduce risks and costs. With phased

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operation, however, only a part of the system is given to all users, while pilot operation provides the entire system but to only some users.

One advantage of a phased approach is that the risk of errors or failures is limited to the implemented module only. For instance, if a new production control subsystem fails to operate properly, that failure might not affect the new purchasing subsystem or the existing shop floor control subsystem.

Phased operation is less expensive than full parallel operation because the analyst has to work with only one part of the system at a time. A phased approach is not possible, however, if the system cannot be separated easily into logical modules or segments. In addition, if the system involves a large number of separate phases, phased operation can cost more than a pilot approach.

Figure 11-27 shows that each changeover method has risk and cost factors. A systems analyst must weigh the advantages and disadvantages of each method and recommend the best choice in a given situation. The final changeover decision will be based on input from the IT staff, users, and management—and the choice must reflect the nature of the business and the degree of acceptable risk.

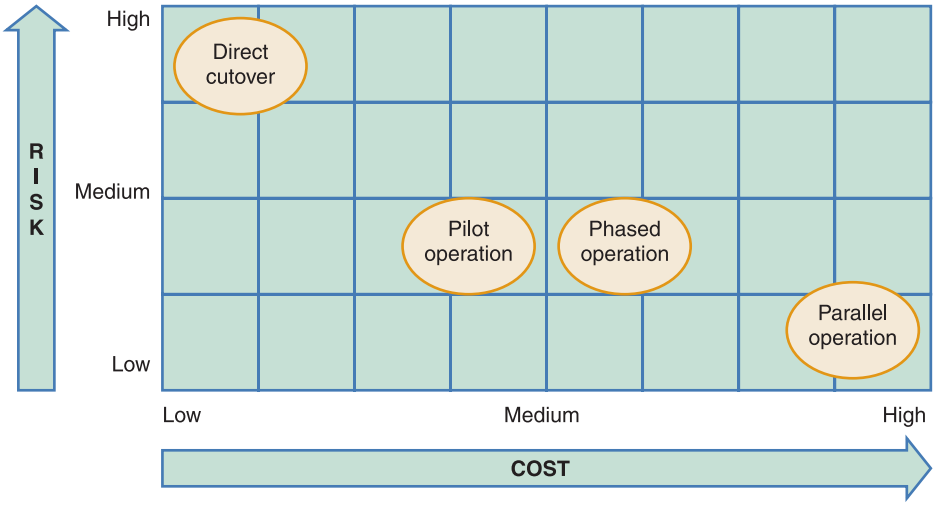


FIGURE 11-27 Relative risk and cost characteristics of the four changeover methods.

CASE IN POINT 11.2: GLOBAL COOLING

You are a systems analyst at Global Cooling, a leading manufacturer of air conditioning units. You are leading a team that is developing a new production scheduling system. The project is now in the application development stage. You are in the final stages of integration testing. Your supervisor is eager to implement the new application ahead of schedule and asked if you could trim system testing from two weeks to three days and use a direct cutover method instead of the parallel changeover method that originally was planned. Write a brief memo expressing your views.

11.9.3 Data Conversion

Data conversion is an important part of the system installation process. During **data conversion**, existing data is loaded into the new system. Depending on the system, data conversion can be done before, during, or after the operational environment is

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complete. A data conversion plan should be developed as early as possible, and the conversion process should be tested when the test environment is developed.

When a new system replaces an existing system, the data conversion process should be automated, if possible. The old system might be capable of exporting data in an acceptable format for the new system or in a standard format, such as ASCII or ODBC. **Open database connectivity (ODBC)** is an industry-standard protocol that allows DBMSs from various vendors to interact and exchange data. Most database vendors provide ODBC drivers, which are a form of middleware. As discussed in Chapter 10, middleware connects dissimilar applications and enables them to communicate.

If a standard format is not available, a program to extract the data and convert it to an acceptable format must be developed. Data conversion is more difficult when the new system replaces a manual system, because all data must be entered manually unless it can be scanned. Even when the data conversion is automated, a new system often requires additional data items, which might require manual entry.

Strict input controls should be maintained during the conversion process, when data is extremely vulnerable. System control measures should be in place and operational to protect data from unauthorized access and to help prevent erroneous input.

Even with careful data conversion and input controls, some errors will occur. For example, duplicate customer records or inconsistent part numbers might have been tolerated by the old system but will cause the new system to crash. Most organizations require that users verify all data, correct all errors, and supply every missing data item during conversion. Although the process can be time consuming and expensive, it is essential that the new system be loaded with accurate, error-free data.

11.9.4 Training

No system can be successful without proper training, whether it involves software, hardware, or manufacturing. A successful information system requires training for users, managers, and IT staff members. The entire systems development effort can depend on whether or not people understand the system and know how to use it effectively.

TRAINING PLAN: A **training plan** should be considered early in the systems development process. As documentation is created, consider how to use the material in future training sessions. When the system is implemented, it is essential to provide the right training for the right people at the right time. The first step is to identify who should receive training and what training is needed. The organization should be carefully examined to determine how the system will support business operations and who will be involved or affected. Figure 11-28 shows specific training topics for users, managers, and IT staff. Note that each group needs a mix of general background and detailed information to understand and use the system.

As shown in Figure 11-28, the three main groups for training are users, managers, and IT staff. A manager does not need to understand every submenu or feature, but he or she does need a system overview to ensure that users are being trained properly and are using the system correctly. Similarly, users need to know how to perform their day-to-day job functions, but they do not need to know how the company allocates system operational charges among user departments. IT staff people probably need the most information. To support the new system, they must have a clear understanding of how the system functions, how it supports business requirements, and the skills that users need to operate the system and perform their tasks.

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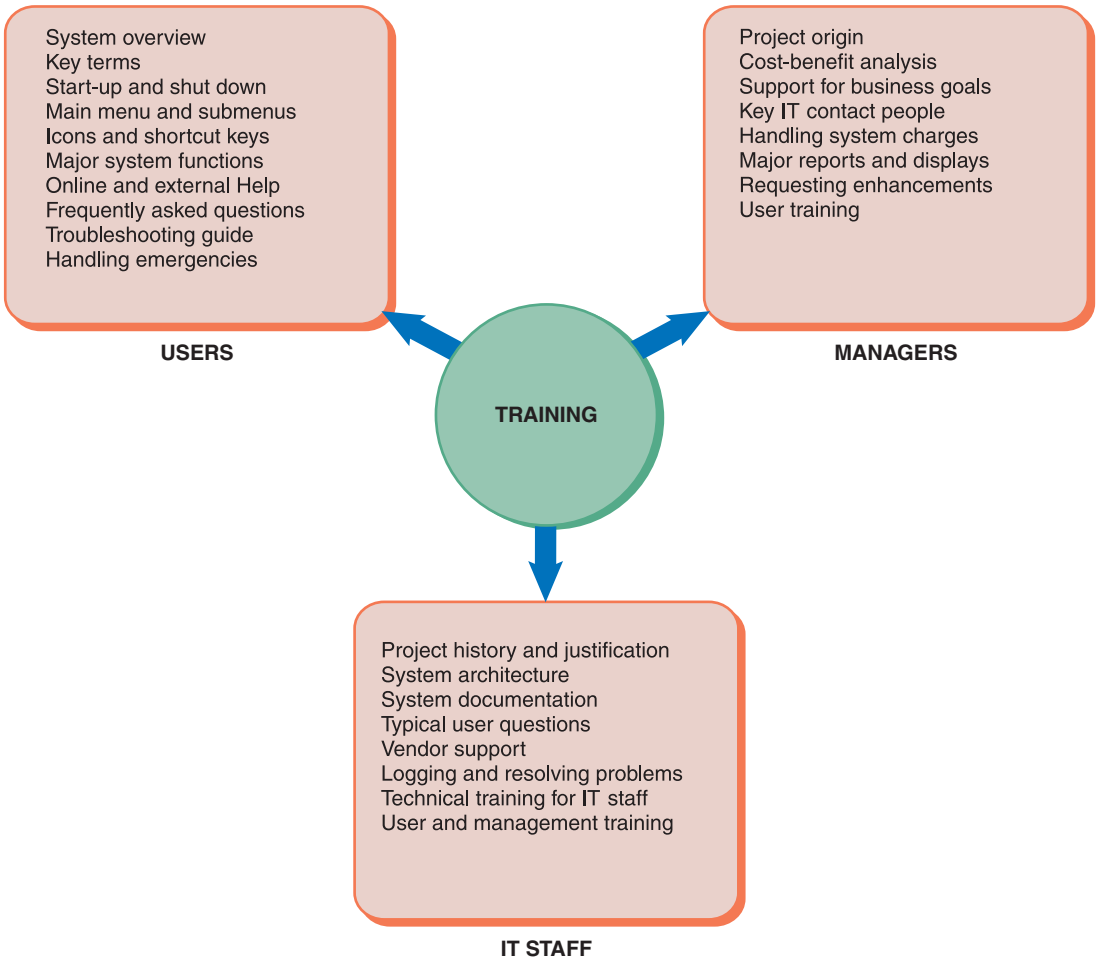


FIGURE 11-28 Examples of training topics for three different groups. Users, managers, and IT staff members have different training needs.

After the objectives are identified, how the company will provide training must be determined. The main choices are to obtain training from vendors, outside training firms, or use IT staff and other in-house resources.

VENDOR TRAINING: If the system includes the purchase of software or hardware, then vendor-supplied training is one of the features that should be included in the requests for proposal (RFP) and requests for quotation (RFQ) that are sent to potential vendors.

Many hardware and software vendors offer training programs free or at a nominal cost for the products they sell. In other cases, the company might negotiate the price for training, depending on their relationship with the vendor and the prospect of future purchases. The training usually is conducted at the vendor's site by experienced trainers who provide valuable hands-on experience. If a large number of people need training, classes may be held at the company's location.

Vendor training often gives the best return on training dollars because it is focused on products that the vendor developed. The scope of vendor training, however, usually is limited to a standard version of the vendor's software or hardware. The vendor's training may have to be supplemented with in-house training, especially if the IT staff customized the vendor's package.

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WEBINARS, PODCASTS, AND TUTORIALS: Many vendors offer web-based training options, including webinars, podcasts, and tutorials. A **webinar**, which combines the words *web* and *seminar*, is an Internet-based training session that provides an interactive experience. Most webinars are scheduled events with a group of preregistered users and an online presenter or instructor. A prerecorded webinar session also can be delivered as a **webcast**, which is a one-way transmission, whenever a user wants or needs training support.

A **podcast** refers to a web-based broadcast that allows a user to download multimedia files to a PC or portable device. Podcasts can be prescheduled, made available on demand, or delivered as automatic updates, depending on a user's preference. An advantage of a podcast is that subscribers can access the recorded material anywhere, anytime.

A **tutorial** is a series of online interactive lessons that present material and provide a dialog with users. Software vendors can develop tutorials, or a company's IT team can develop them. They can also be developed by third parties for popular software packages and sold separately online.

OUTSIDE TRAINING RESOURCES: Independent training firms can also provide in-house hardware or software training. If vendor training is not practical and the project organization does not have the internal resources to perform the training, outside training consultants can be a viable alternative.

The rapid expansion of information technology has produced tremendous growth in the computer-training field. Many training consultants, institutes, and firms are available that provide either standardized or customized training packages. For example, many people now use one of the many sources of online training, such as Udemy shown in Figure 11-29, to satisfy their training needs. Assistance can also be sought from nonprofit sources with an interest in training, including universities, industry associations, and information management organizations.

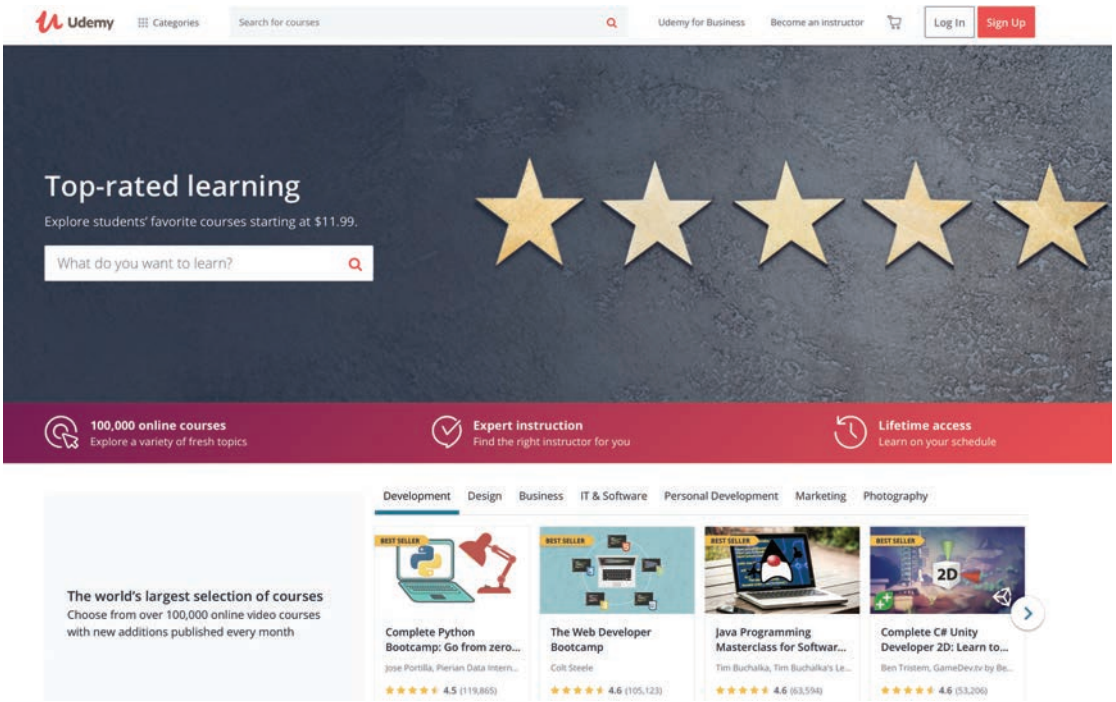


FIGURE 11-29 Udemy is one of many sources of online training.
Source: Udemy.com

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TRAINING TIPS: The IT staff and user departments often share responsibility for developing and conducting training programs for internally developed software. If the organization has a service desk, their staff might be able to handle user training.

Multimedia is an effective training method. Presentation software, such as Microsoft PowerPoint or Apple Keynote, can be used to design training sessions that combine slides, animation, and sound. Programs that capture actual keystrokes and mouse actions, such as Camtasia and Panopto (shown in Figure 11-30), can be used to replay the screens as a demonstration for users. If a media or graphic arts group is available, they can help prepare training aids such as videos, charts, and other instructional materials.

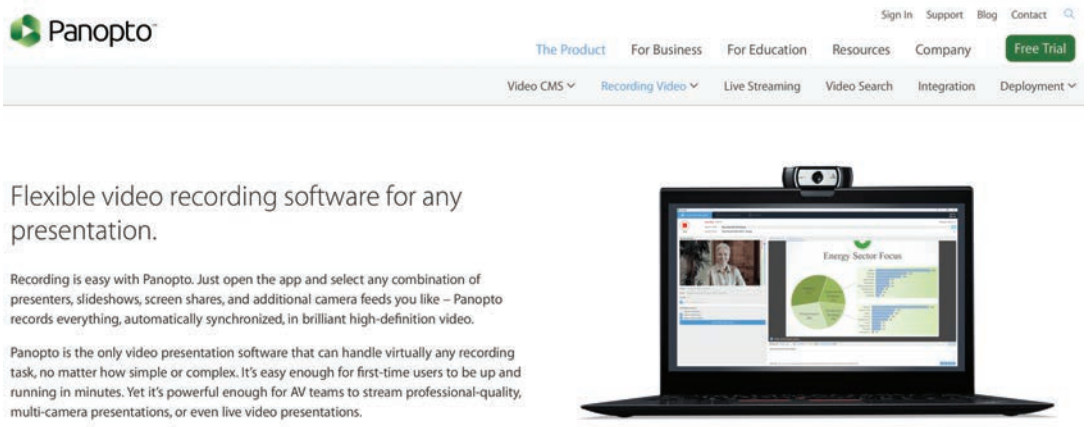


FIGURE 11-30 Panopto is a screen capture and video presentation program that can be used to prepare webcasts and online learning materials.
Source: Panopto.com

Keep the following guidelines in mind when developing a training program:

- *Train people in groups, with separate training programs for distinct groups.* Group training makes the most efficient use of time and training facilities. In addition, if the group is small, trainees can learn from the questions and problems of others. A training program must address the job interests and skills of a wide range of participants. For example, IT staff personnel and users require very different information. Problems often arise when some participants have technical backgrounds and others do not. A single program will not meet everyone's needs.
- *Select the most effective place to conduct the training.* Training employees at the company's location offers several advantages. Employees incur no travel expense, they can respond to local emergencies that require immediate attention, and training can take place in the actual environment where the system will operate. There can be some disadvantages, however. Employees who are distracted by telephone calls and other duties will not get the full benefit of the training. In addition, using the organization's computer facilities for training can disrupt normal operations and limit the amount of actual hands-on training.
- *Provide for learning by hearing, seeing, and doing.* Some people learn best from lectures, discussions, and question-and-answer sessions. Others learn best

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from viewing demonstrations or from reading documentation and other material. Most people learn best from hands-on experience. Training that supports each type of learning should be provided.

- *Rely on previous trainees*. After one group of users has been trained, they can assist others. Users often learn more quickly from coworkers who share common experience and job responsibilities. Using a **train-the-trainer** strategy, knowledgeable users can be selected who then conduct sessions for others. When utilizing train-the-trainer techniques, the initial training must include not only the use of the application or system but also some instruction on how to present the materials effectively.

INTERACTIVE TRAINING: Usually, a relationship exists between training methods and costs. Training an airline pilot in a state-of-the-art simulator is quite different from helping corporate users learn a new inventory system. Obviously, training budgets are business decisions, and IT staff sometimes has to work with the resources that are available, rather than the resources they wish they had. Most people prefer hands-on training. However, other less-expensive methods can be used, including training manuals, printed handouts, and online materials.

If a new system is being launched and the resources to develop formal training materials are lacking, a series of dialog boxes that respond with help information and suggestions whenever users select various menu topics can still be designed. A good user interface also includes helpful error messages and hints, as discussed in Chapter 8. However, the most effective training is interactive, self-paced, and multimedia-based. Online training and video tutorials are discussed in the following sections.

ONLINE TRAINING: Regardless of the instructional method, training lessons should include step-by-step instructions for using the features of the information system. Training materials should resemble actual screens, and tasks should be typical of a user's daily work—the more realistic, the better. Video lessons are particularly popular online. For example, Figure 11-31 shows a sample lesson on learning Python in an online tutorial from lynda.com.

Sophisticated online training systems may offer interactive sessions where users can perform practice tasks and view feedback. Online training materials also should include a reference section that summarizes all options and commands, lists all possible error messages, and lists what actions the user should take when a problem arises.

When training is complete, many organizations conduct a full-scale test, or **simulation**, which is a dress rehearsal for users and IT support staff. Organizations include all procedures, such as those that they execute only at the end of a month, quarter, or year, in the simulation. As questions or problems arise, the participants consult the system documentation, help screens, or each other to determine appropriate answers or actions. This full-scale test provides valuable experience and builds confidence for everyone involved with the new system.

11.9.5 Post-Implementation Tasks

Once the new system is installed and operational, two additional tasks must be performed: (1) prepare a post-implementation evaluation, and (2) deliver a final report to management.

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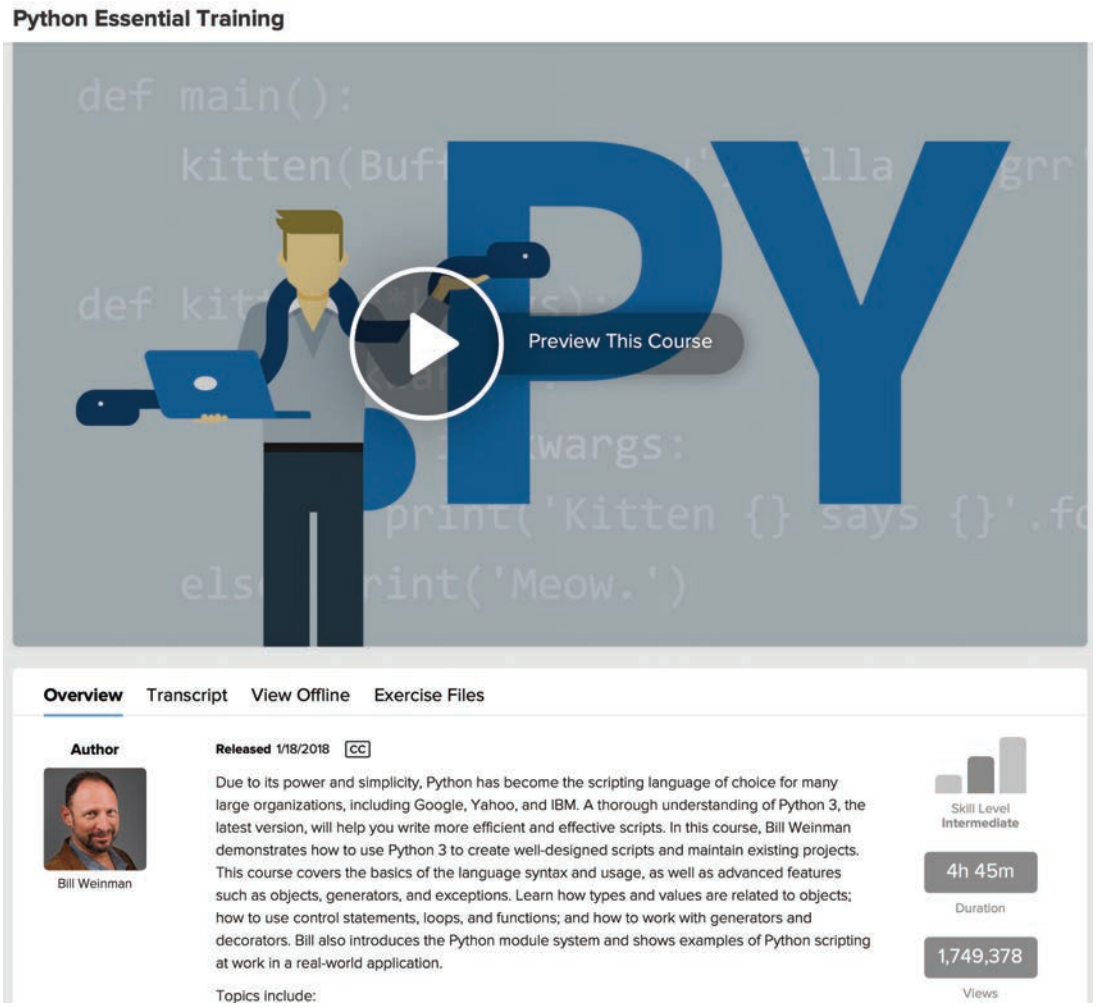


FIGURE 11-31 A sample lesson on learning Python in an online tutorial from lynda.com.
Source: LinkedIn Corporation

POST-IMPLEMENTATION EVALUATION: A post-implementation evaluation assesses the overall quality of the information system. The evaluation verifies that the new system meets specified requirements, complies with user objectives, and produces the anticipated benefits. In addition, by providing feedback to the development team, the evaluation also helps improve IT development practices for future projects.

A post-implementation evaluation should examine all aspects of the development effort and the end product—the developed information system. A typical evaluation includes feedback for the following areas:

- Accuracy, completeness, and timeliness of information system output
- User satisfaction
- System reliability and maintainability
- Adequacy of system controls and security measures
- Hardware efficiency and platform performance
- Effectiveness of database implementation
- Performance of the IT team

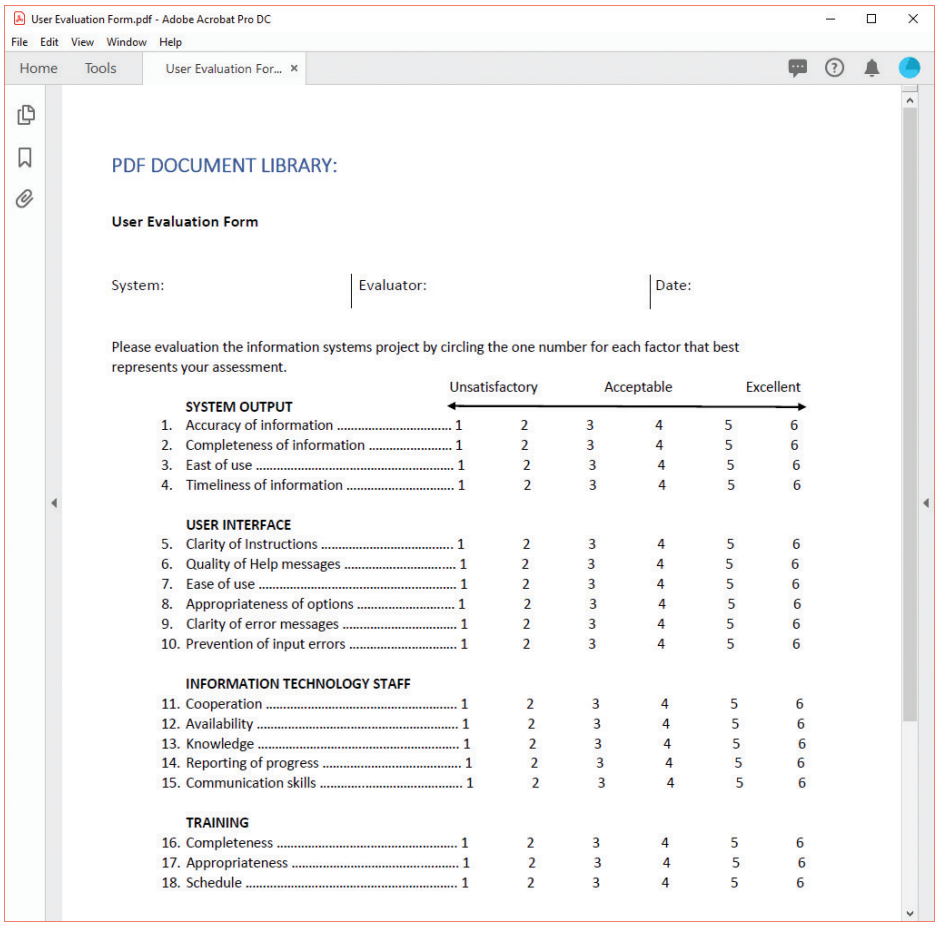
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- Completeness and quality of documentation
- Quality and effectiveness of training
- Accuracy of cost-benefit estimates and development schedules

The same fact-finding techniques can be applied in a post-implementation evaluation, which were used to determine the system requirements during the systems analysis phase. When evaluating a system, the following should be done:

- Interview members of management and key users
- Observe users and computer operations personnel actually working with the new information system
- Read all documentation and training materials
- Examine all source documents, output reports, and screen displays
- Use questionnaires to gather information and opinions from a large number of users
- Analyze maintenance and help desk logs

Figure 11-32 shows the first page of a sample user evaluation form for the new information system where users evaluate 18 separate elements on a numerical scale, so the results can be tabulated easily. Following that section, the form provides space for open-ended comments and suggestions.


User Evaluation Form.pdf - Adobe Acrobat Pro DC

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User Evaluation Form

System: Evaluator: Date:

Please evaluation the information systems project by circling the one number for each factor that best represents your assessment.

	Unsatisfactory		Acceptable		Excellent	
SYSTEM OUTPUT						
1. Accuracy of information	1	2	3	4	5	6
2. Completeness of information	1	2	3	4	5	6
3. East of use	1	2	3	4	5	6
4. Timeliness of information	1	2	3	4	5	6
USER INTERFACE						
5. Clarity of Instructions	1	2	3	4	5	6
6. Quality of Help messages	1	2	3	4	5	6
7. Ease of use	1	2	3	4	5	6
8. Appropriateness of options	1	2	3	4	5	6
9. Clarity of error messages	1	2	3	4	5	6
10. Prevention of input errors	1	2	3	4	5	6
INFORMATION TECHNOLOGY STAFF						
11. Cooperation	1	2	3	4	5	6
12. Availability	1	2	3	4	5	6
13. Knowledge	1	2	3	4	5	6
14. Reporting of progress	1	2	3	4	5	6
15. Communication skills	1	2	3	4	5	6
TRAINING						
16. Completeness	1	2	3	4	5	6
17. Appropriateness	1	2	3	4	5	6
18. Schedule	1	2	3	4	5	6

FIGURE 11-32 Sample user evaluation form. The numerical scale allows easy tabulation of results. Following this section, the form provides space for open-ended comments and suggestions.

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Whenever possible, people who were not directly involved in developing the system should conduct the post-implementation evaluation. IT staff and users usually perform the evaluation, although some firms use an internal audit group or independent auditors to ensure the accuracy and completeness of the evaluation.

When to perform a post-implementation evaluation for a new system is not always clear. Users can forget details of the developmental effort if too much time elapses before the evaluation. After several months or a year, for instance, users might not remember whether they learned a procedure through training, from user documentation, or by experimenting with the system on their own.

Users also might forget their impressions of IT team members over time. An important purpose of the post-implementation evaluation is to improve the quality of IT department functions, including interaction with users, training, and documentation. Consequently, the evaluation team should perform the assessment while users are able to recall specific incidents, successes, and problems so they can offer suggestions for improvement.

On the other hand, if the evaluation is done too soon, the users may not be able to provide sufficient feedback due to lack of experience with the new system. Post-implementation evaluation is primarily concerned with assessing the quality of the new system. If the team performs the evaluation too soon after implementation, users will not have enough time to learn the new system and appreciate its strengths and weaknesses. Although many IT professionals recommend conducting the evaluation after at least six months of system operation, pressure to finish the project sooner usually results in an earlier evaluation in order to allow the IT department to move on to other tasks.

Ideally, conducting a post-implementation evaluation should be standard practice for all information systems projects. Sometimes, evaluations are skipped because users are eager to work with the new system or because IT staff members have more pressing priorities. In some organizations, management might not recognize the importance and benefits of a post-implementation evaluation. The evaluations are extremely important, however, because they enable the development team and the IT department to learn what worked and what did not work. Otherwise, developers might commit the same errors in another system.

FINAL REPORT TO MANAGEMENT: At the end of each SDLC phase, a final report is submitted to management, and the systems implementation phase is no exception. The report should include the following:

- Final versions of all system documentation
- Planned modifications and enhancements to the system that have been identified
- Recap of all systems development costs and schedules
- Comparison of actual costs and schedules to the original estimates
- Post-implementation evaluation, if it has been performed

The final report to management marks the end of systems development work. The next chapter examines the role of a systems analyst during systems operation, security, and support, which is the final phase of the SDLC.

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CASE IN POINT 11.3: YORKTOWN INDUSTRIES

You like your new job as lead systems analyst at Yorktown Industries. You were pleased that your development team completed the new human resources system ahead of schedule and under budget. You looked forward to receiving the post-implementation evaluation because you were confident that both the system and the development team would receive high marks from users and managers.

After the system operated for one month, you received a call from your supervisor, who told you that you would have to handle the evaluation—even though you headed the development effort. You told your supervisor that you did not feel comfortable evaluating your own team's work. You explained that someone who was not involved in its development should do an independent evaluation. Your supervisor responded that he had full confidence in your ability to be objective. He explained that no one else was available and he needed the evaluation quickly so he could move forward with the next stage in the corporate development plan.

You are troubled about the situation. What should you do, and why?

A QUESTION OF ETHICS



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A team member is handling the testing for the new accounting system, and right now she is very upset about the most recent results. "It seems like every time we fix one problem, another pops up! After ten days of testing and adjusting, we are meeting over 90% of the goals and benchmarks. If we're looking for perfection, we'll never make the implementation deadline for the new system, and the users will be all over us. Not to mention top management's reaction to a delay. I'm sure we can resolve some of these issues after the system becomes operational."

How would you respond to this statement? Are ethical issues involved? What are your responsibilities, as an employee, as an IT professional, and as a coworker?

11.10 SUMMARY

The systems implementation phase consists of application development, testing, installation, and evaluation of the new system. During application development, analysts determine the overall design strategy and work with programmers to complete design, coding, testing, and documentation. QA is essential during the implementation phase. Many companies utilize software engineering concepts and quality standards established by the ISO.

Each systems development approach has its own set of tools. For example, structured development relies heavily on DFDs and structure charts. A structure chart consists of symbols that represent program modules, data couples, control couples, conditions, and loops. O-O methods use a variety of UML diagrams, including

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use case, class, sequence, and transition state diagrams. Agile methods tend to use iterative and incremental models.

System developers also can use more generic tools to help them translate the system logic into properly functioning program modules. These tools include ERDs, flowcharts, pseudocode, decision tables, and decision trees.

Cohesion measures a module's scope and processing characteristics. A module that performs a single function or task has a high degree of cohesion, which is desirable. Coupling measures relationships and interdependence among modules. Modules that are relatively independent are loosely coupled, which is desirable. Cohesion and coupling concepts are not only used in structured development but also applicable to OOD.

Typically, three steps are followed when creating a structure chart. DFDs and object models are reviewed to identify the processes and methods, identify the program modules and determine control-subordinate relationships, and add symbols for couples and loops. The structure chart is then analyzed to ensure that it is consistent with the system documentation.

If an agile development approach is used, then the customer creates user stories that describe required features and priority levels. In agile methodology, new system releases are made after many iterations and each is test-driven carefully by the customer.

Programmers perform desk checking, code review, and unit testing tasks during application development. Systems analysts design the initial test plans, which include test steps and test data for integration testing and system testing. Integration testing is necessary for programs that interact. The final step is system testing for the completed system. System testing includes users in the testing process.

In addition to system documentation, analysts and technical writers also prepare operations documentation and user documentation. Operations documentation provides instructions and information to the IT operations group. User documentation consists of instructions and information for users who interact with the system and includes user manuals, help screens, and tutorials.

During the installation process, an operational, or production, environment is established for the new information system that is completely separate from the test environment. The operational environment contains live data and is accessible only by authorized users. All future changes to the system must be verified in the test environment before they are applied to the operational environment.

System changeover is the process of putting the new system into operation. Four changeover methods exist: direct cutover, parallel operation, pilot operation, and phased operation. With direct cutover, the old system stops and the new system starts simultaneously; direct cutover is the least expensive but the riskiest changeover method. With parallel operation, users operate both the old and new information systems for some period of time; parallel operation is the most expensive and least risky of the changeover methods. Pilot operation and phased operation represent compromises between direct cutover and parallel operation; both methods are less risky than direct cutover and less costly than parallel operation. With pilot operation, a specified group within the organization uses the new system for a period of time, while the old system continues to operate for the rest of the users. After the system proves successful at the pilot site, it is implemented throughout the organization. With phased operation, the system is implemented in the entire organization, but only one module at a time, until the entire system is operational.

Data conversion often is necessary when installing a new information system. When a new system replaces a computerized system, the data conversion process should be automated if possible. The old system might be capable of exporting data

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in a format that the new system can use, or the data might have to be extracted and converted to an acceptable format. Data conversion from a manual system often requires labor-intensive data entry or scanning. Even when data conversion can be automated, a new system often requires additional data items, which might require manual entry. Strict input controls are important during the conversion process to protect data integrity and quality. Typically, data is verified, corrected, and updated during the conversion process.

Everyone who interacts with the new information system should receive training appropriate to his or her role and skills. The IT department usually is responsible for training. Software or hardware vendors or professional training organizations also can provide training. When a training program is developed, remember the following guidelines: train people in groups; utilize people already trained to help train others; develop separate programs for distinct employee groups; and provide for learning by using discussions, demonstrations, documentation, training manuals, tutorials, webinars, and podcasts. Users learn better with interactive, self-paced training methods.

A post-implementation evaluation assesses and reports on the quality of the new system and the work done by the project team. Although it is best if people who were not involved in the systems development effort perform the evaluation, that is not always possible. The evaluation should be conducted early so users have a fresh recollection of the development effort but not before users have experience using the new system.

The final report to management includes the final system documentation, describes any future system enhancements that already have been identified, and details the project costs. The report represents the end of the development effort and the beginning of the new system's operational life.

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Key Terms

acceptance test Testing involves the entire information system, including all typical processing situations. During an acceptance test, users enter data, including samples of actual or live data, perform queries, and produce reports to simulate actual operating conditions. All processing options and outputs are verified by users and the IT project development team to ensure that the system functions correctly. Sometimes known as a system test.

application development The process of constructing the programs and code modules that are the building blocks of an information system. Application development is handled by an application development group within a traditional IT department that is composed of systems analysts and programmers who handle information system design, development, and implementation.

attribute A single characteristic or fact about an entity. An attribute, or field, is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of an attribute. In O-O analysis, an attribute is part of a class diagram that describes the characteristics of objects in the class. Also known as a data element.

bug tracking software System developers use defect tracking software, sometimes called bug tracking software, to document and track program defects, code changes, and replacement code, called patches.

Capability Maturity Model (CMM)® A model developed by SEI that integrates software and systems development into a process improvement framework.

Capability Maturity Model Integration (CMMI)® An SEI-developed process to improve quality, reduce development time, and cut costs. A CMM tracks an organization's software development goals and practices, using five maturity levels, from Level 1 (relatively unstable, ineffective software) to Level 5 (software that is refined, efficient, and reliable).

code review A review of a project team member's work by other members of the team to spot logic errors. Generally, systems analysts review the work of other systems analysts, and programmers review the work of other programmers, as a form of peer review. Structured walk-throughs should take place throughout the SDLC and are called requirements reviews, design reviews, code reviews, or testing reviews, depending on the phase in which they occur. Also known as a structured walk-through.

coding The process of turning program logic into specific instructions that a computer system can execute.

cohesion A measure of a module's scope and processing characteristics. A module that performs a single function or task has a high degree of cohesion, which is desirable.

condition A specified action or state in a structure chart.

control couple In a structure chart, a control couple shows a message, also called a flag, which one module sends to another.

control module In a structure chart, a control module is a higher-level module that directs lower-level modules, called subordinate modules.

coupling Measures relationships and interdependence among modules. The opposite of cohesion.

customer Primary user of a system, service, or product.

data conversion Existing data is loaded into the new system, transformed as needed. Depending on the system, data conversion can be done before, during, or after the operational environment is complete.

data couple In a structure chart, a data couple shows data that one module passes to another.

defect tracking software System developers use defect tracking software, sometimes called bug tracking software, to document and track program defects, code changes, and replacement code, called patches.

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design walk-through A session with users to review the interface with a cross section of people who will work with the new system. This is a continuation of the modeling and prototyping effort that began early in the systems development process.

desk checking The process of reviewing the program code to spot logic errors, which produce incorrect results.

direct cutover The direct cutover approach causes the changeover from the old system to the new system to occur immediately when the new system becomes operational.

documentation Material that explains a system, helps people interact with it, and includes program documentation, system documentation, operations documentation, and user documentation.

flowchart A diagram used to describe program logic that represents logical rules and interaction graphically using a series of symbols connected by arrows. Flowcharts can be useful in visualizing modular program designs.

integrated development environment (IDE) A suite of integrated tools to make it easier to plan, construct, and maintain a specific software product. An IDE is designed to allow the easy integration of system components with less time being spent on developing code for interactive modules.

integration testing The testing of two or more programs that depend on each other.

ISO 9000-3:2014 A set of guidelines established and updated by the ISO to provide a QA framework for developing and maintaining software.

iteration cycle An agile development cycle that includes planning, designing, coding, and testing one or more features based on user stories.

iteration planning meeting In agile development, a meeting held at the beginning of each iteration cycle to break down user stories into specific tasks that are assigned to team members.

library module In a structure chart, a library module is a module that is reusable and can be invoked from more than one point in the chart.

logic error Mistakes in the underlying logic that produce incorrect results.

loop In a structure chart, a loop indicates that one or more modules are repeated.

loosely coupled Modules that are relatively independent. Loosely coupled modules are easier to maintain and modify, because the logic in one module does not affect other modules.

methods In a class diagram, methods represent program logic.

modular design A design that can be broken down into logical blocks. Also known as partitioning, or top-down design.

module A module consists of related program code organized into small units that are easy to understand and maintain. A complex program could have hundreds or even thousands of modules.

object-oriented development (OOD) The process of translating an object model directly into an O-O programming language.

online documentation Provides immediate help when users have questions or encounter problems.

open database connectivity (ODBC) An industry-standard protocol that makes it possible for software from different vendors to interact and exchange data.

operational environment The environment for the actual system operation. It includes hardware and software configurations, system utilities, and communications resources. Also called the production environment.

operations documentation Contains all the information needed for processing and distributing online and printed output.

pair programming A practice in XP in which two programmers work on the same task on the same computer; one drives (programs) while the other navigates (watches).

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parallel operation The parallel operation changeover method requires that both the old and the new information systems operate fully for a specified period. Data is input into both systems, and output generated by the new system is compared with the equivalent output from the old system.

partitioning The breaking down of overall objectives into subsystems and modules.

patch Replacement code that is applied to fix bugs or security holes in software.

phased operation The phased operation method allows a new system to be implemented in stages, or modules.

pilot operation The pilot operation changeover method involves implementing the complete new system at a selected location of the company.

pilot site In a pilot operation, the group that uses the new system first is called the pilot site.

podcast A web-based broadcast that allows a user to receive audio or multimedia files using music player software, such as iTunes, and listen to them on a PC or download them to a portable MP3 player or smart phone.

post-implementation evaluation An assessment of the overall quality of the information system. The evaluation verifies that the new system meets specified requirements, complies with user objectives, and achieves the anticipated benefits. In addition, by providing feedback to the development team, the evaluation also helps improve IT development practices for future projects.

process improvement The framework used to integrate software and systems development by a new SEI model, CMMI.

production environment The environment for the actual system operation. It includes hardware and software configurations, system utilities, and communications resources. Also called the operational environment.

program documentation Preparation of program documentation starts in the systems analysis phase and continues during systems implementation. Systems analysts prepare overall documentation, such as process descriptions and report layouts, early in the SDLC. Programmers provide documentation by constructing modules that are well supported by internal and external comments and descriptions that can be understood and maintained easily.

pseudocode A technique for representing program logic in semi-structured prose.

quality assurance (QA) A process or procedure for minimizing errors and ensuring quality in products. Poor quality can result from inaccurate requirements, design problems, coding errors, faulty documentation, and ineffective testing. A QA team reviews and tests all applications and systems changes to verify specifications and software quality standards.

release plan In agile development, a plan that specifies when user stories will be implemented and the timing of the releases. Releases are relatively frequent, and each release is treated as a system prototype that can be tested and modified as needed.

simulation A dress rehearsal for users and IT support staff. Organizations typically include all procedures, such as those that they execute only at the end of a month, quarter, or year, in their simulations.

software engineering A software development process that stresses solid design, effective structure, accurate documentation, and careful testing.

status flag In structured application development, an indicator that allows one module to send a message to another module.

structure chart A top-down representation of business functions and processes. Also called an FDD.

structured walk-through A review of a project team member's work by other members of the team. Generally, systems analysts review the work of other systems analysts, and programmers review the work of other programmers, as a form of peer review. Structured walk-throughs should take place throughout the SDLC and are called requirements reviews, design reviews, code reviews, or testing reviews, depending on the phase in which they occur.

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stub testing A form of testing where the programmer simulates each program outcome or result and displays a message to indicate whether or not the program executed successfully. Each stub represents an entry or exit point that will be linked later to another program or data file.

subordinate module A lower-level module in a structure chart.

syntax error Programming language grammar error.

system changeover The process of putting the new information system online and retiring the old system. Changeover can be rapid or slow, depending on the method.

system documentation A description of a system's functions and how they are implemented. The analyst prepares most of the system documentation during the systems analysis and systems design phases. System documentation includes data dictionary entries, DFDs, object models, screen layouts, source documents, and the systems request that initiated the project.

system testing A form of testing involving an entire information system and includes all typical processing situations. During a system test, users enter data, including samples of actual or live data, perform queries, and produce reports to simulate actual operating conditions. All processing options and outputs are verified by users and the IT project development team to ensure that the system functions correctly.

test data The data used in unit testing. Test data should contain both correct data and erroneous data and should test all possible situations that could occur.

test-driven development (TDD) An XP concept that unit tests are designed before code is written, focusing on end results and preventing programmers from straying from their goals.

test environment The environment that analysts and programmers use to develop and maintain programs.

test plan A plan designed by a systems analyst that includes test steps and test data for integration testing and system testing.

tightly coupled If modules are tightly coupled, one module refers to internal logic contained in another module.

top-down approach A design approach, also called modular design, where the systems analyst defines the overall objectives of the system and then breaks them down into subsystems and modules. This breaking-down process also is called partitioning.

training plan A successful information system requires training for users, managers, and IT staff members. The entire systems development effort can depend on whether or not people understand the system and know how to use it effectively. The training plan is a document that details these requirements.

train-the-trainer A strategy where one group of users has been trained and can assist others. Users often learn more quickly from coworkers who share common experience and job responsibilities.

tutorial A series of online interactive lessons that present material and provide a dialog with users.

unit testing The testing of an individual program or module. The objective is to identify and eliminate execution errors that could cause the program to terminate abnormally and logic errors that could have been missed during desk checking.

user documentation Instructions and information to users who will interact with the system. Includes user manuals, help screens, and tutorials.

user story In agile development, a short, simple requirements definition provided by the customer. Programmers use user stories to determine a project's requirements, priorities, and scope.

webcast A one-way transmission of information or training materials, such as a webinar session, available on demand or for a specific period to online participants.

webinar An Internet-based training session that provides an interactive experience. The word *webinar* combines the words *web* and *seminar*.

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Exercises

Questions

1. What is QA?
2. What is application development?
3. Explain how structure charts are used in application development.
4. Should classes be tightly coupled or loosely coupled in OOD? Explain why.
5. What is pair programming?
6. What role do IDEs play in coding?
7. Describe three main types of testing and the order in which they are performed.
8. What are the differences between program, system, operations, and user documentation?
9. What is the role of online documentation?
10. What is the difference between an operational environment and a test environment?

Discussion Topics

1. Discuss the three techniques used to improve QA.
2. What are the most significant differences among structured, O-O, and agile methods? What do they have in common?
3. Experienced programmers sometimes eschew IDEs for handcrafted tools, often connected in a pipeline to facilitate complex workflows. What advantages and disadvantages would this approach have over sophisticated IDEs?
4. Your supervisor said, "Integration testing is a waste of time. If each program is tested adequately, integration testing isn't needed. Instead, we should move on to system testing as soon as possible. If modules don't interact properly, we'll handle it then." Do you agree or disagree with this comment? Explain your answer.
5. Suppose that you designed a tutorial to train a person in the use of specific software or hardware, such as a web browser. What specific information would you want to know about the recipient of the training? How would that information affect the design of the training material?

Projects

1. Using the material in this chapter and your own Internet research, prepare a presentation on the pros and cons of agile development methods.
2. In this chapter, you learned about the importance of testing. Design a generic test plan that describes the testing for an imaginary system.
3. Which system changeover method would you recommend for an air traffic control system upgrade? Explain your answer.
4. Design a generic post-implementation evaluation form. The form should consist of questions that you could use to evaluate any information system. The form should evaluate the training received and any problems associated with the program.
5. Create an online training module using one of the systems discussed in this chapter, such as Udemy or lynda.com, on the topic of managing systems implementations.

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PHASE 5 SYSTEMS SUPPORT AND SECURITY

DELIVERABLE
An operational system that is properly maintained, supported, and secured

Systems support and security is the final phase in the systems development life cycle. In the previous phase, systems implementation, a functioning system was delivered. The system now moves into the support phase, where the analyst maintains the system, handles security issues, protects the integrity of the system and its data, and is alert to any signs of obsolescence.

Security concerns have become a matter of national importance. Major security breaches at large corporations are unfortunately quite commonplace. Sadly, system security is rarely solved by a simple app—it requires a disciplined approach that affects virtually all tasks in the SDLC.

Chapter 12 focuses on managing systems support and security throughout the useful life of the system. This includes user support, maintenance tasks, maintenance management, performance management, security levels, backup and recovery, system retirement, and future challenges and opportunities.

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CHAPTER 12 Managing Systems Support and Security

Chapter 12 describes systems support and security tasks that continue throughout the useful life of the system. The systems support and security phase begins when a system becomes operational and continues until the system reaches the end of its useful life. Throughout the development process, the objective has been to create an information system that is efficient, easy to use, and affordable. After delivering the system, the IT team focuses on support and maintenance tasks. Managing systems support and security involves three main concerns: user expectations, system performance, and security requirements.

The chapter includes three "Case in Point" discussion questions to help contextualize the concepts described in the text. There are two "Question of Ethics" scenarios in this chapter. The first scenario concerns known security vulnerabilities in a system and what should be done about them. The second scenario is about divulging personal information, social media, and free speech.

LEARNING OBJECTIVES

When you finish this chapter, you should be able to:

1. Describe user support activities
2. Define the four types of maintenance
3. Explain seven strategies and techniques for maintenance management
4. Describe techniques for system performance management
5. Explain system security concepts and common attacks against the system
6. Explain three tasks related to risk management concepts
7. Assess system security at six levels: physical security, network security, application security, file security, user security, and procedural security
8. Describe backup and disaster recovery
9. List six factors indicating that a system has reached the end of its useful life
10. List future challenges and opportunities for IT professionals

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12.1 User Support
12.2 Maintenance Tasks
Case in Point 12.1: Outback Outsourcing, Inc.
12.3 Maintenance Management
12.4 System Performance Management
12.5 System Security
12.6 Security Levels
Case in Point 12.2: Outer Banks County
Case in Point 12.3: Chain Link Consulting, Inc.
12.7 Backup and Recovery
12.8 System Retirement
12.9 Future Challenges and Opportunities
A Question of Ethics
12.10 Summary
Key Terms
Exercises

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12.1 User Support

A systems analyst is like an internal consultant who provides guidance, support, and training. Successful systems often need the most support because users want to learn the features, try all the capabilities, and discover how the system can help them perform their tasks. In most organizations, more than half of all IT department effort goes into supporting existing systems. Companies provide user support in many forms, including user training and a help desk to provide technical support and assistance. This help can be provided in-house or outsourced.

12.1.1 User Training

Chapter 11 described the initial training that is performed when a new system is introduced. Additionally, new employees must be trained on the company's information systems. If significant changes take place in the existing system or if a new version is released, the IT department might develop a **user training package**. Depending on the nature of the changes, the package could include online support via email, a special website, a revision to the user guide, a training manual supplement, or formal training sessions. Training users about system changes is similar to initial training. The main objective is to show users how the system can help them perform their jobs.

12.1.2 Help Desks

As systems become more complex, users need constant support and guidance. To make data more accessible and to empower users, many IT departments create help desks. A **help desk**, also called a **service desk**, is a centralized resource staffed by IT professionals who provide users with the support they need to do their jobs. A help desk has three main objectives: (1) show people how to use system resources more effectively, (2) provide answers to technical or operational questions, and (3) make users more productive by teaching them how to meet their own information needs. A help desk is the first place users turn when they need information or assistance.

A help desk does not replace traditional IT maintenance and support activities. Instead, help desks enhance productivity and improve utilization of a company's information resources.

Help desk representatives need strong interpersonal and technical skills plus a solid understanding of the business because they interact with users in many departments. A help desk should document carefully all inquiries, support tasks, and activity levels. The information can identify trends and common problems and can help build a technical support knowledge base.

A help desk can boost its productivity by using **remote control software**, which allows IT staff to take over a user's workstation and provide support and troubleshooting. One example of such a software application is GoToMyPC by Citrix, shown in Figure 12-1.

During a typical day, the help desk staff members might have to perform the following tasks:

- Show a user how to create a data query or report that displays specific business information
- Resolve network access or password problems
- Demonstrate an advanced feature of a system or a commercial package
- Help a user recover damaged data

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- Offer tips for better operation
- Explain an undocumented software feature
- Show a user how to use web conferencing
- Explain how to access the company's intranet or the Internet
- Assist a user in developing a simple database to track time spent on various projects
- Answer questions about software licensing and upgrades
- Provide information about system specifications and the cost of new hardware or software
- Recommend a system solution that integrates data from different locations to solve a business problem
- Provide hardware support by installing or reconfiguring devices such as scanners, printers, network cards, wireless devices, optical drives, backup devices, and multimedia systems
- Show users how to maintain data consistency and integrity among a desktop computer, a notebook computer, and a handheld computer or smartphone
- Troubleshoot software issues via remote control utilities

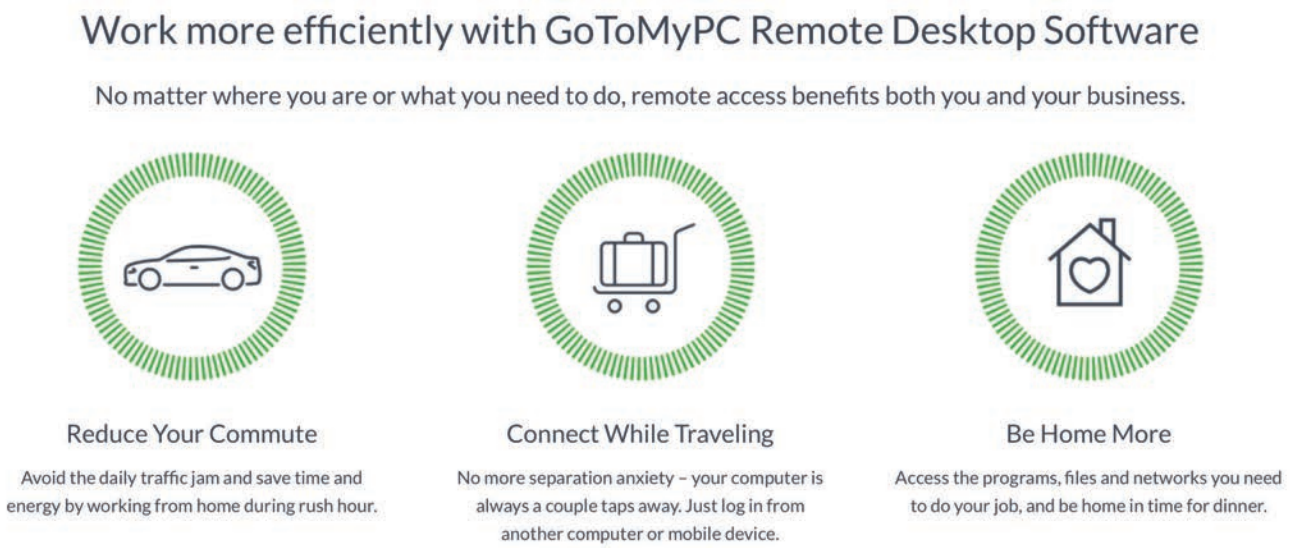


FIGURE 12-1 Remote access software, such as GoToMyPC shown here, lets users access their PCs from anywhere—even with their smartphones or tablets.
Source: gotomypc.com

In addition to functioning as a valuable link between IT staff and users, the help desk is a central contact point for all IT maintenance activities. The help desk is where users report system problems, ask for maintenance, or submit new systems requests. A help desk can utilize many types of automated support, just as outside vendors do, including email responses, on-demand fax capability, an online knowledge base, frequently asked questions (FAQs), discussion groups, bulletin boards, and automated voice mail. Many vendors now provide a live chat feature for online visitors.

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12.1.3 Outsourcing Issues

As discussed in Chapter 7, many firms outsource various aspects of application development. This trend also includes outsourcing IT support and help desks. As with most business decisions, outsourcing has pros and cons. Typically, the main reason for outsourcing is cost reduction. Offshore call centers can trim expenses and free up valuable human resources for product development.

However, firms have learned that if tech support quality goes down, customers are likely to notice and might shop elsewhere. Critical factors might include phone wait times, support staff performance, and online support tools. The real question is whether a company can achieve the desired savings without endangering its reputation and customer base. Risks can be limited but only if a firm takes an active role in managing and monitoring support quality and consistency.

12.2 Maintenance Tasks

The systems support and security phase is an important component of total cost of ownership (TCO) because ongoing maintenance expenses can determine the economic life of a system. Figure 12-2 shows a typical pattern of operational and maintenance expenses during the useful life of a system. **Operational costs** include items such as supplies, equipment rental, and software leases. Note that the lower area shown in Figure 12-2 represents fixed operational expenses, while the upper area represents maintenance expenses.

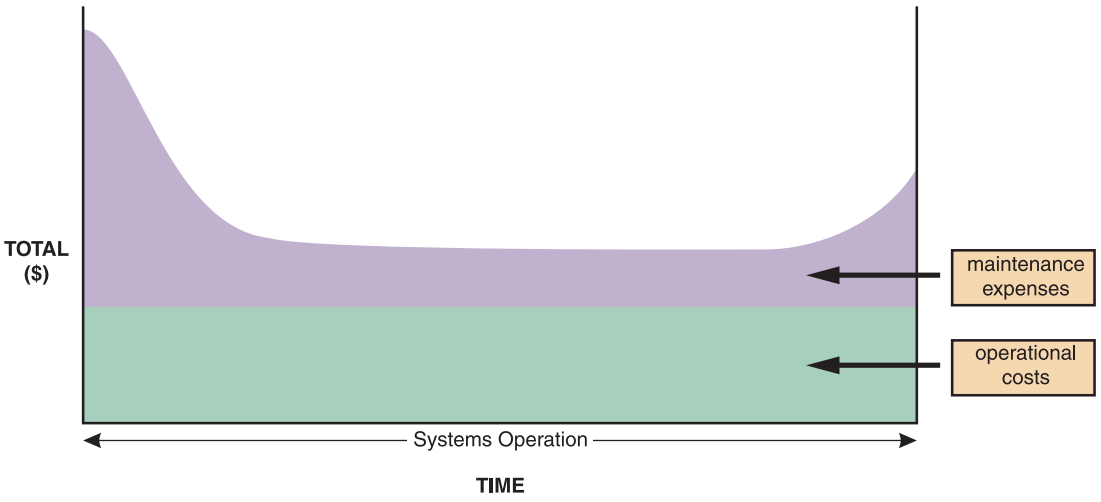


FIGURE 12-2 The total cost of operating an information system includes operational and maintenance costs. Operational costs (green) are relatively constant, while maintenance costs (purple) vary over time.

Maintenance expenses vary significantly during the system's operational life and include spending to support **maintenance activities**. Maintenance activities include changing programs, procedures, or documentation to ensure correct system performance; adapting the system to changing requirements; and making the system operate more efficiently. Those needs are met by different types of maintenance.

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12.2.1 Types of Maintenance

Although some overlap exists, four types of maintenance tasks can be identified, as shown by the examples in Figure 12-3. **Corrective maintenance** is performed to fix errors, **adaptive maintenance** adds new capability and enhancements, **perfective maintenance** improves efficiency, and **preventive maintenance** reduces the possibility of future system failure. Some analysts use the term *maintenance* to describe only corrective maintenance that fixes problems. It is helpful, however, to view the maintenance concept more broadly and identify the different types of tasks.

Maintenance expenses usually are high when a system is implemented because problems must be detected, investigated, and resolved by corrective maintenance. Once the system becomes stable, costs usually remain low and involve minor adaptive maintenance. Eventually, both adaptive and perfective maintenance activities increase in a dynamic business environment.

Near the end of a system's useful life, adaptive and corrective maintenance expenses increase rapidly, but perfective maintenance typically decreases when it becomes clear that the company plans to replace the system. Figure 12-4 shows the typical patterns for each of the four classifications of maintenance activities over a system's life span.

Examples of Maintenance Tasks

Corrective Maintenance
- Diagnose and fix logic errors
- Replace defective network cabling
- Restore proper configuration settings
- Debug program code
- Update drivers
- Utilize remote control software for problem diagnosis and resolution

Adaptive Maintenance
- Add online capability
- Add support for mobile devices
- Add new data entry field to input screen
- Install links to website
- Create employee portal

Perfective Maintenance
- Upgrade or replace outdated hardware
- Write macros to handle repetitive tasks
- Compress system files
- Optimize user desktop settings
- Upgrade wireless network capability
- Install more powerful network server

Preventive Maintenance
- Install new antivirus software
- Develop standard backup schedule, including off-site and cloud-based strategies
- Implement regular defragmentation process
- Analyze problem report for patterns
- Tighten all cable connections
- Develop user guide covering confidentiality rules and unauthorized use of company IT resources

FIGURE 12-3 Corrective maintenance fixes errors and problems. Adaptive maintenance provides enhancements to a system. Perfective maintenance improves a system's efficiency, reliability, or maintainability. Preventive maintenance avoids future problems.

12.2.2 Corrective Maintenance

Corrective maintenance diagnoses and corrects errors in an operational system. To avoid introducing new problems, all maintenance work requires careful analysis before making changes. The best maintenance approach is a scaled-down version of the SDLC itself, where investigation, analysis, design, and testing are performed before implementing any solution. Recall from Chapter 11 the differences between a test environment and an operational environment. Any maintenance work that could affect the system must be performed first in the test environment and then migrated to the operational system.

IT support staff respond to errors in various ways, depending on the nature and severity of the problem. Most organizations have standard procedures for minor errors, such as an incorrect report title or an improper format for a data element. In a typical procedure, a user submits a system request that is evaluated, prioritized, and scheduled by the system administrator or the systems review committee. If the request is approved, the maintenance team designs, tests, documents, and implements a solution.

As stated in Chapter 2, many organizations use a standard online form for systems requests. In smaller firms, the process might be an informal email message. For more serious situations, such as incorrect report totals or inconsistent data, a user submits a system request with supporting evidence. Those requests receive a high priority and a maintenance team begins work on the problem immediately.

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	Immediately After Implementation	Early Operational Life	Middle Operational Life	Later Operational Life
Corrective Maintenance	High	Low	Low	High
Adaptive Maintenance (Minor Enhancements)	None	Medium	Medium	Medium
Adaptive Maintenance (Major Enhancements)	None	None	Medium to High	Medium to High
Perfective Maintenance	Low	Low to Medium	Medium	Low
Preventive Maintenance	Low	Medium	Medium	Low

FIGURE 12-4 Information systems maintenance costs depend on the type of maintenance and the age of the system.

The worst-case situation is a system failure. If an emergency occurs, the maintenance team bypasses the initial steps and tries to correct the problem immediately. This often requires a **patch**, which is a specially written software module that provides temporary repairs so operations can resume. Meanwhile, a written systems request is prepared by a user or a member of the IT department and added to the maintenance log. When the system is operational again, the maintenance team determines the cause, analyzes the problem, and designs a permanent solution. The IT response team updates the test data files, thoroughly tests the system, and prepares full documentation. Regardless of how the priorities are set, a standard ranking method can be helpful. For example, Figure 12-5 shows a three-level framework for IT support potential impact.

PRIORITY	IMPACT	TIME FRAME
Level 1	Significant impact on IT operations, security, or business activity that requires immediate attention.	Implement patch as soon as possible.
Level 2	Some impact on IT operations, security, or business activity. Requires prompt attention, but operations can continue.	Patch as necessary and begin implementation prior to next release.
Level 3	Little or no impact on current IT operations, security, or business activity	Implement in the next release.

FIGURE 12-5 This three-level ranking framework for IT support considers potential impact and response urgency.

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The process of managing system support is described in more detail in Section 12.3, including an overview of maintenance tasks and a procedural flowchart.

12.2.3 Adaptive Maintenance

Adaptive maintenance adds enhancements to an operational system and makes the system easier to use. An **enhancement** is a new feature or capability. The need for adaptive maintenance usually arises from business environment changes such as new products or services, new manufacturing technology, or support for a new web-based operation.

The procedure for minor adaptive maintenance is similar to routine corrective maintenance. A user submits a system request that is evaluated and prioritized by the systems review committee. A maintenance team then analyzes, designs, tests, and implements the enhancement. Although the procedures for the two types of maintenance are alike, adaptive maintenance requires more IT department resources than minor corrective maintenance.

A major adaptive maintenance project is like a small-scale SDLC project because the development procedure is similar. Adaptive maintenance can be more difficult than new systems development because the enhancements must work within the constraints of an existing system.

12.2.4 Perfective Maintenance

Perfective maintenance involves changing an operational system to make it more efficient, reliable, or maintainable. Requests for corrective and adaptive maintenance normally come from users, while the IT department usually initiates perfective maintenance.

During system operation, changes in user activity or data patterns can cause a decline in efficiency, and perfective maintenance might be needed to restore performance. When users are concerned about performance, it should be determined if a perfective maintenance project could improve response time and system efficiency.

Perfective maintenance also can improve system reliability. For example, input problems might cause a program to terminate abnormally. By modifying the data entry process, errors can be highlighted, and users notified that they must enter proper data. When a system is easier to maintain, support is less costly and less risky. In many cases, a complex program can be simplified to improve maintainability.

In many organizations, perfective maintenance is not performed frequently enough. Companies with limited resources often consider new systems development, adaptive maintenance, and corrective maintenance more important than perfective maintenance. Managers and users constantly request new projects, so few resources are available for perfective maintenance work. As a practical matter, perfective maintenance can be performed as part of another project. For example, if a new function must be added to a program, perfective maintenance can be included in the adaptive maintenance project.

Perfective maintenance usually is cost-effective during the middle of the system's operational life. Early in systems operation, perfective maintenance usually is not needed. Later, perfective maintenance might be necessary but have a high cost. Perfective maintenance is less important if the company plans to discontinue the system.

When performing perfective maintenance, analysts often use a technique called software reengineering. **Software reengineering** uses analytical techniques to identify potential quality and performance improvements in an information system. In that sense, software reengineering is similar to business process reengineering, which seeks to simplify operations, reduce costs, and improve quality.

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Programs that need a large number of maintenance changes usually are good candidates for reengineering. The more a program changes, the more likely it is to become inefficient and difficult to maintain. Detailed records of maintenance work can identify systems with a history of frequent corrective, adaptive, or perfective maintenance.

12.2.5 Preventive Maintenance

To avoid problems, preventive maintenance requires analysis of areas where trouble is likely to occur. Like perfective maintenance, the IT department normally initiates preventive maintenance. Preventive maintenance often results in increased user satisfaction, decreased downtime, and reduced TCO. Preventive maintenance competes for IT resources along with other projects and sometimes does not receive the high priority that it deserves.

Regardless of the type of maintenance, trained professionals must support computer systems, just as skilled technicians must service the particle detector at CERN shown in Figure 12-6. In both cases, the quality of the maintenance will directly affect the organization's success.

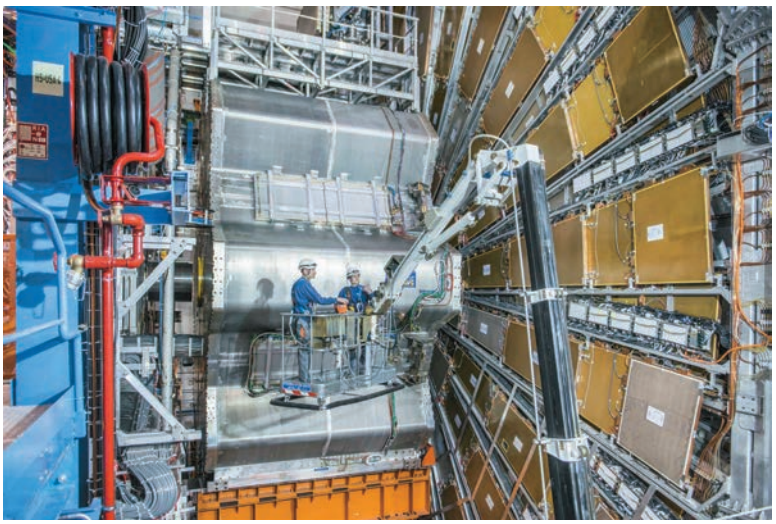


FIGURE 12-6 Technicians use a motorized lift to get into position by the ATLAS particle detector at CERN. Regardless of the type of system, trained professionals must perform high-quality maintenance.
Source: Anna Pantelia/CERN

CASE IN POINT 12.1: Outback Outsourcing, Inc.

You are a systems analyst at Outback Outsourcing, a firm that handles payroll processing for many large companies. Outback Outsourcing uses a combination of payroll package programs and in-house developed software to deliver custom-made payroll solutions for its clients. Lately, users have flooded you with requests for more new features and web-based capability to meet customer expectations. Your boss, the IT manager, comes to you with a question. She wants to know when to stop trying to enhance the old software and develop a totally new version better suited to the new marketplace. How would you answer her?

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12.3 Maintenance Management

System maintenance requires effective management, quality assurance, and cost control. To achieve these goals, companies use various strategies, such as a maintenance team, a maintenance management program, a configuration management process, and a maintenance release procedure. In addition, firms use version control and baselines to track system releases and analyze the system's life cycle. These concepts are described in the following sections.

12.3.1 The Maintenance Team

A **maintenance team** includes a system administrator and one or more systems analysts and programmers. The system administrator should have solid technical expertise, and experience in troubleshooting and configuring operating systems and hardware. Successful analysts need a strong IT background, solid analytical abilities, good communication skills, and an overall understanding of business operations.

SYSTEM ADMINISTRATOR: A **system administrator** manages computer and network systems. A system administrator must work well under pressure, have good organizational and communication skills, and be able to understand and resolve complex issues in a limited time frame. In most organizations, a system administrator has primary responsibility for the operation, configuration, and security of one or more systems. The system administrator is responsible for routine maintenance and usually is authorized to take preventive action to avoid an immediate emergency, such as a server crash, network outage, security incident, or hardware failure.

SYSTEMS ANALYSTS: Systems analysts assigned to a maintenance team are like skilled detectives who investigate and rapidly locate the source of a problem by using analysis and synthesis skills. *Analysis* means examining the whole in order to learn about the individual elements, while *synthesis* involves studying the parts to understand the overall system. In addition to strong technical skills, an analyst must have a solid grasp of business operations and functions. Analysts also need effective interpersonal and communications skills, and they must be creative, energetic, and eager for new knowledge.

PROGRAMMERS: In a small organization, a programmer might be expected to handle a wide variety of tasks, but in larger firms, programming work tends to be more specialized. For example, typical job titles include an **applications programmer**, who works on new systems development and maintenance; a **systems programmer**, who concentrates on operating system software and utilities; and a **database programmer**, who focuses on creating and supporting large-scale database systems. Many IT departments also use a job title of **programmer/analyst** to designate positions that require a combination of systems analysis and programming skills.

ORGANIZATIONAL ISSUES: IT managers often divide systems analysts and programmers into two groups: One group performs new system development, and the other group handles maintenance. Some organizations use a more flexible approach and assign IT staff members to various projects as they occur. By integrating development and support work, the people developing the system assume responsibility for maintaining it. Because the team is familiar with the project, additional training or expense is unnecessary, and members are likely to have a sense of ownership from the onset.

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Unfortunately, many analysts feel that maintenance is less interesting and less creative than developing new systems. In addition, an analyst might find it challenging to troubleshoot and support someone else's work that might have been poorly documented and organized.

Some organizations that have separate maintenance and new systems groups rotate people from one assignment to the other. When analysts learn different skills, the organization is more versatile, and people can shift to meet changing business needs. For instance, systems analysts working on maintenance projects learn why it is important to design easily maintainable systems. Similarly, analysts working on new systems get a better appreciation of the development process and the design compromises necessary to meet business objectives.

One disadvantage of rotation is that it increases overhead because time is lost when people move from one job to another. When systems analysts constantly shift between maintenance and new development, they have less opportunity to become highly skilled at any one job.

Newly hired and recently promoted IT staff members often are assigned to maintenance projects because their managers believe that the opportunity to study existing systems and documentation is a valuable experience. In addition, the mini-SDLC used in many adaptive maintenance projects is good training for the full-scale systems development life cycle. For a new systems analyst, however, maintenance work might be more difficult than systems development, and it might make sense to assign a new person to a development team where experienced analysts are available to provide training and guidance.

12.3.2 Maintenance Requests

Typically, maintenance requests involve a series of steps, as shown in Figure 12-7. After a user submits a request, a system administrator determines whether immediate action is needed and whether the request is under a prescribed cost limit. In nonemergency requests that exceed the cost limit, a system review committee assesses the request and either approves it, with a priority, or rejects it. The system administrator notifies affected users of the outcome.

Users submit most requests for corrective and adaptive maintenance when the system is not performing properly or if they want new features. IT staff members usually initiate requests for perfective and preventive maintenance. To keep a complete maintenance log, all work must be covered by a specific request that users submit in writing or by email.

INITIAL DETERMINATION: When a user submits a maintenance request, the system administrator makes an initial determination. If the request is justifiable and involves a severe problem that requires immediate attention, the system administrator takes action at once. In justifiable, but noncritical, situations, the administrator determines whether the request can be performed within a preauthorized cost level. If so, he or she assigns the maintenance tasks and monitors the work.

THE SYSTEM REVIEW COMMITTEE: When a request exceeds a predetermined cost level or involves a major configuration change, the system review committee either approves it and assigns a priority or rejects it.

TASK COMPLETION: The system administrator usually is responsible for assigning maintenance tasks to individuals or to a maintenance team. Depending on the situation and the company's policy, the system administrator might consider rotating assignments among the IT staff or limiting maintenance tasks to certain individuals or teams, as explained in the previous section.

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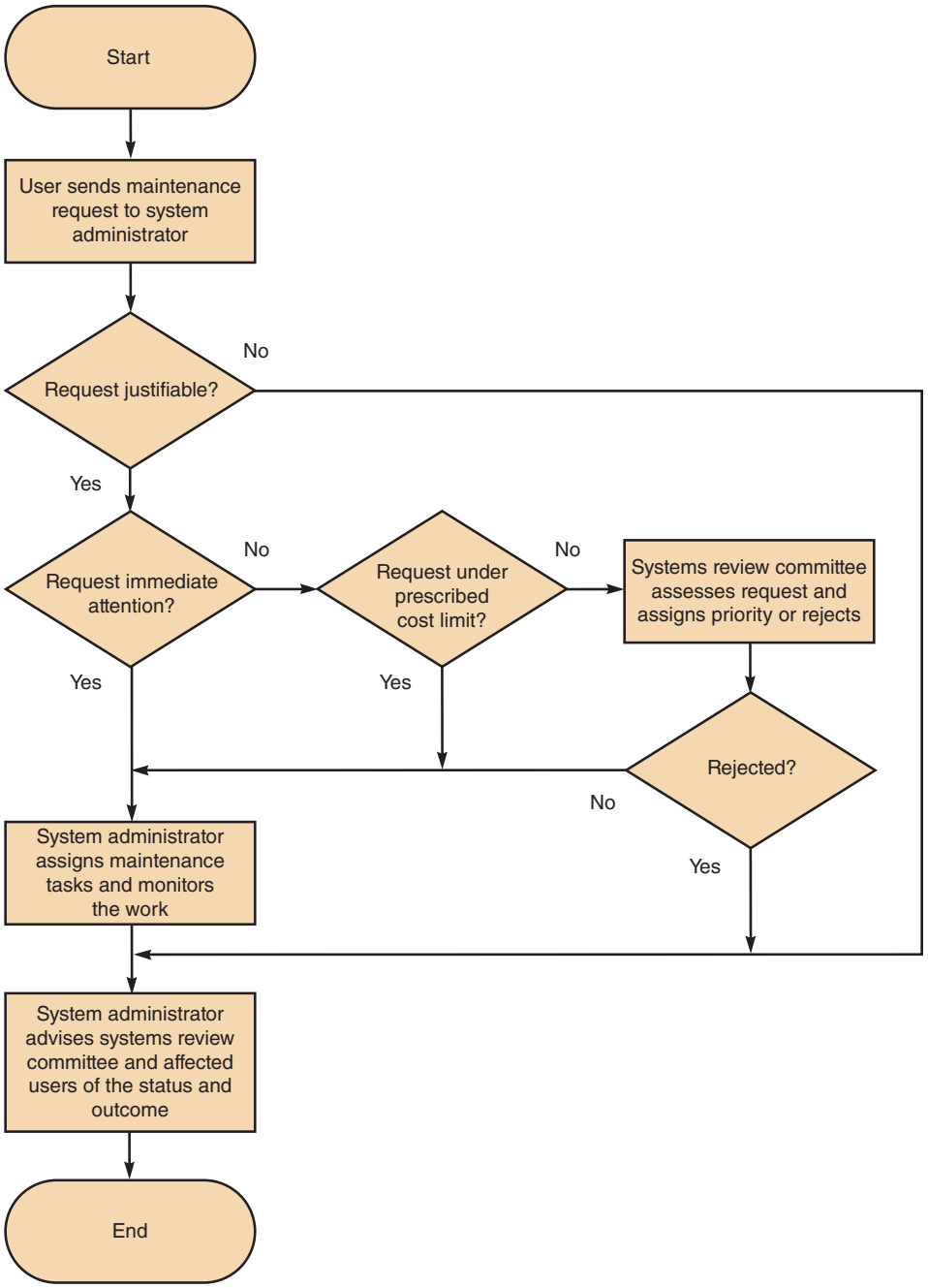


FIGURE 12-7 Although the procedure varies from company to company, the chart shows a typical process for handling maintenance requests.

USER NOTIFICATION: Users who initiate maintenance requests expect a prompt response, especially if the situation directly affects their work. Even when corrective action cannot occur immediately, users appreciate feedback from the system administrator and should be kept informed of any decisions or actions that could affect them.

12.3.3 Establishing Priorities

In many companies, the system review committee separates maintenance and new development requests when setting priorities. In other organizations, all requests are

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considered together, and the most important project gets top priority, whether it is maintenance or new development.

Some IT managers believe that evaluating all projects together leads to the best possible decisions because maintenance and new development require similar IT department resources. In IT departments where maintenance and new development are not integrated, it might be better to evaluate requests separately. Another advantage of a separate approach is that maintenance is more likely to receive a proportional share of IT department resources.

The most important objective is to have a procedure that balances new development and necessary maintenance work to provide the best support for business requirements and priorities.

12.3.4 Configuration Management

Configuration management (CM), sometimes referred to as **change control (CC)**, is a process for controlling changes in system requirements during software development. CM also is an important tool for managing system changes and costs after a system becomes operational. Most companies establish a specific process that describes how system changes must be requested and documented.

As enterprise-wide information systems grow more complex, CM becomes critical. Industry standards have emerged, such as the IEEE's Standard 828-2012 for CM in systems and software, as shown in Figure 12-8.



FIGURE 12-8 IEEE Standard 828-2012 for configuration management in systems and software engineering.
Source: IEEE

CM is especially important if a system has multiple versions that run in different hardware and software environments. CM also helps to organize and handle documentation. An operational system has extensive documentation that covers development, modification, and maintenance for all versions of the installed system. Most

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documentation material, including the initial systems request, project management data, end-of-phase reports, data dictionary, and the IT operations and user manuals, is stored in the IT department.

Keeping track of all documentation and ensuring that updates are distributed properly are important aspects of CM.

12.3.5 Maintenance Releases

Keeping track of maintenance changes and updates can be difficult, especially for a complex system. When a **maintenance release methodology** is used, all noncritical changes are held until they can be implemented at the same time. Each change is documented and installed as a new version of the system called a **maintenance release**.

For an in-house developed system, the time between releases usually depends on the level of maintenance activity. A new release to correct a critical error, however, might be implemented immediately rather than saved for the next scheduled release.

When a release method is used, a numbering pattern distinguishes the different releases. In a typical system, the initial version of the system is 1.0, and the release that includes the first set of maintenance changes is version 1.1. A change, for example, from version 1.4 to 1.5 indicates relatively minor enhancements, while whole number changes, such as from version 1.0 to 2.0 or from version 3.4 to 4.0, indicate a significant upgrade.

The release methodology offers several advantages, especially if two teams perform maintenance work on the same system. When a release methodology is used, all changes are tested together before a new system version is released. This approach results in fewer versions, less expense, and less interruption for users. Using a release methodology also reduces the documentation burden because all changes are coordinated and become effective simultaneously.

A release methodology also has some potential disadvantages. Users expect a rapid response to their problems and requests, but with a release methodology, new features or upgrades are available less often. Even when changes would improve system efficiency or user productivity, the potential savings must wait until the next release, which might increase operational costs.

Commercial software suppliers also provide maintenance releases, often called **service packs**, as shown in Figure 12-9. As Microsoft explains, a service pack contains all the fixes and enhancements that have been made available since the last program version or service pack.

12.3.6 Version Control

Version control is the process of tracking system releases, or versions. When a new version of a system is installed, the prior release is **archived** or stored. If a new version causes a system to fail, a company can reinstall the prior version to restore operations. In addition to tracking system versions, the IT staff is responsible for configuring systems that have several modules at various release stages. For example, an accounting system might have a one-year-old accounts receivable module that must interface with a brand-new payroll module.

Many firms use commercial applications to handle version control for complex systems. There are also numerous free and open-source alternatives. For example, one of the most popular version control systems is git, which is shown in Figure 12-10. Git is a free and open-source program designed for distributed systems. It is relatively easy to use, is available across most major platforms, and is supported by the developer community.

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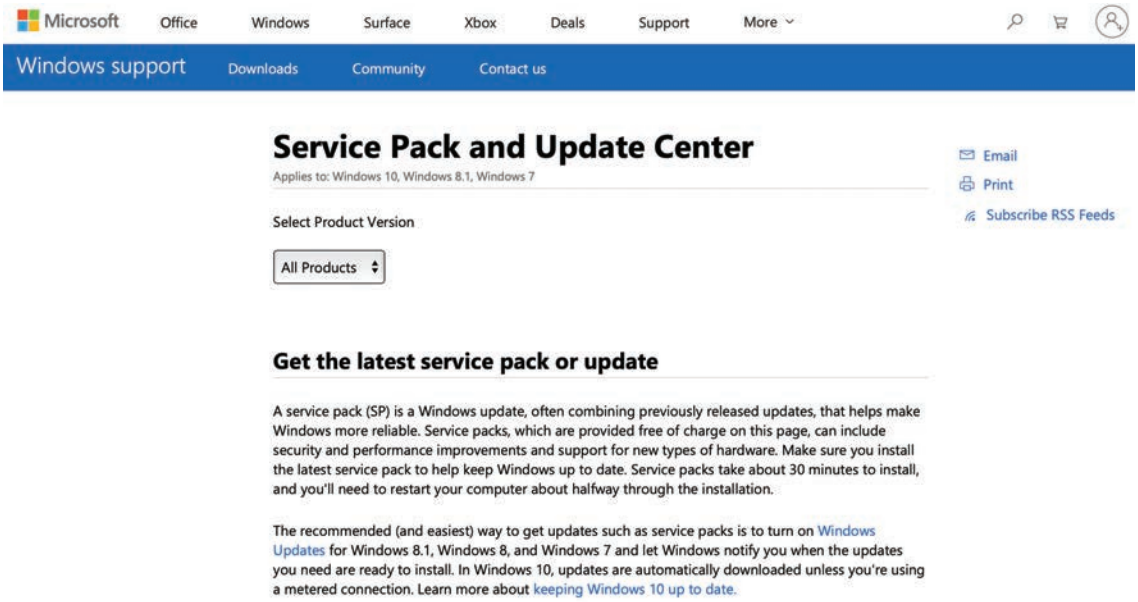


FIGURE 12-9 A Microsoft service pack provides access to updated drivers, tools, security patches, and customer-requested product changes.
Source: Microsoft

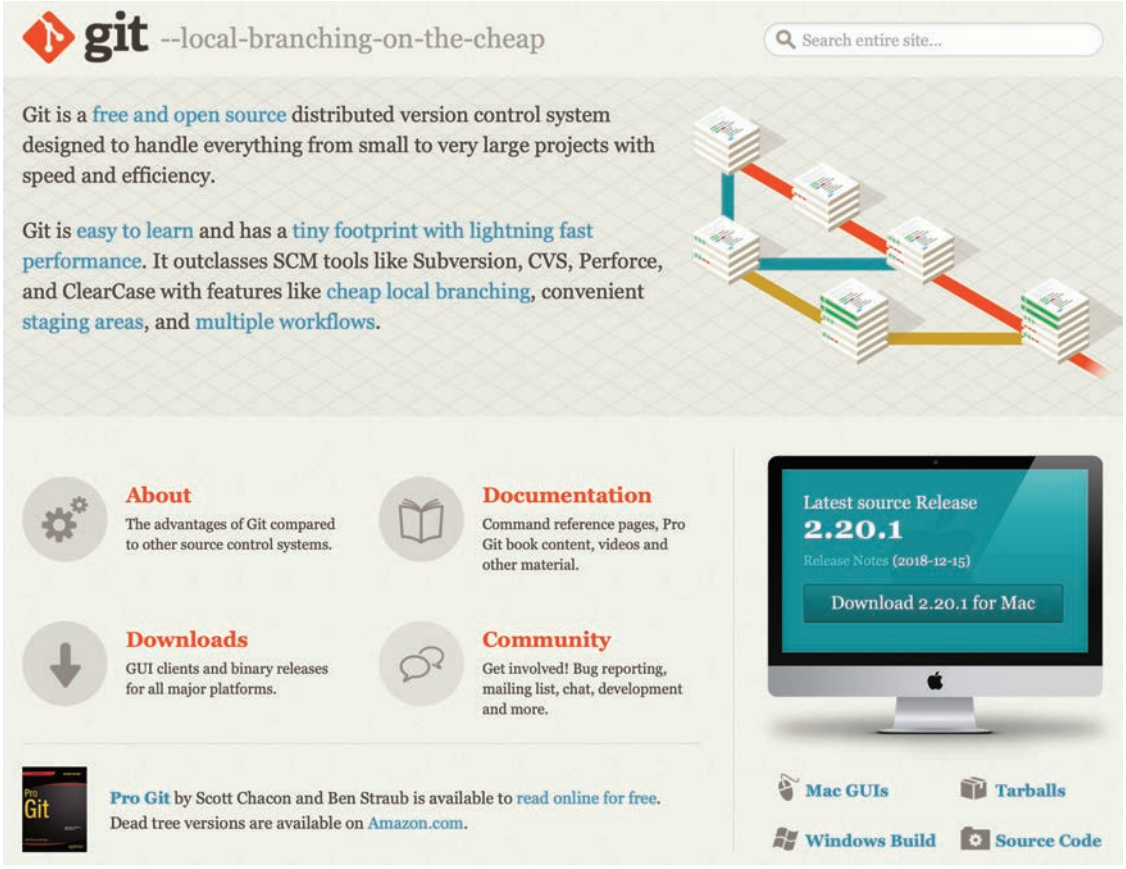


FIGURE 12-10 Git is a popular free version control system.
Source: git-scm.com

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12.3.7 Baselines

A **baseline** is a formal reference point that measures system characteristics at a specific time. Systems analysts use baselines as yardsticks to document features and performance during the systems development process. The three types of baselines are functional, allocated, and product.

The **functional baseline** is the configuration of the system documented at the beginning of the project. It consists of all the necessary system requirements and design constraints.

The **allocated baseline** documents the system at the end of the design phase and identifies any changes since the functional baseline. The allocated baseline includes testing and verification of all system requirements and features.

The **product baseline** describes the system at the beginning of system operation. The product baseline incorporates any changes made since the allocated baseline and includes the results of performance and acceptance tests for the operational system.

12.4 System Performance Management

Years ago, when most firms used a central computer for processing data, it was relatively simple to manage a system and measure its efficiency. Today, companies use complex networks, client/server systems, and cloud computing environments to support business needs. A user at a client workstation often interacts with an information system that depends on other clients, servers, networks, and data located throughout the company. Rather than a single computer, it is the integration of all those components that determines the system's capability and performance.

To ensure satisfactory support for business operations, the IT department must manage system faults and interruptions, measure system performance and workload, and anticipate future needs. In many situations, IT managers use automated software and CASE tools to help with these tasks. Automated tools can provide valuable assistance during the operation and support phases. Many CASE tools include system evaluation and maintenance features, such as the following:

- Performance monitors that provide data on program execution times
- Program analyzers that scan source code, provide data element cross-reference information, and help evaluate the impact of a program change
- Interactive debugging analyzers that locate the source of a programming error
- Reengineering tools
- Automated documentation capabilities
- Network activity monitors
- Workload forecasting tools

In addition to CASE tools, spreadsheet and presentation software can be used to calculate trends, perform what-if analyses, and create attractive charts and graphs to display the results. Information technology planning is an essential part of the business planning process and often part of the presentations made to management.

12.4.1 Fault Management

No matter how well it is designed, every system will experience some problems, such as hardware failures, software errors, user mistakes, and power outages. A system

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administrator must detect and resolve operational problems as quickly as possible. That task, often called **fault management**, includes monitoring the system for signs of trouble, logging all system failures, diagnosing the problem, and applying corrective action.

The more complex the system, the more difficult it can be to analyze symptoms and isolate a cause. In addition to addressing the immediate problem, it is important to evaluate performance patterns and trends. For example, the Activity Monitor application shown in Figure 12-11 runs on Apple's Mac OS X to display CPU, memory, energy, disk, and network activity of all running applications in real time. Similar programs, such as the Resource Monitor, are available on Windows. Fault management software can help identify underlying causes, speed up response time, and reduce service outages.

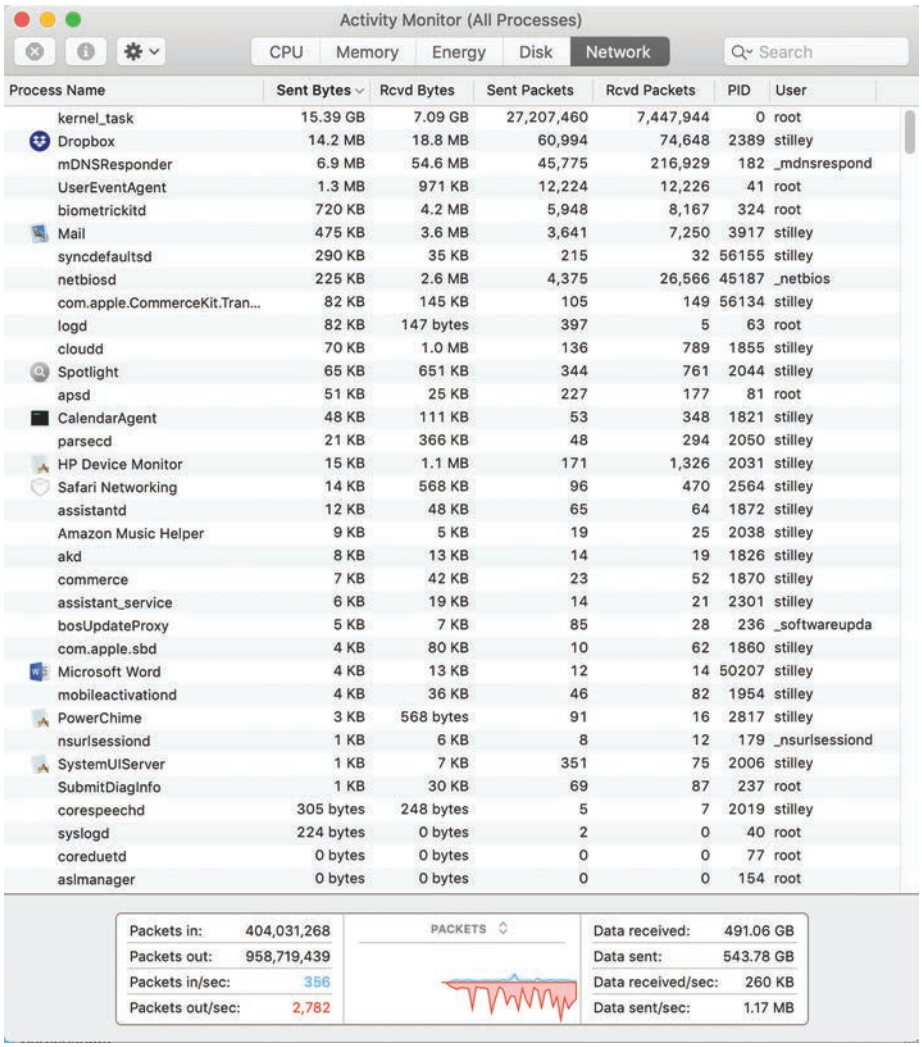


FIGURE 12-11 The Activity Monitor application on Apple's Mac OS X displays CPU, memory, energy, disk, and network activity of all running applications in real time.
Source: Apple

Although system administrators must deal with system faults and interruptions as they arise, the best strategy is to prevent problems by monitoring system performance and workload.

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12.4.2 Performance and Workload Measurement

In e-business, slow performance can be as devastating as no performance at all. Network delays and application bottlenecks affect customer satisfaction, user productivity, and business results. In fact, many IT managers believe that network delays do more damage than actual stoppages because they occur more frequently and are difficult to predict, detect, and prevent. Customers expect reliable, fast response 24 hours a day, seven days a week. To support that level of service, companies use performance management software.

To measure system performance, many firms use **benchmark testing**, which uses a set of standard tests to evaluate system performance and capacity. In addition to benchmark testing, performance measurements, called **metrics**, can monitor the number of transactions processed in a given time period, the number of records accessed, and the volume of online data. Network performance metrics include response time, bandwidth, throughput, and turnaround time, among others.

RESPONSE TIME: **Response time** is the overall time between a request for system activity and the delivery of the response. In the typical online environment, response time is measured from the instant the user presses the Enter key or clicks a mouse button until the requested screen display appears or printed output is ready. Response time is affected by the system design, capabilities, and processing methods. If the request involves network or Internet access, response time is affected by data communication factors.

Online users expect an immediate response, and they are frustrated by any apparent lag or delay. Of all performance measurements, response time is the one that users notice and complain about most.

BANDWIDTH AND THROUGHPUT: Bandwidth and throughput are closely related terms, and many analysts use them interchangeably. **Bandwidth** describes the amount of data that the system can transfer in a fixed time period. Bandwidth requirements are expressed in bits per second. Depending on the system, bandwidth can be measured in **kilobits per second (Kbps)**, **megabits per second (Mbps)**, or **gigabits per second (Gbps)**. Analyzing bandwidth is similar to forecasting the hourly number of vehicles that will use a highway in order to determine the number of lanes required.

Throughput measures actual system performance under specific circumstances and is affected by network loads and hardware efficiency. Like bandwidth, throughput is expressed as a data transfer rate, such as Kbps, Mbps, or Gbps. Just as traffic jams delay highway traffic, throughput limitations can slow system performance and response time. That is especially true with graphics-intensive systems and web-based systems that are subject to Internet-related conditions.

In addition to the performance metrics explained in the previous section, system administrators measure many other performance characteristics. Although no standard set of metrics exists, several typical examples are as follows:

- Arrivals: The number of items that appear on a device during a given observation time.
- Busy: The time that a given resource is unavailable.
- Completions: The number of arrivals that are processed during a given observation period.
- Queue length: The number of requests pending for a service.

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- Service time: The time it takes to process a given task once it reaches the front of the queue.
- Think time: The time it takes an application user to issue another request.
- Utilization: How much of a given resource was required to complete a task.
- Wait time: The time that requests must wait for a resource to become available.

TURNAROUND TIME: **Turnaround time** applies to centralized batch processing operations, such as customer billing or credit card statement processing. Turnaround time measures the time between submitting a request for information and the fulfillment of the request. Turnaround time also can be used to measure the quality of IT support or services by measuring the time from a user request for help to the resolution of the problem.

The IT department often measures response time, bandwidth, throughput, and turnaround time to evaluate system performance both before and after changes to the system or business information requirements. Performance data also is used for cost-benefit analyses of proposed maintenance and to evaluate systems that are nearing the end of their economically useful lives.

Finally, management uses current performance and workload data as input for the capacity planning process.

12.4.3 Capacity Planning

Capacity planning is a process that monitors current activity and performance levels, anticipates future activity, and forecasts the resources needed to provide desired levels of service.

The first step in capacity planning is to develop a current model based on the system's present workload and performance specifications. Then future demand and user requirements are projected over a one- to three-year time period. The model is analyzed to see what is needed to maintain satisfactory performance and meet requirements. To assist in the process, a technique called what-if analysis can be used.

What-if analysis varies one or more elements in a model in order to measure the effect on other elements. For example, what-if analysis might be used to answer questions such as the following: How will response time be affected if more client workstations were added to the network? Will the client/server system be able to handle the growth in sales from the new website? What will be the effect on server throughput if more memory is added?

Powerful spreadsheet tools also can assist in performing what-if analysis. For example, Microsoft Excel contains a feature called Goal Seek that determines what changes are necessary in one value to produce a specific result for another value. In the example shown in Figure 12-12, a capacity planning worksheet indicates that the system can handle 3,840 web-based orders per day, at 22.5 seconds each. Excel calculates this automatically using the simple formula =86400/B4 for cell B5. (There are 86,400 seconds in a 24-hour day.) The user wants to know the effect on processing time if the number of transactions increases to 9,000. As the Goal Seek solution in the bottom figure shows, order processing will have to be performed in 9.6 seconds to achieve that goal.

During plan capacity, detailed information is needed about the number of transactions; the daily, weekly, or monthly transaction patterns; the number of

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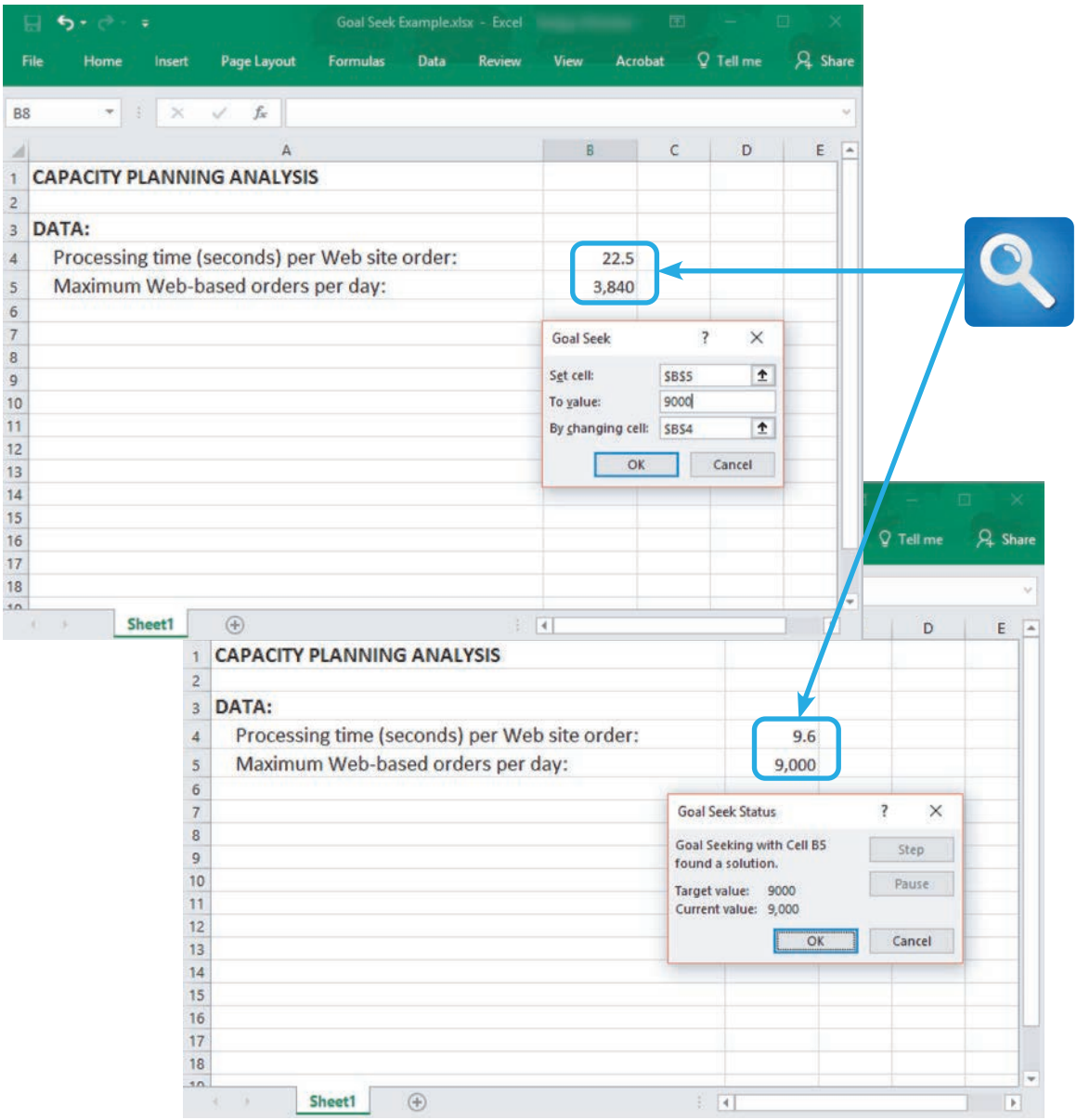


FIGURE 12-12 In this Goal Seek example, the user wants to know the effect on processing time if the number of daily transactions increases from 3,840 to 9,000.

queries; and the number, type, and size of all generated reports. If the system involves a LAN, network traffic levels must be estimated to determine whether or not the existing hardware and software can handle the load. If the system uses a client/server design, performance and connectivity specifications must be examined for each platform.

Most important, an accurate forecast of future business activities is needed. If new business functions or requirements are predicted, contingency plans should be developed based on input from users and management. The main objective is to ensure that the system meets all future demands and provides effective support for business operations. Some firms handle their own capacity planning, while others purchase software such as Idera's Uptime Infrastructure Monitor, shown in Figure 12-13.

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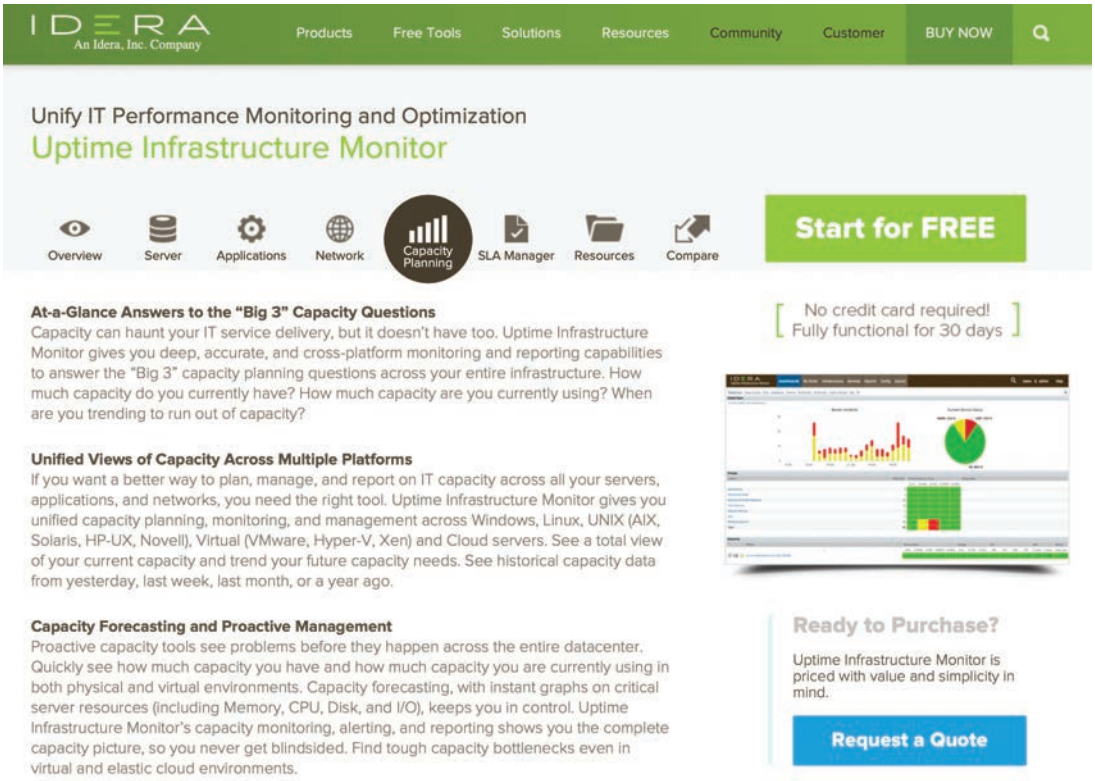


FIGURE 12-13 Idera's Uptime Infrastructure Monitor is an example of capacity planning software and services.

Source: Uptime Software

12.5 System Security

Security is a vital part of every information system. **Security** protects the system and keeps it safe, free from danger, and reliable. In a global environment that includes many types of threats and attacks, security is more important than ever. This section includes a discussion of system security concepts, risk management, and common attacks against the system.

12.5.1 System Security Concepts

The **CIA triangle** in Figure 12-14 shows the three main elements of system security: confidentiality, integrity, and availability. **Confidentiality** protects information from unauthorized disclosure and safeguards privacy. **Integrity** prevents unauthorized users from creating, modifying, or deleting information. **Availability** ensures that authorized users have timely and reliable access to necessary information. The first step in managing IT security is to develop a **security policy** based on these three elements.

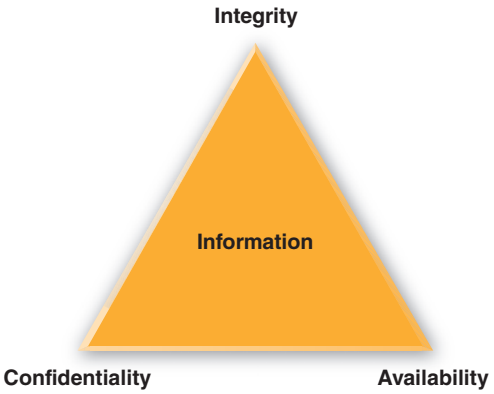


FIGURE 12-14 System security must provide information confidentiality, integrity, and availability (CIA).

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FIGURE 12-15 Risk management requires continuous risk identification, assessment, and control.

12.5.2 Risk Management

In the real world, *absolute* security is not a realistic goal. Instead, managers must balance the value of the assets being protected, potential risks to the organization, and security costs. For example, it might not be worth installing an expensive video camera monitoring system to protect an empty warehouse. To achieve the best results, most firms use a **risk management** approach that involves constant attention to three interactive tasks: risk identification, risk assessment, and risk control, as shown in Figure 12-15.

Risk identification analyzes the organization's assets, threats, and vulnerabilities. **Risk assessment** measures risk likelihood and impact. **Risk control** develops safeguards that reduce risks and their impact.

RISK IDENTIFICATION: The first step in risk identification is to list and classify business assets. An **asset** might include company

Threat Categories and Examples

THREAT CATEGORY	EXAMPLE
Extortion	Hacker steals trade secrets and threatens to release them if not paid.
Hardware and software failures	Router stops functioning, or software causes the application server to crash.
Human error or failure	Employee accidentally deletes a file.
Natural disasters	Flood destroys company building and networked systems.
Service failure	Electricity is disrupted and brings the entire system down for hours.
Software attack	A group plants destructive software, a virus, or a worm into a company network.
Technical obsolescence	Outdated software is slow, difficult to use, and vulnerable to attacks.
Theft of physical or intellectual property	Physical server is stolen, intellectual property is stolen or used without permission; may be physical or electronic.
Trespass and espionage	Employee enters unlocked server room and views the payroll data on a forbidden system.
Vandalism	Attacker defaces website logo, or destroys CEO's hard drive physically or electronically.

FIGURE 12-16 System threats can be grouped into several broad categories.

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hardware, software, data, networks, people, or procedures. For each asset, a risk manager rates the impact of an attack and analyzes possible threats. A **threat** is an internal or external entity that could endanger an asset. For example, threat categories might include natural disasters, software attacks, or theft, as shown in Figure 12-16.

Next, the risk manager identifies vulnerabilities and how they might be exploited. A **vulnerability** is a security weakness or soft spot, and an **exploit** is an attack that takes advantage of a vulnerability. To identify vulnerabilities, a risk manager might ask questions like these: *Could hackers break through the proxy server? Could employees retrieve sensitive files without proper authorization? Could people enter the computer room and sabotage our servers?* Each vulnerability is rated and assigned a value. The output of risk identification is a list of assets, vulnerabilities, and ratings.

RISK ASSESSMENT: In IT security terms, a **risk** is the impact of an attack multiplied by the likelihood of a vulnerability being exploited. For example, an impact value of 2 and a vulnerability rating of 10 would produce a risk of 20. On the other hand, an impact value of 5 and a vulnerability rating of 5 would produce a risk of 25. When risks are calculated and prioritized, **critical risks** will head the list. Although ratings can be subjective, the overall process provides a consistent approach and framework.

RISK CONTROL: After risks are identified and assessed, they must be controlled. Control measures might include the following examples: *We could place a firewall on the proxy server. We could assign permissions to sensitive files. We could install biometric devices to guard the computer room.* Typically, management chooses one of four risk control strategies: avoidance, mitigation, transference, or acceptance. **Avoidance** eliminates the risk by adding protective safeguards. For example, to prevent unauthorized access to LAN computers, a secure firewall might be installed. **Mitigation** reduces the impact of a risk by careful planning and preparation. For example, a company can prepare a disaster recovery plan in case a natural disaster occurs. **Transference** shifts the risk to another asset or party, such as an insurance company. **Acceptance** means that nothing is done. Companies usually accept a risk only when the protection clearly is not worth the expense.

The risk management process is iterative—risks are constantly identified, assessed, and controlled. To be effective, risk managers need a combination of business knowledge, IT skills, and experience with security tools and techniques.

12.5.3 Attacker Profiles and Attacks

An **attack** is a hostile act that targets the system, or the company itself. Thus, a disgruntled employee, or a hacker who is 6,000 miles away, might launch an attack. Attackers break into a system to cause damage, steal information, or gain recognition, among other reasons. Attackers can be grouped into categories, as shown in Figure 12-17, while Figure 12-18 describes some common types of attacks. Companies combat security threats and challenges by using a multilevel strategy.

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Attacker Characteristics

ATTACKER	DESCRIPTION	SKILL SET
Cyberterrorist	Attacks to advance political, social, or ideological goals.	High
Employee	Uses unauthorized information or privileges to break into computer systems, steal information, or cause damage.	Varies
Hacker	Uses advanced skills to attack computer systems with malicious intent (black hat) or to expose flaws and improve security (white hat).	High
Hacktivist	Attacks to further a social or political cause; often involves shutting down or defacing websites.	Varies
Script kiddie	Inexperienced or juvenile hacker who uses readily available malicious software to disrupt or damage computer systems, and gain recognition.	Low
Spy	Non-employee who breaks into computer systems to steal information and sell it.	High

FIGURE 12-17 IT security professionals have names for various types of attackers.

Types of Attacks and Examples

ATTACK	EXAMPLES
Back door	Attacker finds vulnerability in software package and exploits it.
Denial of service or distributed denial of service	One or more computers send a stream of connection requests to disable a Web server.
Dumpster diving	Attacker scours the trash for valuable information that can be used to compromise the system.
Mail bombing	Enormous volumes of email are sent to a target address.
Malicious code	Attacker sends infected email to the target system. Attackers may use viruses, worms, Trojan horses, keystroke loggers, spyware, or scripts to destroy data, bog down systems, spy on users, or assume control of infected systems.
Man in the middle	The attacker intercepts traffic and poses as the recipient, sending the data to the legitimate recipient but only after reading the traffic or modifying it.
Password cracking	Hacker attempts to discover a password to gain entry into a secured system. This can be a dictionary attack, where numerous words are tried, or a brute force attack, where every combination of characters is attempted.
Phishing	False DNS (Domain Name Server) information steers the user to the attacker's website. Attackers trick users into thinking they are visiting a legitimate site, such as a bank site, then attempt to obtain bank account numbers, usernames, and passwords.
Privilege escalation	Employee tricks a computer into raising his or her account to the administrator level.

(continues)

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ATTACK	EXAMPLES
Sniffing	Network traffic is intercepted and scanned for valuable information.
Social engineering	An attacker calls the service desk posing as a legitimate user and requests that his or her password be changed.
Spam	Unwanted, useless email is sent continuously to business email accounts, wasting time and decreasing productivity.
Spoofing	IP address is forged to match a trusted host, and similar content may be displayed to simulate the real site for unlawful purposes.

FIGURE 12-18 Attacks can take many forms, as this table shows. IT security managers must be able to detect these attacks and respond with suitable countermeasures.

12.6 Security Levels

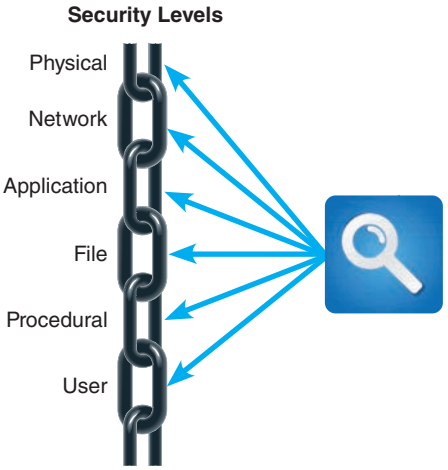


FIGURE 12-19 Each security link has a specific focus, and the overall chain is only as strong as the weakest link.

To provide system security, six separate but interrelated levels must be considered: physical security, network security, application security, file security, user security, and procedural security. Like the chain shown in Figure 12-19, system security is only as strong as the weakest link. The following sections describe these security levels, and the issues that must be addressed. Top management often makes the final strategic and budget decisions regarding security, but systems analysts should understand the overall picture in order to make informed recommendations.

12.6.1 Physical Security

The first level of system security concerns the physical environment, including IT resources and people throughout the company. Special attention must be paid to critical equipment located in operations centers, where servers, network hardware, and related equipment operate. Large companies usually have a dedicated room built specifically for IT operations. Smaller firms might use an office or storage area. Regardless of its size and shape, an operations center requires special protection from unwanted intrusion. In addition to centrally located equipment, all computers on the network must be secure because each server or workstation can be a potential access point. Physical access to a computer represents an entry point into the system and must be controlled and protected.

OPERATIONS CENTER SECURITY: Perimeter security is essential in any room or area where computer equipment is operated or maintained. Physical access must be controlled tightly, and each entrance must be equipped with a suitable security device. All access doors should have internal hinges and electromagnetic locks that are equipped with a battery backup system to provide standby power in the event of a power outage. When the battery power is exhausted, the doors should fail in a closed position, but it should be possible for someone locked inside the room to open the door with an emergency release.

To enhance security, many companies are installing **biometric scanning systems**, which map an individual's facial features, fingerprints, handprint, or eye characteristics, as shown in Figure 12-20. These high-tech authentication systems replace magnetic identification badges, which can be lost, stolen, or altered. Apple's Face ID system, described in Chapter 2, is an example of a biometric security system for smartphones and mobile

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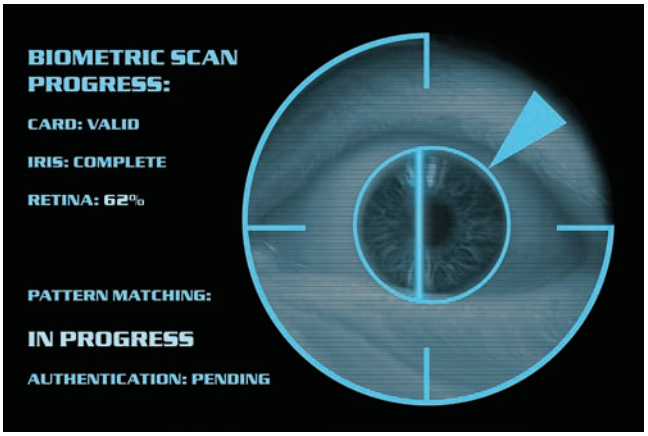


FIGURE 12-20 Companies use biometric scanning to analyze the features of the eye's iris, which has more than 200 points that can be measured and used for comparison.
Andy Piatt/Shutterstock.com

devices, as discussed in the section on portable computers that follows.

Video cameras and motion sensors can be used to monitor computer room security and provide documentation of all physical activity in the area. A motion sensor uses infrared technology to detect movement and can be configured to provide audible or silent alarms, and to send email messages when one is triggered. Other types of sensors can monitor temperature and humidity in the computer room. Motion sensor alarms can be activated at times when there is no expected activity in the computer room, and authorized technicians should have codes to enable or disable the alarms.

SERVERS AND DESKTOP COMPUTERS: If possible, server and desktop computer cases should be equipped with locks. This simple, but important, precaution might prevent an intruder from modifying the hardware configuration of a server, damaging the equipment, or removing a disk drive. Server racks should be locked to avoid the unauthorized placement and retrieval of keystroke loggers. A **keystroke logger** is a device that can be inserted between a keyboard and a computer. Typically, the device resembles an ordinary cable plug, so it does not call attention to itself. The device can record everything that is typed into the keyboard, including passwords, while the system continues to function normally. Keystroke loggers can be used legitimately to monitor, back up, and restore a system, but if placed by an intruder, a keystroke logger represents a serious security threat.

In addition to hardware devices, keystroke logging software also exists. A keystroke logging program can be disguised as legitimate software and downloaded from the Internet or a company network. The program remains invisible to the user as it records keystrokes and uploads the information to whoever installed the program. Such malicious software can be removed by antivirus and antispyware software, discussed later in the Application Security section.

Tamper-evident cases should be used where possible. A tamper-evident case is designed to show any attempt to open or unlock the case. In the event that a computer case has been opened, an indicator LED remains lit until it is cleared with a password. Tamper-evident cases do not prevent intrusion, but a security breach is more likely to be noticed. Many servers now are offered with tamper-evident cases as part of their standard configuration.

Monitor screen savers that hide the screen and require special passwords to clear should be used on any server or workstation that is left unattended. Locking the screen after a period of inactivity is another safeguard. A **BIOS-level password**, also called a **boot-level password** or a **power-on password**, can also be used. This password must be entered before the computer can be started. A boot-level password can prevent an unauthorized person from booting a computer by using a secondary device.

Finally, companies must consider electric power issues. In mission-critical systems, large-scale backup power sources are essential to continue business operations. In other cases, computer systems and network devices should be plugged into an **uninterruptible power supply (UPS)** that includes battery backup with suitable capacity. The UPS should be able to handle short-term operations in order to permit an orderly backup and system shutdown.

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PORTABLE COMPUTERS: When assessing physical security issues, be sure to consider additional security provisions for notebook, laptop, and tablet computers. Because of their small size and high value, these computers are tempting targets for thieves and industrial spies. Although the following suggestions are intended as a checklist for notebook computer security, many of them also apply to desktop workstations.

- Select an operating system that allows secure logons, BIOS-level passwords, and strong firewall protection. Log on and work with a user account that has limited privileges rather than an administrator account and mask the administrator account by giving it a different name that would be hard for a casual intruder to guess.
- Mark or engrave the computer's case with the company name and address, or attach a tamper-proof asset ID tag. Many hardware vendors allow corporate customers to add an asset ID tag in the BIOS. For example, after powering up, the following message may appear: *Property of SCR Associates—Company Use Only*. These measures might not discourage a professional thief, but might deter a casual thief, or at least make the computer relatively less desirable because it would be more difficult to use or resell. Security experts also recommend using a generic carrying case, such as an attaché case, rather than a custom carrying case that calls attention to itself and its contents.
- Consider devices that have a built-in fingerprint reader or facial recognition system.
- Many notebook computers have a **Universal Security Slot (USS)** that can be fastened to a cable lock or laptop alarm. Again, while these precautions might not deter professional thieves, they might discourage and deter casual thieves.
- Back up all vital data before using the notebook computer outside the office. Save and transport highly sensitive data on removable media, such as a flash memory device, instead of the computer's hard drive.
- Use tracking software that directs the laptop to periodically contact a security tracking center. If the notebook is stolen, the call-in identifies the computer and its physical location. Armed with this information, the security tracking center can alert law enforcement agencies and communications providers.
- Apple, Google, and Microsoft offer services to locate lost customer smartphones. The services also permit remote data wipe and factory reset of the devices. For example, Apple's Find My iPhone app is shown in Figure 12-21. Apple also provides a similar cloud-based service.
- While traveling, try to be alert to potential high-risk situations, where a thief, or thieves, might create a distraction and attempt to snatch the computer. These situations often occur in crowded, noisy places like airport baggage claim areas, rental car counters, and security checkpoints. Also, when traveling by car, store the computer in a trunk or lockable compartment where it will not be visible.



FIGURE 12-21 Apple's Find My iPhone app helps customers locate lost devices and perform remote data wipes and factory resets if needed.
Source: Scott Tilley/Apple

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- Establish stringent password protection policies that require minimum length and complexity and set a limit on how many times an invalid password can be entered before the system locks itself down. In some situations, consider establishing file encryption policies to protect extremely sensitive files.

CASE IN POINT 12.2: Outer Banks County

Outer Banks County is a 200-square-mile area in coastal North Carolina, and you are the IT manager. The county has about a hundred office employees who perform clerical tasks in various departments. A recent budget crisis has resulted in a wage and hiring freeze, and morale has declined. The county manager has asked you to install some type of keystroke logger to monitor employees and determine whether they are fully productive. After your conversation, you wonder whether there might be some potential privacy and security issues involved.

For example, does an employer have a duty to notify its employees that it is monitoring them? Should the employer notify them even if not required to do so? From a human resources viewpoint, what would be the best way to approach this issue? Also, does a potential security issue exist? If an unauthorized person gained possession of the keystroke log, he or she might be able to uncover passwords and other sensitive data.

What are your conclusions? Are these issues important, and how would you respond to the county manager's recommendation? Before you answer, you should go on the Internet and learn more about keystroke loggers generally, and specific products that currently are available.

12.6.2 Network Security

A **network** is defined as two or more devices that are connected for the purpose of sending, receiving, and sharing data, which is called network traffic. In order to connect to a network, a computer must have a **network interface**, which is a combination of hardware and software that allows the computer to interact with the network. To provide security for network traffic, data can be encrypted, which refers to a process of encoding the data so it cannot be accessed without authorization.

ENCRYPTING NETWORK TRAFFIC: Network traffic can be intercepted and possibly altered, redirected, or recorded. For example, if an **unencrypted**, or **plain text**, password or credit card number is transmitted over a network connection, it can be stolen. When the traffic is encrypted, it still is visible, but its content and purpose are masked.

Two commonly used encryption techniques are private key encryption and public key encryption. **Private key encryption** is symmetric because a single key is used to encrypt and decrypt information. While this method is simple and fast, it poses a fundamental problem. To use symmetric encryption, both the sender and receiver must possess the same key beforehand, or it must be sent along with the message, which increases the risk of interception and disclosure.

In contrast, **public key encryption (PKE)** is asymmetric, because each user has a pair of keys: a public key and a private key. Public keys are used to encrypt messages. Users can share their public keys freely, while keeping their private keys tightly guarded. Any message encrypted with a user's public key can only be decrypted with that user's private key. This method is commonly used in secure online e-commerce systems.

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WIRELESS NETWORKS: As discussed in Chapter 10, wireless network security is a vital concern because wireless transmission is much more vulnerable than traffic on a wired network. However, if wireless traffic is encrypted, any data that is intercepted by an unintended recipient will be useless to the intruder.

The earliest form of wireless security, called **Wired Equivalent Privacy (WEP)**, required each wireless client to use a special, pre-shared key. Although many home and small office networks used this method, it provided relatively weak protection.

WEP was replaced by **Wi-Fi Protected Access (WPA)**, which offered major security improvements based on protocols created by the Wi-Fi Alliance. The most recent wireless security enhancement, called **WPA2**, further strengthens the level of wireless protection. WPA2 is an extension of WPA based on a full implementation of the **IEEE 802.11i** standard. According to the Wi-Fi Alliance, the WPA2 standard became mandatory for all new devices seeking Wi-Fi certification after 2006. WPA2 is compatible with WPA, so companies easily can migrate to the new security standard.

PRIVATE NETWORKS: It is not always practical to secure all network traffic. Unfortunately, encrypting traffic increases the burden on a network, and can decrease network performance significantly. In situations where network speed is essential, such as a web server linked to a database server, many firms use a private network to connect the computers. A **private network** is a dedicated connection, similar to a leased telephone line. Each computer on the private network must have a dedicated interface to the network, and no interface on the network should connect to any point outside the network. In this configuration, unencrypted traffic safely can be transmitted because it is not visible and cannot be intercepted from outside the network.

VIRTUAL PRIVATE NETWORKS: Private networks work well with a limited number of computers, but if a company wants to establish secure connections for a larger group, it can create a virtual private network. A **virtual private network (VPN)** uses a public network, such as the Internet or a company intranet, to connect remote users securely. Instead of using a dedicated connection, a VPN allows remote clients to use a special key exchange that must be authenticated by the VPN. Once authentication is complete, a secure network connection, called a **tunnel**, is established between the client and the access point of the local intranet. All traffic is encrypted through the VPN tunnel, which provides an additional level of encryption and security. As more companies allow employees to work from home, a VPN can provide acceptable levels of security and reliability.

PORTS AND SERVICES: A **port**, which is identified by a number, is used to route incoming traffic to the correct application on a computer. In TCP/IP networks, such as the Internet, all traffic received by a computer contains a destination port. Because the destination port determines where the traffic will be routed, the computer sorts the traffic by port number, which is included in the transmitted data. An analogy might be a large apartment building with multiple mailboxes. Each mailbox has the same street address, but a different box number. Port security is critically important because an attacker could use an open port to gain access to the system.

A **service** is an application that monitors, or listens on, a particular port. For example, a typical email application listens on port 25. Any traffic received by that port is routed to the email application. Services play an important role in computer security, and they can be affected by port scans and denial-of-service attacks.

- Port scans. **Port scans** attempt to detect the services running on a computer by trying to connect to various ports and recording the ports on which a connection was accepted. For example, the result of an open port 25 would

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indicate that a mail server is running. Port scans can be used to draw an accurate map of a network, and pinpoint possible weaknesses.

- Denial of service. A **denial of service (DoS)** attack occurs when an attacking computer makes repeated requests to a service or services running on certain ports. Because the target computer has to respond to each request, it can become bogged down and fail to respond to legitimate requests. A much more devastating attack based on this method is called a **distributed denial of service (DDoS)** attack. This attack involves multiple attacking computers that can synchronize DOS attacks and immobilize a server, as shown in Figure 12-22. A DDoS attack is an example of the type of serious cyberattacks that United States Computer Emergency Readiness Team (US-CERT), shown in Figure 12-23, was created to address.

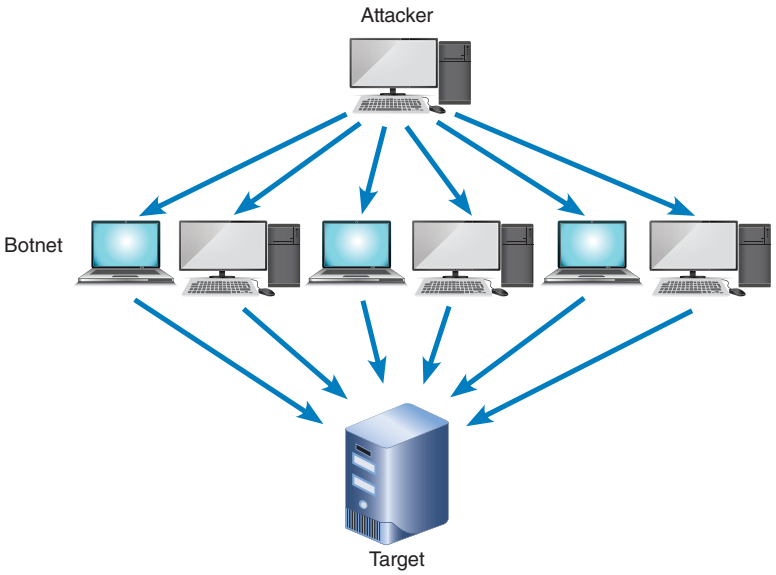


FIGURE 12-22 In a DoS attack, an attacker sends numerous authentication requests with false return addresses. The server tries unsuccessfully to send out authentication approval and is eventually disabled by the floor of requests. More sophisticated DoS attacks are distributed (DDoS), as shown in this figure. Instead of a single computer, the attacker uses an army of botnets (computers unknowingly infected with malware that are difficult to trace) to attack the target.



FIGURE 12-23 The US-CERT is a key player in the battle against cybersecurity threats.
Source: US-CERT

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FIREWALLS: A firewall is the main line of defense between a local network, or intranet, and the Internet. A firewall must have at least one network interface with the Internet, and at least one network interface with a local network or intranet. Firewall software examines all network traffic sent to and from each network interface. Preset rules establish certain conditions that determine whether the firewall will allow the traffic to pass. When a matching rule is found, the firewall automatically accepts, rejects, or drops the traffic. When a firewall rejects traffic, it sends a reply indicating that the traffic is not permissible. When a firewall drops traffic, no reply is sent. Firewalls can be configured to detect and respond to denial-of-service attacks, port scans, and other suspicious activity.

Figure 12-24 shows a basic set of firewall rules for a company that has a web server and a mail server. In this example, the firewall would accept public web server traffic only on ports 80 and 443 and public mail server traffic only on port 25. The firewall would allow private LAN traffic to any destination and port.

RULE	INTERFACE	SOURCE	DESTINATION	PORT	ACTION
1	Public	Any	Web Server	80	Accept
2	Public	Any	Web Server	443	Accept
3	Public	Any	Web Server	Any	Reject
4	Public	Any	Mail Server	25	Accept
5	Public	Any	Mail Server	Any	Reject
6	Public	Any	Any	Any	Drop
7	Private	LAN	Any	Any	Accept

FIGURE 12-24 Examples of rules that determine whether the firewall will allow traffic to pass.

NETWORK INTRUSION DETECTION: Suppose an intruder attempts to gain access to the system. Obviously, an intrusion alarm should be sounded when certain activity or known attack patterns are detected. A **network intrusion detection system (NIDS)** is like a burglar alarm that goes off when it detects a configuration violation. The NIDS also can alert the administrator when it detects suspicious network traffic patterns. An NIDS requires fine-tuning to detect the difference between legitimate network traffic and an attack. It is also important that an NIDS be placed on a switch or other network device that can monitor all network traffic. Although an NIDS requires some administrative overhead, it can be very helpful in documenting the efforts of attackers and analyzing network performance.

12.6.3 Application Security

In addition to securing the computer room and shielding network traffic, it is necessary to protect all server-based applications. To do so, the analyst must analyze the application's functions, identify possible security concerns, and carefully study all available documentation. Application security requires an understanding of services, hardening, application permissions, input validation techniques, software patches and updates, and software logs.

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SERVICES: The network security section explained how a service is an application that monitors, or listens, on a particular port. Which services are running can be determined by using a port scan utility. If a particular application is not needed, it should be disabled. This will improve system security, performance, and reliability. An unnecessary or improperly configured service could create a vulnerability called a **security hole**. For example, if a loosely configured File Transfer Protocol (FTP) service is available to a hacker, he or she might be able to upload destructive code to the server.

HARDENING: The **hardening** process makes a system more secure by removing unnecessary accounts, services, and features. Hardening is necessary because the default configuration of some software packages might create vulnerability. For example, initial software settings often include relatively weak account permissions or file sharing controls. Hardening can be done manually or by using a configuration template, which speeds up the process in a large organization.

Hardening also includes additional protection such as antivirus and antispyware software. These programs can detect and remove **malware**, which is hostile software designed to infiltrate, damage, or deny service to a computer system. Malware includes worms, Trojan horses, keystroke loggers, and spyware, among others.

APPLICATION PERMISSIONS: Typically, an application is configured to be run only by users who have specific rights. For example, an **administrator account**, or **superuser account**, allows essentially unrestricted access. Other users might be allowed to enter data, but not to modify or delete existing data. To prevent unauthorized or destructive changes, the application should be configured so that non-privileged users can access the program but cannot make changes to built-in functions or configurations. **User rights**, also called **permissions**, are discussed in more detail in the file security section.

INPUT VALIDATION: As discussed in Chapter 8, when designing the user interface, input validation can safeguard data integrity and security. For example, if an application requires a number from *1* to *10*, what happens if an alphabetic character or the number *31* is entered? If the application is designed properly, it will respond with an appropriate error message. Chapter 8 also explained data entry and validation checks, which are important techniques that can improve data integrity and quality. Failure to validate input data can result in output errors, increased maintenance expense, and erratic system behavior.

PATCHES AND UPDATES: In an operational system, security holes or vulnerabilities might be discovered at any time. Patches can be used to repair these holes, reduce vulnerability, and update the system. Like any other new software, patches must be tested carefully. Before applying a patch, an effort should be made to determine the risks of *not* applying the patch, and the possibility that the patch might affect other areas of the system.

Many firms purchase software packages called **third-party software**. Patches released by third-party software vendors usually are safe, but any patch must be reviewed carefully before it is applied. Because researching and applying patches is time consuming and expensive, many software vendors offer an **automatic update service** that enables an application to contact the vendor's server and check for a needed patch or update. Depending on the configuration, available patches can be downloaded and installed without human intervention or might require approval by IT managers. Although it is convenient, automatic updating carries substantial risks,

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and should be used only if changes can readily be undone if unexpected results or problems develop.

SOFTWARE LOGS: Operating systems and applications typically maintain a **log** that documents all events, including dates, times, and other specific information. Logs can be important in understanding past attacks and preventing future intrusions. For example, a pattern of login errors might reveal the details of an intrusion attempt. A log also can include system error messages, login histories, file manipulation, and other information that could help track down unauthorized use. Software logs should be monitored constantly to determine if misuse or wrongdoing has occurred. As explained in the network security section, an NIDS can alert a system administrator whenever suspicious events occur.

12.6.4 File Security

Computer configuration settings, users' personal information, and other sensitive data are stored in files. The safety and protection of these files is a vital element in any computer security program, and a systems analyst needs to consider the importance of encryption or encoding files to make them unreadable by unauthorized users, and permissions, which can be assigned to individual users or to user groups.

ENCRYPTION: As explained in the section on network security, **encryption** scrambles the contents of a file or document to protect it from unauthorized access. All corporate data must be protected, but encryption is especially important for sensitive material such as personnel or financial records. User data can be encrypted using features built-in to most modern operating systems.

PERMISSIONS: File security is based on establishing a set of permissions, which describe the rights a user has to a particular file or directory on a server. The most common permissions are read, write, and execute. Typical examples of permissions include the following:

- Read a file: The user can read the contents of the file.
- Write a file: The user can change the contents of the file.
- Execute a file: The user can run the file, if it is a program.
- Read a directory: The user can list the contents of the directory.
- Write a directory: The user can add and remove files in the directory.

When assigning file permissions, a system administrator should ensure that each user has only the minimum permissions necessary to perform his or her work—not more. In some firms, the system administrator has broad discretion in assigning these levels; in other companies, an appropriate level of management approval is required for any permissions above a standard user level. In any case, a well-documented and enforced permissions policy is necessary to promote file security and reduce system vulnerability.

USER GROUPS: Individual users who need to collaborate and share files often request a higher level of permissions that would enable any of them to change file content. A better approach, from a system administrator's viewpoint, might be to create a user group, add specific users, and assign file permissions to the group, rather than to the individuals. Many firms use this approach because it allows a user's rights to be determined by his or her work responsibilities, rather than by

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job title or rank. If a person is transferred, he or she leaves certain groups and joins others that reflect current job duties.

12.6.5 User Security

User security involves the identification of system users and consideration of user-related security issues. Regardless of other security precautions and features, security ultimately depends on system users and their habits, practices, and willingness to support security goals. Unfortunately, many system break-ins begin with a user account that is compromised in some way. Typically, an intruder accesses the system using the compromised account and may attempt a **privilege escalation attack**, which is an unauthorized attempt to increase permission levels.

User security requires identity management, comprehensive password protection, defenses against social engineering, an effective means of overcoming user resistance, and consideration of new technologies. These topics are discussed in the following sections.

IDENTITY MANAGEMENT: **Identity management** refers to controls and procedures necessary to identify legitimate users and system components. An identity management strategy must balance technology, security, privacy, cost, and user productivity. Identity management is an evolving technology that is being pursued intensively by corporations, IT associations, and governments.

Gartner has described identity management as a "set of electronic records that represent . . . people, machines, devices, applications, and services." This definition suggests that not just users, but also each component in a system, must have a verifiable identity that is based on unique characteristics. For example, user authentication might be based on a combination of a password, a Social Security number, an employee number, a job title, and a physical location.

Because of the devastating consequences of intrusion, IT managers should give top priority to identity management strategies and solutions.

PASSWORD PROTECTION: As the section on physical security points out, a secure system must have a password policy that requires minimum length, complexity, and a limit on invalid login attempts. Although passwords are a key element in any security program, users often choose passwords that are easy to recall, and they sometimes resent having to remember complex passwords. For example, for several years in a row, one of the most common computer passwords has been "123456," an unfortunate choice that is trivially easy to crack.

As long as passwords are used, IT managers should insist on passwords that have a minimum length, require a combination of case-sensitive letters and numbers, and must be changed periodically. Unfortunately, any password can be compromised if a user writes it down and stores it in an easily accessible location such as a desk, a bulletin board, or under the keyboard.

Several years ago, a hacker made headlines by gaining access to the email account of a political candidate. The intruder signed on as the candidate, requested a new password, guessed the answers to the security questions, and was able to enter the account. These actions were totally illegal and constituted a serious felony under federal law.

SOCIAL ENGINEERING: Even if users are protecting and securing their passwords, an intruder might attempt to gain unauthorized access to a system using a tactic called **social engineering**. In a social engineering attack, an intruder uses social

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interaction to gain access to a computer system. For example, the intruder might pretend to be a new employee, an outside technician, or a journalist. Through a series of questions, the intruder tries to obtain the information that he or she needs to compromise the system. A common ploy is for the attacker to contact several people in the same organization and use some information from one source to gain credibility and entry to another source.

An intruder also might contact the help desk and say, "Hi. This is Anna Dressler from accounting. I seem to have forgotten my password. Could you give me a new one?" Although this request might be legitimate, it also might be an attacker trying to access the system. A password never should be given based solely on this telephone call. The user should be required to provide further information to validate his or her identity, such as a unique employee ID, a telephone extension, and a company email address.

One highly publicized form of social engineering is called **pretexting**, which is a method of obtaining personal information under false pretenses. Pretexting is commonly used as part of **identity theft**, wherein personal information or online credentials are stolen and used for illegal purposes. The Federal Trade Commission's division of Privacy, Identity & Online Security has a section dedicated to helping consumers battle identify theft. The best way to combat social engineering attacks is with employee education, more training, and a high level of awareness during day-to-day operations.

USER RESISTANCE: Many users, including some senior managers, dislike tight security measures because the measures can be inconvenient and time consuming. Systems analysts should remind users that the company owes the best possible security to its customers, who have entrusted personal information to the firm; to its employees, who also have personal information stored in company files; and to its shareholders, who expect the company to have a suitable, effective, and comprehensive security program that will safeguard company assets and resources. When users understand this overall commitment to security and feel that they are part of it, they are more likely to choose better passwords, be more alert to security issues, and contribute to the overall success of the company's security program.

NEW TECHNOLOGIES: In addition to traditional measures and biometric devices, new technologies can enhance security and prevent unauthorized access. For example, the **security token** shown in Figure 12-25 is a physical device that authenticates a legitimate user. Some firms provide employees with security tokens that generate a numeric validation code, which the employee enters in addition to his or her normal password.

Unfortunately, new technology sometimes creates new risks. For example, a powerful search application can scan all the files, documents, emails, chats, and stored webpages on a user's computer. Although this might provide a convenient way for users to locate and retrieve their data, it also can make it easier for an intruder to obtain private information, especially in a multiuser environment, because the program can recall and display almost anything stored on the computer. Also, if an



FIGURE 12-25 Security tokens, which come in various forms, can provide an additional level of security.
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intruder uses the term *password* in a search, the program might be able to find password reminders that are stored anywhere on the computer. To increase privacy for multiuser computers, each user should have a separate account, with individual usernames and passwords.

Business and personal users also should use caution when they consider cloud-based storage and services. In this environment, where the technology changes rapidly, the best bet may be to work with well-established vendors, who can provide significant cloud security experience and safeguards.

12.6.6 Procedural Security

Procedural security, also called **operational security**, is concerned with managerial policies and controls that ensure secure operations. In fact, many IT professionals believe that security depends more on managerial issues than technology. Management must work to establish a corporate culture that stresses the importance of security to the firm and its people. Procedural security defines how particular tasks are to be performed, from large-scale data backups to everyday tasks such as storing emails or forms. Other procedures might spell out how to update firewall software or how security personnel should treat suspected attackers.

All employees should understand that they have a personal responsibility for security. For example, an employee handbook might require that users log out of their system accounts, clear their desks, and secure all documents before leaving for the day. These policies reduce the risk of **dumpster diving** attacks, in which an intruder raids desks or trash bins for valuable information. In addition, paper shredders should be used to destroy sensitive documents.

Procedural security also includes safeguarding certain procedures that would be valuable to an attacker. The most common approach is a *need-to-know* concept, where access is limited to employees who need the information to perform security-related tasks. Many firms also apply a set of classification levels for access to company documents. For example, highly sensitive technical documents might be available only to the IT support team, while user-related materials would be available to most company employees. If classification levels are used, they should be identified clearly and enforced consistently.

Procedural security must be supported by upper management and fully explained to all employees. The organization must provide training to explain the procedures and issue reminders from time to time that will make security issues a priority.

CASE IN POINT 12.3: Chain Link Consulting, Inc.

Chain Link Consulting is an IT consulting firm that specializes in system security issues. The company's president has asked you to help her put together a presentation to a group of potential clients at a trade show meeting next month. First, she wants you to review system security issues, considering all six security levels. Then she wants you to come up with a list of ways that Chain Link could test a client's security practices, in order to get a real-world assessment of vulnerability.

To make matters more interesting, she told you it was OK to be creative in your recommendations, but not to propose any action that would be illegal or unethical. For example, it would be OK to pose as a job applicant with false references to see if they were being checked, but it would not be appropriate to pick a lock and enter the computer room.

Your report is due tomorrow. What will you suggest?

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12.7 Backup and Recovery

Every system must provide for data backup and recovery. **Backup** refers to copying data at prescribed intervals, or continuously. **Recovery** involves restoring the data and restarting the system after an interruption. An overall backup and recovery plan that prepares for a potential disaster is called a **disaster recovery plan**.

12.7.1 Global Terrorism

The tragic events of September 11, 2001, and increased concern about global terrorism, have led many companies to upgrade their backup and disaster recovery plans. Heightened focus on disaster recovery has spawned a whole new industry, which includes new tools and strategies. Many IT professionals feel that terrorism concerns have raised security awareness throughout the corporate world. Although they are separate topics, backup and disaster recovery issues usually are intertwined.

12.7.2 Backup Policies

The cornerstone of business data protection is a **backup policy**, which contains detailed instructions and procedures. An effective backup policy can help a firm continue business operations and survive a catastrophe. The backup policy should specify backup media, backup types, and retention periods.

BACKUP MEDIA: **Backup media** can include tape, hard drives, optical storage, and online storage. Physical backups must be carefully identified and stored in a secure location. **Offsiting** refers to the practice of storing backup media away from the main business location, in order to mitigate the risk of a catastrophic disaster such as a flood, a fire, or an earthquake. Even if the operating system includes a backup utility, many system administrators prefer to use specialized third-party software that offers more options and better controls for large-scale operations.

In addition to onsite data storage, cloud-based storage is growing rapidly. Many companies use online backup and retrieval services offered by leading vendors. For a small- or medium-sized firm, this option can be cost effective and reliable.

BACKUP TYPES: Backups can be full, differential, incremental, or continuous. A **full backup** is a complete backup of every file on the system. Frequent full backups are time consuming and redundant if most files are unchanged since the last full backup. Instead of performing a full backup, another option is to perform a **differential backup**, which is faster because it backs up *only* the files that are new or changed since the last full backup. To restore the data to its original state, the last full backup is restored first, and then the last differential backup is restored. Many IT managers believe that a combination of full and differential backups is the best option because it uses the least amount of storage space and is simple.

The fastest method, called an **incremental backup**, only includes recent files that never have been backed up by any method. This approach, however, requires multiple steps to restore the data—one for each incremental backup.

Most large systems use **continuous backup**, which is a real-time streaming method that records all system activity as it occurs. This method requires hardware, software, and substantial network capacity. However, system restoration is rapid and effective because data is being captured in real time, as it occurs. Continuous backup often uses a **redundant array of independent disks (RAID)** system that mirrors the data. RAID systems are called **fault tolerant** because a failure of any one disk does

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not disable the system. Compared to one large drive, a RAID design offers better performance, greater capacity, and improved reliability. When installed on a server, a RAID array of multiple drives appears to the computer as a single logical drive. Figure 12-26 shows a comparison of various backup methods.

Comparison of Backup Methods

BACKUP TYPE	CHARACTERISTICS	PROS AND CONS	TYPICAL FREQUENCY
Full	Backs up all files.	Slowest backup time and requires the most storage space. Rapid recovery because all files are restored in a single step.	Monthly or weekly.
Differential	Only backs up files that are new or changed since the last full backup.	Faster than a full backup and requires less storage space. All data can be restored in just two steps by using the last full backup and the last differential backup.	Weekly or daily.
Incremental	Only backs up files that are new or changed since the last backup of any kind.	Fastest backup and requires the least storage space because it only saves files that have never been backed up. However, requires many restore steps—one for each incremental backup.	Daily or more often.
Continuous	Real-time, streaming method that records all system activity.	Very expensive hardware, software, and network capacity. Recovery is very fast because system can be restored to just before an interruption.	Usually only used by large firms and network-based systems.

FIGURE 12-26 Comparison of full, differential, incremental, and continuous backup methods.

RETENTION PERIODS: Backups are stored for a specific **retention period** after which they are either destroyed or the backup media is reused. Retention periods can be a specific number of months or years, depending on legal requirements and company policy. Stored media must be secured, protected, and inventoried periodically.

12.7.3 Business Continuity Issues

Global concern about terrorism has raised awareness levels and increased top management support for a business continuity strategy in the event of an emergency. A disaster recovery plan describes actions to be taken, specifies key individuals and rescue authorities to be notified, and spells out the role of employees in evacuation, mitigation, and recovery efforts. The disaster recovery plan should be accompanied by a **test plan**, which can simulate various levels of emergencies and record the responses, which can be analyzed and improved as necessary.

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After personnel are safe, damage to company assets should be mitigated. The plan might require shutting down systems to prevent further data loss or moving physical assets to a secure location. Afterward, the plan should focus on resuming business operations, including the salvaging or replacement of equipment and the recovery of backup data. The main objective of a disaster recovery plan is to restore business operations to pre-disaster levels.

Disaster recovery plans are often part of a larger **business continuity plan (BCP)**, which goes beyond a recovery plan, and defines how critical business functions can continue in the event of a major disruption. Some BCPs specify the use of a hot site. A **hot site** is an alternate IT location, anywhere in the world, that can support critical systems in the event of a power outage, system crash, or physical catastrophe. A hot site requires **data replication**, which means that any transaction on the primary system must be mirrored on the hot site. If the primary system becomes unavailable, the hot site will have the latest data and can function seamlessly, with no downtime.

Although hot sites are attractive backup solutions, they are very expensive. However, a hot site provides the best insurance against major business interruptions. In addition to hot sites, business insurance can be important in a worst-case scenario. Although expensive, business insurance can offset the financial impact of system failure and business interruption.

12.8 System Retirement

At some point, every system becomes obsolete and is ripe for retirement. For example, in the 1960s, punched cards represented the cutting edge of data management. Data was stored by punching holes at various positions and was retrieved by machines that could sense the presence or absence of a punched hole. Most full-size cards stored only 80 characters, or bytes, so more than 12,000 cards would be needed to store a megabyte. Punched cards were even used as checks and utility bills. Today, this technology is obsolete.

Constantly changing technology means that every system has a limited economic life span. Analysts and managers can anticipate system obsolescence in several ways and it never should come as a complete surprise.

A system becomes obsolete when it no longer supports user needs, or when the platform becomes outmoded. The most common reason for discontinuing a system is that it has reached the end of its economically useful life, as indicated by the following signs:

- The system's maintenance history indicates that adaptive and corrective maintenance are increasing steadily.
- Operational costs or execution times are increasing rapidly, and routine perfective maintenance does not reverse or slow the trend.
- A software package is available that provides the same or additional services faster, better, and less expensively than the current system.
- New technology offers a way to perform the same or additional functions more efficiently.
- Maintenance changes or additions are difficult and expensive to perform.
- Users request significant new features to support business requirements.

Systems operation and support continue until a replacement system is installed. Toward the end of a system's operational life, users are unlikely to submit new

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requests for adaptive maintenance because they are looking forward to the new release. Similarly, the IT staff usually does not perform much perfective or preventive maintenance because the system will not be around long enough to justify the cost. A system in its final stages requires corrective maintenance only to keep the system operational.

User satisfaction typically determines the life span of a system. The critical success factor for any system is whether or not it helps users achieve their operational and business goals. All negative feedback should be investigated and documented, because it can be the first signal of system obsolescence.

At some point in a system's operational life, maintenance costs start to increase, users begin to ask for more features and capability, new systems requests are submitted, and the SDLC begins again.

12.9 Future Challenges and Opportunities

There is an old saying that the only constant in life is change. The same is true for information technology—except that the rate of change in IT seems to increase every year. Rapid change can present numerous challenges to organizations and individuals, but it can also offer exciting new opportunities. The secret to success is to be ready for the changes that are bound to occur and be proactive, not reactive.

No prudent professional would start a complex journey without a map and a plan. To navigate the future of information technology, companies require strategic plans, which were discussed in Chapter 2. An individual also needs a plan to reach to a specific goal or destination. This section discusses trends and predictions that will affect all IT professionals. To prepare for the challenges ahead, individuals will need to plan and develop their knowledge, skills, and credentials.

12.9.1 Trends and Predictions

Navigating an IT career can be compared to sailing a small ship in difficult seas. Even a very good captain with a clear map for guidance will be subjected to forces and circumstances that are sometimes beyond their control. What can be done is to understand these forces and try to prepare for them. Figure 12-27 describes some winds of change that may influence IT trends, including globalization, technology integration, service orientation, cloud computing, and the workplace of the future.

In addition to the trends described in Figure 12-27, most firms will face economic, social, and political uncertainty. Many IT experts believe that in this environment, the top priorities will be the safety and security of corporate operations, agility and the ability to quickly respond to changing market forces, and bottom-line TCO. Here are some examples of possible trends and developments over the next few years:

- Cybercrime will increase significantly, with negative financial, social, and national security implications.
- Smartphones and tablets will become the dominant computing platform for most users, bypassing the traditional PC or laptop as the device of choice.
- Software as a Service (SaaS) will become the norm, which will affect business models and consumer costs as the industry moves from a purchase to a leasing model for computer applications.
- Cloud computing will become the principal computing infrastructure for the enterprise, which in turn will enable software-as-a-service and lower TCO.

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TREND	DESCRIPTION	IMPACT ON IT GENERALLY	IMPACT ON FUTURE SYSTEMS ANALYSTS
Globalization	New kinds of corporations will be globally integrated, driven by the Internet, and free of traditional trade barriers.	Language skills will be extremely important. Technology will open new opportunities for developing countries to compete more effectively. Knowledge workers will communicate and collaborate across borders and boundaries. Work will be done 24/7 across multiple time zones.	Systems analysts will be directly affected by global trends. They will probably work for more firms in their careers, be exposed to more information, need more technical skills, and see greater change than at any time in history.
Technology Integration	Powered by an enormous increase in computing power, new IT models will include networks with smart, interconnected devices such as communication systems, automobiles, entertainment, transportation infrastructure, and "smart" power grids.	New technology will drive major changes in how personal and business services are provided. Firms will compete in a global marketplace that will reward innovation, creativity, and positive societal outcomes.	The systems analyst will need a mix of business savvy and technical skills. He or she will have a unique opportunity to work at the intersection of business operations and IT. Synergy between technology growth and globalization will create jobs and opportunities for people with the right skills.
Service Orientation	A business model of computing where processing capabilities and data storage are leased (rented) instead of bought (owned). Computing capabilities are seen as services used on-demand, like electricity or water, rather than as managed programs.	Service orientation is a paradigm shift. It represents a maturing of the field, where end users no longer care about technical details as much as business functionality. IT systems will be built using SOA (service-oriented architecture) to enable current and new functionality to be delivered as services to customers.	Systems analysts will need to increase their business acumen to work effectively in a service-oriented IT environment. Technical skills will still be needed, but services are about fulfilling business requirements.
Cloud Computing	Cloud computing is a new model for delivering business and IT services. It will have a profound impact on business strategies, including product innovation, marketing, customer relationships, and social media. Cloud computing provides the IT infrastructure that enables service orientation.	The full potential of cloud computing will be realized by firms that can integrate cloud-based infrastructure, services, servers, data access, and a secure environment. Creativity and innovation will be rewarded, and competition will be intense. Cloud computing will lower TCO by reducing capital expenditures.	Like any new technology, systems development for cloud-based applications will be a challenge for some and an opportunity for others. Regardless of the development method or platform, an analyst will need business savvy and technical know-how to help an organization take full advantage of the cloud.
The Workplace	In the face of worldwide competition and enormous technology change, firms will stress innovation, vision, and the ability to adapt rapidly. The ability to think critically will be vital.	Successful IT workers must be able to innovate, analyze, communicate effectively, and "think outside the box." The winners will be those who can adapt to change and embrace new technology and new ways of doing business.	Students preparing for the workplace of tomorrow will need a strong skill set. Systems analysts will be expected to bring communications, modeling, problem-solving, decision making, and critical thinking skills to the workplace — and to be aware of ethical issues that might affect them.

FIGURE 12-27 Major trends and their impact on IT in general and on future systems analysts.

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- Insourcing (the moving of jobs from off-shore locations back home) will increase, due to economic factors such as higher wages in emerging markets, improved automation through the use of sophisticated manufacturing robots, security concerns from outsourced components (hardware and software) developed overseas, and political pressure to preserve jobs.

It is entirely possible that large enterprises would require suppliers to certify their security credentials and sourcing policies. Another issue might relate to the growth of cloud computing and large-scale data centers such as the one shown in Figure 12-28. Access controls and issues related to international law concerning ownership and surveillance of network activity between the data centers and customers around the world will become progressively more important as the digital life of companies and individuals are placed online.

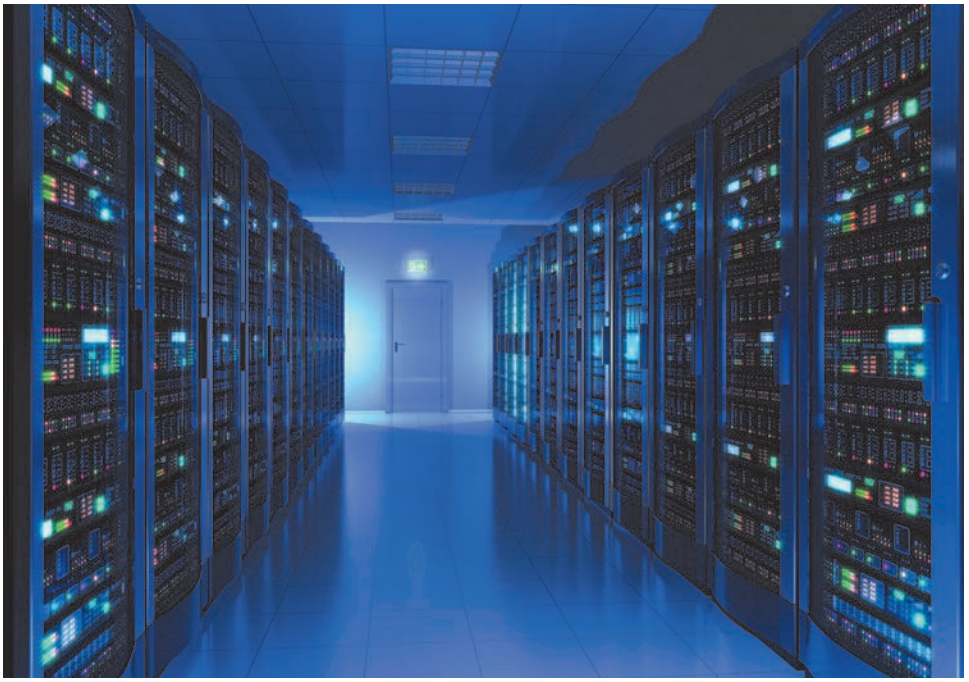


FIGURE 12-28 The rapid growth of data centers and cloud computing has increased security and privacy concerns.
Oleksiy Mark/Shutterstock.com

It's also possible that large enterprises will require suppliers to certify their green credentials and sourcing policies. One issue might relate to the explosion of data storage and server farms, such as the one shown in Figure 12-28. These server farms can use massive amounts of electricity, for normal operation and for cooling, which affects the environment and the corporate bottom line.

12.9.2 Strategic Planning for IT Professionals

A systems analyst should think like a small business entrepreneur who has certain assets, potential liabilities, and specific goals. Individuals, like companies, must have a strategic plan. The starting point is to formulate an answer to the following question: Have career goals been set for the next year, the next three years, and the next five years?

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Working backward from these goals, intermediate milestones can be developed. An analyst's career can be managed just as an IT project would be managed. The project management tools described in Chapter 3 can be used to construct a Gantt chart or a PERT/CPM chart using months (or years) as time units. Once the plan is developed, it should be monitored regularly to stay on track. As with an agile enterprise, progress toward satisfying career goals should be corrected as needed.

12.9.3 IT Credentials and Certification

In recent years, technical **credentials** and certification have become extremely important to IT employers and employees. In a broad sense, credentials include formal degrees, diplomas, or certificates granted by learning institutions to show that a certain level of education has been achieved. The term **certification** also has a special meaning that relates to specific hardware and software skills that can be measured and verified by examination. For example, a person might have a two- or four-year degree in Information Systems and possess an ISTQB foundation level certification shown in Figure 12-29, which attests to the person's software testing knowledge and skills.

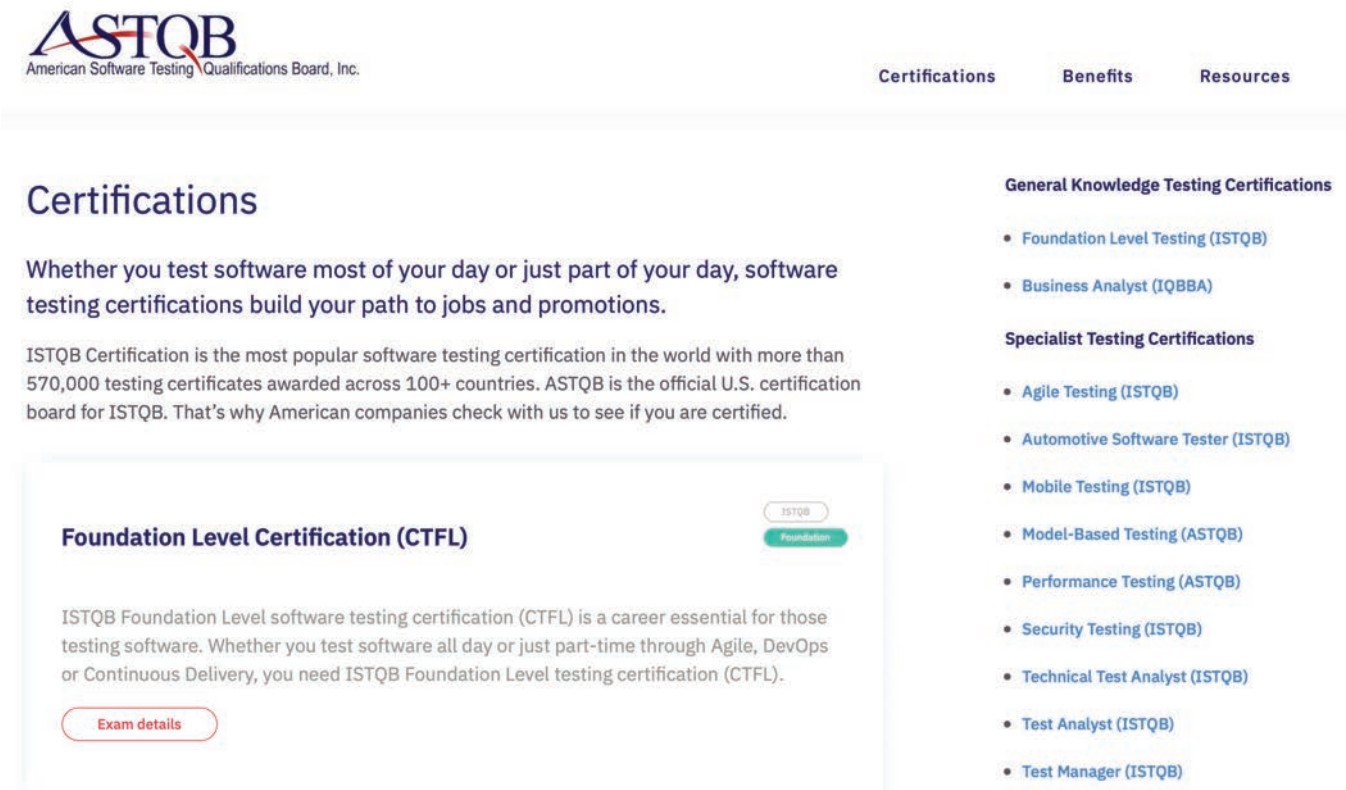


FIGURE 12-29 ASTQB has created a very successful scheme for certifying software testers.
Source: American Software Testing Qualifications Board, Inc.

Rapid changes in the IT field require professionals adopt a life-long learning approach to managing their career. Even advanced degrees from universities have a short half-life, which means continuing education credits are needed to maintain competency. Many professional organizations offer continuing education courses and

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credentialed certificates, such as the ACM and the IEEE, as do IT industry leaders such as Microsoft, Cisco, and Oracle.

12.9.4 Critical Thinking Skills

In addition to technical skills, systems analysts must have **soft skills**, such as communications, interpersonal, and perceptive abilities. In fact, employers often lament the fact that their new hires are technically adept but lacking in these other areas. For a successful career, these areas must be mastered too—particularly for more senior leadership positions in the organization.

IT professionals also need **critical thinking skills** to succeed in the workplace. Perhaps the most important skill taught to students in school is how to learn, so that they can adapt to dynamic environments later in their career. For example, it's not so important for developers to know the latest programming languages as it is for them to be able to learn a new programming language very quickly.

The importance of critical thinking skills has been recognized for some time. They have been part of the higher cognitive levels of Bloom's taxonomy of learning objectives in education for many years. What has changed—particularly within information technology—is the relative importance of critical thinking skills for long-term career success.

Our digital society is inundated with massive amounts of data. Data mining, sophisticated algorithms, and technical innovation are important, but the most valuable asset is an employee who can solve problems. The IT community has become interested in critical thinking skills that can help a person find, organize, analyze, and use the information that he or she needs on the job. Many employers now seek critical thinkers who can locate data, identify important facts, and apply their knowledge in real-world decisions.

Many training courses exist for technical skills but developing critical thinking skills is equally important. Performing practice tasks that resemble actual workplace tasks can develop critical thinking skills. Studying systems analysis and design can help, because it provides a solid foundation in techniques for developing models, organizing data, and recognizing patterns. Just as with hardware or software skills, formal certification is valuable in the job marketplace, but the greatest value is in learning the skills and using them to achieve career goals.

Many instructors find that individual and team-based exercises can strengthen critical thinking skills. Examples include games, puzzles, brainstorming, creative problem-solving, decision tables, working with ethical questions, Boolean logic, Venn diagrams, and using cause-and-effect tools such as Pareto charts, X-Y diagrams, and fishbone diagrams, all of which are found in this text.

12.9.5 Cyberethics

As computers permeate more and more of our lives, the decisions made by IT professionals can have serious implications. Situations may arise involving ethical considerations that are not easy to resolve. Nevertheless, ethical, social, and legal aspects of IT are topics that today's systems analyst should be prepared to address.

In the two scenarios presented in the following "Question of Ethics" section, ask yourself what would *you* do? Where would you draw the line? How much would you be willing to risk doing what you thought was the right thing? The decisions you make could well affect your job and future employment (Scenario 1), but there are other situations where the implications can be even more severe (Scenario 2).

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A QUESTION OF ETHICS



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SCENARIO 1: You have just completed a routine security audit on the company's information systems, and you found several areas of vulnerability. For example, file permissions have not been updated in some time, no comprehensive password policy exists, and network traffic is not fully encrypted. You noted these areas, among others, in a report to your supervisor. The report included specific recommendations to fix the problems.

Your supervisor responded by saying that budgets are tight right now, and she could not approve your requests to resolve these issues. As an IT professional, you are very uncomfortable with the risk level, but you have been unable to sway your supervisor. When you discussed the situation with a colleague, he said, "Why worry about it? If it's good enough for her, it should be good enough for you."

What do you think of your colleague's advice, and why? Is this an ethical question? If you are still is uncomfortable, what are your options?

SCENARIO 2: You work for a large IT company. The company is presented with a legal directive from the federal government to divulge personal data regarding some of the company's customers who are suspected of wrongdoing.

You feel that this is a violation of the customers' privacy and you are reluctant to comply with the request. Your boss tells you the company has no choice; it must follow the law. You are told you can always resign from the company if you feel so strongly about the situation.

Instead of complying or resigning, you go public. You use the media to advocate your point of view for freedom and privacy, even while knowing that your actions will have far-reaching consequences. Instead of just losing your job, you risk losing your freedom and your future.

Did you do the right thing? Are you a hero of free speech or a criminal (and possibly even a traitor)? What other options were available to you? What should the company have done when you went public? What should the government do?

12.10 Summary

Systems support and security cover the period from the implementation of an information system until the system no longer is used. A systems analyst's primary involvement with an operational system is to manage and solve user support requests.

Corrective maintenance includes changes to correct errors. Adaptive maintenance satisfies new systems requirements, and perfective maintenance makes the system more efficient. Adaptive and perfective maintenance changes often are called enhancements. Preventive maintenance is performed to avoid future problems.

The typical maintenance process resembles a miniature version of the systems development life cycle. A system request for maintenance work is submitted and evaluated. If it is accepted, the request is prioritized and scheduled for the IT group. The maintenance team then follows a logical progression of investigation, analysis, design, development, testing, and implementation.

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Corrective maintenance projects occur when a user or an IT staff member reports a problem. Standard maintenance procedures usually are followed for relatively minor errors but work often begins immediately when users report significant errors.

In contrast to corrective maintenance, adaptive, perfective, and preventive maintenance projects always follow the organization's standard maintenance procedures. Adaptive maintenance projects occur in response to user requests for improvements to meet changes in the business or operating environments. The IT staff usually initiates perfective maintenance projects to improve performance or maintainability. Automated program restructuring and reengineering are forms of perfective maintenance. In order to avoid future problems, IT staff perform preventive maintenance, which involves analysis of areas where trouble is likely to occur.

A maintenance team consists of one or more systems analysts and programmers. Systems analysts need the same talents and abilities for maintenance work as they use when developing a new system. Many IT departments are organized into separate new development and maintenance groups where staff members are rotated from one group to the other.

CM is necessary to handle maintenance requests, to manage different versions of the information system, and to distribute documentation changes. Maintenance changes can be implemented as they are completed, or a release methodology can be used in which all noncritical maintenance changes are collected and implemented simultaneously. A release methodology usually is cost effective and advantageous for users because they do not have to work with a constantly changing system. Systems analysts use functional, allocated, and product baselines as formal reference points to measure system characteristics at a specific time.

System performance measurements include response time, bandwidth, throughput, and turnaround time. Capacity management uses those measurements to forecast what is needed to provide future levels of service and support. Also, CASE tools that include system evaluation and maintenance features can be used during the systems operation, security, and support phase.

Security is a vital part of every information system. System security is dependent upon a comprehensive security policy that defines how organizational assets are to be protected and how attacks are to be responded to.

Risk management creates a workable security policy by identifying, analyzing, anticipating, and reducing risks to an acceptable level. Because information systems face a wide array of threats and attacks, six separate but interrelated security levels should be analyzed: physical security, network security, application security, file security, user security, and procedural security. Physical security concerns the physical environment, including critical equipment located in a computer room, as well as safeguards for servers and desktops throughout the company. Network security involves encryption techniques, as well as private networks and other protective measures, especially where wireless transmissions are concerned. Application security requires an understanding of services, hardening, application permissions, input validation techniques, software patches and updates, and software logs. File security involves the use of encryption and permissions, which can be assigned to individual users or to user groups. User security involves identity management techniques, a comprehensive password protection policy, an awareness of social engineering risks, and an effective means of overcoming user resistance. Procedural security involves managerial controls and policies that ensure secure operations.

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Data backup and recovery issues include backup media, backup schedules, and retention periods, as well as backup designs such as RAID and cloud-based backups.

All information systems eventually become obsolete. The end of a system's economic life usually is signaled by rapidly increasing maintenance or operating costs, the availability of new software or hardware, or new requirements that cannot be achieved easily by the existing system. When a certain point is reached, an information system must be replaced, and the entire systems development life cycle begins again.

Many IT experts predict intense competition in the future, along with economic, political, and social uncertainty. Facing these challenges, top IT priorities will be the safety and security of corporate operations, environmental concerns, and bottom-line TCO.

An IT professional should have a strategic career plan that includes long-term goals and intermediate milestones. An important element of a personal strategic plan is the acquisition of IT credentials and certifications that document specific knowledge and skills. Many IT industry leaders offer certification. In addition to technical ability, other skills, such as critical thinking skills, also are extremely valuable.

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Key Terms

acceptance One of four risk control strategies. In acceptance, the risk is accepted and nothing is done. Risk is usually accepted only if protection from risk is clearly not worth the expense.

adaptive maintenance Adds new capability and enhancements to an existing system.

administrator account An account that allows essentially unrestricted access to the application.

allocated baseline Documents the system at the end of the design phase and identifies any changes since the functional baseline. The allocated baseline includes testing and verification of all system requirements and features.

applications programmer A person who works on new systems development and maintenance.

archived The storage of previous version of a system when a new version is installed.

asset Hardware, software, data, networks, people, or procedures that provide tangible or intangible benefit to an organization.

attack A hostile act that targets an information system, or an organization itself.

automatic update service Enables an application to contact the vendor's server and check for a needed patch.

availability One of the three main elements of system security: confidentiality, integrity, and availability (CIA). Availability ensures that authorized users have timely and reliable access to necessary information.

avoidance One of four risk control strategies. In avoidance, adding protective safeguards eliminates the risk.

backup The process of saving a series of file or data copies to be retained for a specified period of time. Data can be backed up continuously, or at prescribed intervals.

backup media Data storage options, including tape, hard drives, optical storage, and online storage.

backup policy Detailed instructions and procedures for all backups.

bandwidth The amount of data that the system can handle in a fixed time period. Bandwidth requirements are expressed in bits per second (bps).

baseline A formal reference point that measures system characteristics at a specific time. Systems analysts use baselines as yardsticks to document features and performance during the systems development process.

benchmark testing A form of testing used by companies to measure system performance.

biometric scanning systems Mapping an individual's facial features, handprint, or eye characteristics for identification purposes.

BIOS-level password A password that must be entered before the computer can be started. It prevents an unauthorized person from booting a computer by using a secondary device. Also called a power-on password or a boot-level password.

boot-level password *See* **BIOS-level password**.

business continuity plan (BCP) A plan that defines how critical business functions can continue in the event of a major disruption.

capacity planning A process that monitors current activity and performance levels, anticipates future activity, and forecasts the resources needed to provide desired levels of service.

certification A credential an individual earns by demonstrating a certain level of knowledge and skill on a standardized test.

change control (CC) A process for controlling changes in system requirements during software development; also an important tool for managing system changes and costs after a system becomes operational.

CIA triangle The three main elements of system security: confidentiality, integrity, and availability.

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confidentiality One of the three main elements of system security: confidentiality, integrity, and availability (CIA). Confidentiality protects information from unauthorized discloser and safeguards privacy.

configuration management (CM) A process for controlling changes in system requirements during the development phases of the SDLC. CM also is an important tool for managing system changes and costs after a system becomes operational.

continuous backup A real-time streaming backup method that records all system activity as it occurs.

corrective maintenance Changes to the system to fix errors.

credentials Formal qualifications that include degrees, diplomas, or certificates granted by learning institutions to show that a certain level of education has been achieved.

critical risk When risks are categorized and prioritized, critical risks (those with the highest vulnerability and impact ratings) head the list.

critical thinking skills The ability to compare, classify, evaluate, recognize patterns, analyze cause and effect, and apply logic. Such skills are valued in the IT industry.

data replication In normal operating conditions, any transaction that occurs on the primary system must automatically propagate to the hot site.

database programmer A person who focuses on creating and supporting large-scale database systems.

denial of service (DOS) An online attack that occurs when an attacking computer makes repeated requests to a service or services running on certain ports.

differential backup A backup that includes only the files that have changed since the last full backup.

disaster recovery plan A documented procedure consisting of an overall backup and recovery plan.

distributed denial of service (DDOS) A service attack involving multiple attacking computers that can synchronize DOS attacks on a server.

dumpster diving Raiding desks or trash bins for valuable information.

encryption A process where data is coded (converted into unreadable characters) so that only those with the required authorization can access the data (usually via decoding software).

enhancement A new feature or capability.

exploit An attack that takes advantage of a system vulnerability, often due to a combination of one or more improperly configured services.

fault management The timely detection and resolution of operational problems. Fault management includes monitoring a system for signs of trouble, logging all system failures, diagnosing the problem, and applying corrective action.

fault tolerant A system or application is said to be fault tolerant if the failure of one component does not disable the rest of the system or application.

firewall The main line of defense between a local network, or intranet, and the Internet.

full backup A complete backup of every file on the system.

functional baseline The configuration of the system documented at the beginning of the project. It consists of all the necessary system requirements and design constraints.

gigabits per second (Gbps) A bandwidth or throughput measurement.

hardening Making a system more secure by removing unnecessary accounts, services, and features.

help desk A centralized resource staffed by IT professionals that provides users with the support they need to do their jobs. A help desk has three main objectives: to show people how to use system resources more effectively, to provide answers to technical or operational questions, and to make users more productive by teaching them how to meet their own information needs. Also called service desk or information center.

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hot site A separate IT location, which might be in another state or even another country, that can support critical business systems in the event of a power outage, system crash, or physical catastrophe.

identity management Controls and procedures necessary to identify legitimate users and system components.

identity theft The stealing of personally identifying information online.

IEEE 802.11i A security standard for Wi-Fi wireless networks that uses the WPA2 protocol, currently the most secure encryption method for Wi-Fi networks.

incremental backup Saving a copy of only the files that have changed since the last full backup.

integrity One of the three main elements of system security: confidentiality, integrity, and availability (CIA). Integrity prevents unauthorized users from creating, modifying, or deleting information.

Kbps (kilobits per second) A bandwidth or throughput measurement.

keystroke logger A device that can be inserted between a keyboard and a computer to record keystrokes.

log Record typically kept by operating systems and applications that documents all events, including dates, times, and other specific information. Logs can be important in understanding past attacks and preventing future intrusions.

maintenance activities Changing programs, procedures, or documentation to ensure correct system performance. Adapting the system to changing requirements, and making the system operate more efficiently. Those needs are met by corrective, adaptive, perfective, and preventive maintenance.

maintenance expenses Costs that vary significantly during the system's operational life and include spending to support maintenance activities.

maintenance release A formal release of a new system version that contains a number of changes.

maintenance release methodology A system of numbered releases used by organizations (especially software vendors) that helps organize maintenance changes and updates.

maintenance team One or more systems analysts and programmers working on product maintenance issues together.

malware Malicious software that might jeopardize the system's security or privacy.

megabits per second (Mbps) A bandwidth or throughput measurement.

metrics Workload measurements, also called metrics, include the number of lines printed, the number of records accessed, and the number of transactions processed in a given time period.

mitigation One of four risk control strategies. Mitigation reduces the impact of a risk by careful planning and preparation. For example, a company can prepare a disaster recovery plan to mitigate the effects of a natural disaster should one occur.

network Two or more devices that are connected for the purpose of sending, receiving, and sharing data.

network interface A combination of hardware and software that allows the computer to interact with the network.

network intrusion detection system (NIDS) Software that monitors network traffic to detect attempted intrusions or suspicious network traffic patterns and sends alerts to network administrators. Can be helpful in documenting the efforts of attackers and analyzing network performance.

offsiting The practice of storing backup media away from the main business location, in order to mitigate the risk of a catastrophic disaster such as a flood, fire, or earthquake.

operational costs Expenses that are incurred after a system is implemented and continue while the system is in use. Examples include system maintenance, supplies, equipment rental, and annual software license fees.

operational security Concerned with managerial policies and controls that ensure secure operations. Also called procedural security.

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patch Replacement code that is applied to fix bugs or security holes in software.

perfective maintenance Changes to a system to improve efficiency.

permissions User-specific privileges that determine the type of access a user has to a database, file, or directory. Also called user rights.

plain text Data that is not encrypted.

port A positive integer that is used for routing incoming traffic to the correct application on a computer.

port scan An attempt to detect the services running on a computer by trying to connect to various ports and recording the ports on which a connection was accepted.

power-on password *See* **BIOS-level password**.

pretexting Obtaining personal information under false pretenses.

preventive maintenance Changes to a system to reduce the possibility of future failure.

private key encryption A common encryption technology called PKE. The private key is one of a pair of keys, and it decrypts data that has been encrypted with the second part of the pair, the public key.

private network A dedicated connection, similar to a leased telephone line.

privilege escalation attack An unauthorized attempt to increase permission levels.

procedural security Concerned with managerial policies and controls that ensure secure operations. Also called operational security.

product baseline Describes the system at the beginning of operation. The product baseline incorporates any changes made since the allocated baseline and includes the results of performance and acceptance tests for the operational system.

programmer/analyst A designation for positions that require a combination of systems analysis and programming skills.

public key encryption (PKE) A common encryption technique. Each user on the network has a pair of keys: a public key and a private key. The public key encrypts data that can be decrypted with the private key.

redundant array of independent disks (RAID) A RAID system may be part of an organization's backup and recovery plans. A RAID system mirrors the data while processing continues. RAID systems are called fault-tolerant, because a failure of any one disk does not disable the system.

recovery The process of restoring data and restarting a system after an interruption.

remote control software Applications that allow IT staff to take over a user's workstation and provide support and troubleshooting.

response time The overall time between a request for system activity and the delivery of the response. In the typical online environment, response time is measured from the instant the user presses the ENTER key or clicks a mouse button until the requested screen display appears or printed output is ready.

retention period Backups are stored for a specific retention period after which they are either destroyed or the backup media is reused.

risk An event that could affect the project negatively.

risk assessment Measures the likelihood and impact of risks.

risk control Develops safeguards that reduce the likelihood and impact of risks.

risk identification Listing each risk and assessing the likelihood that it could affect a project.

risk management The process of identifying, evaluating, tracking, and controlling risks to minimize their impact.

security Hardware, software, and procedural controls that safeguard and protect a system and its data from internal or external threats.

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security hole Created by a combination of one or more improperly configured services.

security policy A plan that addresses the three main elements of system security: confidentiality, integrity, and availability.

security token A physical device that authenticates a legitimate user, such as a smart card or keychain device.

service An application that monitors, or listens on, a particular port.

service desk A centralized resource staffed by IT professionals that provides users with the support they need to do their jobs. Also called help desk.

service pack A maintenance release supplied by commercial software suppliers.

social engineering An intruder uses social interaction to gain access to a computer system.

soft skills Communications, interpersonal skills, perceptive abilities, and critical thinking are soft skills. IT professionals must have soft skills as well as technical skills.

software reengineering Uses analytical techniques to identify potential quality and performance improvements in an information system.

superuser account A login account that allows essentially unrestricted access to the application.

system administrator A person who is responsible for the CM and maintenance of an organization's computer networks.

systems programmer A person who concentrates on operating system software and utilities.

tamper-evident case A case designed to show any attempt to open or unlock the case.

test plan A plan designed by a systems analyst that includes test steps and test data for integration testing and system testing.

third-party software An application that is not developed in-house.

threat In risk management, an internal or external or external entity that could endanger an asset.

throughput A measurement of actual system performance under specific circumstances and is affected by network loads and hardware efficiency. Throughput, like bandwidth, is expressed as a data transfer rate, such as Kbps, Mbps, or Gbps.

transference One of four risk control strategies. In transference, risk is shifted to another asset or party, such as an insurance company.

tunnel A secure network connection established between the client and the access point of the local intranet.

turnaround time A measure applied to centralized batch processing operations, such as customer billing or credit card statement processing. Turnaround time measures the time between submitting a request for information and the fulfillment of the request. Turnaround time also can be used to measure the quality of IT support or services by measuring the time from a user request for help to the resolution of the problem.

unencrypted Data that is not encrypted.

uninterruptible power supply (UPS) Battery-powered backup power source that enables operations to continue during short-term power outages and surges.

Universal Security Slot (USS) Can be fastened to a cable lock or laptop alarm.

user rights User-specific privileges that determine the type of access a user has to a database, file, or directory. Also called permissions.

user training package The main objective of a user training package is to show users how the system can help them perform their jobs.

version control The process of tracking system releases.

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virtual private network (VPN) Uses a public network to connect remote users securely. Allows a remote client to use a special key exchange that must be authenticated by the VPN.

vulnerability A security weakness or soft spot.

what-if analysis A feature of business support systems that allows analysis to define and account for a wide variety of issues (including issues not completely defined).

Wi-Fi Protected Access (WPA) A common method used to secure a wireless network. This approach requires each wireless client be configured manually to use a special, pre-shared key, rather than key pairs. The most recent and more secure version is WPA2.

Wired Equivalent Privacy (WEP) One of the earliest methods used to secure a wireless network, superseded by WPA and WPA2.

WPA2 A wireless security standard based on 802.11i that provides a significant increase in protection over WEP and WPA.

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Exercises

Questions

1. In what forms can companies provide user support?
2. Describe four types of system maintenance.
3. What is CM and why is it important?
4. Define the following terms: *response time*, *bandwidth*, *throughput*, and *turnaround time*. How are the terms related?
5. What is the CIA triangle?
6. Explain the concept of risk management, including risk identification, assessment, and control.
7. What are the six security levels? Provide examples of threat categories, attacker profiles, and types of attacks.
8. What are some key issues that you must address when considering data backup and recovery?
9. Provide an example of technical obsolescence and explain how it can be a threat to an information system.
10. Why is strategic planning important for IT professionals?

Discussion Topics

1. The four types of IT system maintenance also apply to other industries. Suppose you were in charge of aircraft maintenance for a small airline. What would be a specific example of each type of maintenance?
2. Assume that your company uses a release methodology for its sales system. The current version is 5.5. Decide whether each of the following changes would justify a version 6.0 release or be included in a version 5.6 update: (a) Add a new report, (b) add a web interface, (c) add data validation checks, (d) add an interface to the marketing system, and (e) change the user interface.
3. How could you use a spreadsheet in capacity planning?
4. What are the most important IT security issues facing companies today? Have these changed in the last five years, and will they continue to change? How should companies prepare themselves for security threats and problems in the future?
5. Many people don't back up their data until it's too late. Once they go through a catastrophic loss of all their work, they tend to change their habits. What are some of the better ways to perform personal backups, such as cloud-based services?

Projects

1. Develop a process for managing change requests and design a form to handle a generic change request. The process should include a contingency plan for changes that must be resolved immediately.
2. Visit the IT department at your school or at a local company and find out whether performance measurements are used. Write a brief report describing your findings.
3. Security breaches are in the news all the time. Document a recent hack involving the theft of employee information or customer data. Suggest ways the attack could have been avoided.
4. Using the Internet, locate a software package designed to automate version control. List the key features and describe your findings in a brief memo.
5. How do you decide if a car should be repaired or replaced? Develop an assessment framework to aid this decision process. Is the framework also applicable to software systems?

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GLOSSARY

1:1 A type of entity relationship. A one-to-one relationship, abbreviated 1:1, exists when exactly one of the second entity occurs for each instance of the first entity.

1:M A type of entity relationship. A one-to-many relationship, abbreviated 1:M, exists when one occurrence of the first entity can be related to many occurrences of the second entity, but each occurrence of the second entity can be associated with only one occurrence of the first entity.

802.11 A family of wireless network specifications developed by the IEEE.

802.11ac An IEEE wireless network specification, approved in 2014, that uses expanded MIMO technology to achieve theoretical speeds of nearly 7 Gbps while increasing the wireless range and is backward compatible with 802.11a, b, g, and n.

802.11b An IEEE wireless network specification introduced in 1999 based on a frequency of 2.4 GHz and maximum bandwidth of 11 Mbps. Replaced by 802.11g.

802.11g An IEEE wireless network specification introduced in 2003 based on a frequency of 2.4 GHz and maximum bandwidth of 54 Mbps; compatible with and replaced 802.11b and has been superseded by the 802.11n standard.

802.11n An IEEE wireless network specification adopted in 2009 that uses MIMO technology to achieve speeds of 200+ Mbps while increasing the wireless range and is backward compatible with 802.11a, b, and g.

abbreviation code Alphabetic abbreviation. For example, standard state codes include NY for New York, ME for Maine, and MN for Minnesota.

absolute date The total number of days from some specific base date. To calculate the number of days between two absolute dates, subtract one date from the other. For example, using a base date of January 1, 1900, September 27, 2012, has an absolute date value of 41179 and July 13, 2011, has an absolute date of 40737. If the earlier date value is subtracted from the later one, the result is 442 days.

acceptance One of four risk control strategies. In acceptance, the risk is accepted and nothing is done. Risk is usually accepted only if protection from risk is clearly not worth the expense.

acceptance test Testing involves the entire information system, including all typical processing situations. During an acceptance test, users enter data, including samples of actual or live data, perform queries, and produce reports to simulate actual operating conditions. All processing options and outputs are verified by users and the IT project development team to ensure that the system functions correctly. Sometimes known as a system test.

access point A central wireless device that provides network services to wireless clients.

action code Indicates what action is to be taken with an associated item. For example, a student records program might prompt a user to enter or click an action code such as D (to display the student's record), A (to add a record), and X (to exit the program).

activity Any work that has a beginning and an end and requires the use of company resources including people, time, and/or money. Examples include conducting a series of interviews, designing a report, selecting software, waiting for the delivery of equipment, and training users. *See also* **task**.

activity diagram A diagram that resembles a horizontal flowchart that shows the actions and events as they occur. Activity diagrams show the order in which actions take place and identify the outcome.

actor An external entity with a specific role. In a use case model, actors are used to model interaction with the system.

adaptive maintenance Adds new capability and enhancements to an existing system.

administrator account An account that allows essentially unrestricted access to the application.

agile methods Systems development methods that attempt to develop a system incrementally by building a series of prototypes and constantly adjusting them to user requirements. Also called adaptive methods.

alias A term used in various data dictionaries to indicate an alternate name, or a name other than the standard data element name, that is used to describe the same data element.

allocated baseline Documents the system at the end of the design phase and identifies any changes since the functional baseline. The allocated baseline includes testing and verification of all system requirements and features.

alphabetic code Uses alphabet letters to distinguish one item from another based on a category, an abbreviation, or an easy-to-remember value, called a mnemonic code.

app A software application that runs on a mobile device, such as a smartphone or tablet.

application Part of the information system, an application handles the input, manages the processing logic, and provides the required output.

application development The process of constructing the programs and code modules that are the building blocks of an information system. Application development is handled by an application development group within a traditional IT department that is composed of systems analysts and programmers who handle information system design, development, and implementation.

application lifecycle management (ALM) Activities that cover the entire SDLC, including requirements, design, development, testing, and deployment and management of software applications.

application logic The underlying business rules or logic for an application.

application server A computer acting as "middlemen" between customers and an organization's databases and applications. Often used to facilitate complex business transactions.

application service provider (ASP) A firm that delivers a software application, or access to an application, by charging a usage or subscription fee.

application software Software programs, such as email, word processors, spreadsheets, and graphics packages, used by employees in typical office scenarios.

applications programmer A person who works on new systems development and maintenance.

archived The storage of previous version of a system when a new version is installed.

artificial intelligence The attempt to recreate natural intelligence through software in machines.

ASCII Stands for American Standard Code for Information Interchange, a data storage coding method used on most personal computers and workstations.

asset Hardware, software, data, networks, people, or procedures that provide tangible or intangible benefit to an organization.

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associative entity An entity that has its own set of attributes and characteristics. Associative entities are used to link between many-to-many (M:N) relationships.

attack A hostile act that targets an information system, or an organization itself.

attribute A single characteristic or fact about an entity. An attribute, or field, is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of an attribute. In object-oriented analysis, an attribute is part of a class diagram that describes the characteristics of objects in the class. Also known as a data element.

audit fields Special fields within data records to provide additional control or security information. Typical audit fields include the date the record was created or modified, the name of the user who performed the action, and the number of times the record has been accessed.

audit log files Record details of all accesses and changes to a file or database and can be used to recover changes made since the last backup.

audit trail A record of the source of each data item and when it entered a system. In addition to recording the original source, an audit trail must show how and when data is accessed or changed, and by whom. All these actions must be logged in an audit trail file and monitored carefully.

authorization zone Part of a form that contains any required signatures.

automated fax A system that allows a customer to request a fax using email, the company website, or a telephone. The response is transmitted in a matter of seconds back to the user's fax machine. *See* **faxback**.

automatic update service Enables an application to contact the vendor's server and check for a needed patch.

availability One of the three main elements of system security: confidentiality, integrity, and availability (CIA). Availability ensures that authorized users have timely and reliable access to necessary information.

avoidance One of four risk control strategies. In avoidance, adding protective safeguards eliminates the risk.

B2B (business-to-business) A commercial exchange (e.g., products or services) between businesses, typically enabled by the Internet or electronic means.

B2C (business-to-consumer) A commercial exchange (e.g., products or services) between businesses and consumers conducted over the Internet.

backup The process of saving a series of file or data copies to be retained for a specified period of time. Data can be backed up continuously, or at prescribed intervals.

backup media Data storage options, including tape, hard drives, optical storage, and online storage.

backup policy Detailed instructions and procedures for all backups.

balancing A process used to maintain consistency among an entire series of diagrams, including input and output data flows, data definition, and process descriptions.

bandwidth The amount of data that the system can handle in a fixed time period. Bandwidth requirements are expressed in bits per second (bps).

baseline A formal reference point that measures system characteristics at a specific time. Systems analysts use baselines as yardsticks to document features and performance during the systems development process.

Basic Service Set (BSS) A wireless network configuration in which a central wireless device called an access point is used to serve all wireless clients; also called infrastructure mode.

batch A group of data, usually inputted into an information system at the same time.

batch control A total used to verify batch input. Batch controls might check data items such as record counts and numeric field totals. For example, before entering a batch of orders, a user might calculate the total number of orders and the sum of all the order quantities. When the batch of orders is entered, the order system also calculates the same two totals. If the system totals do not match the input totals, then a data entry error has occurred.

batch input A process where data entry is performed on a specified time schedule, such as daily, weekly, monthly, or longer. For example, batch input occurs when a payroll department collects time cards at the end of the week and enters the data as a batch.

benchmark A measures of the time a package takes to process a certain number of transactions.

benchmark testing A form of testing used by companies to measure system performance.

best-case estimate The most optimistic outcome.

big data Extremely large datasets (e.g., petabytes) requiring nontraditional approaches to deal with them. Sometimes characterized by three terms: volume, variety, and velocity.

binary storage format A format that offers efficient storage of numeric data. For example, when numeric data types are specified using Microsoft Access, there are a variety of storage formats choices, including integer and long integer, among others.

biometric devices A mechanism used to uniquely identify a person by a retina scan or by mapping a facial pattern.

biometric scanning systems Mapping an individual's facial features, handprint, or eye characteristics for identification purposes.

BIOS-level password A password that must be entered before the computer can be started. It prevents an unauthorized person from booting a computer by using a secondary device. Also called a power-on password or a boot-level password.

bit The smallest unit of data is one binary digit.

black box A metaphor for a process or an action that produces results in a non-transparent or non-observable manner. In data flow diagrams, a process appears as a black box where the inputs, outputs, and general function of the process are known, but the underlying details are not shown.

black hole A process that has no output.

block sequence code Cipher that uses blocks of numbers for different classifications.

blockchain A distributed ledger system. The technology underlying Bitcoin.

blog An online journal. The term is a contraction of "web log."

Bluetooth A form of wireless transmission very popular for short-distance wireless communication that does not require high power.

boot-level password *See* **BIOS-level password**.

bottom-up technique A method for analyzing a large, complex project as a series of individual tasks, called project tasks.

brainstorming A fact-finding technique for gaining information through the use of a small group discussion of a specific problem, opportunity, or issue.

bring your own device (BYOD) An equipment management model where employees are in charge of their devices (e.g., computers, tablets, smartphones) at work, not the IT department. This includes device selection and setup, program installation and updating, and network connectivity (including security).

Brooks' law Frederick Brooks, an IBM engineer, observed that adding more manpower to a late software project only makes it later.

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bug tracking software System developers use defect tracking software, sometimes called bug tracking software, to document and track program defects, code changes, and replacement code, called patches.

build or buy A choice between developing in-house software and purchasing software, often called a build or buy, or make or buy, decision.

bus network A computer network where a single communication path connects the mainframe computer, server, workstations, and peripheral devices. Information is transmitted in either direction from any workstation to another workstation, and any message can be directed to a specific device.

business case Refers to the reasons, or justification, for a proposal.

business continuity plan (BCP) A plan that defines how critical business functions can continue in the event of a major disruption.

business logic Rules to determine how a system handles data and produces useful information, reflecting the operational requirements of the business. Examples include adding the proper amount of sales tax to invoices, calculating customer balances and finance charges, and determining whether a customer is eligible for a volume-based discount. Also called **business rules**.

business model A graphical representation of business functions that consist of business processes, such as sales, accounting, and purchasing.

business process A description of specific events, tasks, and desired results.

business process model (BPM) A graphical representation of one or more business processes.

business process modeling notation (BPMN) A standard set of shapes and symbols used to represent events, processes, and workflows in computer-based modeling tools.

business process outsourcing (BPO) The outsourcing of a basic business process. *See also* **outsourcing**.

business profile A definition of a company's overall functions, processes, organization, products, services, customers, suppliers, competitors, constraints, and future direction.

business rules How a system handles data and produces useful information. Business rules, also called business logic, reflect the operational requirements of the business. Examples include adding the proper amount of sales tax to invoices, calculating customer balances and finance charges, and determining whether a customer is eligible for a volume-based discount.

business rules *See* **business logic**.

business support systems Provide job-related information support to users at all levels of a company.

byte A group of eight bits is called a byte, or a character. A set of bytes forms a field, which is an individual fact about a person, a place, a thing, or an event.

calendar control A calendar control allows the user to select a date that the system will display and store as a field value.

candidate key Sometimes it is possible to have a choice of fields or field combinations to use as the primary key. Any field that could serve as a primary key is called a candidate key.

Capability Maturity Model (CMM)® A model developed by SEI that integrates software and systems development into a process improvement framework.

Capability Maturity Model Integration (CMMI)® An SEI-developed process to improve quality, reduce development time, and cut costs. A CMM tracks an organization's software development goals and practices, using five maturity levels, from Level 1 (relatively unstable, ineffective software) to Level 5 (software that is refined, efficient, and reliable).

capacity planning A process that monitors current activity and performance levels, anticipates future activity, and forecasts the resources needed to provide desired levels of service.

cardinality A concept that describes how instances of one entity relate to instances of another entity. Described in entity-relationship diagrams by notation that indicates combinations that include zero or one-to-many, one-to-one, and many-to-many.

cardinality notation Code that shows relationships between entities.

case for action A part of the preliminary investigation report to management that summarizes project requests and makes specific recommendations.

CASE tools Powerful software used in computer-aided systems engineering (CASE) to help systems analysts develop and maintain information systems.

category codes Ciphers that identify a group of related items. For example, a local department store may use a two-character category code to identify the department in which a product is sold.

certification A credential an individual earns by demonstrating a certain level of knowledge and skill on a standardized test.

change control (CC) A process for controlling changes in system requirements during software development; also an important tool for managing system changes and costs after a system becomes operational.

character A group of eight bits is called a character, or a byte. A set of bytes forms a field, which is an individual fact about a person, a place, a thing, or an event.

character-based report A report created using a single mono-spaced character set.

check box Used to select one or more choices from a group. A check mark, or an X, represents selected options.

child diagram The lower-level diagram in an exploded DFD.

child In inheritance, a child is the object that derives one or more attributes from another object, called the parent.

CIA triangle The three main elements of system security: confidentiality, integrity, and availability.

cipher codes Use of a keyword to encode a number. A retail store, for example, may use a 10-letter word, such as CAMPGROUND, to code wholesale prices, where the letter C represents 1, A represents 2, and so on. Thus, the code, GRAND, would indicate that the store paid $562.90 for the item.

class A term used in object-oriented modeling to indicate a collection of similar objects.

class diagram A detailed view of a single use case, showing the classes that participate in the use case, and documenting the relationship among the classes.

clicks to close The average number of page views to accomplish a purchase or obtain desired information.

clickstream storage Recording web visitor behavior and traffic trends for later data mining. use.

client Workstation that users interact within a client/server design. These workstations, or computers, are supplied data, processing services, or other support from other computers, called servers.

client/server architecture Generally refers to systems that divide processing between one or more networked clients and a central server. In a typical client/ server system, the client handles the entire user interface, including data entry, data query, and screen presentation logic. The server stores the data and provides data access and database management functions. Application logic is divided in some manner between the server and the clients.

closed-ended questions Queries that limit or restrict the range of responses. Used in the interview process when specific information or fact verification is desired.

cloud computing An online software and data environment in which applications and services are accessed and used through an Internet connection rather than on a local computer; refers to the cloud symbol for the Internet.

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code A set of letters or numbers that represents a data item. Codes can be used to simplify output, input, and data formats.

code review A review of a project team member's work by other members of the team to spot logic errors. Generally, systems analysts review the work of other systems analysts, and programmers review the work of other programmers, as a form of peer review. Structured walk-throughs should take place throughout the SDLC and are called requirements reviews, design reviews, code reviews, or testing reviews, depending on the phase in which they occur. Also known as a structured walk-through. *See* **structured walk-through**.

coding The process of turning program logic into specific instructions that a computer system can execute.

cohesion A measure of a module's scope and processing characteristics. A module that performs a single function or task has a high degree of cohesion, which is desirable.

combination check A type of data validation check that is performed on two or more fields to ensure that they are consistent or reasonable when considered together. Even though all the fields involved in a combination check might pass their individual validation checks, the combination of the field values might be inconsistent or unreasonable.

combination key A type of data validation check that is performed on two or more fields to ensure that they are consistent or reasonable when considered together. Even though all the fields involved in a combination check might pass their individual validation checks, the combination of the field values might be inconsistent or unreasonable.

command button Onscreen button that initiates an action such as printing a form or requesting Help.

common field An attribute that appears in more than one entity. Common fields can be used to link entities in various types of relationships.

composite key Sometimes it is necessary for a primary key to consist of a combination of fields. In that case, the primary key is called a combination key, composite key, concatenated key, or multivalued key.

computer resources committee A group of key managers and users responsible for evaluating systems requests. The term "systems review committee" is also used.

computer-aided software engineering (CASE) A technique that uses powerful programs called CASE tools to provide an overall framework for systems development. The tools support a wide variety of design methodologies, including structured analysis and object-oriented analysis. Also referred to as computer-aided systems engineering.

computer-aided systems engineering (CASE) *See* computer-aided software engineering (CASE).

concatenated key *See* **composite key**.

concurrent task A task that can be completed at the same time as (in parallel with) another task.

condition A specified action or state in a structure chart.

confidentiality One of the three main elements of system security: confidentiality, integrity, and availability (CIA). Confidentiality protects information from unauthorized discloser and safeguards privacy.

configuration management (CM) A process for controlling changes in system requirements during the development phases of the SDLC. CM also is an important tool for managing system changes and costs after a system becomes operational.

constraint A requirement or a condition that the system must satisfy or an outcome that the system must achieve.

construction phase A phase that focuses on program and application development tasks similar to the SDLC.

context diagram A top-level view of an information system that shows the boundaries and scope.

context-sensitive A feature that is sensitive to the current conditions when it is invoked. For example, context-sensitive help offers assistance for a task in progress.

continuous backup A real-time streaming backup method that records all system activity as it occurs.

control break A control break usually causes specific actions to occur, such as printing subtotals for a group of records.

control break report A detail report that focuses on control breaks.

control couple In a structure chart, a control couple shows a message, also called a flag, which one module sends to another.

control field order In a control break report, the records are arranged or sorted in the same order as the control fields.

control module In a structure chart, a control module is a higher-level module that directs lower-level modules, called subordinate modules.

control structure Serve as building blocks for a process. Control structures have one entry and exit point. They may be completed in sequential order, as the result of a test or condition, or repeated until a specific condition changes. Also called **logical structure**.

corporate culture A set of beliefs, rules, traditions, values, and attitudes that define a company and influence its way of doing business.

corporate portal A website that provides various tools and features for an organization's customers, employees, suppliers, and the public.

corrective maintenance Changes to the system to fix errors.

coupling Measures relationships and interdependence among modules. The opposite of cohesion.

credentials Formal qualifications that include degrees, diplomas, or certificates granted by learning institutions to show that a certain level of education has been achieved.

critical path A series of events and activities with no slack time. If any activity along the critical path falls behind schedule, the entire project schedule is similarly delayed. As the name implies, a critical path includes all activities that are vital to the project schedule.

Critical Path Method (CPM) Shows a project as a network diagram. The activities are shown as vectors, and the events are displayed graphically as nodes. Although CPM developed separately from the Program Evaluation Review Technique (PERT), the two methods are essentially identical. *See also* **PERT/CPM**.

critical risk When risks are categorized and prioritized, critical risks (those with the highest vulnerability and impact ratings) head the list.

critical success factors Vital objectives that must be achieved for the enterprise to fulfill its mission.

critical thinking skills The ability to compare, classify, evaluate, recognize patterns, analyze cause and effect, and apply logic. Such skills are valued in the IT industry.

crow's foot notation A type of cardinality notation. It is called crow's foot notation because of the shapes, which include circles, bars, and symbols, that indicate various possibilities. A single bar indicates one, a double bar indicates one and only one, a circle indicates zero, and a crow's foot indicates many.

customer Primary user of a system, service, or product.

customer relationship management (CRM) Many companies implement systems to integrate all customer-related events and transactions including marketing, sales, and customer service activities.

cutover phase A phase that resembles the final tasks in the SDLC implementation phase, including data conversion, testing, changeover to the new system, and user training.

data The raw material or basic facts used by information systems.

data center A large concentration of networked computers working together.

data conversion Existing data is loaded into the new system, transformed as needed. Depending on the system, data conversion can be done before, during, or after the operational environment is complete.

data couple In a structure chart, a data couple shows data that one module passes to another.

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data dictionary A central storehouse of information about a system's data.

data element A single characteristic or fact about an entity. A data element, field, or attribute is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of a data element. Also called **data item**.

data flow A path for data to move from one part of the information system to another.

data flow diagram (DFD) Graphical representation of the system, showing it stores, processes, and transforms data into useful information.

data frames Traffic on a computer network.

data item *See* **data element**.

data manipulation language (DML) A DML controls database operations, including storing, retrieving, updating, and deleting data. Most commercial DBMSs, such as Oracle and IBM's DB2, use a DML.

data mart A specialized database designed to serve the needs of a specific department, such as sales, marketing, or finance. Each data mart includes only the data that users in that department require to perform their jobs.

data mining Looking for meaningful patterns and relationships among data. For example, data mining software could help a consumer products firm identify potential customers based on their prior purchases.

data processing center A central location where physical data was delivered or transmitted in some manner and entered into the system. Users in the organization had no input or output capability, except for printed reports that were distributed by a corporate IT department.

data replication In normal operating conditions, any transaction that occurs on the primary system must automatically propagate to the hot site.

data repository A symbol used in DFDs to represent a situation in which a system must retain data because one or more processes need to use that stored data at a later time. Used interchangeably with the term **data store**.

data science Interdisciplinary field that blends computer science, math and statistics, and business methods to analyze large datasets. Involves artificial intelligence, machine learning and predictive analytics, and visualization techniques.

data security Protection of data from loss or damage and recovers data when it is lost or damaged.

data store *See* **data repository**.

data structure A meaningful combination of related data elements that are included in a data flow or retained in a data store. A framework for organizing and storing data.

data type check A type of data validation check that is used to ensure that a data item fits the required data type. For example, a numeric field must have only numbers or numeric symbols, and an alphabetic field can contain only the characters A through Z or the characters a through z.

data validation rule A mechanism to improve input quality by testing the data and rejecting any entry that fails to meet specified conditions.

data warehouse An integrated collection of data that can support management analysis and decision making.

database administrator (DBA) Someone who manages a DBMS. The DBA assesses overall requirements and maintains the database for the benefit of the entire organization rather than a single department or user.

database management system (DBMS) A collection of tools, features, and interfaces that enables users to add, update, manage, access, and analyze data in a database.

database programmer A person who focuses on creating and supporting large-scale database systems.

decision table A table that shows a logical structure, with all possible combinations of conditions and resulting actions.

decision tree A graphical representation of the conditions, actions, and rules found in a decision table.

decomposing Another way of conveying a process or system that has been broken down from a general, top-level view to more detail. The terms *exploded* and *partitioned* also can be used.

default value A value that a system displays automatically.

defect tracking software System developers use defect tracking software, sometimes called bug tracking software, to document and track program defects, code changes, and replacement code, called patches.

deliverable A polished, final product, suitable for its intended use. End products or deliverables often coincide with the completion of each SDLC phase.

denial of service (DOS) An online attack that occurs when an attacking computer makes repeated requests to a service or services running on certain ports.

dependent task A task is said to be dependent when it has to be completed in a serial sequence.

derivation code Combining data from different item attributes, or characteristics, to build the code. Most magazine subscription codes are derivation codes.

design prototyping Creating a prototype of user requirements, after which the prototype is discarded and implementation continues. Also called throwaway prototyping.

design review *See* **structured walk-through**.

design walk-through A session with users to review the interface with a cross section of people who will work with the new system. This is a continuation of the modeling and prototyping effort that began early in the systems development process.

desk checking The process of reviewing the program code to spot logic errors, which produce incorrect results.

detail report A detail report produces one or more lines of output for each record processed.

diagram 0 A diagram depicting the first level of detail below the initial context diagram. Diagram 0 (zero) zooms in on the context diagram and shows major processes, data flows, and data stores, as well as repeating the external entities and data flows that appear in the context diagram.

dialog box Allows a user to enter information about a task that a system will perform.

differential backup A backup that includes only the files that have changed since the last full backup.

direct cutover The direct cutover approach causes the changeover from the old system to the new system to occur immediately when the new system becomes operational.

disaster recovery plan A documented procedure consisting of an overall backup and recovery plan.

discretionary projects Where management has a choice in implementing a project, they are called discretionary. For example, creating a new report for a user is an example of a discretionary project.

diskless workstation A network terminal that supports a full-featured user interface but limits the printing or copying of data, except to certain network resources that can be monitored and controlled more easily.

distributed database management system (DDBMS) A system for managing data stored at more than one location. Using a DDBMS offers several advantages: Data stored closer to users can reduce network traffic; the system is scalable, so new data sites can be added without reworking the system design; and with data stored in various locations, the system is less likely to experience a catastrophic failure. A potential disadvantage of distributed data storage involves data security. It can be more difficult to maintain controls and standards when data is stored in various locations.

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distributed denial of service (DDOS) A service attack involving multiple attacking computers that can synchronize DOS attacks on a server.

distributed system Company-wide systems that are connected by one or more LANs or WANs. The capabilities of a distributed system depend on the power and capacity of the underlying data communication network.

Diverging data flow A data flow in which the same data travels to two or more different locations.

document review A review of baseline documentation. A useful fact-finding technique that helps an analyst understand how the current system is supposed to work.

documentation Material that explains a system, helps people interact with it, and includes program documentation, system documentation, operations documentation, and user documentation.

domain The set of values permitted for a data element.

dumpster diving Raiding desks or trash bins for valuable information.

duration The amount of time it will take to complete a task.

EBCDIC Stands for Extended Binary Coded Decimal Interchange Code, a coding method used on mainframe computers and some high-capacity servers.

e-commerce (electronic commerce) Transactions (e.g., buying and selling of goods and information) that occur on the Internet. Includes both business-to-consumer and business-to-business.

economic feasibility Achieved if the projected benefits of the proposed system outweigh the estimated costs involved in acquiring, installing, and operating it.

economy of scale The inherent efficiency of high-volume processing on larger computers. Database design allows better utilization of hardware. If a company maintains an enterprise-wide database, processing is less expensive using a powerful mainframe server instead of using several smaller computers.

electronic data interchange (EDI) The exchange of business documents between computers using a standard electronic format.

electronic health record (EHR) An electronic record of a patient's health information generated as the patient encounters various healthcare providers and shared among multiple facilities and agencies.

electronic product code (EPC) Technology that uses RFID tags to identify and monitor the movement of each individual product, from the factory floor to the retail checkout counter.

electronic proof of delivery (EPOD) A supplier uses RFID tags on each crate, case, or shipping unit to create a digital shipping list to verify receipt of goods.

empowerment A business practice that places more responsibility and accountability throughout all levels of an organization.

encapsulation The idea that all data and methods are self-contained, as in a black box.

encryption A process where data is coded (converted into unreadable characters) so that only those with the required authorization can access the data. (usually via decoding software)

engaged listening The ability to really concentrate on what someone is saying and avoid the temptation to hear what is expected. Also includes noticing nonverbal communication.

enhancement A new feature or capability.

enterprise applications Company-wide applications, such as order processing systems, payroll systems, and company communications networks.

enterprise computing Information systems that support company-wide data management requirements, such as airline reservations or credit card billing systems.

enterprise resource planning (ERP) A process that establishes an enterprise-wide strategy for IT resources. ERP defines a specific architecture, including standards for data, processing, network, and user interface design.

entity A person, a place, a thing, or an event for which data is collected and maintained. For example, an online sales system may include entities named CUSTOMER, ORDER, PRODUCT, and SUPPLIER.

entity-relationship diagram (ERD) A graphical model of the information system that depicts the relationships among system entities.

epic In an agile project, a simple, high-level statement of a requirement. *See* **feature**.

evaluation and selection team A group of people involved in selecting hardware and software. The group includes systems analysts and users. A team approach ensures that critical factors are not overlooked and that a sound choice is made.

evaluation model A technique that uses a common yardstick to measure and compare vendor ratings.

event A reference point that marks a major occurrence. Used to monitor progress and manage a project. *See also* **milestone**.

exception report A document displaying only those records that meet a specific condition or conditions. Exception reports are useful when the user wants information only on records that might require action but does not need to know the details.

existence check A type of data validation check that is used for mandatory data items. For example, if an employee record requires a Social Security number, an existence check would not allow the user to save the record until he or she enters a suitable value in the SSN field.

exploding A diagram is said to be exploded if it "drills down" to a more detailed or expanded view

exploit An attack that takes advantage of a system vulnerability, often due to a combination of one or more improperly configured services.

Extended Service Set (ESS) A wireless network configuration made up of two or more BSS networks, which allows wireless clients to roam from BSS to BSS.

extensibility Refers to a system's ability to expand, change, or downsize easily to meet the changing needs of a business enterprise. Also known as scalability.

fact-finding The process of gathering requirements. *See* **requirements elicitation**.

fat client A network design that locates all or most of the application processing logic at the client. Also called a thick client design.

fault management The timely detection and resolution of operational problems. Fault management includes monitoring a system for signs of trouble, logging all system failures, diagnosing the problem, and applying corrective action.

fault tolerant A system or application is said to be fault tolerant if the failure of one component does not disable the rest of the system or application.

faxback *See* **automated fax**.

feasibility study An initial investigation to clearly identify the nature and scope of the business opportunity or problem. Also called preliminary investigation.

feature In an agile project, a simple, high-level statement of a requirement. *See* **epic**.

field A single characteristic or fact about an entity. A field, or attribute, is the smallest piece of data that has meaning within an information system. For example, a Social Security number or company name could be examples of a field. The terms *data element*, *data item*, and *field* are used interchangeably.

file Each file or table contains data about people, places, things, or events that interact with the information system.

file-oriented system A file-oriented system, also called a file processing system, stores and manages data in one or more separate files.

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fill-in form A template used to collect data on the Internet or a company intranet.

finish day/date The day or date when a task is scheduled to be finished.

firewall The main line of defense between a local network, or intranet, and the Internet.

first normal form (1NF) A record is said to be in 1NF if it does not contain a repeating group (a set of data items that can occur any number of times in a single record).

fishbone diagram An analysis tool that represents the possible causes of a problem as a graphical outline. Also called an Ishikawa diagram.

fixed fee model A service model that charges a set fee based on a specified level of service and user support.

flowchart A diagram used to describe program logic that represents logical rules and interaction graphically using a series of symbols connected by arrows. Flowcharts can be useful in visualizing modular program designs.

focus In a sequence diagram, a focus indicates when an object sends or receives a message. It is indicated by a narrow vertical rectangle that covers the lifeline.

foreign key A field in one table that must match a primary key value in another table in order to establish the relationship between the two tables.

form filling A very effective method of online data entry where a blank form that duplicates or resembles the source document is completed on the screen. The user enters the data and then moves to the next field.

form layout The physical appearance and placement of data on a form. Form layout makes the form easy to complete and provides enough space, both vertically and horizontally, for users to enter the data.

forum An online discussion on a particular topic, where people meet, offer support, and exchange ideas.

four-model approach A physical model of the current system, a logical model of the current system, a logical model of the new system, and a physical model of the new system are all developed.

full backup A complete backup of every file on the system.

functional baseline The configuration of the system documented at the beginning of the project. It consists of all the necessary system requirements and design constraints.

functional decomposition diagram (FDD) A top-down representation of business functions and processes. Also called a structure chart.

functional primitive A single function that is not exploded further. The logic for functional primitives is documented in a data dictionary process description.

functional requirement A statement of the services a system provides.

functionally dependent Functional dependence is an important concept for understanding the 2NF. The field X is said to be functionally dependent on the field Y if the value of X depends on the value of Y. For example, an order date is dependent on an order number; for a particular order number, there is only one value for the order date. In contrast, the product description is not dependent on the order number. For a particular order number, there might be several product descriptions, one for each item ordered.

Gane and Sarson A popular symbol set used in DFDs. Processes, data flows, data stores, and external entities all have a unique symbol.

Gantt chart A horizontal bar chart that illustrates a schedule. Developed many years ago by Henry L. Gantt as a production control technique. Still are in common use today.

garbage in, garbage out (GIGO) The concept that the quality of the output is only as good as the quality of the input.

gateway (1) In business processing modeling notation, a fork in the process, allowing the flow to go one way or another. (2) A router or other network device used to connect to a larger, dissimilar type of network, such as the Internet.

gigabits per second (Gbps) A bandwidth or throughput measurement.

global outsourcing The practice of shifting IT development, support, and operations to other countries.

glueware *See* **middleware**.

graphical user interface (GUI) The use of graphical objects and techniques allowing users to communicate with a system. A well-designed GUI can help users learn a new system rapidly and work with the system effectively.

gray hole A process with an input obviously insufficient to generate the shown output.

groupware Programs that run on a network that enable users to share data, collaborate on projects, and work in teams. Also called workgroup software.

hardening Making a system more secure by removing unnecessary accounts, services, and features.

hardware The physical layer of the information system, to include computers, networks, communications equipment, and other technology-based infrastructure.

hash totals Not meaningful numbers themselves but are useful for comparison purposes. Also known as batch control totals.

Hawthorne Effect A phenomenon where employees who know they are being observed are more productive.

help desk A centralized resource staffed by IT professionals that provides users with the support they need to do their jobs. A help desk has three main objectives: to show people how to use system resources more effectively, to provide answers to technical or operational questions, and to make users more productive by teaching them how to meet their own information needs. Also called service desk or information center.

hierarchical network A network design where one computer (typically a mainframe) controls the entire network. Satellite computers or servers control lower levels of processing and network devices.

histogram A common tool for showing the distribution of questionnaire or sampling results. It takes the form of a vertical bar chart.

horizontal application A software package that can be used by many different types of organizations.

horizontal system A basic system, such as an inventory or payroll package, that is commonly used by a variety of companies.

hot site A separate IT location, which might be in another state or even another country, that can support critical business systems in the event of a power outage, system crash, or physical catastrophe.

HTTP/2 The second major version of the network protocol used by the web. Released as a standard in 2015.

hub The center of a star network. Switches in modern networks have largely replaced hubs.

human-computer interaction (HCI) A description of the relationship between computers and the people who use them to perform business-related tasks. HCI concepts apply to everything from a PC desktop to the main menu for a global network.

identity management Controls and procedures necessary to identify legitimate users and system components.

identity theft The stealing of personally identifying information online.

IEEE 802.11i A security standard for Wi-Fi wireless networks that uses the WPA2 protocol, currently the most secure encryption method for Wi-Fi networks.

incremental backup Saving a copy of only the files that have changed since the last full backup.

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inference rules Instructions that direct a knowledge management system to identify data patterns and relationships.

informal structure An organization based on interpersonal relationships, which can develop from previous work assignments, physical proximity, unofficial procedures, or personal relationships.

information Data that has been changed into a useful form of output.

information system A combination of information technology, people, and data to support business requirements. The five key components are hardware, software, data, processes, and people.

information technology (IT) A combination of hardware, software, and telecommunications systems that support business operations, improve productivity, and help managers make decisions.

infrastructure mode A wireless network configuration in which a central wireless device called an access point is used to serve all wireless clients; also called BSS.

inheritance A type of object relationship. Inheritance enables an object to derive one or more of its attributes from another object (e.g., an INSTRUCTOR object may inherit many traits from the EMPLOYEE object, such as hire date).

in-house software An information center or help desk within the IT department responsible for providing user support and offering services such as hotline assistance, training, and guidance to users who need technical help.

input control The necessary measures to ensure that input data is correct, complete, and secure. A systems analyst must focus on input control during every phase of input design, starting with source documents that promote data accuracy and quality.

input mask Template or pattern that makes it easier for users to enter data. Often used in automated forms to guide an unfamiliar user.

instance A specific member of a class.

Institute of Electrical and Electronics Engineers (IEEE) A professional organization that establishes standards for telecommunications.

intangible benefits Positive outcomes that are difficult to measure in dollars. However, intangible benefits can be very important in the calculation of economic feasibility. An example of an intangible benefit might be a new website that improves a company's image.

intangible costs Items that are difficult to measure in dollar terms, such as employee dissatisfaction.

integrated development environment (IDE) A suite of integrated tools to make it easier to plan, construct, and maintain a specific software product. An IDE is designed to allow the easy integration of system components with less time being spent on developing code for interactive modules.

integrated development environments (IDE) An application for building other software applications. Typically includes a visual code editor, an integrated compiler, a debugger, a configuration management system, and a test framework.

integration testing The testing of two or more programs that depend on each other.

integrity One of the three main elements of system security: confidentiality, integrity, and availability (CIA). Integrity prevents unauthorized users from creating, modifying, or deleting information.

International Organization for Standardization (ISO) A network of national standards institutes from over a hundred countries working in partnership with international organizations, governments, industries, and business and consumer representatives. The ISO acts as a bridge between public and private sectors.

Internet business services (IBSs) Services that provide powerful web-based support for transactions such as order processing, billing, and customer relationship management.

The Internet-of-Things (IOT) Devices connected to one another over a computer network.

Internet operating system Part of the Web 2.0 model, an online computing environment created by online communities and services, based on layers of shared information that can contain text, sound bytes, images, and video clips.

interview A planned meeting during which information is obtained from another person.

ISO 9000-3:2014 A set of guidelines established and updated by the ISO to provide a QA framework for developing and maintaining software.

iteration cycle An agile development cycle that includes planning, designing, coding, and testing one or more features based on user stories.

iteration planning meeting In agile development, a meeting held at the beginning of each iteration cycle to break down user stories into specific tasks that are assigned to team members.

iteration The completion of a process step that is repeated until a specific condition changes.

iterative An adaptive method typically uses a spiral development model, which builds on a series of iterations.

java database connectivity (JDBC) A standard that enables Java applications to exchange data with any database that uses SQL statements and is ODBC-compliant.

joint application development (JAD) A systems development technique that uses a task force of users, managers, and IT professionals who work together to gather information, discuss business needs, and define the new system requirements.

just-in-time (JIT) The exchange or delivery of information when and where it is needed. For example, just-in-time inventory systems rely on computer-to-computer data exchange to minimize unnecessary inventory.

Kbps (kilobits per second) A bandwidth or throughput measurement.

key fields Used during the systems design phase to organize, access, and maintain data structures. The four types of key fields are primary keys, candidate keys, foreign keys, and secondary keys.

keystroke logger A device that can be inserted between a keyboard and a computer to record keystrokes.

knee of the curve A performance characteristic of a client/server computing environment. Client/server response times tend to increase gradually and then rise dramatically as the system nears its capacity. The point where response times increase dramatically.

knowledge base A popular systems development technique that uses a group of users, managers, and IT professionals who work together to gather information, discuss business needs, and define the new system requirements.

leading questions Queries that suggest or favor a particular reply.

legacy data The data associated with an older, less technologically advanced legacy system.

legacy system An older system that is typically less technologically advanced than currently available systems.

leveling The process of drawing a series of increasingly detailed diagrams to reach the desired level of detail.

library module In a structure chart, a library module is a module that is reusable and can be invoked from more than one point in the chart.

lifeline In a sequence diagram, a lifeline is used to represent the time during which the object above it is able to interact with the other objects in the use case. An X marks the end of a lifeline.

limit check Occurs when a validation check involves a minimum or a maximum value, but not both. Checking that a payment amount is greater than zero, but not specifying a maximum value, is an example of a limit check.

list box An output mechanism that displays a list of choices that the user can select.

local area network (LAN) A network design that allows the sharing of data and hardware, such as printers and scanners. Advances in data communication technology have made it possible to create powerful networks that use satellite links, high-speed fiber-optic lines, or the Internet to share data.

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log Record typically kept by operating systems and applications that documents all events, including dates, times, and other specific information. Logs can be important in understanding past attacks and preventing future intrusions.

logic error Mistakes in the underlying logic that produce incorrect results.

logical design The definition of an information system's functions and features, and the relationships among its components.

logical model Shows what a system must do, regardless of how it will be implemented physically.

logical record A logical record contains field values that describe a single person, place, thing, or event. Application programs *see* a logical record as a set of fields, regardless of how or where the data is stored physically.

logical storage Refers to information as seen through a user's eyes, regardless of how or where that information is organized or stored.

logical structure *See* **control structure**.

logical topology A view of a network that describes the way the components interact, rather than the actual network cabling and connections.

loop In a structure chart, a loop indicates that one or more modules are repeated.

looping Refers to a process step that is repeated until a specific condition changes. For example, a process that continues to print paychecks until it reaches the end of the payroll file is looping. Also known as repetition.

loosely coupled Modules that are relatively independent. Loosely coupled modules are easier to maintain and modify, because the logic in one module does not affect other modules.

M:N A type of entity relationship. A many-to-many relationship, abbreviated M:N, exists when one instance of the first entity can be related to many instances of the second entity, and one instance of the second entity can be related to many instances of the first entity.

machine learning An application of computer science and artificial intelligence that uses automated approaches to pattern recognition and predictive analytics based on large datasets.

mainframe architecture A system design where the server performs all the processing.

maintenance activities Changing programs, procedures, or documentation to ensure correct system performance. Adapting the system to changing requirements, and making the system operate more efficiently. Those needs are met by corrective, adaptive, perfective, and preventive maintenance.

maintenance agreement A specification of the conditions, charges, and time frame for users to contact the vendor for assistance when they have system problems or questions.

maintenance expenses Costs that vary significantly during the system's operational life and include spending to support maintenance activities.

maintenance release A formal release of a new system version that contains a number of changes.

maintenance release methodology A system of numbered releases used by organizations (especially software vendors) that helps organize maintenance changes and updates.

maintenance team One or more systems analysts and programmers working on product maintenance issues together.

make or buy The choice between developing in-house software and purchasing software often is called a make or buy, or build or buy, decision.

malware Malicious software that might jeopardize the system's security or privacy.

managed hosting An operation is managed by the outside firm, or host. Another term for IBSs.

management information system (MIS) A computer-based information system used in business planning, control, decision making, and problem solving.

many-to-many relationship *See* **M:N**.

market basket analysis A type of analysis that can detect patterns and trends in large amounts of data.

megabits per second (Mbps) A bandwidth or throughput measurement.

menu bar A set of user-selectable software application options, usually located across the top of the screen.

mesh network A network design in which each node connects to every other node. While this design is very reliable, it is also expensive to install and maintain.

message An O-O command that tells an object to perform a certain method.

method Defines specific tasks that an object must perform. Describes what and how an object does something.

methods In a class diagram, methods represent program logic.

metrics Workload measurements, also called metrics, include the number of lines printed, the number of records accessed, and the number of transactions processed in a given time period.

middleware Software that connects dissimilar applications and enables them to communicate and exchange data. For example, middleware can link a departmental database to a Web server that can be accessed by client computers via the Internet or a company intranet. *See also* **glueware**.

milestone A reference point that marks a major occurrence. Used to monitor progress and manage a project. *See also* **event**.

mission statement A document or statement that describes the company for its stakeholders and briefly states the company's overall purpose, products, services, and values.

mission-critical system An information system that is vital to a company's operations.

mitigation One of four risk control strategies. Mitigation reduces the impact of a risk by careful planning and preparation. For example, a company can prepare a disaster recovery plan to mitigate the effects of a natural disaster should one occur.

mnemonic code Ciphers using a specific combination of letters that are easy to remember. Many three-character airport codes are mnemonic codes. For example, LAX represents Los Angeles.

mobile device Smartphones, tablets, and other computing devices that are not permanently tethered to a desk. They connect to the network wirelessly.

mock-up When designing a report, a sample report is prepared, which is a mock-up, or prototype, for users to review. The sample should include typical field values and contain enough records to show all the design features.

model-based systems engineering (MBSE) An approach to systems engineering that relies on domain models, rather than traditional documents, to design large-scale systems and convey information between engineers.

modeling A process that produces a graphical representation of a concept or process that systems developers can analyze, test, and modify.

modular design A design that can be broken down into logical blocks. Also known as partitioning or top-down design.

module A module consists of related program code organized into small units that are easy to understand and maintain. A complex program could have hundreds or even thousands of modules.

Moore's law A prediction that computing power would double every 18 to 24 months due to increased miniaturization of electronic components.

multipath design A network design that relies on multiple data paths to increase bandwidth and range, using MIMO technology.

multiple input/multiple output (MIMO) A wireless networking technology incorporated in the IEEE 802.11n and 802.11ac standards that uses multiple data streams and multiple antennas to achieve higher transmission speeds and substantially increase wireless range over earlier standards.

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multivalued key Sometimes it is necessary for a primary key to consist of a combination of fields. In that case, the primary key is called a combination key, composite key, concatenated key, or multivalued key.

natural language A software feature that allows users to type commands or requests in normal English (or other language) phrases.

net-centric computing A distributed environment where applications and data are downloaded from servers and exchanged with peers across a network on an as-needed basis.

net present value (NPV) The total value of the benefits minus the total value of the costs, with both the costs and benefits being adjusted to reflect the point in time at which they occur.

network Two or more devices that are connected for the purpose of sending, receiving, and sharing data.

network diagram A PERT chart also is referred to as a network diagram.

network interface A combination of hardware and software that allows the computer to interact with the network.

network intrusion detection system (NIDS) Software that monitors network traffic to detect attempted intrusions or suspicious network traffic patterns and sends alerts to network administrators. Can be helpful in documenting the efforts of attackers and analyzing network performance.

network topology The way a network is configured. LAN and WAN networks typically are arranged in one of four common patterns: hierarchical, bus, star, and ring.

node A physical device, wired or wireless, that can send, receive, or manage network data.

nondiscretionary projects Where management has no choice in implementing a project, they are called nondiscretionary. For example, adding a report required by a new federal law.

non-functional requirements A statement of operational system constraints.

nonkey field Any field that is not a primary key or a candidate key is called a nonkey field.

normalization A process by which analysts identify and correct inherent problems and complexities in their record designs.

NoSQL databases Database systems that use a flat, nontabular (nonrelational) structure to store and process large-scale datasets.

***n*-tier design** A multilevel design or architecture. For example, three-tier designs also are called *n*-tier designs, to indicate that some designs use more than one intermediate layer.

object In object-oriented analysis or programming, an object represents a real person, place, event, or transaction.

object model Describes objects, which combine data and processes. Object models are the end product of O-O analysis.

object-oriented (O-O) analysis The act of understanding an information system by identifying things called objects. An object represents a real person, place, event, or transaction. Object-oriented analysis is a popular approach that sees a system from the viewpoint of the objects themselves as they function and interact with the system.

object-oriented development (OOD) The process of translating an object model directly into an O-O programming language.

observation A fact-finding technique where an analyst sees a system in action. Observation allows the verification of statements made in interviews.

offshore outsourcing The practice of shifting IT development, support, and operations to other countries.

offshoring *See* **offshore outsourcing**.

offsiting The practice of storing backup media away from the main business location, in order to mitigate the risk of a catastrophic disaster such as a flood, fire, or earthquake.

one-to-many relationship *See* **1:M**.

one-to-one relationship *See* **1:1**.

online data entry A data entry method used for most business activity. The online method offers major advantages, including the immediate validation and availability of data.

online documentation Provides immediate help when users have questions or encounter problems.

online system Handling transactions when and where they occur and providing output directly to users. Because it is interactive, online processing avoids delays and allows a constant dialog between the user and the system.

open database connectivity (ODBC) An industry-standard protocol that makes it possible for software from different vendors to interact and exchange data.

open source Software that is supported by a large group of users and developers. The source code is made freely available.

Open Systems Interconnection (OSI) model Describes how data actually moves from an application on one computer to an application on another networked computer. The OSI consists of seven layers, and each layer performs a specific function.

open-ended questions Queries that allow for a range of answers. They encourage spontaneous and unstructured responses and are useful in understanding a larger process.

operational costs Expenses that are incurred after a system is implemented and continue while the system is in use. Examples include system maintenance, supplies, equipment rental, and annual software license fees.

operational environment The environment for the actual system operation. It includes hardware and software configurations, system utilities, and communications resources. Also called the production environment.

operational feasibility A system that that will be used effectively after it has been developed.

operational security Concerned with managerial policies and controls that ensure secure operations. Also called procedural security.

operations documentation Contains all the information needed for processing and distributing online and printed output.

option button Radio buttons that represent groups of options. The user can select only one option at a time; a selected option contains a black dot. *See also* **radio button**.

orphan An unassociated or unrelated record or field. An orphan could be created if a customer order was entered in an order table where that customer did not already exist in the customer table. Referential integrity would prevent the creation of this orphan.

output control Methods to maintain output integrity and security. For example, every report should include an appropriate title, report number or code, printing date, and time period covered. Reports should have pages that are numbered consecutively, identified as Page xx of xx, and the end of the report should be labeled clearly.

output security Output security protects privacy rights and shields the organization's proprietary data from theft or unauthorized access.

outsourcing The transfer of information systems development, operation, or maintenance to an outside firm that provides these services, for a fee, on a temporary or long-term basis.

page footer Appears at the bottom of the page and is used to display the name of the report and the page number.

page header Appears at the top of the page and includes the column headings that identify the data.

pair programming A practice in XP in which two programmers work on the same task on the same computer; one drives (programs) while the other navigates (watches).

parallel operation The parallel operation changeover method requires that both the old and the new information systems operate fully for a specified period. Data is input into both systems, and output generated by the new system is compared with the equivalent output from the old system.

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parent In inheritance, a parent is the object from which the other object, the child, derives one or more attributes.

parent diagram The higher or more top-level diagram in an exploded DFD.

Pareto chart A vertical bar graph named for a nineteenth century economist. The bars, which represent various causes of a problem, are arranged in descending order, so the team can focus on the most important causes.

partitioning The breaking down of overall objectives into subsystems and modules.

patch Replacement code that is applied to fix bugs or security holes in software.

payback analysis A determination of how long it takes an information system to pay for itself through reduced costs and increased benefits.

perfective maintenance Changes to a system to improve efficiency.

permissions User-specific privileges that determine the type of access a user has to a database, file, or directory. Also called user rights.

personal digital assistant A program that responds to user requests through a natural interface, such as regular speech, to provide assistance to general-purpose queries. Often embedded in devices such as Internet-connected speakers and smartphones.

personal information manager (PIM) A tool that helps manage tasks and schedules. Many handheld devices also include this function.

person-day The amount of work that one person can complete in one day.

PERT/CPM The Program Evaluation Review Technique (PERT) was developed by the U.S. Navy to manage very complex projects, such as the construction of nuclear submarines. At approximately the same time, the Critical Path Method (CPM) was developed by private industry to meet similar project management needs. The important distinctions between the two methods have disappeared over time, and today the technique is called either PERT, CPM, or PERT/CPM.

phased operation The phased operation method allows a new system to be implemented in stages, or modules.

physical design A plan for the actual implementation of the system.

physical model A model that describes how a system will be constructed.

physical storage Information storage mechanism that is strictly hardware related, because it involves the process of reading and writing binary data to physical media, such as a hard drive, flash drive, or DVD.

physical topology The connection structure of an actual network's cabling.

pilot operation The pilot operation changeover method involves implementing the complete new system at a selected location of the company.

pilot site In a pilot operation, the group that uses the new system first is called the pilot site.

plain text Data that is not encrypted.

platform A specific hardware and software configuration that supports IT business goals such as hardware connectivity and easy integration of future applications. Also called an environment.

podcast A web-based broadcast that allows a user to receive audio or multimedia files using music player software such as iTunes, and listen to them on a PC or download them to a portable MP3 player or smart phone.

point-of-sale (POS) The part of an information system that handles daily sales transactions and maintains the online inventory file.

polymorphism The concept that a message gives different meanings to different objects (e.g., a GOOD NIGHT message might produce different results depending if it is received by a child or the family dog).

pool The overall diagram in BPMN.

port A positive integer that is used for routing incoming traffic to the correct application on a computer.

port scan An attempt to detect the services running on a computer by trying to connect to various ports and recording the ports on which a connection was accepted.

portal An entrance to a multifunction website. After entering a portal, a user can navigate to a destination, using various tools and features provided by the portal designer.

post-implementation evaluation An assessment of the overall quality of the information system. The evaluation verifies that the new system meets specified requirements, complies with user objectives, and achieves the anticipated benefits. In addition, by providing feedback to the development team, the evaluation also helps improve IT development practices for future projects.

power-on password *See* **BIOS-level password**.

predecessor task A single prior task upon which two or more concurrent tasks depend.

preliminary investigation An initial analysis to clearly identify the nature and scope of the business opportunity or problem. Also called a feasibility study.

pretexting Obtaining personal information under false pretenses.

preventive maintenance Changes to a system to reduce the possibility of future failure.

primary key A field or combination of fields that uniquely and minimally identifies a particular member of an entity. For example, in a customer table the customer number is a unique primary key because no two customers can have the same customer number. That key also is minimal because it contains no information beyond what is needed to identify the customer.

private key encryption A common encryption technology called PKE. The private key is one of a pair of keys, and it decrypts data that has been encrypted with the second part of the pair, the public key.

private network A dedicated connection, similar to a leased telephone line.

privilege escalation attack An unauthorized attempt to increase permission levels.

probable-case estimate The most likely outcome is called a probable-case estimate.

procedural security Concerned with managerial policies and controls that ensure secure operations. Also called operational security.

process Procedure or task that users, managers, and IT staff members perform. Also, the logical rules of a system that are applied to transform data into meaningful information. In data flow diagrams, a process receives input data and produces output that has a different content, form, or both.

process 0 In a DFD, process 0 (zero) represents the entire information system but does not show the internal workings.

process description A documentation of a functional primitive's details, which represents a specific set of processing steps and business logic.

process improvement The framework used to integrate software and systems development by a new SEI model, CMMI.

product baseline Describes the system at the beginning of operation. The product baseline incorporates any changes made since the allocated baseline and includes the results of performance and acceptance tests for the operational system.

product lifecycle management (PLM) *See* **application lifecycle management (ALM)**.

production environment The environment for the actual system operation. It includes hardware and software configurations, system utilities, and communications resources. Also called the operational environment.

productivity software Applications such as word processing, spreadsheet, database management, and presentation graphics programs.

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product-oriented Companies that manufacture computers, routers, or microchips.

program documentation Preparation of program documentation starts in the systems analysis phase and continues during systems implementation. Systems analysts prepare overall documentation, such as process descriptions and report layouts, early in the SDLC. Programmers provide documentation by constructing modules that are well supported by internal and external comments and descriptions that can be understood and maintained easily.

Program Evaluation Review Technique (PERT) *See* **PERT/CPM**.

programmer/analyst A designation for positions that require a combination of systems analysis and programming skills.

project coordinator The person who handles administrative responsibilities for the development team and negotiates with users who might have conflicting requirements or want changes that would require additional time or expense.

project creep The process by which projects with very general scope definitions expand gradually, without specific authorization.

project leader The person charged with leading a project from a technical perspective.

project management The process of planning, scheduling, monitoring, controlling, and reporting upon the development of an information system.

project manager The person charged with managing a project from an administrative perspective.

project monitoring Guiding, supervising, and coordinating the project team's workload.

project planning Identifying project tasks and estimating completion time and costs.

project reporting Providing regular progress reports to management, users, and the project team itself.

project scheduling The creation of a specific timetable to facilitate completion of a project. Also involves selecting and staffing the project team and assigning specific tasks to team members.

project scope A specific determination of a project's boundaries or extent.

project triangle The three major components of a project: cost, scope, and time. A project manager tries to find the optimal balance among these factors.

properties In object-oriented (O-O) analysis, characteristics that objects inherit from their class or possess on their own.

prototype An early, rapidly constructed working version of the proposed information system.

prototyping The method by which a prototype is developed. It involves a repetitive sequence of analysis, design, modeling, and testing. It is a common technique that can be used to design anything from a new home to a computer network.

proxy server A networking device that provides Internet connectivity for internal LAN users.

pseudocode A technique for representing program logic in semi-structured prose.

public key encryption (PKE) A common encryption technique. Each user on the network has a pair of keys: a public key and a private key. The public key encrypts data that can be decrypted with the private key.

qualitative risk analysis Evaluating risk by estimating the probability that it will occur and the degree of impact.

quality assurance (QA) A process or procedure for minimizing errors and ensuring quality in products. Poor quality can result from inaccurate requirements, design problems, coding errors, faulty documentation, and ineffective testing. A QA team reviews and tests all applications and systems changes to verify specifications and software quality standards.

quality attributes *See* **non-functional requirements**.

quantitative risk analysis Evaluating risk in terms of the actual impact in terms of dollars, time, project scope, or quality.

query by example (QBE) A language allows the user to provide an example of the data requested.

query language Allows a user to specify a task without specifying how the task will be accomplished. Some query languages use natural language commands that resemble ordinary English sentences.

questionnaire A document containing a number of standard questions that can be sent to many individuals. Also called a survey.

radio button Buttons that represent groups of options. The user can select only one option at a time; a selected option contains a black dot. *See also* **option button**.

radio frequency identification (RFID) Technology that uses high-frequency radio waves to track physical objects.

radio frequency identification (RFID) tag An input device used in source data automation.

random sample A selection taken in a random, unplanned manner. For example, a random sample might be a sample that selects any 20 customers.

range check A type of data validation check that tests data items to verify that they fall between a specified minimum and maximum value. The daily hours worked by an employee, for example, must fall within the range of 0 to 24.

range-of-response questions Closed-ended questions that ask the person to evaluate something by providing limited answers to specific responses or on a numeric scale.

rapid application development (RAD) A team-based technique that speeds up information systems development and produces a functioning information system. RAD is similar in concept to JAD but goes further by including all phases of the SDLC.

reasonableness check A type of data validation check that identifies values that are questionable but not necessarily wrong. For example, input payment values of $0.05 and $5,000,000.00 both pass a simple limit check for a payment value greater than zero, and yet both values could be errors.

record A set of related fields that describes one instance, or member of an entity, such as one customer, one order, or one product. A record might have one or dozens of fields, depending on what information is needed. Also called a tuple.

records retention policy Rules designed to meet all legal requirements and business needs for keeping records.

recovery The process of restoring data and restarting a system after an interruption.

recovery procedure Process for restoring data and restarting a system after an interruption. Recovery procedures can be used to restore a file or database to its current state at the time of the last backup.

redundant array of independent disks (RAID) A RAID system may be part of an organization's backup and recovery plans. A RAID system mirrors the data while processing continues. RAID systems are called fault-tolerant, because a failure of any one disk does not disable the system.

referential integrity A type of validity check. Referential integrity is a set of rules that avoids data inconsistency and quality problems.

relational database A database in which tables are related by common fields, creating a unified data structure that provides improved data quality and access.

relational model A model used in relational databases. The relational model was introduced during the 1970s and became popular because it was flexible and powerful.

relationships Enable objects to communicate and interact as they perform the business functions and transactions required by a system. Relationships describe what objects need to know about each other, how objects respond to changes in other objects, and the effects of membership in classes, superclasses, and subclasses.

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release plan In agile development, a plan that specifies when user stories will be implemented and the timing of the releases. Releases are relatively frequent, and each release is treated as a system prototype that can be tested and modified as needed.

remote control software Applications that allow IT staff to take over a user's workstation and provide support and troubleshooting.

repeating group A set of one or more fields that can occur any number of times in a single record, with each occurrence having different values.

report footer Appears at the end of the report, can include grand totals for numeric fields and other end-of-report information.

report header Appears at the beginning of a report and identifies the report as well as the report title, date, and other necessary information.

request for proposal (RFP) A written list of features and specifications given to prospective vendors before a specific product or package has been selected.

request for quotation (RFQ) Used to obtain a price quotation or bid on a specific product or package.

requirements definitions A description of the system requirements from the user's point of view.

requirements elicitation The process of gathering requirements. *See* **fact-finding**.

requirements engineering Used in the systems planning phase of the SDLC. It involves using various fact-finding techniques, such as interviews, surveys, observation, and sampling, to describe the current system and identify the requirements for the new system.

requirements planning phase A phase that combines elements of the systems planning and systems analysis phases of the SDLC.

requirements specifications A description of the system requirements from the analyst or engineering team's point of view.

research An important fact-finding technique that includes the review of journals, periodicals, and books to obtain background information, technical material, and news about industry trends and developments.

response time The overall time between a request for system activity and the delivery of the response. In the typical online environment, response time is measured from the instant the user presses the ENTER key or clicks a mouse button until the requested screen display appears or printed output is ready.

retention period Backups are stored for a specific retention period after which they are either destroyed or the backup media is reused.

return on investment (ROI) A percentage rate that measures profitability by comparing the total net benefits (the return) received from a project to the total costs (the investment) of the project. ROI = (total benefits – total costs)/total costs.

ring network A network resembling a circle of computers that communicate with each other. A ring network often is used when processing is performed at local sites rather than at a central location.

risk An event that could affect the project negatively.

risk assessment Measures the likelihood and impact of risks.

risk control Develops safeguards that reduce the likelihood and impact of risks.

risk identification Listing each risk and assessing the likelihood that it could affect a project.

risk management The process of identifying, evaluating, tracking, and controlling risks to minimize their impact.

risk management plan Includes a review of the project's scope, stakeholders, budget, schedule, and any other internal or external factors that might affect the project. The plan should define project roles and responsibilities, risk management methods and procedures, categories of risks, and contingency plans.

risk response plan A proactive effort to anticipate a risk and describe an action plan to deal with it. An effective risk response plan can reduce the overall impact by triggering a timely and appropriate action.

roaming A process that allows wireless clients to move from one access point to another, automatically associating with the stronger access point and allowing for uninterrupted service.

router A device that connects network segments, determines the most efficient data path, and guides the flow of data.

sampling A process where an analyst collects examples of actual documents, which could include records, reports, or various forms.

scalability A characteristic of a system, implying that the system can be expanded, modified, or downsized easily to meet the rapidly changing needs of a business enterprise.

scalable The ability of a system to expand to meet new business requirements and volumes.

scaling on demand The ability to match network resources to needs at any given time; a feature of cloud computing. For example, during peak loads, additional cloud servers might come on line automatically to support increased workloads.

scatter diagram A tool used by system analysts to graphically show the correlation between two variables. Also called an XY chart.

scenarios In an agile project, a real-world example of how users will interact with the system.

schedule feasibility A project can be implemented in an acceptable time frame.

schema The complete definition of a database, including descriptions of all fields, records, and relationships.

scroll bar In user interface design, a scroll bar allows the user to move through the available choices for an input field.

Scrum A popular technique for agile project management. Derived from a rugby term. In Scrum, team members play specific roles and interact in intense sessions.

second normal form (2NF) A record design is in 2NF if it is in 1NF and if all fields that are not part of the primary key are dependent on the entire primary key. If any field in a 1NF record depends on only one of the fields in a combination primary key, then the record is not in 2NF. A 1NF record with a primary key that is a single field is automatically in 2NF.

secondary key A field or combination of fields that can be used to access or retrieve records. Secondary key values are not unique. For example, to access records for only those customers in a specific postal code, the postal code field could be used as a secondary key.

security Hardware, software, and procedural controls that safeguard and protect a system and its data from internal or external threats.

security hole Created by a combination of one or more improperly configured services.

security policy A plan that addresses the three main elements of system security: confidentiality, integrity, and availability.

security token A physical device that authenticates a legitimate user, such as a smart card or keychain device.

selection A control structure in modular design, it is the completion of two or more process steps based on the results of a test or condition.

semantic web An evolution of the web where the documents shared on the Internet have semantics (meaning) and not just syntax (HTML markup). Sometimes called Web 3.0.

sequence The completion of steps in sequential order, one after another.

sequence check A type of data validation check that is used when the data must be in some predetermined sequence. If the user must enter work orders in numerical sequence, for example, then an out-of-sequence order number indicates an error. If the user must enter transactions chronologically, then a transaction with an out-of-sequence date indicates an error.

sequence code Numbers or letters assigned in a specific order. Sequence codes contain no additional information other than an indication of order of entry into a system.

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sequence diagram A UML diagram that shows the timing of transactions between objects as they occur during system execution.

server Computer in a client/server design that supplies data, processing, and services to client workstations.

service An application that monitors, or listens on, a particular port.

service desk A centralized resource staffed by IT professionals that provides users with the support they need to do their jobs. Also called help desk.

service pack A maintenance release supplied by commercial software suppliers.

service provider A firm that offers outsourcing solutions. Two popular outsourcing options involve ASPs and firms that offer IBSs.

service-oriented A company that primarily offers information or services or sells goods produced by others.

significant digit code Cipher that distinguishes items by using a series of subgroups of digits. U.S. Postal Service zip codes, for example, are significant digit codes.

simulation A dress rehearsal for users and IT support staff. Organizations typically include all procedures, such as those that they execute only at the end of a month, quarter, or year, in their simulations.

sink An external entity that receives data from an information system.

site visit A trip to a physical location to observe a system in use at another location.

slack time The amount of time by which an event can be late without delaying the project. The difference between latest completion time (LCT) and earliest completion time (ECT).

social engineering An intruder uses social interaction to gain access to a computer system.

soft skills Communications, interpersonal skills, perceptive abilities, and critical thinking are soft skills. IT professionals must have soft skills as well as technical skills.

software A program run by computers for a specific function or task.

Software as a Service (SaaS) A model of software delivery in which functionality is delivered on demand as a network-accessible service, rather than as a traditional software application that is downloaded and installed on the customer's computer.

software engineering A software development process that stresses solid design, effective structure, accurate documentation, and careful testing.

software license A legal agreement that gives users the right to use the software under certain terms and conditions.

software package Software that is purchased or leased from another firm. A commercially produced software product, or family of products.

software reengineering Uses analytical techniques to identify potential quality and performance improvements in an information system.

software vendor Company that develops software for sale.

source An external entity that supplies data to an information system.

source data automation A popular online input method that combines online data entry and automated data capture using input devices such as magnetic data strips or swipe scanners.

source document A form used to request and collect input data, trigger or authorize an input action, and provide a record of the original transaction. During the input design stage, you develop source documents that are easy to complete and inexpensive.

spiral model A development model with a series of iterations, or revisions, based on user feedback.

spontaneous generation An unexplained generation of data or information. With respect to DFDs, processes cannot spontaneously generate data flows—they must have an input to have an output.

stakeholder Anyone who is affected by the company's performance, such as customers, employees, suppliers, stockholders, and members of the community.

stand-alone When personal computers first appeared in large numbers in the 1990, users found that they could run their own word processing, spreadsheet, and database applications, without assistance from the IT group, in a mode called stand-alone computing.

standard notation format A representation that makes designing tables easier as it clearly shows a table's structure, fields, and primary key.

star network A network design with a central device and one or more workstations connected to it in a way that forms a star pattern.

start day/date The day or date when a task is scheduled to begin.

state An adjective that describes an object's current status (e.g., a student could be a CURRENT, FUTURE, or PAST student).

state transition diagram Shows how an object changes from one state to another, depending on the events that affect the object.

status flag In structured application development, an indicator that allows one module to send a message to another module.

storyboard In an agile project, a simple graphic organizer that helps systems analysts visualize the status of a project.

strategic planning The process of identifying long-term organizational goals, strategies, and resource.

strategic plans The long-range plans that define the corporate mission and goals. Typically defined by top management, with input from all levels.

stratified sample A set metric is collected across functional areas. For example, a certain percentage of transactions from every work shift, or five customers from each of four zip codes, could be a stratified sample.

structure chart A top-down representation of business functions and processes. Also called an FDD.

structured analysis A traditional systems development technique that uses phases to plan, analyze, design, implement, and support an information system. Processes and data are treated as separate components.

structured brainstorming A group discussion where each participant speaks when it is his or her turn or passes.

structured English A subset of standard English that describes logical processes clearly and accurately.

Structured Query Language (SQL) A query language that allows PC users to communicate with servers and mainframe computers.

structured walk-through A review of a project team member's work by other members of the team. Generally, systems analysts review the work of other systems analysts, and programmers review the work of other programmers, as a form of peer review. Structured walk-throughs should take place throughout the SDLC and are called requirements reviews, design reviews, code reviews, or testing reviews, depending on the phase in which they occur.

stub testing A form of testing where the programmer simulates each program outcome or result and displays a message to indicate whether or not the program executed successfully. Each stub represents an entry or exit point that will be linked later to another program or data file.

subclass A further division of objects in a class. Subclasses are more specific categories within a class.

subordinate module A lower-level module in a structure chart.

subschema A view of the database used by one or more systems or users. A subschema defines only those portions of the database that a particular system or user needs or is allowed to access.

subscription model A service model that charges a variable fee for an application based on the number of users or workstations that have access to the application.

successor task Each of the concurrent tasks of a predecessor task.

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summary report A report used by individuals at higher levels in the organization that includes less detail than reports used by lower-level employees.

superclass A more generalized category to which objects may belong (e.g., a NOVEL class might belong to a superclass called BOOK).

superuser account A login account that allows essentially unrestricted access to the application.

supply chain A traditional systems development technique that uses phases to plan, analyze, design, implement, and support an information system. Processes and data are treated as separate components.

supply chain management (SCM) The coordination, integration, and management of materials, information, and finances as they move from suppliers to customers, both within and between companies. In a totally integrated supply chain, a customer order could cause a production planning system to schedule a work order, which in turn could trigger a call for certain parts from one or more suppliers.

survey A document containing a number of standard questions that can be sent to many individuals. Also called a questionnaire.

swim lanes In a business process diagram, the overall diagram is called a pool and the designated customer areas are called swim lanes.

switch Central networking device in a star network, which manages the network and acts as a conduit for all network traffic.

switchboard The use of command buttons in a user interface to enable users to navigate a system and select from groups of related tasks.

SWOT analysis An examination of a company's strengths (S), weaknesses (W), opportunities (O), and threats (T).

syntax error Programming language grammar error.

SysML A dialect of UML 2, used for representing requirements (and other things), primarily in MBSE applications.

system A set of related components that produces specific results.

system administrator A person who is responsible for the CM and maintenance of an organization's computer networks.

system architecture A translation of the logical design of an information system into a physical structure that includes hardware, software, network support, and processing methods.

system boundary Shows what is included and excluded from a system. Depicted by a shaded rectangle in use case diagrams.

system changeover The process of putting the new information system online and retiring the old system. Changeover can be rapid or slow, depending on the method.

system design specification A document that presents the complete design for the new information system, along with detailed costs, staffing, and scheduling for completing the next SDLC phase, systems implementation. Also called the technical design specification or the detailed design specification.

system documentation A description of a system's functions and how they are implemented. The analyst prepares most of the system documentation during the systems analysis and systems design phases. System documentation includes data dictionary entries, DFDs, object models, screen layouts, source documents, and the systems request that initiated the project.

system prototyping Producing a full-featured, working model of the information system being developed.

system requirement A characteristic or feature that must be included in an information system to satisfy business requirements and be acceptable to users.

system requirements document A document that contains the requirements for the new system, describes the alternatives that were considered, and makes a specific recommendation to management. It is the end product of the systems analysis phase.

system software Programs that control the computer, including the operating system, device drivers that communicate with hardware, and low-level utilities.

system testing A form of testing involving an entire information system and includes all typical processing situations. During a system test, users enter data, including samples of actual or live data, perform queries, and produce reports to simulate actual operating conditions. All processing options and outputs are verified by users and the IT project development team to ensure that the system functions correctly.

systematic sample A sample that occurs at a predetermined periodicity. For example, every tenth customer record might be selected as a systematic sample for review.

systems analysis and design The process of developing information systems that effectively use hardware, software, data, processes, and people to support the company's business objectives.

systems analysis phase The second SDLC phase. The purpose of this phase is to build a logical model of the new system.

systems analyst A person who plans, analyzes, and implements information systems. They may work internally within a company's IT department or be hired by a company as an independent consultant.

systems design phase The third SDLC phase. The purpose of systems design is to create a blueprint for the new system that will satisfy all documented requirements, whether the system is being developed in-house or purchased as a package.

systems development life cycle (SDLC) Activities and functions that systems developers typically perform, regardless of how those activities and functions fit into a particular methodology. The SDLC model includes five phases: (1) systems planning, (2) systems analysis, (3) systems design, (4) systems implementation, and (5) systems support and security.

systems implementation phase The fourth phase of the SDLC. During this phase, the new system is constructed—programs are written, tested, and documented, and the system is installed.

systems planning phase The first phase of the SDLC. During this phase, the systems project gets started. The project proposal is evaluated to determine its feasibility. The project management plan is formulated, with the help of CASE tools where appropriate.

systems programmer A person who concentrates on operating system software and utilities.

systems request A formal appeal to the IT department that describes problems or desired changes in an information system or business process. It might propose enhancements for an existing system, the correction of problems, or the development of an entirely new system.

systems request A formal request to the IT department that describes problems or desired changes in an information system or business process. It might propose enhancements for an existing system, the correction of problems, or the development of an entirely new system.

systems review committee A group of key managers and users responsible for evaluating systems requests. The term computer resources committee is sometimes also used.

systems support and security phase During the systems support and security phase of the SDLC, the IT staff maintains, enhances, and protects the system.

table Each file or table contains data about people, places, things, or events that interact with the information system.

table design Specifies the fields and identifies the primary key in a particular table or file.

tamper-evident case A case designed to show any attempt to open or unlock the case.

tangible benefits Positive outcomes that can be measured in dollars. They can result from a decrease in expenses, an increase in revenues, or both.

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tangible costs Expenses that have a specific dollar value. Examples include employee salaries and hardware purchases.

task Any work that has a beginning and an end and requires the use of company resources including people, time, and/or money. Examples include conducting a series of interviews, designing a report, selecting software, waiting for the delivery of equipment, and training users. *See also* **activity**.

task box A component of a PERT/CPM chart that contains important scheduling and duration information about a task. Each task in a project is represented by its own task box in the PERT/CPM chart.

task group A task that represents several activities.

task ID A number or code that uniquely identifies a task.

task name A brief descriptive name for a task, which does not have to be unique in the project. For example, a task named Conduct Interviews might appear in several phases of the project.

task pattern A logical sequence of tasks in a WBS. Can involve sequential tasks, multiple successor tasks, and multiple predecessor tasks.

technical feasibility When an organization has the resources to develop or purchase, install, and operate the system.

technical support Technical support is necessary to support the wide variety of IT systems and users. It includes six main functions: application development, systems support, user support, database administration, network administration, and web support. These functions overlap considerably and often have different names in different companies.

terminator A DFD symbol that indicates a data origin or final destination. Also called an external entity.

test data The data used in unit testing. Test data should contain both correct data and erroneous data and should test all possible situations that could occur.

test-driven development (TDD) An XP concept that unit tests are designed before code is written, focusing on end results and preventing programmers from straying from their goals.

test environment The environment that analysts and programmers use to develop and maintain programs.

test plan A plan designed by a systems analyst that includes test steps and test data for integration testing and system testing.

testing review *See* **structured walk-through**.

thick client A system design that locates most or all of the application processing logic at the client. Also called a fat client design.

third normal form (3NF) A record design is in 3NF if it is in 2NF and if no nonkey field is dependent on another nonkey field. A nonkey field is a field that is not a candidate key for the primary key.

third-party software An application that is not developed in-house.

threat In risk management, an internal or external or external entity that could endanger an asset.

three-tier design In a three-tier design, the user interface runs on the client and the data is stored on the server, just as in a two-tier design. A three-tier design also has a middle layer between the client and server that processes the client requests and translates them into data access commands that can be understood and carried out by the server.

throughput A measurement of actual system performance under specific circumstances and is affected by network loads and hardware efficiency. Throughput, like bandwidth, is expressed as a data transfer rate, such as Kbps, Mbps, or Gbps.

throwaway prototyping *See* **design prototyping**.

tightly coupled If modules are tightly coupled, one module refers to internal logic contained in another module.

toggle button A GUI element used to represent on or off status. Clicking the toggle button switches to the other status.

toolbar A GUI element that contains icons or buttons that represent shortcuts for executing common commands.

top-down approach A design approach, also called modular design, where the systems analyst defines the overall objectives of the system and then breaks them down into subsystems and modules. This breaking-down process also is called partitioning.

total cost of ownership (TCO) A number used in assessing costs, which includes ongoing support and maintenance costs, as well as acquisition costs.

totals zone If a form has data totals, they will appear in this section of the form.

traceability The ability to follow a requirement backward to its origins and forward through the SDLC to link design documents, code fragments, and test artifacts.

training plan A successful information system requires training for users, managers, and IT staff members. The entire systems development effort can depend on whether or not people understand the system and know how to use it effectively. The training plan is a document that details these requirements.

train-the-trainer A strategy where one group of users has been trained and can assist others. Users often learn more quickly from coworkers who share common experience and job responsibilities.

transaction model A service model that charges a variable fee for an application based on the volume of transactions or operations performed by the application. Also called a usage model.

transaction processing (TP) systems Operational systems used to process day-to-day recurring business transactions, such as customer billing.

transference One of four risk control strategies. In transference, risk is shifted to another asset or party, such as an insurance company.

transparent A network is transparent if a user sees the data as if it were stored on his or her own workstation.

transparent interface A user interface that users don't really notice—a user-friendly interface that does not distract the user and calls no attention to itself.

tunnel A secure network connection established between the client and the access point of the local intranet.

tuple A tuple (rhymes with couple), or record, is a set of related fields that describes one instance, or member of an entity, such as one customer, one order, or one product. A tuple might have one or dozens of fields, depending on what information is needed.

turnaround document Output document that is later entered back into the same or another information system. A telephone or utility bill, for example, might be a turnaround document printed by the company's billing system. When the bill is returned with payment, it is scanned into the company's accounts receivable system to record the payment accurately.

turnaround time A measure applied to centralized batch processing operations, such as customer billing or credit card statement processing. Turnaround time measures the time between submitting a request for information and the fulfillment of the request. Turnaround time also can be used to measure the quality of IT support or services by measuring the time from a user request for help to the resolution of the problem.

tutorial A series of online interactive lessons that present material and provide a dialog with users.

two-tier design A network design where the user interface resides on the client, all data resides on the server, and the application logic can run either on the server or on the client or be divided between the client and the server.

unencrypted Data that is not encrypted.

Unicode A relatively recent coding method that represents characters as integers. Unlike EBCDIC and ASCII, which use eight bits for each

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character, Unicode requires 16 bits per character, which allows it to represent more than 65,000 unique characters.

Unified Modeling Language (UML) A widely used method of visualizing and documenting software systems design. UML uses object-oriented design concepts, but it is independent of any specific programming language and can be used to describe business processes and requirements generally.

uninterruptible power supply (UPS) Battery-powered backup power source that enables operations to continue during short-term power outages and surges.

unit testing The testing of an individual program or module. The objective is to identify and eliminate execution errors that could cause the program to terminate abnormally and logic errors that could have been missed during desk checking.

Universal Security Slot (USS) Can be fastened to a cable lock or laptop alarm.

unnormalized A record that contains a repeating group, which means that a single record has multiple occurrences of a particular field, with each occurrence having different values.

unstructured brainstorming A group discussion where any participant can speak at any time.

usability In user interface design, includes user satisfaction, support for business functions, and system effectiveness.

usability metrics Data that interface designers can obtain by using software that can record and measure user interactions with the system.

usage model *See* **transaction model**.

use case description A description in UML that documents the name of the use case, the actor, a description of the use case, a step-by-step list of the tasks required for successful completion, and other key descriptions and assumptions.

use case diagram A visual representation that illustrates the interaction between users and the information system in UML.

use case Represents the steps in a specific business function or process in UML.

user application Programs that utilize standard business software, such as Microsoft Office, which has been configured in a specific manner to enhance user productivity.

user design phase In this phase, users interact with systems analysts and develop models and prototypes that represent all system processes, outputs, and inputs.

user documentation Instructions and information to users who will interact with the system. Includes user manuals, help screens, and tutorials.

user interface (UI) The mechanism through which the user interacts with the system. The interface can be graphical, textual, aural, or a combination of different modes of interaction.

user interface Includes screens, commands, controls, and features that enable users to interact more effectively with an application.

user productivity systems Applications that provide employees of all levels a wide array of tools to improve job performance. Examples include email, word processing, graphics, and company intranets.

user rights User-specific privileges that determine the type of access a user has to a database, file, or directory. Also called permissions.

user stories In an agile project, a set of more refined requirements derived from **features**.

user story In agile development, a short, simple requirements definition provided by the customer. Programmers use user stories to determine a project's requirements, priorities, and scope.

user training package The main objective of a user training package is to show users how the system can help them perform their jobs.

user-centered A term that indicates the primary focus is upon the user. In a user-centered system, the distinction blurs between input, output, and the interface itself.

users Stakeholders inside and outside the company who will interact with the system.

validity check A type of data validation check that is used for data items that must have certain values. For example, if an inventory system has 20 valid item classes, then any input item that does not match one of the valid classes will fail the check.

validity rules Checks that are applied to data elements when data is entered to ensure that the value entered is valid. For example, a validity rule might require that an employee's salary number be within the employer's predefined range for that position.

value-added reseller (VAR) A firm that enhances a commercial package by adding custom features and configuring it for a particular industry.

version control The process of tracking system releases.

vertical application A software package that has been developed to handle information requirements for a specific type of business.

vertical system A system designed to meet the unique requirements of a specific business or industry, such as a web-based retailer or auto-supply store.

virtual private network (VPN) Uses a public network to connect remote users securely. Allows a remote client to use a special key exchange that must be authenticated by the VPN.

vulnerability A security weakness or soft spot.

waterfall model The traditional model of software development. A graph that depicts the result of each SDLC phase flowing down into the next phase.

Web 2.0 A second generation of the web that enables people to collaborate, interact, and share information much more dynamically, based on continuously available user applications rather than static HTML web pages. Interactive experience is a hallmark of Web 2.0.

webcast A one-way transmission of information or training materials, such as a Webinar session, available on demand or for a specific period to online participants.

web-centric A strategy or approach that emphasizes a high degree of integration with other web-based components. A web-centric architecture follows Internet design protocols and enables a company to integrate the new application into its e-commerce strategy.

webinar An Internet-based training session that provides an interactive experience. The word *webinar* combines the words *web* and *seminar*.

weight An important multiplier that managers factor into estimates so they can be analyzed.

what-if analysis A feature of business support systems that allows analysis to define and account for a wide variety of issues (including issues not completely defined).

wide area network (WAN) A network spanning long distances that can link users who are continents apart.

Wi-Fi Alliance A nonprofit international association formed in 1999 to certify interoperability of wireless network products based on IEEE 802.11 specifications.

Wi-Fi Protected Access (WPA) A common method used to secure a wireless network. This approach requires each wireless client be configured manually to use a special, pre-shared key, rather than key pairs. The most recent and more secure version is WPA2.

wiki A web-based repository of information that anyone can access, contribute to, or modify.

Wi-Max IEEE 802.16 specifications, which are expected to enable wireless multimedia applications with a range of up to 30 miles.

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Wired Equivalent Privacy (WEP) One of the earliest methods used to secure a wireless network, superseded by WPA and WPA2.

wireless access point (WAP) A central wireless device that provides network services to wireless clients. Also called an access point.

wireless fidelity (Wi-Fi) Family of popular IEEE LAN wireless networking standards, also known as 802.11, including 802.11a, b, g, and n. 802.11n is the most recent standard. 802.11ac and 802.11ad are proposed new standards.

wireless local area network (WLAN) A wireless network that is relatively inexpensive to install and is well suited to workgroups and users who are not anchored to a specific desk or location.

work breakdown structure (WBS) A project broken down into a series of smaller tasks. *See also* **Gantt chart; PERT/CPM chart**.

worst-case estimate The most pessimistic outcome.

WPA2 A wireless security standard based on 802.11i that provides a significant increase in protection over WEP and WPA.

XY chart A tool used by system analysts to graphically show the correlation between two variables. Also called a scatter diagram.

Y2K issue A problem faced by many firms in the year 2000 because their computer systems used only two digits to represent the year; most dates now use a four-digit format for the year (YYYYMMDD).

Yourdon A type of symbol set that is used in DFDs. Processes, data flows, data stores, and external entities each have a unique symbol in the Yourdon symbol set.

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