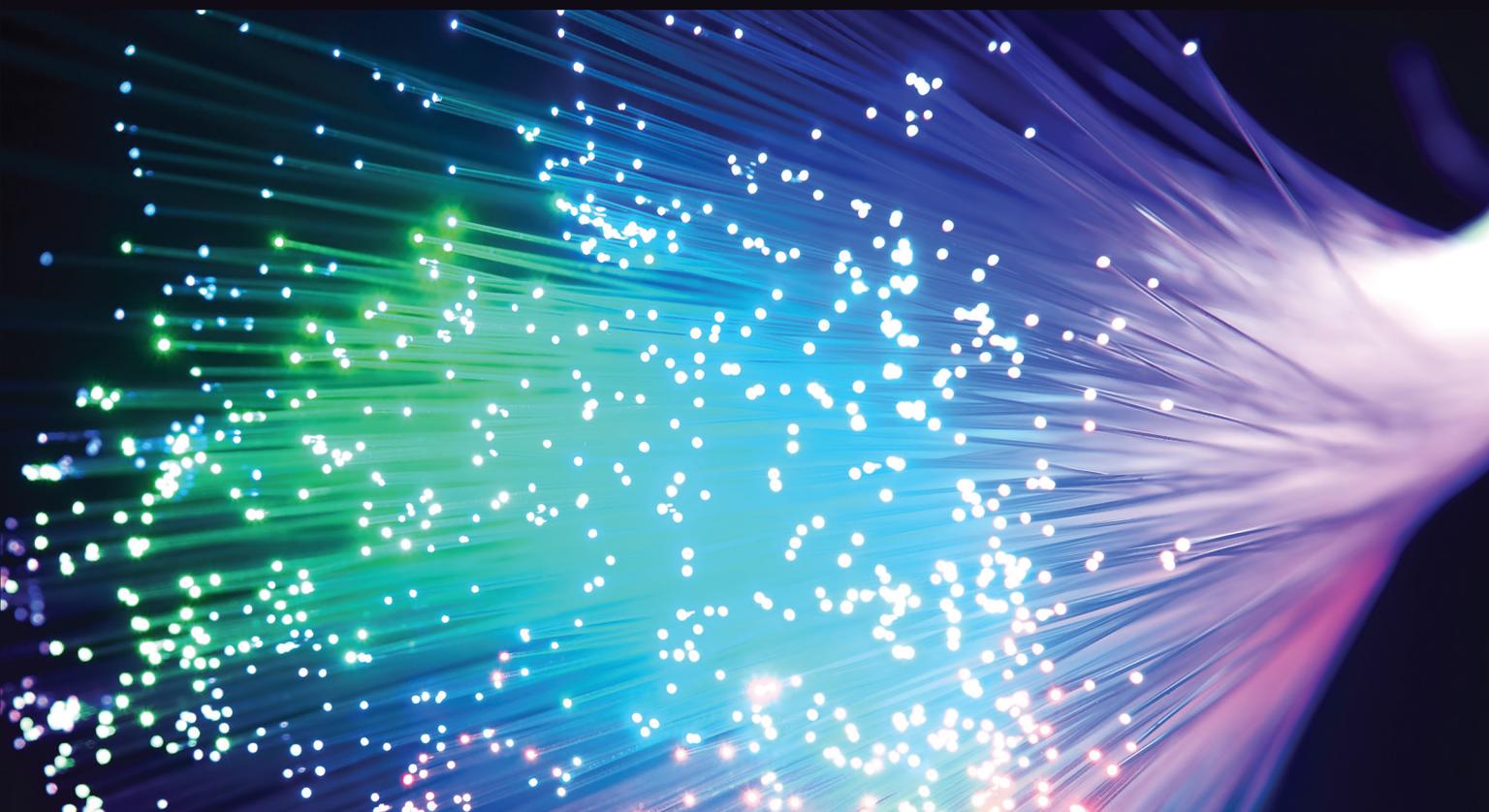


Eighth Edition

# Systems Analysis and Design

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Alan Dennis • Barbara Haley Wixom  
Roberta M. Roth



WILEY

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# SYSTEMS ANALYSIS AND DESIGN

EIGHTH  
EDITION

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*Indiana University*

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*To Kelly*

*To Chris, Haley, and Hannah*

*To my dear friends, Sue and Karen. Thanks for all your care and support.*

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# PREFACE

## Purpose of This Book

Systems Analysis and Design (SAD) is an exciting, active field in which analysts continually learn new techniques and approaches to develop systems more effectively and efficiently. However, there is a core set of skills that all analysts need to know no matter what approach or methodology is used. All information systems projects move through the four phases of planning, analysis, design, and implementation; all projects require analysts to gather requirements, model the business needs, and create blueprints for how the system should be built; and all projects require an understanding of organizational behavior concepts like change management and team building.

This book captures the dynamic aspects of the field by keeping students focused on doing SAD while presenting the core set of skills that we feel every systems analyst needs to know today and in the future. This book builds on our professional experience as systems analysts and on our experience in teaching SAD in the classroom.

This book will be of particular interest to instructors who have students do a major project as part of their course. Each chapter describes one part of the process, provides clear explanations on how to do it, gives a detailed example, and then has exercises for the students to practice. In this way, students can leave the course with experience that will form a rich foundation for further work as a systems analyst.

## Outstanding Features

**A Focus on Doing SAD** The goal of this book is to enable students to do SAD—not just read about it, but understand the issues so that they can actually analyze and design systems. The book introduces each major technique, explains what it is, explains how to do it, presents an example, and provides opportunities for students to practice before they do it in a real-world project. After reading each chapter, the student will be able to perform that step in the system development life cycle (SDLC) process.

**Rich Examples of Success and Failure** The book includes a running case about a fictitious company called DrönTeq. Each chapter shows how the concepts are applied in situations at DrönTeq. Unlike running cases in other books, this text focuses examples on planning, managing, and executing the activities described in the chapter, rather than on detailed dialogue between fictitious actors. In this way, the running case serves as a template that students can apply to their own work. Each chapter also includes numerous Concepts in Action boxes that describe how real companies succeeded—and failed—in performing the activities in the chapter. Many of these examples are drawn from our own experiences as systems analysts.

**Incorporation of Object-Oriented Concepts and Techniques** The field is moving toward object-oriented concepts and techniques, often by gradually incorporating object-oriented concepts into traditional techniques. We have integrated several object-oriented concepts into our discussion of traditional techniques, although this may not be noticed by the students because few concepts are explicitly labeled as object-oriented concepts. For example, we include the

development of use cases as the first step in process modeling (i.e., data flow diagramming) in Chapter 4, and the use (and reuse) of standard interface templates and use scenarios for interface design in Chapter 8.

**Real-World Focus** The skills that students learn in a systems analysis and design course should mirror the work that they ultimately will do in real organizations. We have tried to make this book as “real” as possible by building extensively on our experience as professional systems analysts for organizations such as IBM, the U.S. Department of Defense, and the Australian Army. We have also worked with diverse industry advisory boards of IS professionals and consultants in developing the book and have incorporated their stories, feedback, and advice throughout. Many students who use this book will eventually apply the skills on the job in a business environment, and we believe that they will have a competitive edge by understanding what successful practitioners feel is relevant in the real world.

**Project Approach** We have presented the topics in this book in the SDLC order in which an analyst encounters them in a typical project. Although the presentation necessarily is linear (because students have to learn concepts in the way in which they build on each other), we emphasize the iterative, complex nature of SAD as the book unfolds. The presentation of the material should align well with courses that encourage students to work on projects because it presents topics as students need to apply them.

**Graphic Organization** The underlying metaphor for the book is doing SAD through a project. We have tried to emphasize this graphically throughout the book so that students can better understand how the major elements in the SDLC are related to each other. First, at the start of every major phase of the system development life cycle, we present a graphic illustration showing the major deliverables that will be developed and added to the electronic “project binder” during that phase. Second, at the start of each chapter, we present a checklist of key tasks or activities that will be performed to produce the deliverables associated with this chapter. These graphic elements—the deliverables tied to each phase and the task checklist tied to each chapter—can help students better understand how the tasks, deliverables, and phases are related to and flow from one to another.

Finally, we have highlighted important practical aspects throughout the book by marking boxes and illustrations with a “push pin.” These topics are particularly important in the practical day-to-day life of systems analysts and are the kind of topics that junior analysts should pull out of the book and post on the bulletin board in their office to help them avoid costly mistakes.

## What's New in the Eighth Edition

The eighth edition features several changes from the seventh edition. A new chapter (Chapter 13) has been added that introduces students to Agile development, focusing specifically on the Scrum approach. While this book will always emphasize structured systems development, the increasingly widespread use of Agile methods in practice makes it important that students today have a basic appreciation of the characteristics, concepts, processes, and roles associated with Agile development.

To accommodate the new material in the eighth edition, some project management-oriented material was eliminated. The coverage of use cases and data flow diagramming was merged into a single chapter that emphasizes the way these two tools reinforce the analyst's understanding of processes.

Throughout the book, the chapter objectives have been revised to reflect active learning objectives. Chapter references to outside sources have been updated to current resources wherever possible. New Concepts in Action features appear throughout the book to provide updated,

real-world illustrations of the textbook content. A number of new minicases have also been added. Many of the minicases include directions to the instructor on how to use the minicase in a flipped (or inverted) classroom. Flipping the Systems Analysis and Design class enables instructors to employ active learning activities while in the classroom with students, enhancing student engagement and understanding.

For this edition, a series of tutorial lessons have been created that will teach students how to use and apply the Visible Analyst™ computer-assisted software engineering (CASE) software to a simple systems development project scenario. (Instructors should visit the instructor's website at [www.wiley.com/go/dennis/sad8e](http://www.wiley.com/go/dennis/sad8e) for information about these lessons.)

We know that most professors and students find the Systems Analysis and Design class to have a lot of demanding content, particularly in those classes that include a significant project. Many professors would like their students to be able to experience first-hand how useful a CASE tool is to a systems analyst, but find it difficult to include instruction on a CASE tool in an already full course. The goal of these lessons is to enable students to learn the basics of the Visible Analyst CASE software with little involvement on the part of the professor. The lesson material is found on the student website for this textbook at [www.wiley.com/go/dennis/sad8e](http://www.wiley.com/go/dennis/sad8e). Professors have the flexibility to assign these tutorial lessons if they want to include the Visible Analyst software in their courses, but are also free to exclude this material if they prefer. The tutorial lessons have been written to provide students with a sufficient foundation to apply Visible Analyst to a more significant systems development project, should that be a part of their course.

## Organization of This Book

This book is organized by the phases of the systems development life cycle (SDLC). Each chapter has been written to teach students specific tasks that analysts need to accomplish over the course of a project, and the deliverables that will be produced from the tasks. As students complete the book, tasks will be “checked off” and deliverables will be completed and stored in project folders.

Part 1 covers the first phase of the SDLC, the Planning Phase. Chapter 1 introduces the SDLC, the roles and skills needed for a project team, project initiation, the systems request, and feasibility analysis. Chapter 2 discusses project selection, the selection of an SDLC methodology for the project, and project management, with emphasis on the staffing plan, project charter, risk assessment, and tools used to help manage and control the project.

Part 2 presents techniques needed during the analysis phase. In Chapter 3, students are introduced to requirements determination and are taught a variety of analysis techniques to help with business process automation, business process improvement, and business process reengineering. Chapter 4 focuses on use cases and process models, and Chapter 5 explains data models and normalization.

The Design Phase is covered in Part 3 of the textbook. In Chapter 6, students create an alternative matrix that compares custom, packaged, and outsourcing alternatives. Chapter 7 focuses on designing the system architecture, which includes the architecture design, hardware/software specification, and security plan. Chapter 8 focuses on the user interface and presents interface design; in this chapter, students learn how to create use scenarios, the interface structure diagram, interface standards, and interface prototypes. Finally, data storage design and program design are discussed in Chapters 9 and 10, which contain information regarding the data storage design, the program structure chart, and program specifications.

The Implementation Phase is presented in Chapters 11 and 12. Chapter 11 focuses on system construction, and students learn how to build and test the system. It includes information about the test plan and user documentation. Conversion is covered in Chapter 12, where students learn about the conversion plan, the change management plan, the support plan, and the project assessment.

In this edition, Agile Development concepts are introduced in Chapter 13. Following an introduction to Agile values and principles, students get an in-depth look at the Scrum development method.

## Supplements

[www.wiley.com/go/dennis/sad8e](http://www.wiley.com/go/dennis/sad8e)

**Instructors Manual** The instructor's manual provides resources to support the instructor both in and out of the classroom:

- Short experiential exercises can be used to help students experience and understand key topics in each chapter.
- Short stories have been provided by people working in both corporate and consulting environments for instructors to insert into lectures to make concepts more colorful and real.
- Additional mini-cases for every chapter allow students to perform some of the key concepts that were learned in the chapter.
- Answers to end-of-chapter questions and exercises are provided.

**Power Point Slides** PowerPoint slides are provided that instructors can tailor to their classroom needs and that students can use to guide their reading and studying activities.

**Test Bank** Test Bank includes a variety of questions ranging from multiple choice to essay-style questions. A computerized version of the Test Bank is also available.

**Wiley E-Text: Powered by VitalSource** This Wiley e-text offers students continuing access to materials for their course. Your students can access content on a mobile device, online from any Internet-connected computer, or by a computer via download. With dynamic features built into this e-text, students can search across content, highlight, and take notes that they can share with teachers and classmates. Readers will also have access to interactive images and embedded podcasts.

## Acknowledgments

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Thanks also to our families and friends for their patience and support along the way, especially to Christopher, Haley, and Hannah Wixom; and Alec Dennis; and Richard Jones, in loving memory.

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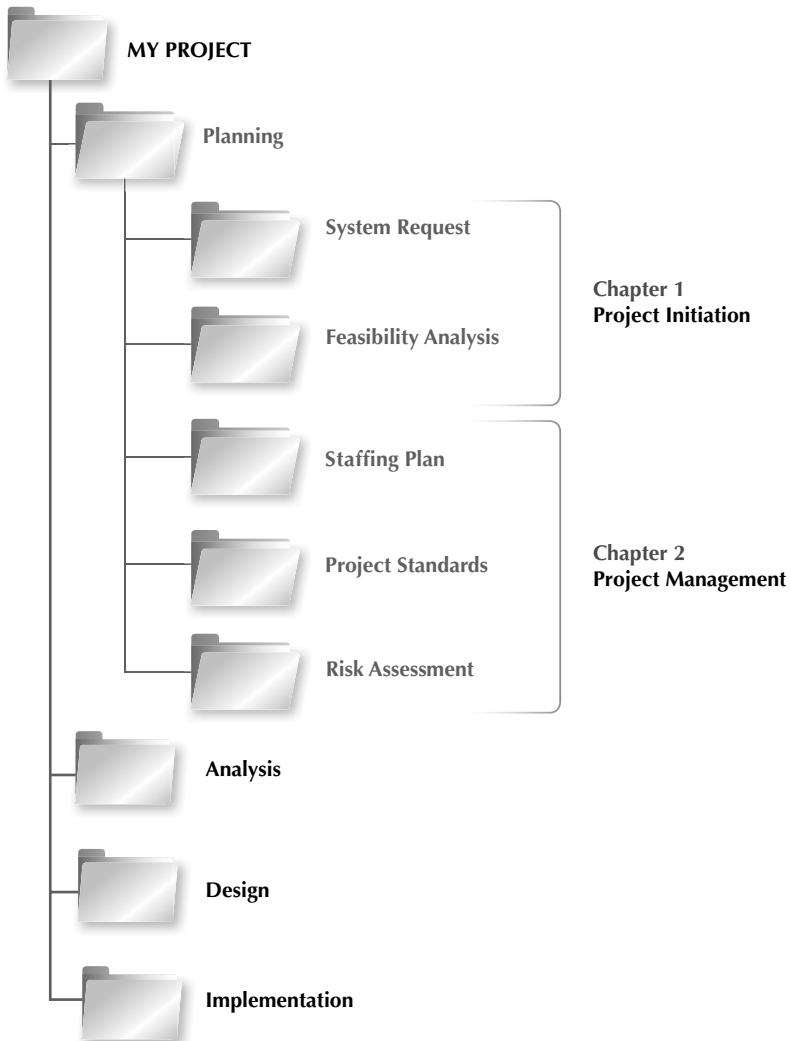
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# PLANNING PHASE

PART 1



The Planning Phase involves two primary issues: understanding why an information system should be developed and creating a plan for how the project team should develop it.

The deliverables from both steps are combined into the project plan. The project sponsor and approval committee then decide if the project should continue on.

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# The Systems Analyst and Information Systems Development

1

PLANNING	
TASK CHECKLIST	
<ul style="list-style-type: none"><li><input type="checkbox"/> Identify project.</li><li><input type="checkbox"/> Develop systems request.</li><li><input type="checkbox"/> Analyze technical feasibility.</li><li><input type="checkbox"/> Analyze economic feasibility.</li><li><input type="checkbox"/> Analyze organizational feasibility.</li><li><input type="checkbox"/> Perform project selection review.</li><li><input type="checkbox"/> Manage scope.</li><li><input type="checkbox"/> Staff project.</li><li><input type="checkbox"/> Create project charter.</li><li><input type="checkbox"/> Set up CASE repository.</li><li><input type="checkbox"/> Develop standards.</li><li><input type="checkbox"/> Begin documentation.</li><li><input type="checkbox"/> Assess and manage risk.</li></ul>	

This chapter introduces the role of the systems analyst in information systems development projects. First, the fundamental four-stage systems development life cycle (planning, analysis, design, and implementation) is established as the basic framework for the information system (IS) development process. Next, ways in which organizations identify and initiate potential projects are discussed. The first steps in the process are to identify a project that will deliver value to the business and to create a system request that provides the basic information about the proposed system. Next, the analysts perform a feasibility analysis to determine the technical, economic, and organizational feasibility of the system.

## OBJECTIVES

- Explain the role played in IS development by the systems analyst.
- Describe the fundamental systems development life cycle and its four phases.
- Explain how organizations identify IS development projects.
- Explain the importance of linking the IS to business needs.
- Be able to create a system request.
- Describe technical, economic, and organizational feasibility assessment.
- Be able to perform a feasibility analysis.

## Introduction

The **systems development life cycle (SDLC)** is the process of determining how an information system (IS) can support business needs, designing the system, building it, and delivering it to users.

If you have taken a programming class or have programmed on your own, you have probably experienced some success in developing small software applications. Creating high-quality IS that meet expectations and provide meaningful value to organizations is a much more complex endeavor, however.

Numerous studies over the years report that projects involving information technology experience failure rates from 30 to 70%.<sup>1</sup> The definition of failure in these studies is often quite different, so the meaning of these statistics is hard to pin down. It is clear, though, that bringing an IS development project to a successful conclusion is difficult and many things need to be done right if we hope to achieve a positive outcome.

Although we would like to promote this book as a “silver bullet” that will keep you from experiencing failed IS projects, we must admit that such a silver bullet guaranteeing IS development success does not exist.<sup>2</sup> Instead, this book will provide you with many fundamental concepts and practical techniques that you can use to improve the likelihood of success. We also discuss how the approach to systems development projects has evolved to improve the odds of project success.

The systems analyst plays a key role in the SDLC, analyzing the business situation, identifying opportunities for improvements, and designing an IS to implement the improvements. Many systems analysts view their profession as one of the most interesting, exciting, and challenging jobs around. As a systems analyst, you will work as a team with a variety of people, including business and technical experts. You will feel the satisfaction of seeing systems that you designed and developed make a significant positive business impact, while knowing that your unique skills helped make that happen.

It is important to remember that the primary objective of the systems analyst is not to create a wonderful system. The primary goal is to create value for the organization, which for most companies means increasing profits. (Government agencies and not-for-profit organizations measure value differently.) Many failed projects were abandoned because the analysts tried to build a wonderful system without clearly understanding how the system would support the organization’s goals, improve business processes, and integrate with other IS to provide value. An investment in an IS is like any other investment, such as a new machine tool. The goal is not to acquire the tool, because the tool is simply a means to an end; the goal is to enable the organization to perform work better so that it can earn greater profits or serve its constituents more effectively.

<sup>1</sup>Michael Kringsman, “CIO Analysis: Why 37 Percent of Project Fail,” *zdnet.com*, accessed February 2014.

<sup>2</sup>The idea of using the silver bullet metaphor was first described in a paper by Frederick Brooks. See Frederick P. Brooks, Jr., “No Silver Bullet—Essence and Accident in Software Engineering,” *Information Processing 1986, the Proceedings of the IFIP Tenth World Computing Conference*, H.-J. Kugler (ed.), 1986: 1069–76.

This book introduces you to the fundamental skills needed by a systems analyst. This is a pragmatic book that discusses best practices in systems development; it does not present a general survey of systems development that exposes you to everything about the topic. Systems analysts *do things* and challenge the current way that an organization works. To get the most out of this book, you will need to actively apply the ideas and concepts in the examples and in the “Your Turn” exercises that are presented throughout to your own systems development project. This book will guide you through all the steps for delivering a successful IS. In the text, we illustrate how one organization, called DrōnTeq, applies the steps in one project, developing a Web-based intermediary e-commerce system. By the time you finish the book, you will not be an expert systems analyst, but you will be ready to start building systems for real.

### CONCEPTS IN ACTION 1-A

### An Array of IT Failures

A significant proportion of IT projects fail to fulfill their original objectives, resulting in wasted resources and a damaged reputation for the responsible IT department. In many cases, the causes of the failure are organizational issues, not technical issues.

Qantas, the Australian national airline, has endured two high-profile IT failures in recent years. In 1995, Project eQ, a 10-year technology services contract with IBM, was canceled after four years, at a cost of \$200 million. Poor planning contributed to the failure to upgrade a complex and unwieldy IT infrastructure saddled with over 700 applications written in older programming languages.

In 2008, Qantas canceled Jetsmart, a \$40 million parts-management system implementation, due in part to a dispute with the unionized users (aircraft mechanics) of the system. The union advised its members not to assist with the implementation, claiming the software unnecessarily increased the members' workload.

An analysis of these IT failures reveals several contributing factors. First, Qantas faced the challenges of a complicated technical infrastructure and outdated legacy applications. More significantly, however, was the failure of company leadership to understand basic IT issues. In public statements, the company CFO seemed not to care about the user perspectives on new software, preferring instead to put in what management thought was appropriate. This attitude, in part, led to union problems and claims of poorly designed, hard-to-use software and inadequate training.

Aging applications and an unwieldy technical infrastructure are challenges faced by many organizations today. But the senior-management attitude that seemingly disregards the views of software users casts serious questions about Qantas' prospects for IT project success in the future.

Large systems development projects are particularly susceptible to failure. An example was a \$110 million unemployment compensation system upgrade project conducted by IBM for

the state of Pennsylvania that was never completed and ended in a lawsuit. When the project was ended in 2013, the project was 45 months behind schedule and \$60 million over budget.

An analysis of very large development projects conducted by the Standish Group found that for projects that exceed \$100 million in labor costs, only 2% are successful (defined as on time and under budget). Although many factors contributed to this specific project's flaws, several major factors were delays in decision making and a high workforce turnover during the project.

An 18-month long project to implement a SaaS customer relationship management system ultimately was declared a bust and scrapped. This project had top management support and was on time and on budget. So why was it considered a failure?

Although the project team believed it understood the project goals and the outcome that was expected, at the end of the project, the end users did not want the system. Users were distrustful of the new system and resistance to change was extremely high.

In this instance, technical issues did not contribute to project failure. The lack of collaboration between the system developers and the business users ultimately derailed this implementation project. The development team focused on project execution rather than building engagement and buy-in from the users of the system.

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Adapted from: Michael Krigsman, “Quantas Airways: A Perfect Storm for IT Failures?”, February 29, 2008, [zdnet.com](https://www.zdnet.com/article/quantas-airways-a-perfect-storm-for-it-failures/), accessed March 2014.

Adapted from: Patrick Thibodeau, “Pennsylvania Sues IBM Over Troubled \$110M IT Upgrade,” [Computerworld.com](https://www.computerworld.com/article/3180325/pennsylvania-sues-ibm-over-troubled-110m-it-upgrade.html), March 13, 2017, <https://www.computerworld.com/article/3180325/pennsylvania-sues-ibm-over-troubled-110m-it-upgrade.html>, accessed February 2021.

Adapted from: Mary K. Pratt, “Why IT Projects Still Fail,” [CIO.com](https://www.cio.com/article/3211485/why-it-projects-still-fail.html?nsdr=true), August 1, 2017, <https://www.cio.com/article/3211485/why-it-projects-still-fail.html?nsdr=true>, accessed August 2020.

In this chapter, we first describe the role of the systems analyst in IS development projects. We discuss the wide range of skills needed to be successful in this role, and we explain various specialties that systems analysts may develop. We then introduce the basic SDLC that IS projects follow. This life cycle is common to all projects and serves as a framework for understanding how IS projects are accomplished. We discuss how projects are identified and initiated within an organization and how they are initially described in a system request. Finally, we describe the feasibility analysis that is performed, which drives the decision whether to proceed with the project.

## The Systems Analyst

The systems analyst plays a key role in IS development projects. The systems analyst works closely with all project team members so that the team develops the right system in an effective way. Systems analysts must understand how to apply technology to solve business problems. In addition, systems analysts may serve as *change agents* who identify the organizational improvements needed, design systems to implement those changes, and train and motivate others to use the systems.

### Systems Analyst Skills

New IS introduce change to the organization and its people. Leading a successful organizational change effort is one of the most difficult jobs that someone can do. Understanding what to change, knowing how to change it, and convincing others of the need for change require a wide range of skills. These skills can be broken down into six major categories: technical, business, analytical, interpersonal, management, and ethical.

Analysts must have the technical skills to understand the organization's existing technical environment, the new system's technology foundation, and the way in which both can be fit into an integrated technical solution. Business skills are required to understand how IT can be applied to business processes and to ensure that IT delivers real business value. Analysts are continuous problem solvers at both the project and the organizational level, and they put their analytical skills to the test regularly.

Often, analysts need to communicate effectively, one-on-one with users and business managers (who often have little experience with technology), with programmers and other technical



### SPOTLIGHT ON ETHICS - 1

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James is a systems analyst on a new account management system for Hometown National Bank. At a recent meeting with the project sponsor, James learned about some new ideas for the system that were not a part of the original project scope. Specifically, the bank's marketing director has asked that some of the data that will be collected by the new system from customers who open new checking and savings accounts also be used as the basis of a marketing campaign for various loan products the bank offers.

James is uncomfortable with the request. He is not sure the bank has the right to use a person's data for purposes other than the original intent. Who "owns" this data, the bank that collected it as a part of a customer opening an account, or the customer who the data describes? Should James insist that the customers give authorization to use "their" data in this way? Or should he say nothing and ignore the issue? Is it necessary (or appropriate) for a systems analyst to be an ethical watchdog in a systems development project? Why or why not?

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specialists (who often have more technical expertise than the analyst does), and with people from outsourcing firms and vendor organizations. They must be able to give presentations to large and small groups and to write reports. Not only do they need to have strong interpersonal abilities, but they also need to manage people with whom they work, and they must manage the pressure and risks associated with unclear situations.

Finally, analysts must deal fairly, honestly, and ethically with other project team members, managers, and system users. Analysts often deal with confidential information or information that, if shared with others, could cause harm (e.g., dissent among employees); it is important for analysts to maintain confidence and trust with all people.

## Systems Analyst Roles

As organizations and technology have become more complex, most large organizations now build project teams that incorporate several analysts with different, but complementary roles. In smaller organizations, one person may play several of these roles. Here we briefly describe these roles and how they contribute to a systems development project.

The **systems analyst** role focuses on the IS issues surrounding the system. This person develops ideas and suggestions for ways that IT can support and improve business processes, helps design new business processes supported by IT, designs the new IS, and ensures that all IS standards are maintained. The systems analyst will have significant training and experience in analysis and design and in programming.

The **business analyst** role focuses on the business issues surrounding the system. This person helps to identify the business value that the system will create, develops ideas for improving the business processes, and helps design new business processes and policies. The business analyst will have business training and experience, plus knowledge of analysis and design.

The **requirements analyst** role focuses on eliciting the requirements from the stakeholders associated with the new system. As more organizations recognize the critical role that complete and accurate requirements play in the ultimate success of the system, this specialty has gradually evolved. Requirements analysts understand the business well, are excellent communicators, and are highly skilled in an array of requirements elicitation techniques (discussed in Chapter 3).

The **infrastructure analyst** role focuses on technical issues surrounding the ways the system will interact with the organization's technical infrastructure (hardware, software, networks, and databases). This person ensures that the new IS conforms to organizational standards and helps to identify infrastructure changes that will be needed to support the system. The infrastructure analyst will have significant training and experience in networking, database administration, and various hardware and software products. Over time, an experienced infrastructure analyst may assume the role of **software architect**, who takes a holistic view of the organization's entire IT environment and guides application design decisions within that context.

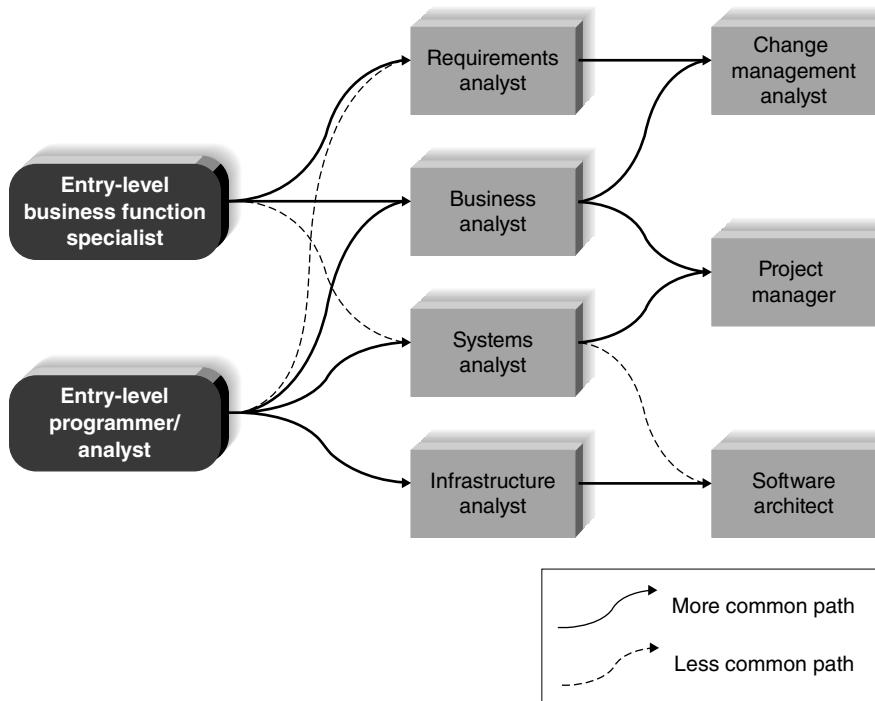
### YOUR TURN 1-1

#### Being an Analyst

Suppose you set a goal to become an analyst after you graduate. What type of analyst would you most prefer to be? Why does this particular analyst role appeal to you? What type of courses should you take before you graduate? What type of summer job or internship should you seek?

#### Question

Develop a short plan that describes how you will prepare for your career as an analyst.



**FIGURE 1-1** Career paths for system developers.

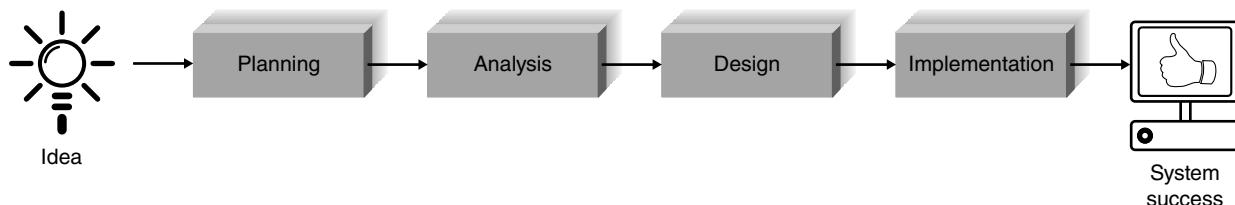
The **change management analyst** role focuses on the people and management issues surrounding the system installation. This person ensures that adequate documentation and support are available to users, provides user training on the new system, and develops strategies to overcome resistance to change. The change management analyst will have significant training and experience in organizational behavior and specific expertise in change management.

The **project manager** role ensures that the project is completed on time and within budget and that the system delivers the expected value to the organization. The project manager is often a seasoned systems analyst who, through training and experience, has acquired specialized project management knowledge and skills.

The roles and the names used to describe them may vary from organization to organization. In addition, there is no single typical career path through these professional roles. Some people may enter the field as a more technically oriented programmer/analyst. Others may enter as a business-oriented functional specialist with an interest in applying IT to solve business problems. As shown in Figure 1-1, those who are interested in the broad field of IS development may follow a variety of paths during their career.

## The Systems Development Life Cycle

In some ways, building an IS is like building a house. First, the owner describes the vision for the house to the developer. Second, this idea is transformed into sketches and drawings that are shown to the owner and refined (often, through several drawings, each improving on the other) until the owner agrees that the pictures depict what he or she wants. Third, a set of detailed blueprints is developed that present much more detailed information about the house (e.g., the layout of rooms, placement of plumbing fixtures and electrical outlets). Finally, the house is built following the blueprints—and often with some changes and decisions made by the owner as the house is erected.



**FIGURE 1-2** The systems development life cycle.

Building an IS using the SDLC follows a similar set of four fundamental **phases**: planning, analysis, design, and implementation (Figure 1-2). Each phase is itself composed of a series of **steps**, which rely on **techniques** that produce **deliverables** (specific documents and files that explain various elements of the system). Figure 1-3 provides more details on the steps, techniques, and deliverables that are included in each phase of the SDLC and outlines how these topics are covered in this textbook.

Figures 1-2 and 1-3 suggest that the SDLC phases proceed in a logical path from start to finish. In some projects, this is true. In many projects, however, the project team moves through

Phase	Chapter	Step	Technique	Deliverable
<b>Planning</b> Focus: Why build this system?	1 1	Identify opportunity Analyze feasibility	Project identification Technical feasibility Economic feasibility Organizational feasibility Scope management	System request Feasibility study
How to structure the project? Primary outputs: —System request with feasibility study —Project plan	2	Develop project plan		Project plan
	2	Staff project	Project staffing Project charter	—Staffing plan
	2	Control and direct project	CASE repository Standards Documentation Timeboxing Risk management	—Standards list —Risk assessment
<b>Analysis</b> Focus: Who, what, where, and when for this system?	3 3	Develop analysis strategy Determine business requirements	Business process automation Business process improvement Business process reengineering Interview JAD session Questionnaire Document analysis Observation	System proposal —Requirements definition
Primary output —System proposal				
	4	Create use cases	Use case analysis	—Use cases
	4	Model processes	Data flow diagramming	—Process models
	5	Model data	Entity relationship modeling Normalization	—Data model
<b>Design</b> Focus: How will this system work?	6 7	Design physical system Design architecture	Design strategy Architecture design Hardware and software selection	Alternative matrix System specification —Architecture report —Hardware and software specification

**FIGURE 1-3** Systems development life cycle phases.

Phase	Chapter	Step	Technique	Deliverable
Primary output: —System specification	8	Design interface	Use scenario Interface structure Interface standards Interface prototype Interface evaluation	—Interface design
	9	Design programs	Data flow diagramming Program structure chart Program specification	—Physical process model —Program design
	10	Design databases and files	Data format selection Entity relationship modeling Denormalization Performance tuning Size estimation	—Database and file specification —Physical data model
<b>Implementation</b> Focus: Delivery and support of completed system Primary output: —Installed system	11	Construct system	Programming Programs	Test plan
	11	Software testing	Documentation	
	12	Performance testing	Conversion strategy selection	Migration plan —Conversion plan —Business contingency plan —Training plan
	12	Install system		Support plan Problem report Change request
	12	Maintain system	<b>Training</b> Support selection System maintenance Project assessment	Postimplementation audit
	12	Postimplementation		Postimplementation audit report

**FIGURE 1-3** (Continued)

the steps consecutively, incrementally, iteratively, or in other patterns. Different projects may emphasize different parts of the SDLC or approach the SDLC phases in different ways, but all projects have elements of these four phases.

For now, there are two important points to understand about the SDLC. First, you should get a general sense of the phases and steps that IS projects move through and some of the techniques that produce certain deliverables. In this section, we provide an overview of the phases, steps, and some of the techniques that are used to accomplish the steps. Second, it is important to understand that the SDLC is a process of **gradual refinement**. The deliverables produced in the analysis phase provide a general idea of what the new system will do. These deliverables are used as input to the design phase, which then refines them to produce a set of deliverables that describes in much more detailed terms exactly how the system should be built. These deliverables in turn are used in the implementation phase to guide the creation of the actual system. Each phase refines and elaborates on the work done previously.

## Planning

The **planning phase** is the fundamental process of understanding *why* an IS should be built and determining how the project team will go about building it. It has two steps:

1. During **project initiation**, the system's business value to the organization is identified—how will it contribute to the organization's future success? Most ideas for new systems come from outside the IS area and are recorded on a system request.

A **system request** presents a brief summary of a business need and explains how a system that addresses the need will create business value. The IS department works together with the person or department generating the request (called the **project sponsor**) to conduct a feasibility analysis. The **feasibility analysis** examines key aspects of the proposed project:

- The technical feasibility (Can we build it?)
  - The economic feasibility (Will it provide business value?)
  - The organizational feasibility (If we build it, will it be used?)
2. The system request and feasibility analysis are presented to an IS **approval committee** (sometimes called a **steering committee**), which decides whether the project should be undertaken.

Once the project is approved, it enters **project management**. During project management, the **project manager** creates a plan, staffs the project, and puts techniques in place to help control and direct the project through the entire SDLC. The deliverable for project management is a plan that describes how the project team will go about developing the system.

## Analysis

The **analysis phase** answers the questions of *who* will use the system, *what* the system will do, and *where* and *when* it will be used (Figure 1-3). During this phase, the project team investigates any current system(s), identifies improvement opportunities, and develops a concept for the new system. This phase has three steps:

1. An **analysis strategy** is developed to guide the project team's efforts. Such a strategy usually includes studying the current system (called the **as-is system**) and its problems, and envisioning ways to design a new system (called the **to-be system**).
2. The next step is *requirements gathering* (e.g., through techniques such as interviews, group workshops, or questionnaires). The analysis of this information—in conjunction with input from the project sponsor and many other people—leads to the development of a concept for a new system. The system concept is explained through a set of *requirement statements* and a set of business **analysis models** that describe how the business will operate if the new system is developed. The analysis models represent user/system interactions and the data and processes needed to support the underlying business process.
3. The analyses, system concept, requirements, and models are combined into a document called the **system proposal**, which is presented to the project sponsor and other key decision makers (e.g., members of the approval committee) who will decide whether the project should continue to move forward.

The system proposal is the initial deliverable describing the requirements the new system should satisfy. Some experts suggest this phase would be better named *analysis and initial design*, rather than *analysis*, since it really provides the first step in the new system design. Since most organizations continue to use the name *analysis* for this phase, we will use it in this book as well. It is important to remember, however, that the deliverable from the analysis phase is both an analysis and a high-level initial design for the new system.

## Design

The **design phase** decides *how* the system will operate in terms of the hardware, software, and network infrastructure that will be in place; the user interface, forms, and reports that will be used; and the specific programs, databases, and files that will be needed. Although most of the strategic decisions about the system are made in the development of the system concept during the analysis phase, the steps in the design phase determine exactly how the system will operate. The design phase has four steps:

1. The **design strategy** must be determined. This clarifies whether the system will be developed by the company's own programmers, whether its development will be outsourced to another firm (usually a consulting firm), or whether the company will buy and install a prewritten software package.
2. This leads to the development of the basic **architecture design** for the system that describes the hardware, software, and network infrastructure that will be used. In most cases, the system will add to or change the infrastructure that already exists in the organization. The **interface design** specifies how the users will move through the system (e.g., by navigation methods such as menus and on-screen buttons) and the forms and reports that the system will use.
3. The **database and file specifications** are developed. These define exactly what data will be stored and where they will be stored.
4. The analyst team develops the **program design**, which defines the programs that need to be written and exactly what each program will do.

This collection of deliverables (architecture design, interface design, database and file specifications, and program design) is the **system specification** that is used by the programming team for implementation. At the end of the design phase, the feasibility analysis and project plan are reexamined and revised, and another decision is made by the project sponsor and approval committee about whether to terminate the project or continue (Figure 1-3).

## Implementation

The final phase in the SDLC is the **implementation phase**, during which the system is actually built (or purchased and installed if the design calls for a prewritten software package). This is the phase that usually gets the most attention, because for most systems it is the longest and most expensive single part of the development process. This phase has three steps:

1. System **construction** is the first step. The system is built and tested to ensure that it performs as designed. Since the cost of fixing bugs can be immense, testing is one of the most critical steps in implementation. Most organizations should spend more time and attention on testing than on writing the programs in the first place.
2. The system is installed. **Installation** is the process by which the old system is turned off and the new one is turned on. There are several approaches that may be used to convert from the old to the new system. One of the most important aspects of conversion is training, during which users are taught to use the new system and help manage the resulting organizational changes.
3. The analyst team establishes a **support plan** for the system. This plan usually includes a formal or informal postimplementation review, as well as a systematic way for identifying major and minor changes needed for the system.

## Project Identification and Initiation

Where do project ideas come from? A project is identified when someone in the organization identifies a **business need** to build a system. Examples of business needs include supporting a new marketing campaign, reaching out to a new type of customer, or improving interactions with suppliers. Sometimes, needs arise from some kind of “pain” within the organization, such as a drop in market share, poor customer service levels, unacceptable product defect rates, or increased competition. New business initiatives and strategies may be created and a system to support them is required, or a merger or acquisition may require systems to be integrated.

Business needs also can surface when the organization identifies unique and competitive ways of using IT. Many organizations keep an eye on **emerging technology**, which is technology that is in the early stages of widespread business use. For example, if companies stay abreast of technological advances such as cloud computing, Big Data, or machine learning, they can develop business strategies that leverage the capabilities of these technologies and introduce them into the marketplace as a **first mover**. Ideally, companies can take advantage of this first mover position by making money and continuing to innovate while competitors trail behind.

Today, many new IS projects grow out of **business process management (BPM)** initiatives. BPM is a methodology used by organizations to continuously improve end-to-end business processes. BPM can be applied to internal organizational processes and to processes spanning multiple business partners. By studying and improving their underlying business processes, organizations can achieve several important benefits, including

- enhanced process agility, giving the organization the ability to adapt more rapidly and effectively to a changing business environment;
- improved process alignment with industry “best practices”; and
- increased process efficiencies as costs are identified and eliminated from process workflows.

BPM generally follows a continuous cycle of systematically creating, assessing, and altering business processes. Business analysts, with their in-depth business knowledge, play a particularly important role in BPM by

1. defining and mapping the steps in a business process;
2. creating ways to improve on steps in the process that add value;
3. finding ways to eliminate or consolidate steps in the process that do not add value;
4. creating or adjusting electronic workflows to match the improved process maps.

The last step is particularly relevant to our discussion since the need for IS projects is frequently identified here. In fact, the automation of business processes [termed **business process automation (BPA)**] is the foundation of many information technology systems. In these situations, technology components are used to complement or substitute for manual information management processes with the goal of gaining cost efficiencies.

BPM practitioners recognize, however, that it is not always advisable to just “pave the cow paths” by simply adding automation to speed up existing processes (step 4 above). In many situations, **business process improvement (BPI)** results from studying the business processes, creating new, redesigned processes to improve the process workflows, and/or utilizing new technologies enabling new process structures (steps 2, 3, and 4 above). For example, could a retail store’s checkout process be redesigned along the lines of the EZPass toll collection system on highways? Could customers check out and pay with their mobile devices while clerks simply review the contents of the customer’s shopping bag?

Projects with a goal of BPI make moderate changes to the organization's operations and can improve efficiency (i.e., doing things right) and improve effectiveness (i.e., doing the right things). These types of projects involve more risk than business process automation projects since more significant changes are made to the organization's operations.

BPM may also reveal the need for the complete revamping of the organization's business processes, termed **business process reengineering (BPR)**. BPR means changing the fundamental way in which the organization operates—"obliterating" the current way of doing business and making major changes to take advantage of new ideas and new technology. As you might expect, BPR projects involve substantial risk due to the significant organizational and operational changes that result. Top management support and careful management are critical in these fairly rare types of projects.

Both IT people (i.e., the IS experts) and business people (i.e., the subject matter experts) should work closely together to find ways for technology to support business needs. In this way, organizations can leverage the exciting technologies available while ensuring that projects are based upon real business objectives such as increasing sales, improving customer service, and decreasing operating expenses. Ultimately, IS need to affect the organization's bottom line (in a positive way!).

When a strong business need for an IS is recognized, often as a result of BPM, a person (or group) who has an interest in the system's success typically steps forward. We call this person (or group) the *project sponsor*. Often, the project sponsor develops the initial vision of the new system. The project sponsor works throughout the SDLC to make sure that the project is moving in the right direction from the perspective of the business and serves as the primary point of contact for the project team. Usually, the sponsor of the project is from a business function such as marketing, accounting, or finance; however, members of the IT area also can sponsor or cosponsor a project.

The size or scope of the project often determines the kind of sponsor who is involved. A small departmental system might be sponsored by a single manager; however, a large, organizational initiative might be sponsored by the entire senior management team and even the CEO. If a project is primarily technical in nature (e.g., improvements to the existing IT infrastructure or research into the viability of an emerging technology), then sponsorship from IT is appropriate. When projects have great importance to the business, yet are technically complex, joint sponsorship by both the business and IT functions may be necessary.

The business need drives the high-level **business requirements** for the system. Business requirements describe the capabilities the system will provide the organization so that the

### CONCEPTS IN ACTION I-B

### BPI on the Farm

In the farming industry, grain is commonly loaded into large grain-hauling trucks by the driver parking under the grain bin, jumping out of the truck cab, signaling the grain bin operator to start filling, monitoring the fill level, signaling the bin operator to stop filling, jumping back into the truck cab, driving 3 feet forward, and repeating the cycle numerous times until the truck bed is full. This laborious process can be simplified by *digitizing* the process. Cameras and secure Wi-Fi can be installed on the grain bin. When a truck arrives, the driver can open an app on his smartphone from the truck cab. Through the app,

the driver can initiate, monitor, and control the filling process without a grain bin operator and without leaving the truck. This real-world example illustrates BPI, the redesign of a business process with the right application of information technology, providing significant efficiency gains.

Adapted from: Nicole Laskowski, "Crowdsourcing is the new cloud computing—Get with it, CIOs," [searchcio.techtarget.com](http://searchcio.techtarget.com), accessed February 2014.

## YOUR TURN 1-2 || Implementing a Satellite Data Network

A major retail store spent \$24 million dollars on a large, private satellite communication system that provides state-of-the-art voice, data, and video transmission between stores and regional headquarters. When an item gets sold, the scanner software updates the inventory system in real time. As a result, store transactions are passed on to regional and national headquarters instantly, which keeps inventory records up to date. One of the store's major competitors has an older system in which transactions are uploaded at the end of a business day. The first company feels that its method of instant communication and feedback allows it to react more quickly to changes in the market, giving the company a competitive advantage. For example, if an early winter snowstorm causes stores across

the upper Midwest to start selling high-end (and high-profit) snow throwers quite quickly, the company's nearest warehouse can prepare next-day shipments to maintain a good inventory balance, while the competitor may not move quite as quickly and thus lose out on such quick inventory turnover.

### Questions

1. Do you think a \$24 million investment in a private satellite communication system could be justified by a cost–benefit analysis? Could this be done with a standard communication line (with encryption)?
2. How might the competitor attempt to close the “information gap” in this example?

business needs are met. These requirements need to be explained at a high level so that the approval committee and, ultimately, the project team understand what the business expects from the final product. Business requirements summarize the features the IS must include, such as the ability to collect customer orders online or the ability for suppliers to receive inventory status information as sales occur.

The project sponsor has the insights needed to determine the **business value** that will be gained from the system, in both tangible and intangible ways. **Tangible value** can be quantified and measured easily (e.g., 2% reduction in operating costs). **Intangible value** results from an intuitive belief that the system provides important, but hard-to-measure, benefits to the organization (e.g., improved customer service, a better competitive position).

Once the project sponsor identifies a project that meets an important business need and he or she can identify the business requirements and business value of the system, it is time to formally initiate the project. In most organizations, project initiation begins by preparing a *system request*.

## System Request

A *system request* is a document that describes the business reasons for building a system and the value that the system is expected to provide. The project sponsor usually completes this form as part of a formal system project selection process within the organization. Most system requests include five elements: project sponsor, business need, business requirements, business value, and special issues (Figure 1-4). The *sponsor* describes the person who will serve as the primary contact for the project, and the *business need* presents the reasons prompting the project. The *business requirements* of the project refer to the business capabilities that the system must have, and the *business value* describes the benefits that the organization should expect from the system. **Special issues** are included on the document as a catchall category for other information that should be considered in assessing the project. For example, the project may need to be completed by a specific deadline. Any special circumstances that could affect the outcome of the project must be clearly identified.

The completed system request is submitted to the *approval committee* for consideration. This approval committee could be a company steering committee that meets regularly to make IS decisions, a senior executive who has control of organizational resources, or any other decision-making body that governs the use of business resources. The committee reviews the system request

Element	Description	Examples
Project Sponsor	The person who initiates the project and who serves as the primary point of contact for the project on the business side	Several members of the finance department Vice president of marketing CIO CEO
Business Need	The business-related reason(s) for initiating the system	Reach a new market segment Offer a capability to keep up with competitors Improve access to information Decrease product defects Streamline supply acquisition processes
Business Requirements	The new or enhanced business capabilities that the system will provide	Provide online access to information Capture customer demographic information Include product search capabilities Produce performance reports Enhance online user support
Business Value	The benefits that the system will create for the organization	3% increase in sales 1% increase in market share Reduction in headcount by 5 FTEs \$200,000 cost savings from decreased supply costs \$150,000 savings from removal of outdated technology
Special Issues or Constraints	Issues that pertain to the approval committee's decision	Government-mandated deadline for May 30 System needed in time for the Christmas holiday season Top-level security clearance needed by project team to work with data
FTE, full-time equivalent.		

**FIGURE 1-4** Elements of the system request form.

and makes an initial determination, based on the information provided, of whether to investigate the proposed project or not. If approved, the next step is to conduct a feasibility analysis.

## Applying the Concepts at DrōnTeq

Throughout the book, we will apply the concepts in each chapter to a fictitious company called DrōnTeq. In this section, we illustrate the creation of a system request.

### CONCEPTS IN ACTION 1-C

### Interview with Don Hallacy, President, Technology Services, Sprint Corporation

At Sprint, network projects originate from two vantage points—IT and the business units. IT projects usually address infrastructure and support needs. The business-unit projects typically begin after a business need is identified locally, and a business group informally collaborates with IT regarding how a solution can be delivered to meet customer expectations.

Once an idea is developed, a more formal request process begins, and an analysis team is assigned to investigate and validate the opportunity. This team includes members from the user community and IT, and they scope out at a high level what the project will do; create estimates for technology, training, and development costs; and create a business case. This business

case contains the economic value added and the net present value of the project.

Of course, not all projects undergo this rigorous process. The larger projects require more time to be allocated to the analysis team. It is important to remain flexible and not let the process consume the organization. At the beginning of each budgetary year, specific capital expenditures are allocated for operational improvements and maintenance. Moreover, this money is set aside to fund quick projects that deliver immediate value without going through the traditional approval process. *Don Hallacy*

**YOUR TURN 1-3****Too Much Paper, Part 1**

The South Dakota Department of Labor, Workers' Compensation division was sinking under a load of paper files. This state agency ascertains that employees are treated fairly when they are injured on the job. If a person (or company) called to see the status of an injury claim, the clerk would have to take a message, get the paper file, review the status, and call the person back. Files were stored in huge filing cabinets and were entered by year and case number (i.e., the 415th person injured in 2008 would be in a file numbered 08-415). Few callers knew the file number and would give their name and address and the date of injury. The clerk would look in a spiral notebook for the last name around the date that was given—and then find the file number to retrieve the folder. Some folders were small—possibly documenting a minor injury requiring

only a brief treatment period. Other folders could be very large, with numerous medical reports from several doctors verifying the extent of a serious injury and treatment (such as an arm amputation). A digital solution was suggested—reports could be submitted online via a secure website. Medical reports could be submitted electronically, either as a pdf file or as a faxed digital file. This solution would also mean that the clerk taking the phone call could query the database by the person's name and access the information in a matter of seconds.

**Question**

Begin a system request for this project. Focus on stating the business need and the business requirements for this project. What is the value of this system?

DrōnTeq is a fictitious technology company that develops numerous unmanned aerial vehicles, called drones, and drone technology for many purposes. DrōnTeq was established by two technology entrepreneurs, Eric Chen and Peter Lyons. The field of drone technology was evolving rapidly, and Eric and Peter quickly established DrōnTeq as a leading maker of commercial-grade drones with advanced sensors and imaging capabilities.

As a technology company, DrōnTeq invests heavily in research and development of its drone products. It also developed proprietary software capable of providing unique analyses of the data collected by the drone's onboard sensors. The Sales department focuses primarily on drone sales and marketing to government and commercial entities. A new Client Services business unit has been formed within DrōnTeq, focusing on outsourced drone services. Carmella Herrera was named director of the Client Services business unit.

**Project Background**

DrōnTeq is a technology company and utilizes IS in a variety of ways. The new Client Services unit requires specialized IS support, however, to allow clients to request and receive drone services. In the business model of new business unit, licensed drone pilots contract with DrōnTeq to fly a DrōnTeq drone when requested by a client that is near the drone pilot. The drone pilot uses a current model DrōnTeq drone, provided at a favorable lease rate, in return for providing prompt flight service when requested by a client. All client drone flight requests will be processed through DrōnTeq's website. Once a request is received, the request will be posted for all contracted drone pilots to see. Pilots will have a specific window of time in which to submit a bid to conduct the flight. An assignment algorithm will determine the "winning" bid after the bidding window closes and automatically notifies the pilots and the client of the results.

Many aspects of the Client Services business unit will require IS support, but the current focus is on the customer-facing aspects of receiving a client request for service and assigning the request to a contracted drone pilot. A project to create the required support for the new business unit has been proposed by Carmella Herrera.

**System Request**

At DrōnTeq, new IS projects are reviewed and approved by an IS project steering committee that meets quarterly. The committee has representatives from IS as well as from other major areas of

<b>System Request—Client Services Project</b>	
<b>Project Sponsor:</b>	Carmella Herrera, General Manager, Client Services Business Unit
<b>Business Need:</b>	This project has been initiated to create the capability of clients requesting drone flight service and data analysis through the company website. The capability is an essential element in the business model of the newly formed Client Services business unit.
<b>Business Requirements:</b>	Using this system from our company website, clients will be able to request specific drone flight services and data analysis. A request will be offered to any contracted DrōnTeq drone pilots in the vicinity, who can submit bids during the bidding window. Once the bidding window closes, the pilot with the “winning” bid will be assigned the request.
<b>Business Value:</b>	The Client Services business unit has been formed to enable clients who do not have a need for actual drone ownership to receive drone flight service and data analysis promptly and cost effectively. As a new business unit, we must estimate additional revenue from two streams: additional drone pilots who contract with DrōnTeq and lease a drone; and clients who contract for specific drone flight service and data analysis.
Conservative estimates of tangible value to the business unit include:	
<ul style="list-style-type: none"> <li>• \$357,500 in revenue from new pilot contracts and drone leases</li> <li>• \$565,000 in revenue from drone flight service and data analysis</li> </ul>	
<b>Special Issues or Constraints:</b>	The capabilities described in the Business Requirements are essential to the business model for the Client Services Business Unit. This project is necessary for the new business unit’s operations.

**FIGURE 1-5** System request for DrōnTeq.

the business. Carmella’s first step was to prepare a system request for the committee. Figure 1-5 shows the system request she prepared. The project sponsor is Carmella, and the business needs are to enable clients to request drone flight service and data analysis through the company website. Notice that the need does not focus on the technology associated with the project. The emphasis is on the business aspects: providing the means for clients to request drone flight service and data analysis and determining a drone pilot who will perform the service.

In the system request, the project sponsor focuses on describing his or her vision of the business requirements at a high level. Carmella has expressed a clear vision of how this system will affect the new unit at DrōnTeq: producing revenues from new drone pilot contracts and drone leases and enabling sales from clients requesting drone flight service and data analysis. Carmella recognized that this system will be essential in supporting the proposed business model of the new business unit.

The estimates of tangible value were difficult to develop since this venture is completely new to DrōnTeq. To prepare for this, Carmella had several of her staff members conduct surveys of commercial drone operators and several agribusiness interest groups (agricultural uses are a prime target for the Client Services business unit). The surveys also attempted to gauge the drone pilots’ and potential clients’ price sensitivity for these offerings.

From the survey results, Carmella and her staff developed a range of sales projections for the various revenue streams: a high-level estimate, a medium-level estimate, and low-level estimate. They also developed probability assessments for each of these outcomes, settling on a 25% likelihood for the high-level estimate, a 60% likelihood for the medium-level estimate, and a 15% likelihood for the low-level estimate. Based on the sales projections and the probability estimates, a weighted average estimated sales figure was computed for each revenue stream.

For example, for revenue from new pilot contracts and drone leases,

$$\begin{aligned}
 \text{Expected sales} &= (500,000 \times .25) + (350,000 \times .60) + (150,000 \times .15) \\
 &= 125,000 + 210,000 + 22,500 \\
 &= 357,500
 \end{aligned}$$

These projections are summarized in Figure 1-6.

After analyzing the survey results, Carmella and her staff were confident that the sales projections and probability estimates were as accurate as they could make them for this new business venture. The completed system request is shown in Figure 1-5.

	Revenue Projections	
	Pilot Contracts and Drone Leases	Client Requests for Drone Flight Service and Data Analysis
High-level estimate (prob. = 25%)	\$500,000	\$700,000
Medium-level estimate (prob. = 60%)	\$350,000	\$550,000
Low-level estimate (prob. = 15%)	\$150,000	\$400,000
Weighted average expected revenue	\$357,500	\$565,000

**FIGURE 1-6** Revenue projections for DrönTeq Client Services project.

### Steering Committee Approval

Carmella presented the system request for the Client Services project to the DrönTeq IS project steering committee at its next meeting. Response to the request was uniformly positive. The strong support for the project by Eric and Peter, the company's top executives, helped to spur the committee's rapid approval of the project. Following approval of the system request, Jiang Tsiao, a senior systems analyst in the IS department, was assigned to work with Carmella to develop a preliminary feasibility analysis for the project.

## Feasibility Analysis

Once the need for the system and its business requirements have been defined, the approval committee authorizes the systems analyst to prepare a more detailed business case to better understand the proposed IS project. Feasibility analysis guides the organization in determining whether to proceed with the project. Feasibility analysis also identifies the important *risks* associated with the project that must be managed if the project is approved. As with the system request, each organization has its own process and format for the feasibility analysis, but most include techniques to assess three areas: technical feasibility, economic feasibility, and organizational feasibility (Figure 1-7). The results of evaluating these three feasibility factors are combined into a **feasibility study** deliverable that is submitted to the approval committee.

#### Technical Feasibility: Can We Build It?

- Familiarity with application: Less familiarity generates more risk.
- Familiarity with technology: Less familiarity generates more risk.
- Project size: Large projects have more risk.
- Compatibility: The harder it is to integrate the system with the company's existing technology, the higher the risk will be.

#### Economic Feasibility: Should We Build It?

- Development costs
- Annual operating costs
- Annual benefits (cost savings and/or increased revenues)
- Intangible benefits and costs

#### Organizational Feasibility: If We Build It, Will They Come?

- Is the project strategically aligned with the business?
- Project champion(s)
- Senior management
- Users
- Other stakeholders

**FIGURE 1-7** Feasibility analysis assessment factors. A template for this figure is available on the student website.

You might wonder at the omission of the element of time as a risk factor for the project. While the time available for a project can certainly be a concern, we consider time to be a project management issue. We will discuss project management strategies that can be used when time is tight in Chapter 2.

Although we will discuss feasibility analysis now within the context of project initiation, most project teams revise the feasibility study throughout the SDLC and revisit its contents at various checkpoints during the project. If at any point the project's risks and limitations outweigh its benefits, the project team may decide to cancel the project or make substantial revisions.

## Technical Feasibility

The first issue in the feasibility analysis is to assess the **technical feasibility** of the project, the extent to which the system can be successfully designed, developed, and installed by the IT group. Technical feasibility analysis is, in essence, a *technical risk analysis* that strives to answer the question: “*Can we build it?*”<sup>3</sup>

Many risks can endanger the successful completion of the project. First and foremost is the users' and analysts' **familiarity with the application**. When analysts are unfamiliar with the business application area, they have a greater chance of misunderstanding the users or missing opportunities for improvement. The risks increase dramatically when the users themselves have limited knowledge of the application. If the project involves a new business innovation, neither the users nor the analysts may have any direct knowledge or experience of the proposed new application. In general, the development of new systems is riskier than extensions to an existing system, because existing systems tend to be better understood.

**Familiarity with the technology** is another important source of technical risk. When a system uses technology that has not been used before *within the organization*, there is a greater chance that problems and delays will occur because of the need to learn how to use the technology. Risk increases dramatically when the technology itself is new (e.g., a Big Data project using Hadoop). When the technology is not new but the organization lacks experience with it, technical risk is reduced somewhat, since outside expertise should be available from vendors and consultants.

**Project size** is an important consideration, whether measured as the number of people on the development team, the length of time it will take to complete the project, or the number of distinct features in the system. Larger projects present more risk, because they are more complicated to manage and because there is a greater chance that some important system requirements will be overlooked or misunderstood. Large systems are typically highly integrated with other systems, increasing project complexity.

Finally, project teams need to consider the **compatibility** of the new system with the technology that already exists in the organization. Systems are rarely built in a vacuum—they are built in organizations that have numerous systems already in place. New technology and applications need to be able to integrate with the existing environment for many reasons. They may rely on data from existing systems, they may produce data that feed other applications, and they may have to use the company's existing communications infrastructure. A new CRM system, for example, has little value if it does not use customer data found across the organization in existing sales systems, marketing applications, and customer service systems.

The assessment of a project's technical feasibility is not cut and dried, because in many cases, some interpretation of the underlying conditions is needed (e.g., how large does a project need to grow before it is considered “big”?). One approach is to compare the project with prior projects undertaken by the organization. Another option is to consult with experienced IT professionals in the organization or with external IT consultants; often, they will be able to judge whether a project is feasible from a technical perspective.

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<sup>3</sup>We use the words “build it” in the broadest sense. Organizations can also choose to buy a commercial software package and install it, in which case the question might be “Can we select the right package and successfully install it?”

## Economic Feasibility

The second element of a feasibility analysis is to perform an **economic feasibility** analysis (also called a **cost–benefit analysis**). This attempts to answer the question “*Should we build the system?*” Economic feasibility is determined by identifying costs and benefits associated with the system, assigning values to them, calculating future cash flows, and measuring the financial worthiness of the project. As a result of this analysis, the financial opportunities and risks of the project can be understood. Keep in mind that organizations have limited capital resources and multiple projects will be competing for funding. The more expensive the project, the more rigorous and detailed the analysis should be. Before illustrating this process with a detailed example, we first introduce the framework we will apply to evaluate project investments and the common assessment measures that are used.

### Cash Flow Analysis and Measures

IT projects commonly involve an initial investment that produces a stream of benefits over time, along with some ongoing support costs. Therefore, the value of the project must be measured over time. Cash flows, both inflows and outflows, are estimated over some future period. Then, these cash flows are evaluated using several techniques to judge whether the projected benefits justify incurring the costs.

A very basic cash flow projection is shown in Figure 1-8 to demonstrate these evaluation techniques. In this simple example, a system is developed in Year 0 (the current year) costing \$100,000. Once the system is operational, benefits and on-going costs are projected over 3 years. In row 3 of this figure, net benefits are computed by subtracting each year’s total costs from its total benefits. Finally, in row 4, we have computed a cumulative total of the net cash flows.

	<b>Year 0</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Total</b>
Total Benefits		45,000	50,000	57,000	152,000
Total Costs	100,000	10,000	12,000	16,000	138,000
Net Benefits ③ (Total Benefits – Total Costs)	(100,000)	35,000	38,000	41,000	14,000
④ Cumulative Net Cash Flow	(100,000)	(65,000)	(27,000)	14,000	

**FIGURE 1-8** Simple cash flow projection.

Two of the common methods for evaluating a project’s worth can now be determined. Each of these calculations will be explained here:

**Return on Investment** The return on investment (ROI) is a calculation that measures the average rate of return earned on the money invested in the project. ROI is a simple calculation that divides the project’s net benefits (total benefits – total costs) by the total costs. The ROI formula is

$$\text{ROI} = \frac{\text{Total Benefits} - \text{Total Costs}}{\text{Total Costs}}$$

$$\text{ROI} = \frac{152,000 - 138,000}{138,000} = \frac{14,000}{138,000} = 10.14\%$$

A high ROI suggests that the project’s benefits far outweigh the project’s cost, although exactly what constitutes a “high” ROI is unclear. ROI is commonly used in practice; however, it is hard to interpret and should not be used as the only measure of a project’s worth.

**Break-Even Point** Another common approach to measuring a project's worth is the break-even point. The **break-even point** (also called the **payback method**) is defined as the number of years it takes a firm to recover its original investment in the project from net cash flows. As shown in row 4 of Figure 1-8, the project's cumulative cash flow figure becomes positive during Year 3, so the initial investment is "paid back" over 2 years plus some fraction of the third year.

*(In the year in which Cumulative Cash Flow turns positive:)*

$$\text{BEP} = \frac{\text{Number of years of negative cash flow}}{\text{That year's Net Cash Flow}} + \frac{\text{That year's Net Cash Flow} - \text{That year's Cumulative Cash Flow}}{\text{That year's Net Cash Flow}}$$

Using the values in Figure 1-8, the BEP calculation is

$$\text{BEP} = 2 + \frac{41,000 - 14,000}{41,000} = 2 + \frac{28,000}{41,000} = 2.68 \text{ years}$$

The break-even point is intuitively easy to understand and does give an indication of a project's liquidity, or the speed at which the project generates cash returns. Also, projects that produce higher returns early in the project's life are thought to be less risky, since we can anticipate near-term events with more accuracy than long-term events. The break-even point ignores cash flows that occur after the break-even point has been reached; therefore, it is biased against longer-term projects.

**Discounted Cash Flow Technique** The simple cash flow projection shown in Figure 1-8, and the return on investment and break-even point calculations all share the weakness of not recognizing the time value of money. In these analyses, the timing of cash flows is ignored. A dollar in Year 3 of the project is considered to be exactly equivalent to a dollar received in Year 1.

Discounted cash flows are used to compare the present value of all cash inflows and outflows for the project in today's dollar terms. The key to understanding present values is to recognize that if you had a dollar today, you could invest it and receive some rate of return on your investment. Therefore, a dollar received in the future is worth less than a dollar received today, since you forgo that potential return. If you have a friend who owes you \$100 today, but instead gives you that \$100 in 3 years—you've been had! Assuming you could have invested those dollars at a 10% rate of return, you will be receiving the equivalent of \$75 in today's terms.

The basic formula to convert a future cash flow to its present value is

$$PV = \frac{\text{Cash flow amount}}{(1 + \text{Rate of return})^n}, \text{ where } n \text{ is the year in which the cash flow occurs.}$$

The rate of return used in the present value calculation is sometimes called the required rate of return, or the cost of obtaining the capital needed to fund the project. Many organizations will have determined the appropriate rate of return to use when analyzing IT investments. The systems analyst should consult with the organization's finance department.

Using our previous illustration, \$100 received in 3 years with a required rate of return of 10% has a PV of \$75.13.

$$PV = \frac{100}{(1 + 0.1)^3} = \frac{100}{1.331} = 75.13$$

In Figure 1-9, the present value of the projected benefits and costs shown in Figure 1-8 have been calculated using a 10% required rate of return.

	<b>Year 0</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Total</b>
Total Benefits		45,000	50,000	57,000	
PV of Total Benefits		40,909	41,322	42,825	125,056
Total Costs	100,000	10,000	12,000	16,000	
PV of Total Costs	100,000	9,091	9,917	12,021	131,029

**FIGURE 1-9**  
Discounted cash flow projection.

**Net Present Value (NPV)** The NPV is simply the difference between the total present value of the benefits and the total present value of the costs.

$$\begin{aligned} \text{NPV} &= \sum \text{PV of Total Benefits} - \sum \text{PV of Total Costs} \\ &= \$125,056 - \$131,029 = (\$5,973) \end{aligned}$$

As long as the NPV is greater than zero, the project is considered economically acceptable. Unfortunately for this project, the NPV is less than zero, indicating that for a required rate of return of 10%, this project should not be accepted. The required rate of return would have to be something less than 6.65% before this project returns a positive NPV. This example illustrates the fact that sometimes the “naïve” techniques of ROI and BEP find that the project appears acceptable, but the more rigorous and financially correct NPV technique finds the project is unacceptable.

Figure 1-10 reviews the steps involved in performing an economic feasibility analysis. Each step will be illustrated by an example in the upcoming sections.

### Identify Costs and Benefits

The systems analyst's first task when developing an economic feasibility analysis is to identify the kinds of costs and benefits the system will have and list them along the left-hand column of a spreadsheet. Figure 1-11 lists examples of costs and benefits that may be included. The costs and

- |   |   |
|---|---|
| <b>1. Identify Costs and Benefits</b>         | List the tangible costs and benefits for the project. Include both one-time and recurring costs.  |
| <b>2. Assign Values to Costs and Benefits</b> | Work with business users and IT professionals to create numbers for each of the costs and benefits. Even intangibles should be valued if possible.  |
| <b>3. Determine Cash Flow</b>                 | Forecast what the costs and benefits will be over a certain period, usually, 3–5 years. Apply a growth rate to the values, if necessary.  |
| <b>4. Assess Project's Economic Value</b>     | Evaluate the project's expected returns in comparison to its costs. Use one or more of the following evaluation techniques:   |
| • <b>Return on Investment (ROI)</b>           | Calculate the rate of return earned on the money invested in the project, using the ROI formula.  |
| • <b>Break-Even Point (BEP)</b>               | Find the year in which the cumulative project benefits exceed cumulative project costs. Apply the break-even formula, using figures for that year. This calculation measures how long it will take for the system to produce benefits that cover its costs. |
| • <b>Net Present Value (NPV)</b>              | Restate all costs and benefits in today's dollar terms (present value), using an appropriate discount rate. Determine whether the total present value of benefits is greater than or less than the total present value of costs.                            |

**FIGURE 1-10** Steps to conduct an economic feasibility analysis.

<b>Development Costs</b>	<b>Operational Costs</b>
Development team salaries	Software upgrades
Consultant fees	Software licensing fees
Development training	Hardware repair and upgrades
Hardware and software	Cloud storage fees
Vendor installation	Operational team salaries
Office space and equipment	Communications charges
Data conversion costs	User training
<b>Tangible Benefits</b>	<b>Intangible Benefits</b>
Increased sales	Increased market share
Reductions in staff	Increased brand recognition
Reductions in inventory	Higher-quality products
Reductions in IT costs	Improved customer service
Better supplier prices	Better supplier relations

**FIGURE 1-11**  
Example of costs and benefits for economic feasibility.

benefits can be broken down into four categories: (1) development costs, (2) operational costs, (3) tangible benefits, and (4) intangibles. **Development costs** are those tangible expenses that are incurred during the creation of the system, such as salaries for the project team, hardware and software expenses, consultant fees, training, and office space and equipment. Development costs are usually thought of as one-time costs. **Operational costs** are those tangible costs that are required to operate the system, such as the salaries for operations staff, software licensing fees, equipment upgrades, and cloud vendor fees. Operational costs are usually thought of as ongoing costs. As you can see from the list of Operational Costs in Figure 1-11, it is important to include every relevant cost factor over the life of the system, so that we estimate the **Total Cost of Ownership (TCO)**.

**Tangible benefits** include revenue that the system enables the organization to collect, such as increased sales. In addition, the system may enable the organization to avoid certain costs, leading to another type of tangible benefit: cost savings. For example, if the system produces a reduction in needed staff, lower salary costs result. Similarly, a reduction in required inventory levels due to the new system produces lower inventory costs. In these examples, the reduction in costs is a tangible benefit of the new system.

Of course, a project also can affect the organization's bottom line by reaping **intangible benefits** or incurring **intangible costs**. Intangible costs and benefits are more difficult to incorporate into the economic feasibility analysis because they are based on intuition and belief rather than on "hard numbers." Nonetheless, they should be listed in the spreadsheet along with the tangible items.

### Assign Values to Costs and Benefits

Once the types of costs and benefits have been identified, the analyst needs to assign specific dollar values to them. This may seem impossible—How can someone quantify costs and benefits that have not happened yet? And how can those predictions be realistic? Although this task is exceedingly difficult, you must do the best you can to come up with reasonable numbers for all of the costs and benefits. Only then can the approval committee make an informed decision about whether to move ahead with the project.

The most effective strategy for estimating costs and benefits is to rely on the people who have the best understanding of them. For example, costs and benefits that are related to the technology or the project itself can be provided by the company's IT group or external consultants, and business users can develop the numbers associated with the business (e.g., sales projections, order levels). The company also can consider past projects, industry reports, and vendor information, although these sources probably will be a bit less accurate. Likely, all the estimates will be revised as the project proceeds.

If predicting a specific value for a cost or benefit is proving difficult, it may be useful to estimate a range of values for the cost or benefit and then assign a likelihood (probability) estimate to each value. With this information, an *expected value* for the cost or benefit can be calculated. Recall the calculations shown in Figure 1-6 in which the DrönTeq staff developed expected values for projected revenue. As more information is learned during the project, the value estimates and the probability estimates can be revised, resulting in a revised expected value for the cost or benefit.

What about the *intangible* benefits and costs? Sometimes, it is acceptable to list intangible benefits, such as improved customer service, without assigning a dollar value. Other times, estimates have to be made regarding how much an intangible benefit is “worth.” We suggest that you quantify intangible costs or benefits if possible. If you do not, how will you know if they have been realized? Suppose that a system claims to improve customer service. This benefit is intangible but let us assume that the improvement in customer service will decrease the number of customer complaints by 10% each year over 3 years and that \$200,000 is currently spent on phone charges and phone operators who handle complaint calls. Suddenly, we have some very tangible numbers with which to set goals and measure the originally intangible benefit.

A detailed cost–benefit analysis is shown in Figure 1-12. In this example, benefits accrue because the project is expected to increase sales, reduce customer complaint calls, and lower

	2022	2023	2024	2025	2026	Total
<b>Benefits</b>						
Increased sales		500,000	530,000	561,800	595,508	2,187,308
Reduction in customer complaint calls <sup>a</sup>		70,000	70,000	70,000	70,000	280,000
Reduced inventory costs		68,000	68,000	68,000	68,000	272,000
<b>Total Benefits<sup>b</sup></b>	<b>638,000</b>	<b>668,000</b>	<b>699,800</b>	<b>733,508</b>	<b>2,739,308</b>	
<b>Development Costs</b>						
2 servers @ \$125,000	250,000	0	0	0	0	250,000
Printer	100,000	0	0	0	0	100,000
Software licenses	34,825	0	0	0	0	34,825
Server software	10,945	0	0	0	0	10,945
Development labor	1,236,525	0	0	0	0	1,236,525
<b>Total Development Costs</b>	<b>1,632,295</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1,632,295</b>
<b>Operational Costs</b>						
Hardware		50,000	50,000	50,000	50,000	200,000
Software		20,000	20,000	20,000	20,000	80,000
Operational labor		115,000	119,600	124,384	129,359	488,343
<b>Total Operational Costs</b>	<b>185,000</b>	<b>189,600</b>	<b>194,384</b>	<b>199,359</b>	<b>768,343</b>	
<b>Total Costs</b>	<b>1,632,295</b>	<b>185,000</b>	<b>189,600</b>	<b>194,384</b>	<b>199,359</b>	<b>2,400,638</b>
<b>Total Benefits – Total Costs</b>	<b>(1,632,295)</b>	<b>453,000</b>	<b>478,400</b>	<b>505,416</b>	<b>534,149</b>	<b>338,670</b>
<b>Cumulative Net Cash Flow</b>	<b>(1,632,295)</b>	<b>(1,179,295)</b>	<b>(700,895)</b>	<b>(195,479)</b>	<b>338,670</b>	
<b>Return on Investment (ROI)</b>	<b>14.1%</b>	$(338,670 / 2,400,638)$				
<b>Break-Even Point</b>	<b>3.37 years</b>	$(3 \text{ years of negative cumulative cash flow} + [534,149 - 338,670] / 534,149 = 0.37)$				

<sup>a</sup>Customer service values are based on reduced costs of handling customer complaint phone calls.

<sup>b</sup>An important yet intangible benefit will be the ability to offer services that our competitors currently offer.

**FIGURE 1-12** Cost–benefit analysis—simple cash flow method.

inventory costs. For simplicity, all development costs are assumed to occur in the current year 2022, and all benefits and operational costs are assumed to begin when the system is implemented at the start of 2023 and continue through 2026. Notice that the customer service intangible benefit has been quantified, based on a decrease in customer complaint phone calls. The intangible benefit of being able to offer services that competitors currently offer was not quantified, but it was listed so that the approval committee will consider the benefit when assessing the system's economic feasibility.

### Determine Cash Flow

A formal cost-benefit analysis usually contains costs and benefits over a selected number of years (usually, 3–5 years) to show cash flow over time (Figures 1-8 and 1-12). For example, Figure 1-12 lists the same amount for customer complaint calls, inventory costs, hardware, and software for all 4 years. Often, amounts are augmented by some rate of growth to adjust for inflation or business improvements, as shown by the 6% increase that is added to the sales numbers in the sample spreadsheet. Similarly, labor costs are assumed to increase at a 4% rate each year. Finally, totals are added to determine the overall benefits and costs.

### Determine ROI

Figure 1-12 includes the ROI calculation for our example project. This project's ROI is calculated to be 14.1%.

### Determine BEP

Figure 1-12 also includes the BEP calculation for our example project. This project's BEP is calculated to be 3.37 years.

### Determine NPV

In Figure 1-13, the present value of the costs and benefits has been calculated and added to our example spreadsheet, using a 6% rate of return. The NPV is simply the difference between the total present value of the benefits and the total present value of the costs. If the NPV is greater than zero, the project is considered economically viable. In this example, since NPV is \$68,292, the project should be accepted from an economic feasibility perspective.

#### CONCEPTS IN ACTION 1-D

#### Intangible Value at Carlson Hospitality

I conducted a case study at Carlson Hospitality, a global leader in hospitality services, encompassing more than 1,300 hotel, resort, restaurant, and cruise ship operations in 79 countries. One of its brands, Radisson Hotels & Resorts, researched guest stay information and guest satisfaction surveys. The company was able to quantify how much of a guest's lifetime value can be attributed to his or her perception of the stay experience. As a result, Radisson knows how much of the collective future value of the enterprise is at stake, given the perceived quality of the stay experience. Using this model, Radisson can

confidently show that a 10% increase in customer satisfaction among the 10% of highest-quality customers will capture a one-point market share for the brand. Each point in market share for the Radisson brand is worth \$20 million in additional revenue. *Barbara Wixom*

#### Question

How can a project team use this information to help determine the economic feasibility of a system?

	2022	2023	2024	2025	2026	Total
<b>Benefits</b>						
Increased sales		500,000	530,000	561,800	595,508	
Reduction in customer complaint calls <sup>a</sup>		70,000	70,000	70,000	70,000	
Reduced inventory costs		68,000	68,000	68,000	68,000	
<b>Total Benefits<sup>b</sup></b>	<b>638,000</b>	<b>668,000</b>	<b>699,800</b>	<b>733,508</b>		
<b>Present Value Total Benefits</b>	<b>601,887</b>	<b>594,518</b>	<b>587,566</b>	<b>581,007</b>	<b>2,364,978</b>	
<b>Development Costs</b>						
2 Servers @ \$125,000	250,000	0	0	0	0	
Printer	100,000	0	0	0	0	
Software licenses	34,825	0	0	0	0	
Server software	10,945	0	0	0	0	
Development labor	1,236,525	0	0	0	0	
<b>Total Development Costs</b>	<b>1,632,295</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	
<b>Operational Costs</b>						
Hardware	50,000	50,000	50,000	50,000	50,000	
Software	20,000	20,000	20,000	20,000	20,000	
Operational labor	115,000	119,600	124,384	129,359		
<b>Total Operational Costs</b>	<b>185,000</b>	<b>189,600</b>	<b>194,384</b>	<b>199,359</b>		
<b>Total Costs</b>	<b>1,632,295</b>	<b>185,000</b>	<b>189,600</b>	<b>194,384</b>	<b>199,359</b>	
<b>Present Value Total Costs</b>	<b>1,632,295</b>	<b>174,528</b>	<b>168,743</b>	<b>163,209</b>	<b>157,911</b>	<b>2,296,686</b>
<b>NPV (PV Total Benefits – PV Total Costs)</b>						<b>68,292</b>

<sup>a</sup>Customer service values are based on reduced costs of handling customer complaint phone calls.

<sup>b</sup>An important yet intangible benefit will be the ability to offer services that our competitors currently offer.

**FIGURE 1-13** Cost–benefit analysis—discounted cash flow method.

## Organizational Feasibility

The **organizational feasibility** of the system concerns how well the system ultimately will be accepted by its users and incorporated into the ongoing operations of the organization. There are many organizational factors that can have an impact on the project, and seasoned developers know that organizational feasibility can be the most difficult feasibility dimension to assess. In essence, an organizational feasibility analysis attempts to answer the question “If we build it, will they come?”

One way to assess the organizational feasibility of the project is to understand how well the goals of the project align with business objectives. **Strategic alignment** is the fit between the project and business strategy—the greater the alignment, the less risky the project will be, from an organizational feasibility perspective. For example, if the marketing department has decided to become more customer focused, then a CRM project that produces integrated customer information would have strong strategic alignment with marketing’s goal. Many projects fail if the IT department alone initiates them and there is little or no alignment with business-unit or organizational strategies.

A second way to assess organizational feasibility is to conduct a **stakeholder analysis**.<sup>4</sup> A **stakeholder** is a person, group, or organization that can affect (or can be affected by) a new system. In general, the most important stakeholders in the introduction of a new system are the project champion, organizational management, and system users (Figure 1-14), but systems sometimes affect other stakeholders as well. For example, a change to a purchasing system will probably affect the firm's supply chain partners.

The **champion** is a high-level executive and is usually, but not always, the project sponsor who created the system request. The champion supports the project by providing time and resources (e.g., money) and by giving political support to the project by conveying its importance to other decision makers. More than one champion is preferable because if the champion leaves the organization, the support could leave as well.

While champions provide day-to-day support for the system, **organizational management** also needs to support the project. Such management support conveys to the rest of the organization the belief that the system will make a valuable contribution and that necessary resources will be made available. Ideally, the management should encourage people in the organization to use the system and to accept the many changes that the system will likely create.

A third important set of stakeholders is the **system users** who ultimately will use the system once it has been installed in the organization. Too often, the project team meets with users at the beginning of a project and then disappears until after the system is created. In this situation, the final product rarely meets the expectations and needs of those who are supposed to use it, because needs change and users become savvier as the project progresses. User participation should be promoted throughout the development process to make sure that the final system will be accepted and used, by getting users actively involved in the development of the system (e.g., performing tasks, providing feedback, and making decisions).

The third column in Figure 1-14 suggests that actions can be taken that influence organizational feasibility. When the organizational feasibility assessment reveals high risks, the team members should employ actions like these to overcome the organizational feasibility concerns.

	<b>Role</b>	<b>To Enhance Organizational Feasibility</b>
Champion	A champion: <ul style="list-style-type: none"> <li>• Initiates the project</li> <li>• Promotes the project</li> <li>• Allocates his or her time to the project</li> <li>• Provides resources</li> </ul>	<ul style="list-style-type: none"> <li>• Make a presentation about the objectives of the project and the proposed benefits to those executives who will benefit directly from the system.</li> <li>• Create a prototype of the system to demonstrate its potential value.</li> </ul>
Organizational Management	Organizational managers: <ul style="list-style-type: none"> <li>• Know about the project</li> <li>• Budget enough money for the project</li> <li>• Encourage users to accept and use the system</li> </ul>	<ul style="list-style-type: none"> <li>• Make a presentation to the management about the objectives of the project and the proposed benefits.</li> <li>• Market the benefits of the system, using memos and organizational newsletters.</li> <li>• Encourage the champion to talk about the project with his organizational newsletters or her peers.</li> </ul>
System Users	Users: <ul style="list-style-type: none"> <li>• Make decisions that influence the project</li> <li>• Perform hands-on activities for the project</li> <li>• Ultimately determine whether the project is successful using or not using the system</li> </ul>	<ul style="list-style-type: none"> <li>• Assign users official roles on the project team.</li> <li>• Assign users specific tasks to perform, with clear deadlines.</li> <li>• Ask for feedback from users regularly (e.g., at weekly meetings).</li> </ul>

**FIGURE 1-14**  
Important  
stakeholders for  
organizational  
feasibility.

<sup>4</sup>A good book on stakeholder analysis that presents a series of stakeholder analysis techniques is R. O. Mason and I. I. Mitroff, *Challenging Strategic Planning Assumptions: Theory, Cases, and Techniques*, New York: John Wiley & Sons, 1981.

**CONCEPTS IN ACTION 1-E****Return on Investment**

Many companies are undergoing *server virtualization*. This is the concept of putting multiple “virtual” servers onto one physical device. The payoffs can be significant: fewer servers, less electricity, less generated heat, less air conditioning, less infrastructure and administration costs, increased flexibility, less physical presence (i.e., smaller server rooms), faster maintenance of servers, and more. There are costs, of course, such as licensing the virtualization software, labor costs in establishing the virtual servers onto a physical device, labor costs in updating tables, and access. But determining the return on

investment can be a challenge. Some companies have lost money on server virtualization, while most would say that they have gained a positive return on investment but have not really quantified the results.

*Questions*

1. How might a company really determine the return on investment for server virtualization?
2. Is this a project that a systems analyst might be involved in? Why or why not?

**YOUR TURN 1-4****Too Much Paper, Part 2**

Review the description of the South Dakota workers’ compensation project in Your Turn 1-3. There were legal hurdles to implementing a digital solution to handle workers’ compensation claims. One hurdle was that the previous paper method had physical signatures from employees signing off that they had received treatment or that the doctor had signed off on medical treatment performed. How could such permissions be preserved and duplicated digitally?

In addition, some clerks were afraid that the digital solution might not work. What if they could not find an electronic file on the computer? What if a hard drive crashed or the files

were accidentally deleted? What if they could not retrieve the electronic file?

*Questions*

1. What legal issues might arise from having only “digital signatures” or only electronic/paper copies of documents instead of physical documents? How do these issues affect the project’s feasibility?
2. In terms of organizational feasibility and adoption, what might an analyst do to convince these clerks to adopt and use the new technology?

The final feasibility study helps organizations make wiser investments regarding IS because it forces project teams to consider technical, economic, and organizational factors that can affect their projects. It protects IT professionals from criticism by keeping the business units educated about decisions and positioned as the leaders in the decision-making process. Remember—the feasibility study should be revised throughout the project at points where the project team makes critical decisions about the system (e.g., before the design begins). The final feasibility study can be used to support and explain the critical choices that are made throughout the SDLC.

## Applying the Concepts at DrōnTeq

The steering committee met and placed the Client Services project high on its list of projects.

The next step was for Carmella and Jiang to develop the feasibility analysis. Figure 1-15 presents the executive summary page of the feasibility study. The report itself was about 10 pages long and provided additional detail and supporting documentation.

As shown in Figure 1-15, the project is somewhat risky from a technical perspective. DrōnTeq has experience with the technology that will be used, but the proposed application has some unfamiliar elements. User involvement will be important. Project size is moderate, and the system should be very compatible with the existing infrastructure.

### Client Services Project Executive Summary

Carmella Herrera and Jiang Tsao created the following feasibility analysis for the DrönTeq Client Services Project. The System Request is attached, along with the detailed feasibility study. The highlights of the feasibility analysis are as follows:

#### Technical Feasibility

The Client Services project is feasible technically, although there is some risk.

*DrönTeq's risk regarding familiarity with a customer-facing drone service request system is moderate.*

- The Sales Department uses a customer-facing system to allow customers to configure and place orders for commercial drone purchases. This system was developed by the DrönTeq IS department.
- The Client Service business model contains an unfamiliar element—the use of a bidding approach to obtain offers from pilots and determine the winning bid based on multiple factors.
- Business user involvement will be essential.

*DrönTeq's risk regarding familiarity with the technology is low.*

- The IT department has extensive knowledge of the current Web-based customer order system and the databases and Internet technology it uses.
- The technology used in the proposed Client Services Project will be very similar to existing systems.

*The project size is considered moderately low.*

- Project scope has been deliberately limited to the front-end of this overall system: customer request, pilot notification, pilot bidding, and flight assignment.
- The project team will likely consist of five or fewer people.

*The compatibility with DrönTeq's existing technical infrastructure should be good.*

- An Internet infrastructure is already in place at corporate headquarters.
- The system will be based on existing technology infrastructure currently supporting the Sales Department.

#### Economic Feasibility

A cost-benefit analysis was performed; see the attached spreadsheet for details (provided in Appendix 1A). Conservative estimates show that the Client Services project has a good chance of enhancing the company's bottom line.

ROI over 3 years: 43%

NPV over 3 years: \$675,818

Break-even occurs after 1.62 years

#### Intangible Costs and Benefits

Enhanced competitive position through expansion of our drone brand into the drone flight service market. Clients who don't wish to own and operate their own drones will still have a convenient and cost-effective way to receive the benefits provided from our drone flights and data analysis services.

#### Organizational Feasibility

*From an organizational perspective, this project has moderately high risk.*

- *Top management support:* The top executives of the company strongly support the project.
- *Project champion:* Carmella Hererra is a respected and knowledgeable business executive.
- *Organizational management:* Overall, managers throughout DrönTeq support the creation of the new business unit. The Sales department, however, may experience some drone sales loss as some prospective customers choose to purchase drone flight services rather than purchase and operate drones themselves.
- *Customers:* Customers will expect a user interface that is clear and simple to use. Customers will want to enter basic facts one time and have those facts stored securely. This will enable them to request repeat flight services quickly and easily. Customers will expect prompt response and accurate status information on all flight service requests. Without these features, customers may be unwilling to use this service.
- *Pilots:* Pilots will depend on this system to provide notification of potential drone flights, bid on flights, and receive flight assignments; therefore, pilots will demand a system that is quick and easy to use and that embodies a fair and consistent bidding and flight assignment mechanism. Otherwise, pilots will reject the business model of the Client Services business unit and the venture's success is doubtful.

#### Additional Comments

- The top executives view this as a strategic system. This system will allow us to extend our drone services to a new audience. Our marketing research tells us this market is strong and we believe the services will be well accepted.
- To enhance acceptance of the new service, the introduction of the system should coincide with the agricultural growing season since agricultural users are a primary audience.

**FIGURE 1-15** Feasibility analysis executive summary for DrönTeq

The economic feasibility analysis includes the assumptions that Carmella made in the system request. The summary spreadsheet that led to the values in the feasibility analysis has been included in Appendix 1A. Development costs are expected to be about \$558,000. This is a very rough estimate, as Jiang has had to make some assumptions about the amount of time it will take to design and program the system. Nonetheless, the Client Services project appears to be very strong economically.

The organizational feasibility is presented in Figure 1-15. There is a strong champion, well placed in the organization, to support the project. The project originated in the business or functional side of the company, not the IS department, and support for the project among the senior management team is strong.

Additional stakeholders in the project are the managers throughout the organization, customers, and drone pilots. Organizational managers are supportive of the new Client Services business unit. The Sales department may lose some drone sales if prospective drone purchasers choose to use the drone flight services rather than buy and operate a drone themselves. Customer acceptance of the drone flight service product will depend, in part, on the quality, simplicity, and speed of the user interface of the system that enables quick and easy flight requests. Pilot recruitment and retention will require the system to be quick and easy to use and provide a fair and consistent bidding and flight assignment mechanism.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Explain the role of the systems analyst in the process of developing IS.
- Discuss the skills needed to be a successful systems analyst.
- List and explain the four primary phases of the SDLC.
- Explain the ways that projects are identified and initiated.
- Explain why it is important to ensure that a proposed IS will add value to the organization.
- Describe the purpose of the system request and explain the contents of its four main sections.
- Be able to create a system request for a proposed project.
- Discuss the purpose of the feasibility study.
- Describe the issues that are considered when evaluating a project's technical feasibility.
- Be able to develop an economic feasibility assessment for a project.
- Understand and evaluate the organizational feasibility of a project.

## KEY TERMS

Analysis models	Business requirements	Familiarity with the technology	Organizational management	Strategic alignment
Analysis phase	Business value	Feasibility analysis	Payback method	Support plan
Analysis strategy	Champion	Feasibility study	Phases	System proposal
Approval committee	Change management analyst	First mover	Planning phase	System request
Architecture design	Compatibility	Gradual refinement	Program design	System specification
As-is system	Construction	Implementation phase	Project initiation	System users
Break-even point	Cost–benefit analysis	Infrastructure analyst	Project management	Systems analyst
Business analyst	Database and file specifications	Installation	Project manager	Systems development life cycle (SDLC)
Business need	Deliverables	Intangible benefits	Project size	Tangible benefits
Business process automation (BPA)	Design phase	Intangible costs	Project sponsor	Tangible value
Business process improvement (BPI)	Design strategy	Intangible value	Requirements analyst	Technical feasibility
Business process management (BPM)	Development costs	Interface design	Software architect	Technical risk analysis
Business process reengineering (BPR)	Economic feasibility	Net present value (NPV)	Special issues	Technique
	Emerging technology	Operational costs	Stakeholder	To-be system
	Familiarity with the application	Organizational feasibility	Stakeholder analysis	Training
			Steering committee	Total cost of ownership (TCO)
			Step	

## QUESTIONS

1. List and describe the six general skills all project team members should have.
2. What are the major roles on a project team?
3. Compare and contrast the role of a systems analyst, business analyst, and infrastructure analyst.
4. Compare and contrast the role of requirements analyst, change management analyst, and project manager.
5. Describe the major phases in the systems development life cycle (SDLC).
6. Describe the principal steps in the planning phase. What are the major deliverables?
7. Describe the principal steps in the analysis phase. What are the major deliverables?
8. Describe the principal steps in the design phase. What are the major deliverables?
9. Describe the principal steps in the implementation phase. What are the major deliverables?
10. Which phase in the SDLC is the most important?
11. What does *gradual refinement* mean in the context of SDLC?
12. Describe the four steps of BPM. Why do companies adopt BPM as a management strategy?
13. Compare and contrast BPA, BPI, and BPR. Which is most risky? Which has the greatest potential value?
14. Give three examples of business needs for a system.
15. Describe the roles of the project sponsor and the approval committee.
16. What is the purpose of an approval committee? Who is usually on this committee?
17. Why should the system request be created by a businessperson as opposed to an IS professional?
18. What is the difference between intangible value and tangible value? Give three examples of each.
19. What are the purposes of the system request and the feasibility analysis? How are they used in the project selection process?
20. Describe two special issues that may be important to list on a system request.
21. Describe the three dimensions of feasibility analysis.
22. What factors are used to determine project size?
23. Describe a “risky” project in terms of technical feasibility. Describe a project that would *not* be considered risky.
24. What are the steps for assessing economic feasibility? Describe each step.
25. List two intangible benefits. Describe how these benefits can be quantified.
26. List two tangible benefits and two operational costs for a system. How would you determine the values that should be assigned to each item?
27. Explain how an expected value can be calculated for a cost or benefit. When would this be done?
28. Explain the net present value and return on investment for a cost–benefit analysis. Why would these calculations be used?
29. What is the break-even point for the project? How is it calculated?
30. What is stakeholder analysis? Discuss three stakeholders that would be relevant for most projects.

## EXERCISES

- A. Go to [www.bls.gov](http://www.bls.gov) and perform a search for “systems analyst.” What is the employment outlook for this career? Compare and contrast the skills listed with the skills that were presented in this chapter.
- B. Think about your ideal analyst position. Write a job posting to hire someone for that position. What requirements would the job have? What skills and experience would be required? How would applicants demonstrate that they have the appropriate skills and experience?
- C. Locate a news article in an IT trade website (e.g., Computerworld.com, InformationWeek.com) about an organization that is implementing a new computer system. Describe the tangible and intangible values that the organization seeks from the new system.
- D. Car dealers have realized how profitable it can be to sell automobiles by using the Web. Pretend that you work for a local car dealership that is part of a large chain such as CarMax. Create a system request that you might use to develop a Web-based sales system. Remember to list special issues that are relevant to the project.
- E. Think about your own university or college and choose an idea that could improve student satisfaction with the course enrollment process. Currently, can students enroll for classes from anywhere? How long does it take? Are directions simple to follow? Is online help available? Next, think about how technology can help support your idea. Would you need completely new technology? Can the current system be changed?

- F. For exercise E, create a system request that you could give to the administration that explains the sponsor, business need, business requirements, and potential value of the project. Include any constraints or issues that should be considered.
- G. Think about the idea that you developed in Exercise E to improve your university or college course enrollment process. List three things that influence the technical feasibility of the system, the economic feasibility of the system, and the organizational feasibility of the system. How can you learn more about the issues that affect the three kinds of feasibility?
- H. Amazon.com was successful when it decided to extend its offerings beyond books to many other products. Amazon.

com was unable to compete successfully with eBay.com's auction site, however, and eventually abandoned its own auction site. What feasibility factors probably had the most significance in this failure? Explain.

- I. Interview someone who works in a large organization and ask him or her to describe the approval process that exists for proposed new development projects. What do they think about the process? What are the problems? What are the benefits?
- J. Reread the "Your Turn 1-2" (Implementing a Satellite Data Network). Create a list of the stakeholders that should be considered in a stakeholder analysis of this project.

## MINICASES

1. Megan Simpson, manager of western regional sales at the Whitefield Company, requested that the IS department develop a sales force communication and tracking system that would enable her to better keep up with her sales staff. Megan wanted to be able to post messages to her team on many topics, including sales tips and strategies, update them on the firm's products, and point out changes in the competitive environment. She also wanted her team to be able to post responses to her posts plus their own ideas, update their schedules, and share their sales success stories.

Unfortunately, due to the massive backlog of work facing the Whitefield Company's IS department, her request was given a low priority. After 6 months of inaction by the IS department, Megan decided to take matters into her own hands. Following the advice of friends, Megan set up a Word Press site to use as a sales force communication and tracking system.

Although it took longer than expected, Megan's site has been "completed" for about 6 weeks. It still has many features that do not work very well, and some functions lead to dead ends. Members of the sales force initially were quite interested in the system. They quickly discovered, however, that the system was confusing and did not seem to provide many benefits, so their interest quickly waned. Megan's assistant is so mistrustful of the scheduling information posted on the site that she has secretly gone back to using her old paper-based system of tracking the sales staff's activities, since it is much more reliable.

Over dinner one evening, Megan complained to a systems analyst friend, "I don't know what went wrong with this project. It seemed pretty simple to me. The IS guys gave me some suggestions for how I should approach this project, but it seemed like such an elaborate set of steps and tasks. I didn't think all that really applied to this small system. I just thought I'd set up the basics for the system and then tweak it around until I got what I wanted without all the fuss and bother of the

approach the IS guys were pushing. I mean, doesn't that just apply to their big, expensive system projects?"

To understand where Megan went wrong, apply what you know about the SDLC to answer the following questions:

A. Planning:

- i. What is the purpose of the Planning Phase for a project such as this?
- ii. What are the typical outcomes of the Planning Phase?
- iii. How did not doing this step affect Megan's project outcome?

B. Analysis:

- i. What is the purpose of the Analysis Phase?
- ii. What is the key outcome produced during the Analysis Phase?
- iii. In what ways do you think this project was hurt by not going through a typical Analysis Phase?

C. Design:

- i. What is the purpose of the Design Phase?
- ii. How do you think this project could have been improved by going through a typical Design Phase?
- iii. Do you think Megan's assistant and sales force members could have helped at all during the design phase? If so, how?

D. Implementation:

- i. What type of work is done in the Implementation Phase for a project like this?
- ii. What is usually done during the Implementation Phase to ensure that the users of the system are satisfied with it?
- iii. Megan's approach to "construction" was to throw something together and "tweak it around." How do you think that approach contributed to the problems she is now experiencing with her project?

*Note: If using the flipped classroom model, students should study the SDLC material before class. Divide the class into four teams, assign each team one of the SDLC phases, and have each team present the question's answers to the rest of the class.*

2. The Amberssen Specialty Company is a chain of 12 retail stores that sell a variety of imported gift items, gourmet chocolates, cheeses, and wines in the Toronto area. Amberssen has an IS staff of three people who have created a simple, but effective, IS of networked point-of-sale registers at the stores, and a centralized accounting system at the company headquarters. Harry Hilman, the head of Amberssen's IS group, has just received the following memo from Bill Amberssen, Sales Director (and son of Amberssen's founder):

*Harry—It's time Amberssen Specialty launched itself on the Internet. Many of our competitors are already there, selling to customers without the expense of a retail storefront, and we should be there too. I project that we could double or triple our annual revenues by selling our products on the Internet. I'd like to have this ready by Thanksgiving, in time for the prime holiday gift-shopping season. Bill*

After pondering this memo for several days, Harry scheduled a meeting with Bill so that he could clarify Bill's vision of this venture. Using the standard content of a system request as your guide, prepare a list of questions that Harry needs to have answered about this project.

*Note: If using the flipped classroom model, students should study the System Request material before class. Divide the class into small groups. Each group should prepare a list of key questions. Then, compile a comprehensive list from all groups and have the class rank the questions in order of importance.*

3. The Decker Company maintains a fleet of 10 service trucks and crew which provides a variety of plumbing, heating, and cooling repair services to residential customers. Currently, it takes on average about 6 hours before a service team responds to a service request. Each truck and crew averages 12 service calls per week, and the average revenue earned per service call is \$150. Each truck is in service 50 weeks per year. Due to the difficulty in scheduling and routing, there is considerable slack time for each truck and crew during a typical week.

Decker management is evaluating the purchase of a pre-written routing and scheduling software package. The benefits of the system will include reduced response time to service requests and more productive service teams, but management is having trouble quantifying these benefits.

One approach is to make an estimate of how much service response time will decrease with the new system, which

then can be used to project the increase in the number of service calls made each week. For example, if the system permits the average service response time to fall to 4 hours, the management believes that each truck will be able to make 16 service calls per week on average—an increase of 4 calls per week. With each truck making 4 additional calls per week and the average revenue per call at \$150, the revenue increase per truck per week is  $\$600(4 \times \$150)$ . With 10 trucks in service 50 weeks per year, the average annual revenue increase will be  $\$300,000(\$600 \times 10 \times 50)$ .

The Decker Company management is unsure whether the new system will enable response time to fall to 4 hours on average or will be some other number. Therefore, management has developed the following range of outcomes that may be possible outcomes of the new system, along with probability estimates of each outcome occurring:

New Response Time	# Calls/Truck/Week	Likelihood
2 hours	20	20%
3 hours	18	30%
4 hours	16	50%

Given these figures, prepare a spreadsheet model that computes the expected value of the annual revenues to be produced by this new system.

Martin is working to develop a preliminary cost-benefit analysis for a new client-server system. He has identified several cost factors and values for the new system, summarized in the following tables:

#### Development Costs—Personnel

2 Systems Analysts	400 hours/ea @ \$50/hour
4 Programmer Analysts	250 hours/ea @ \$35/hour
1 GUI Designer	200 hours/ea @ \$40/hour
1 Telecommunications Specialist	50 hours/ea @ \$50/hour
1 System Architect	100 hours/ea @ \$50/hour
1 Database Specialist	15 hours/ea @ \$45/hour
1 System Librarian	250 hours/ea @ \$15/hour

#### Development Costs—Training

4 Oracle training registration	\$3,500/student
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#### Development Costs—New Hardware and Software

1 Development server	\$18,700
1 Server software (OS, misc.)	\$1,500
1 DBMS server software	\$7,500
7 DBMS client software	\$950/client

<b>Annual Operating Costs—Personnel</b>	
2 Programmer Analysts	125 hours/ea @ \$35/hour
1 System Librarian	20 hours/ea @ \$15/hour
<b>Annual Operating Costs—Hardware, Software, and Misc.</b>	
1 Maintenance agreement for server	\$995
1 Maintenance agreement for server	\$525
DBMS software	
Preprinted forms	15,000/year @ \$.22/form

The benefits of the new system are expected to come from two sources: increased sales and lower inventory levels. Sales are expected to increase by \$30,000 in the first year of the system's operation and will grow at a rate of 10% each year thereafter. Savings from lower inventory levels are expected to be \$15,000 per year for each year of the project's life.

Using a format like the spreadsheets in this chapter, develop a spreadsheet that summarizes this project's cash flow, assuming a 4-year useful life after the project is developed. Compute the present value of the cash flows, using an interest rate of 9%.

What is the NPV for this project? What is the ROI for this project? What is the break-even point? Should this project be accepted by the approval committee?

## APPENDIX 1A DETAILED ECONOMIC FEASIBILITY ANALYSIS FOR DRŌNTEQ

Figure 1A-1 contains the summary spreadsheet for the DrōnTeq Client Services project. As shown, Carmella's initial sales projections are used for the first year's revenues. Revenues are projected to grow 10% in the second year and 8% in the third year.

Cost projections are based on Jiang's assumptions about the time it will take to develop the system and the resources that will be required. Operating costs have a considerable new labor component because a new business unit is being created, requiring additional staff.<sup>5</sup>

Figure 1A-1 incorporates several of the financial analysis techniques we have discussed. The rows marked A and C summarize the annual benefits and costs, respectively. The row marked D shows the yearly net benefits (total benefits – total costs). The ROI calculation shows that this project is expected to return 43% on the investment, calculated by dividing the difference between total benefits in row A and total costs in row C by the total costs in row C.

Row E shows the cumulative cash flow for the project, and this is used to determine the breakeven point. As seen in Figure 1A-1, the project fully recovers its costs in the second year, since the cumulative net cash flow becomes positive in the second year. It takes about 0.27 of the second year before the costs are recovered.

The row marked B computes the present value of each year's total benefits, and the row marked F computes the present value of each year's total costs. A 9% required rate of return was used in these calculations. These values are used in the NPV calculation. The total present value of costs is subtracted from the total present value of benefits, and the result is \$675,818, indicating the strong financial viability of this investment.

This spreadsheet shows that this project can add significant business value even if the underlying assumptions prove to be overly optimistic.

<sup>5</sup>Some of the salary information may seem high to you. Keep in mind that most companies use a "full cost" model for estimating salary cost in which all benefits (e.g., health insurance, retirement, payroll taxes) are included in salaries when estimating costs.

	2022	2023	2024	2025	Total
<b>Benefits</b>					
Revenue from new pilot contracts and drone leases	357,500	393,250	424,710	1,175,460	
Sales from drone flight service and data analysis	565,000	621,500	671,220	1,857,720	
④ Total Benefits	<b>922,500</b>	<b>1,014,750</b>	<b>1,095,930</b>	<b>3,033,180</b>	
⑤ Present Value Total Benefits	<b>846,330</b>	<b>854,095</b>	<b>846,259</b>	<b>2,546,684</b>	
<b>Development Costs</b>					
Labor - Analysis and Design	300,000				300,000
Labor - Implementation	175,000				175,000
Office space and equipment	8,000				8,000
Software	25,000				25,000
Hardware	50,000				50,000
<b>Total Development Costs</b>	<b>558,000</b>				<b>558,000</b>
<b>Operational Costs</b>					
Labor - Webmaster	85,000	89,250	93,713	267,963	
Labor - Network technician	60,000	63,000	66,150	189,150	
Labor - Computer operations	50,000	52,500	55,125	157,625	
Labor - Business manager	60,000	63,000	66,150	189,150	
Labor - Assistant manager	45,000	47,250	49,613	141,863	
Labor - IS maintenance developers (3)	120,000	126,000	132,300	378,300	
Software upgrades	5,000	5,000	5,000	15,000	
Software licenses	8,000	8,000	8,000	24,000	
Hardware upgrades	10,000	10,000	10,000	30,000	
User training and support	8,000	8,400	8,820	25,220	
Additional ISP charges	15,000	15,750	16,538	47,288	
Marketing expenses	30,000	31,500	33,075	94,575	
<b>Total Operational Costs</b>		<b>496,000</b>	<b>519,650</b>	<b>544,483</b>	<b>1,560,133</b>
⑥ Total Costs	<b>558,000</b>	<b>496,000</b>	<b>519,650</b>	<b>544,483</b>	<b>2,118,133</b>
⑦ Total Benefits – Total Costs	<b>-558,000</b>	<b>350,330</b>	<b>334,445</b>	<b>301,777</b>	<b>428,552</b>
⑧ Cumulative New Cash Flow	<b>-558,000</b>	<b>-207,670</b>	<b>126,775</b>	<b>428,552</b>	
⑨ Present Value Total Costs	<b>558,000</b>	<b>455,046</b>	<b>437,379</b>	<b>420,440</b>	<b>1,870,865</b>
Return on Investment (ROI)	143%	(3,033,180 / 2,118,133)			
Break-Even Point	1.62 years	(Costs are fully recovered in the second year; [334,445 – 126,775] / 334,445)			
NPV (PV Total Benefits – PV Total Costs)	<b>675,819</b>				
Intangible Costs and Benefits	Intangible Cost: Effective drone flight service option may reduce the demand for actual drone sales Intangible Benefit: Enhanced competitive position through expansion of our drone brand into the drone flight service market				

FIGURE 1A-1 Economic feasibility analysis for DrōnTeq.

# Project Selection and Management

# 2

## PLANNING

### TASK CHECKLIST

- Identify project.
- Develop systems request.
- Analyze technical feasibility.
- Analyze economic feasibility.
- Analyze organizational feasibility.
- Perform project selection review.
- Manage scope.
- Staff project.
- Create project charter.
- Set up CASE repository.
- Develop standards.
- Begin documentation.
- Assess and manage risk.

This chapter discusses how organizations evaluate and select projects to undertake from the many available projects. Once a project has been selected, the project manager plans the project. Project management involves many tasks. Here, we focus on selecting a project methodology, identifying project staffing requirements, and preparing to manage and control the project. These steps produce important project management deliverables, including the staffing plan, standards list, project charter, and risk assessment.

## OBJECTIVES

- Explain how projects are selected in some organizations.
- Describe various approaches to the systems development life cycle (SDLC) that can be used to structure a development project.
- Explain how to select a project methodology based on project characteristics.
- Describe project staffing issues and concerns.
- Describe and apply techniques to coordinate and manage the project.
- Explain how to manage risk on the project.

## Introduction

Most IT departments face a demand for IT projects that far exceeds the department's ability to supply them. In the past 10 years, business application growth has exploded, and **chief information officers (CIOs)** are challenged to select projects that will provide the highest possible return on IT investments while managing project risk. In a recent analysis, AMR Research, Inc., found that 2–15% of projects taken on by IT departments are not strategic to the business.<sup>1</sup> In today's globally competitive business environment, the corporate IT department needs to carefully prioritize, select, and manage its portfolio of development projects.

Historically, IT departments have tended to select projects by ad hoc methods: first-in, first-out; political clout; or the squeaky wheel getting the grease. In recent years, IT departments have collected project information and mapped the projects' contributions to business goals, using a project portfolio perspective.<sup>2</sup>

**Project portfolio management**, a process of selecting, prioritizing, and monitoring project results, has become a critical success factor for IT departments facing too many potential projects with too few resources.<sup>3</sup> Software for project portfolio management, such as Hewlett Packard's *Project and Portfolio Management*, Primavera Systems' *ProSight*, and open-source *Project.net*, has become a valuable tool for IT organizations.

Once selected, a systems development project undergoes a thorough process of **project management**, the process of planning and controlling the project within a specified time frame, at minimum cost, with the desired outcomes.<sup>4</sup> A **project manager** has the primary responsibility for managing the hundreds of tasks and roles that need to be carefully coordinated. Project management has evolved into an actual profession with many training options and professional certification (e.g., project management professional [PMP]) available through the Project Management Institute ([www.pmi.org](http://www.pmi.org)). Dozens of software products are available to support project management activities.

Although training and software are available to help project managers, unreasonable demands set by project sponsors and business managers can make project management exceedingly difficult. Too often, the approach of the holiday season, the chance at winning a proposal with a low bid, or a funding opportunity pressures project managers to promise systems long before they are

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<sup>1</sup> Tucci, Linda, "PPM Strategy a CIO's Must-Have in Hard Times," *SearchCIO.com*, March 5, 2008.

<sup>2</sup> Ibid.

<sup>3</sup> Tucci, Linda, "Project Portfolio Management Takes Flight at Sabre," *SearchCIO.com*, November 28, 2007.

<sup>4</sup> A good book on project management is by Robert K. Wysocki, *Effective Project Management: Traditional, Adaptive, Extreme*, 7th Ed., New York: John Wiley & Sons, 2013. Also, the Project Management Institute ([www.pmi.org](http://www.pmi.org)) and the Information Systems Special Interest Group of the Project Management Institute ([www.pmi-issig.org](http://www.pmi-issig.org)) have valuable resources on project management in information systems.

**CONCEPTS IN ACTION 2-A****Project Portfolio Management: An Essential Tool for IT Departments**

Information systems are at the core of Sabre Holdings Corporation. The Sabre reservation system is the booking system of choice for travel agencies worldwide. Sabre is also the parent company of Travelocity.com, the second largest online travel agency in the United States.

Like many companies, Sabre's IT department struggles with many more project requests than it has resources to accomplish—as many as 1,500 proposals for 600 funded projects annually. Because of the volatile, competitive nature of the travel industry, Sabre is especially challenged to be certain that IT is doing the right projects under constantly changing conditions. While traditional project management techniques focus on getting individual projects done, Sabre needs to be able to rapidly change the entire set of projects it is working on as market conditions shift.

Project portfolio management software collects and manages information about all projects—those that are underway

and those that are awaiting approval. The software helps prioritize projects, allocate employees, monitor projects in real time, flag cost and time variances, measure the ROI, and help the IT department objectively measure the efficiency and efficacy of IT investments.

Primavera Systems' PPM software has enabled Sabre Holdings to update its queue of projects regularly, and projects are now prioritized quarterly instead of annually. A study of users of Hewlett Packard's PPM Center software found that in all cases, the investment in the software paid for itself in a year. Other findings were an average 30% increase in on-time projects, a 12% reduction in budget variance, and a 30% reduction in the amount of time IT spent on project reporting.

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Sources: Tucci, Linda, "Project portfolio management takes flight at Sabre," SearchCIO.com, November 28, 2007.  
Tucci, Linda, "PPM strategy a CIO's must-have in hard times," SearchCIO.com, March 5, 2008.

realistically able to deliver them. These overly optimistic timetables are thought to be one of the biggest problems that projects face; instead of pushing a project forward faster, they result in delays.

Thus, a critical success factor for project management is to start with a realistic assessment of the work that needs to be accomplished and then manage the project according to the plan. This can be accomplished by carefully following the basic steps of project management. This textbook does not focus on the details of project management. If you are interested in that topic, we encourage you to seek out a project management course.

We focus instead on project management issues that matter to a systems analyst. First, the system development methodology that fits the characteristics of the project is selected. Staffing needs are determined, and the project coordination methods are established. Finally, the project risks are monitored and managed as the project proceeds.

## Project Selection

Many IT organizations tackle several important initiatives simultaneously. For example, new software applications may be under development; new business models may be under consideration; organizational structures may be revised; new technical infrastructures may be evaluated. Collectively, these endeavors are managed as a *program* by the IT steering committee. The steering committee must provide oversight and governance to the entire set of projects that are undertaken by the IT organization. The individual projects that are accepted by the steering committee are temporary endeavors undertaken to create a unique product or service.

Investments in information systems projects today are evaluated in the context of an entire portfolio of projects. Decision makers look beyond project cost and consider a project's anticipated risks and returns in relation to other projects. Companies prioritize their business strategies and then assemble and assess project portfolios based on how they meet those strategic needs.

The focus on a project's contribution to an entire portfolio of projects reinforces the need for the feasibility study as described in Chapter 1. The approval committee has the responsibility

to evaluate not only the project's costs and expected benefits, but also the technical and organizational risks associated with the project. The feasibility analysis is submitted back to the approval committee, along with an updated system request. Using this information, the approval committee can examine the business need (found in the system request) and the project risks (described in the feasibility analysis).

Portfolio management takes into consideration the different kinds of projects that exist in an organization—large and small, high risk and low risk, strategic and tactical. (See Figure 2-1 for different ways of classifying projects.) A good project portfolio will have the most appropriate mix of projects for the organization's needs. The committee acts as a portfolio manager, with the goal of maximizing benefits versus costs and balancing other important factors of the portfolio. For example, an organization may want to keep high-risk projects to a level less than 20% of its total project portfolio.

The approval committee must be selective about where to allocate resources because the organization has limited funds. This involves *trade-offs* in which the organization must give up something in return for something else to keep its portfolio well balanced. If there are three potentially high-payoff projects, yet all have extremely high risk, then maybe only one of the projects will be selected. Also, there are times when a system at the project level makes good business sense, but it does not at the organization level. Thus, a project may show a strong economic feasibility and support important business needs for a part of the company; however, it is not selected. This could happen for many reasons—because there is no money in the budget for another system, the organization is about to go through change (e.g., a merger or the implementation of a company-wide system such as ERP), projects that meet the same business requirements already are underway, or the system does not align well with current or future corporate strategy.

## Applying the Concepts at DrōnTeq

The IS project steering committee met and reviewed the Client Services project along with two other projects—one that called for a new supply-chain portal and another that involved the enhancement of DrōnTeq's data warehouse. Unfortunately, the budget would allow for only one project to be approved, so the committee carefully examined the costs, expected benefits, risks, and strategic alignment of all three projects. Currently, top executives are anxious to bring the client service capability to market to expand drone and data analysis usage to new customers and to provide more value to existing and potential drone pilots. The Client Services project is an essential element of that goal. Therefore, the committee decided to immediately initiate the Client Services project.

<b>Size</b>	What is the size? How many people are needed to work on the project?
<b>Cost</b>	How much will the project cost the organization?
<b>Purpose</b>	What is the purpose of the project? Is it meant to improve the technical infrastructure? Support a current business strategy? Improve operations? Demonstrate a new innovation?
<b>Length</b>	How long will the project take before completion? How much time will go by before value is delivered to the business?
<b>Risk</b>	How likely is it that the project will succeed or fail?
<b>Scope</b>	How much of the organization is affected by the system? A department? A division? The entire corporation?
<b>Economic Value</b>	How much money does the organization expect to receive in return for the amount the project costs?

FIGURE 2-1 Ways to classify projects.

**YOUR TURN 2-1** || To Select or Not to Select

It seems hard to believe that an approval committee would not select a project that meets real business needs, has a high potential ROI, and has a positive feasibility analysis. Think of

a company that you have worked for or know about. Describe a scenario in which a project may be very attractive at the project level, but not at the organization level.

**CONCEPTS IN ACTION 2-B**

## || Interview with Lyn McDermid, CIO, Dominion Virginia Power

A CIO needs to have a global view when identifying and selecting projects for her organization. I would get lost in the trees if I were to manage on a project-by-project basis. Given this, I categorize my projects according to my three roles as a CIO, and the mix of my project portfolio changes depending on the current business environment.

My primary role is to **keep the business running**. That means every day when each person comes to work, they can perform his or her job efficiently. I measure this using various service levels, cost, and productivity measures. Projects that keep the business running could have a high priority if the business were in the middle of a merger, or a low priority if things were running smoothly, and it were “business as usual.”

My second role is to push **innovation that creates value for the business**. I manage this by looking at our lines of business and asking which lines of business create the most value for the company. These are the areas for which I should be providing the most value. For example, if we had a highly innovative marketing strategy, I would push for innovation there. If operations were running smoothly, I would push less for innovation in that area.

My third role is strategic, to look beyond today and find **new opportunities** for both IT and the business of providing energy. This may include investigating process systems, such as automated meter reading or looking into the possibilities of wireless technologies.

*Lyn McDermid*

**CONCEPTS IN ACTION 2-C**

## || Interview with Carl Wilson, CIO, Marriott Corporation

At Marriott, we do not have IT projects—we have business initiatives and strategies that are enabled by IT. As a result, the only time a traditional “IT project” occurs is when we have an infrastructure upgrade that will lower costs or leverage better functioning technology. In this case, IT has to make a business case for the upgrade and prove its value to the company.

The way IT is involved in business projects in the organization is twofold. First, senior IT positions are filled by people with good business understanding. Second, these people are placed on key business committees and forums where the real business happens, such as finding ways to satisfy guests. Because IT has a seat at the table, we are able to spot opportunities to support business strategy. We look for ways in which IT can enable or better support business initiatives as they arise.

Therefore, business projects are proposed, and IT is one component of them. These projects are then evaluated the same as any other business proposal, such as a new resort—by examining the return on investment and other financial measures.

At the organizational level, I think of projects as must-do’s, should-do’s, and nice-to-do’s. The “must-do’s” are required to achieve core business strategy, such as guest preference. The “should-do’s” help grow the business and enhance the functionality of the enterprise. These can be somewhat untested, but good drivers of growth. The “nice-to-do’s” are more experimental and look further out into the future.

The organization’s project portfolio should have a mix of all three kinds of projects, with a much greater proportion devoted to the “must-do’s.”

*Carl Wilson*

## Creating the Project Plan

Projects are launched after being selected by the approval committee. The project manager then follows a set of project management guidelines, sometimes referred to as the project management life cycle, as he or she organizes, guides, and directs the project from inception to completion. The project management phases consist of initiation, planning, execution, control, and closure.

The project manager must make myriad decisions regarding the project, including determining the best project methodology, determining a staffing plan, and establishing mechanisms to coordinate and control the project. Here, we discuss these issues from the perspective of systems analysts who will be part of the project.

## Project Methodology Options

As we discussed in Chapter 1, the SDLC provides the foundation for the processes used to develop an information system. A **methodology** is a formalized approach to implementing the SDLC (i.e., it is a list of tasks, steps, and deliverables). There are many different systems development methodologies, and they vary in terms of the progression that is followed through the phases of the SDLC. Many organizations have their own in-house developed methodologies that explain exactly how each phase of the SDLC is to be performed in that company. In other cases, methodologies are obtained from consulting firms for their clients to follow; provided by the vendor of the software to be installed; or mandated as a part of projects involving government agencies. Before reviewing several of the predominant methodologies that have evolved over time, we provide a list of project characteristics that will affect the methodology selection decision.

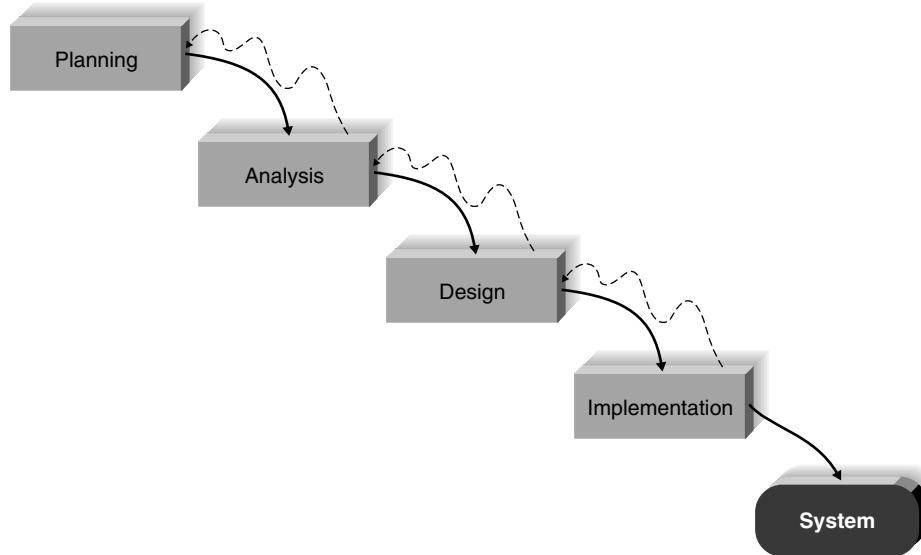
- **Clarity of User Requirements** How well do the users and analysts understand the functions and capabilities needed from the new system?
- **Familiarity with Technology** How much experience does the project team have with the technology that will be used?
- **System Complexity** How much complexity is anticipated in the new system? Does the new system include a wide array of features? Will the system have to integrate with many existing systems? Does it span multiple organizational units, or even multiple organizations?
- **System Reliability** Will this system need to be highly reliable or is some downtime tolerable?
- **Short Time Schedules** Is the project time frame tight?
- **Schedule Visibility** Are the project sponsors, users, or organizational managers anxious to see progress?

Keep these factors in mind as you study the methodologies described here.

### Waterfall Development

With **waterfall development** methodologies, the project team proceeds sequentially from one phase to the next (Figure 2-2). The key deliverables for each phase are typically voluminous (often, hundreds of pages) and are presented to the approval committee and project sponsor for approval as the project moves from phase to phase. Once the work produced in one phase is approved, the phase ends and the next phase begins. As the project progresses from phase to phase, it moves forward in the same manner as a waterfall. While it is possible to go backward through the phases (e.g., from design back to analysis), it is quite difficult. (Imagine yourself as a salmon trying to swim upstream in a waterfall.)

Waterfall development methodologies have several advantages: requirements are identified long before programming begins, and requirement changes are limited as the project progresses. The key disadvantages are that the design must be completely specified before programming begins, significant time elapses between the completion of the system proposal in the analysis phase and the delivery of system, and testing may be treated almost as an afterthought in the implementation phase. In addition, the deliverables are often a poor communication mechanism, so important requirements may be overlooked in the volumes of documentation. If the project



**FIGURE 2-2** Waterfall development.

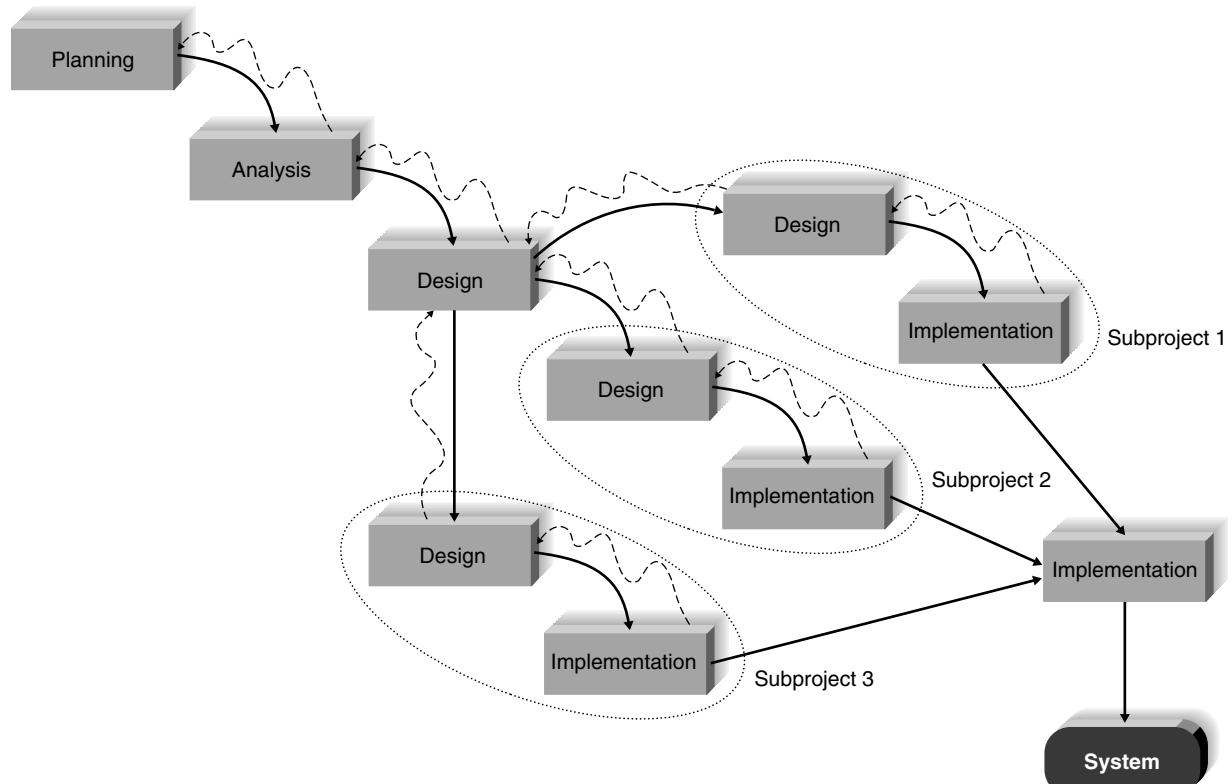
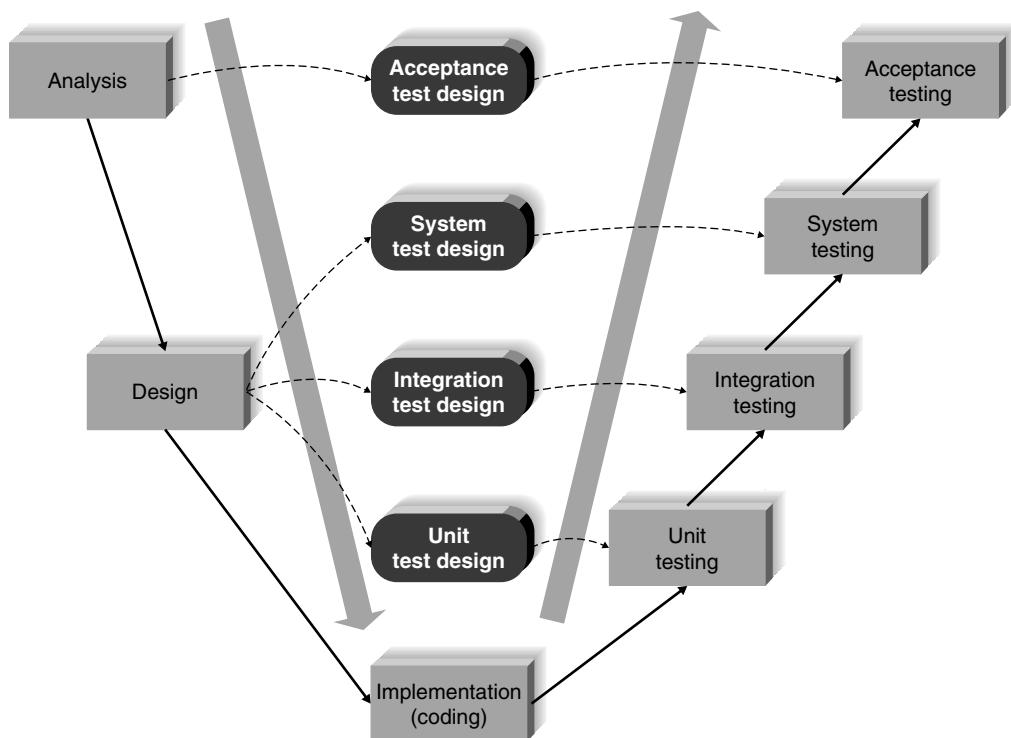
team misses an important requirement, expensive post-implementation programming may be needed. Users may forget the original purpose of the system, since so much time has elapsed between the original idea and actual implementation. Also, in today's dynamic business environment, a system that met the existing environmental conditions during the analysis phase may need considerable rework to match the environment when it is implemented. This rework requires going back to the initial phase and making needed changes through each of the subsequent phases in turn.

There are several important variants of waterfall development. The **parallel development** methodologies evolved to address the lengthy time frame of waterfall development. As shown in Figure 2-3, after the analysis phase, a general design for the whole system is created. Then the project is divided into a series of subprojects that can be designed and implemented in parallel. Once all subprojects are complete, there is a final integration of the separate pieces, and the system is delivered.

Parallel development reduces the time required to deliver a system, so changes in the business environment are less likely to produce the need for rework. The approach still suffers from problems caused by voluminous deliverables. It also adds a new problem: if the subprojects are not completely independent, design decisions in one subproject may affect another, and at the end of the project, integrating the subprojects may be quite challenging.

The **V-model** is another variation of waterfall development that pays more explicit attention to testing. As shown in Figure 2-4, the development process proceeds down the left-hand slope of the V, defining requirements and designing system components. At the base of the V, the code is written. On the upward-sloping right side of the model, testing of components, integration testing, and, finally, acceptance testing are performed. A key concept of this model is that as requirements are specified and components designed, testing for those elements is also defined. In this manner, each level of testing is clearly linked to a part of the analysis or design phase, helping to ensure high quality and relevant testing and maximize test effectiveness.

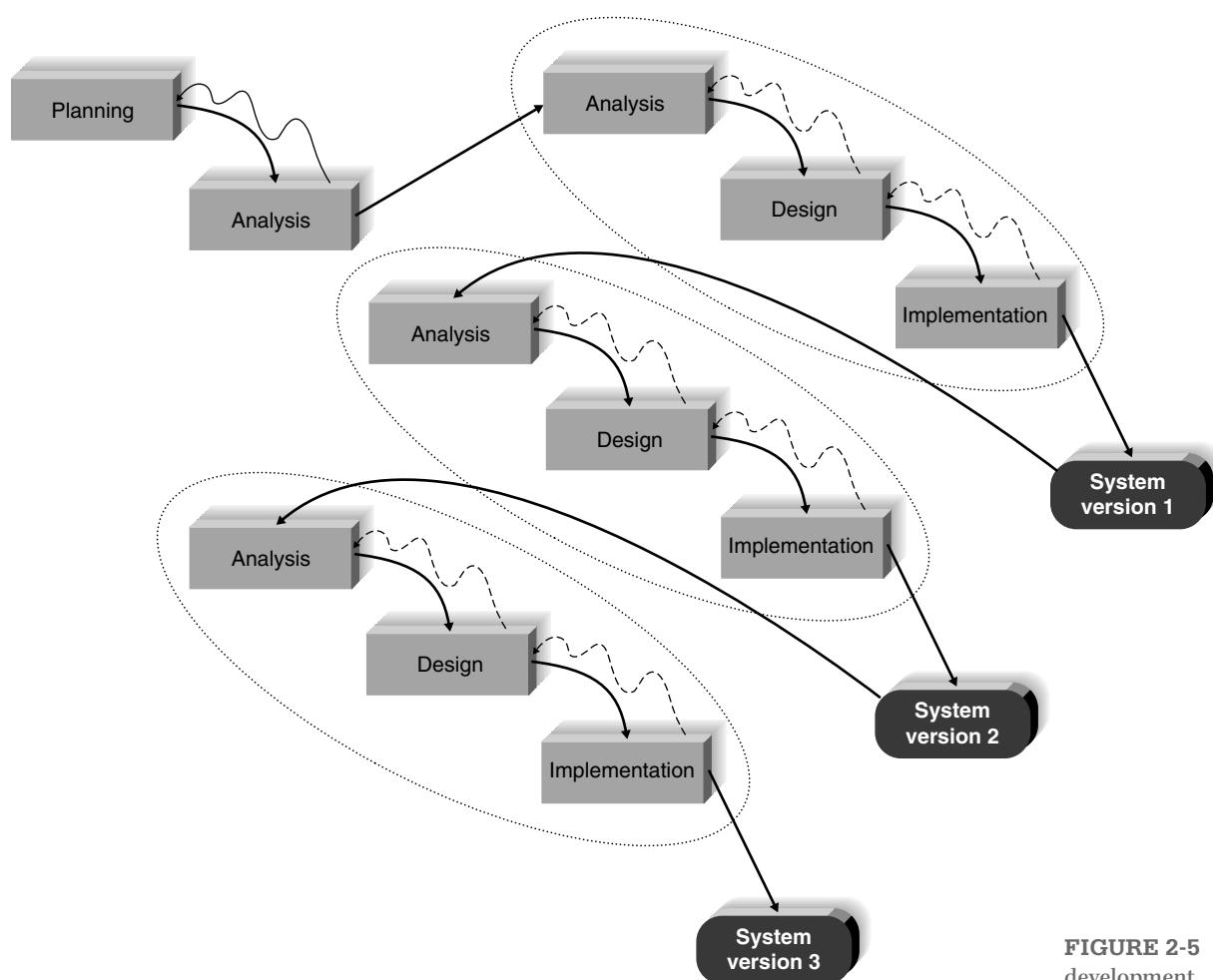
The V-model is simple and straightforward and improves the overall quality of systems through its emphasis on early development of test plans. Projects benefit from an earlier focus on testing, plus the quality assurance personnel's expertise increases the overall quality of the system design. It still suffers from the rigidity of the waterfall development process, however, and is not always appropriate for the dynamic nature of the business environment.

**FIGURE 2-3** Parallel development.**FIGURE 2-4** V-Model.

## Rapid Application Development (RAD)<sup>5</sup>

**Rapid application development (RAD)** is a collection of methodologies that emerged in response to the weaknesses of waterfall development and its variations. RAD incorporates special techniques and computer tools to speed up the analysis, design, and implementation phases in order to get some portion of the system developed quickly and into the hands of the users for evaluation and feedback. **Computer-aided software engineering (CASE)** tools, joint application development (JAD) sessions, fourth generation/visual programming languages (e.g., Visual Basic.NET), and code generators may all play a role in RAD. While RAD can improve the speed and quality of systems development, it may also introduce a problem in managing user expectations. As systems are developed more quickly and users gain a better understanding of information technology, user expectations may dramatically increase, and system requirements may expand during the project (sometimes known as **scope creep** or **feature creep**).

RAD may be conducted in a variety of ways. **Iterative development** breaks the overall project into a series of **versions** that are developed sequentially. The most important and fundamental requirements are bundled into the first version of the system. This version is developed quickly by a mini-waterfall process, and once implemented, the users can provide valuable feedback to be incorporated into the next version of the system (Figure 2-5). Iterative development gets a



**FIGURE 2-5** Iterative development.

<sup>5</sup> One of the best RAD books is by Steve McConnell, *Rapid Development*, Redmond, WA: Microsoft Press, 1996.

preliminary version of the system to the users quickly so that business value is provided. Since users are working with the system, important additional requirements may be identified and incorporated into subsequent versions. The chief disadvantage of iterative development is that users begin to work with a system that is intentionally incomplete. Users must accept that only the most critical requirements of the system will be available in the early versions and must be patient with the repeated introduction of new system versions.

**System prototyping** performs the analysis, design, and implementation phases concurrently to quickly develop a simplified version of the proposed system and give it to the users for evaluation and feedback (Figure 2-6). The system prototype is a “quick and dirty” version of the system and provides minimal features. Following reaction and comments from the users, the developers reanalyze, redesign, and reimplement a second prototype that corrects deficiencies and adds more features. This cycle continues until the analysts, users, and sponsors agree that the prototype provides enough functionality to be installed and used in the organization. System prototyping very quickly provides a system for users to evaluate and reassures users that progress is being made. The approach is especially useful when users have difficulty in expressing requirements for the system. A disadvantage, however, is the lack of careful, methodical analysis before making designs and implementation decisions. System prototypes may have some fundamental design limitations that are a direct result of an inadequate understanding of the system’s true requirements early in the project.

**Throwaway prototyping**<sup>6</sup> includes the development of prototypes but uses the prototypes primarily to explore design alternatives rather than as the actual new system (as in system prototyping). As shown in Figure 2-7, throwaway prototyping has a thorough analysis phase that is used to gather requirements and to develop ideas for the system concept. Many of the features suggested by the users may not be well understood, however, and there may be challenging technical issues to be solved. Each of these issues is examined by analyzing, designing, and building a **design prototype**. A design prototype is not intended to be a working system. It contains only enough details to enable users to understand the issues under consideration.

For example, suppose that users are not completely clear on how an order entry system should work. The analyst team might build a series of HTML pages to be viewed on a Web browser to help the users visualize such a system. In this case, a series of mock-up screens *appear* to be a system, but they really do nothing. Or suppose that the project team needs to develop a sophisticated graphics program in Java. The team could write a portion of the program with artificial data to ensure that they could create a full-blown program successfully.

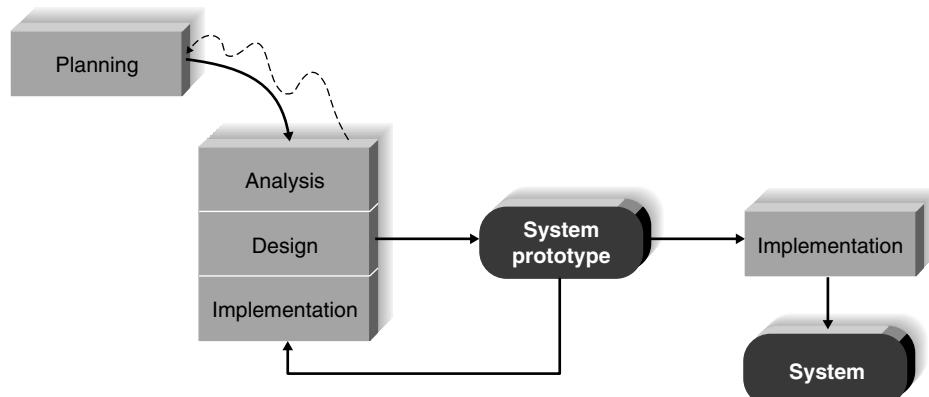
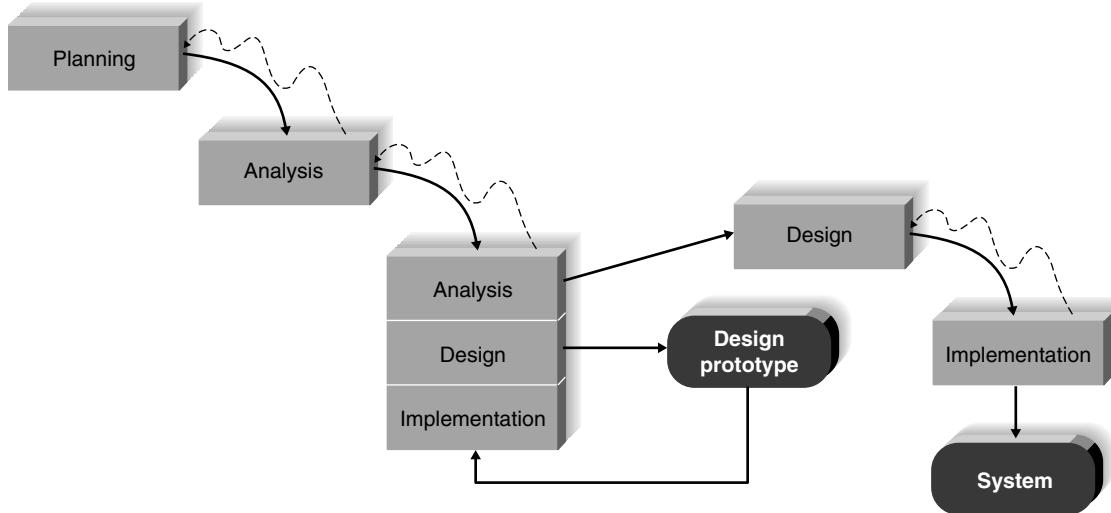


FIGURE 2-6 System prototyping.

<sup>6</sup> Our description of the throwaway prototyping is a modified version of the Spiral Development Model developed by Barry Boehm, “A Spiral Model of Software Development and Enhancement,” *Computer*, May, 1988, 21(5):61–72.



**FIGURE 2-7** Throwaway prototyping.

A system that is developed by this type of methodology probably requires several design prototypes during the analysis and design phases. Each of the prototypes is used to minimize the risk associated with the system by confirming that important issues are understood before the real system is built. Once the issues are resolved, the project moves into design and implementation. At this point, the design prototypes are thrown away, which is an important difference between this approach and system prototyping, in which the prototypes evolve into the final system.

Throwaway prototyping balances the benefits of well-thought-out analysis and design phases with the advantages of using prototypes to refine key issues before a system is built. It may take longer to deliver the final system compared with system prototyping (because the prototypes do not become the final system), but the approach usually produces more stable and reliable systems.

## Agile Development

**Agile development**<sup>7</sup> is a group of programming-centric methodologies that focus on streamlining the SDLC. Much of the modeling and documentation overhead is eliminated; instead, face-to-face communication is preferred. A project emphasizes simple, iterative application development in which every iteration is a complete software project, including planning, requirements analysis, design, coding, testing, and documentation (Figure 2-8). Cycles are kept short (1–4 weeks), and the development team focuses on adapting to the current business environment. There are several popular approaches to agile development, including extreme programming (XP),<sup>8</sup> Scrum,<sup>9</sup> and dynamic systems development method (DSDM).<sup>10</sup> Here, we briefly describe XP. We expand our discussion of Agile development in Chapter 13.

XP<sup>11</sup> emphasizes customer satisfaction and teamwork. Communication, simplicity, feedback, and courage are core values. Developers communicate with customers and fellow programmers. Designs are kept simple and clean. Early and frequent testing provides feedback, and developers can courageously respond to changing requirements and technology. Project teams are kept small.

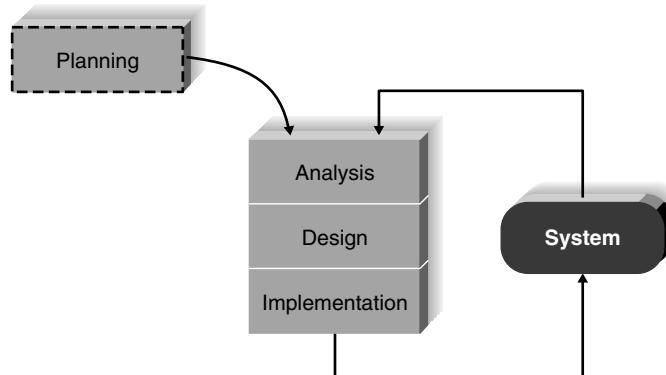
<sup>7</sup> For more information, see [www.AgileAlliance.org](http://www.AgileAlliance.org).

<sup>8</sup> For more information, see [www.extremeprogramming.org](http://www.extremeprogramming.org).

<sup>9</sup> For more information, see [www.scrum.org](http://www.scrum.org).

<sup>10</sup> For more information, see [www.dsdm.com](http://www.dsdm.com).

<sup>11</sup> For more information, see A. Lander, *Agile Methodologies*, New York: John Wiley & Sons, 2014.



**FIGURE 2-8** Extreme programming.

An XP project begins with user stories that describe what the system needs to do. Then, programmers code in small, simple modules and test to meet those needs. Users are required to be available to clear up questions and issues as they arise. Standards are particularly important to minimize confusion, so XP teams use a common set of names, descriptions, and coding practices. XP projects deliver results sooner than even the RAD approaches, and they rarely get bogged down in gathering requirements for the system.

XP works well in projects with highly motivated, cohesive, stable, and experienced teams. If the project is not small or the teams are not jelled,<sup>12</sup> however, then the likelihood of success for the XP project is reduced. XP requires a great deal of discipline to prevent projects from becoming unfocused and chaotic. Furthermore, it is recommended only for small groups of developers (not more than 10), and it is not advised for mission-critical applications. Since little analysis and design documentation is produced with XP, there is only code documentation; therefore, maintenance of large systems developed using XP may be impossible. Also, since mission-critical business information systems tend to exist for a long time, the utility of XP as a business information system development methodology is in doubt. Finally, the methodology requires considerable on-site user involvement, something that is frequently difficult to obtain.<sup>13</sup>

### Agile Versus Waterfall-Based Methodologies

Agile development approaches have existed for several decades. Agile development practices were created in part because of dissatisfaction with the sequential, inflexible structure of waterfall-based approaches. Presently, agile development has made inroads into software development organizations, and studies show an even split between agile and waterfall users.<sup>14</sup> Many organizations are experimenting with agile even while continuing to employ more traditional approaches (see Concepts in Action 2-E). In fact, suggesting that an organization must be “all agile” or “all waterfall” is a false choice. Many software developers actively seek to integrate the best elements of both waterfall and agile into their software development practices. Hybrid agile–waterfall

<sup>12</sup> A “jelled team” is one that has low turnover, a strong sense of identity, a sense of eliteness, a feeling that they jointly own the product being developed, and enjoyment in working together. For more information regarding jelled teams, see T. DeMarco and T. Lister, *Peopleware: Productive Projects and Teams*, New York: Dorsett House, 1987.

<sup>13</sup> Many of the observations described here on the utility of XP as a development approach are based on conversations with Brian Henderson-Sellers.

<sup>14</sup> Jan Stafford, “Agile and Waterfall Neck and Neck as Business Side Fails to Engage.” SearchSoftwareQuality.com, March 16, 2009.

**CONCEPTS IN ACTION 2-D****Agile Development at Travelers**

Travelers Insurance Company of Hartford, Connecticut has adopted agile development methodologies. The insurance field can be competitive, and Travelers wanted to have the shortest “time to implement” in the field. Travelers set up development teams of six people—two systems analysts, two representatives from the user group (such as claim services), a project manager, and a clerical support person. In the agile approach, the users are physically assigned to the development team for the project. While at first it might seem that the users are just sitting around drinking coffee and not doing their regular jobs, that is not the case. The rapport that is developed within the team allows for instant communication. The interaction is very

deep and profound. The resulting software product is delivered quickly—and, generally, with all the features and nuances that the users wanted.

*Questions*

1. Could this be done differently, such as through JAD sessions or having the users review the program on a weekly basis, rather than taking the users away from their real jobs to work on development?
2. What mindset does an analyst need to work on such an approach?

approaches are evolving. The process of developing information systems is never static. Most IS departments and system developers recognize that the choice of the “best” development methodology depends on project characteristics, as we discuss in the next section.

## Selecting the Appropriate Development Methodology

As the previous section shows, there are many methodologies. The first challenge faced by project managers is to select which methodology to use. Choosing a methodology is not simple, because no one methodology is always best. (If it were, we would simply use it everywhere!) Many organizations have standards and policies to guide the choice of methodology. You will find that organizations may have one “approved” methodology, several methodology options, or have no formal policies at all. In the following paragraphs, we describe the various methodologies’ strengths and weaknesses using the project characteristics we introduced earlier. Figure 2-9 provides a concise summary.

<b>Usefulness in Developing Systems</b>	<b>Waterfall</b>	<b>Parallel</b>	<b>V-Model</b>	<b>Iterative</b>	<b>System Prototyping</b>	<b>Throwaway Prototyping</b>	<b>Agile Development</b>
With unclear user requirements	Poor	Poor	Poor	Good	Excellent	Excellent	Excellent
With unfamiliar technology	Poor	Poor	Poor	Good	Poor	Excellent	Poor
That are complex	Good	Good	Good	Good	Poor	Excellent	Poor
That are reliable	Good	Good	Excellent	Good	Poor	Excellent	Good
With short time schedule	Poor	Good	Poor	Excellent	Excellent	Good	Excellent
With schedule visibility	Poor	Poor	Poor	Excellent	Excellent	Good	Good

**FIGURE 2-9** Criteria for selecting a methodology.

### Clarity of User Requirements

When it is difficult to state the user requirements clearly, users may need to interact with technology to really understand what a new system can do and how to best apply it to their needs. System prototyping and throwaway prototyping are most appropriate when user requirements are unclear because they provide prototypes for users to interact with early in the SDLC. Agile development is suitable if on-site user involvement is available.

### Familiarity with Technology

When the system will use new, unfamiliar technology, applying the new technology early in the methodology will improve the chance of success. Without some familiarity with the base technology, design risks increase. Throwaway prototyping is particularly appropriate for situations with limited familiarity with technology because it explicitly encourages the developers to create design prototypes for areas with high uncertainty. Iterative development is good as well, because opportunities are created to investigate the technology in some depth before the design is complete. While one might think that system prototyping would also be appropriate, it is much less so because the early prototypes that are built usually only scratch the surface of the new technology. Typically, it is only after several prototypes and several months that the developers discover weaknesses or problems in the new technology.

### System Complexity

Complex systems require careful and detailed analysis and design. Throwaway prototyping is particularly well suited to such detailed analysis and design, but system prototyping is not. The waterfall methodologies can handle complex systems, but without the ability to get the system or prototypes into users' hands early on, some key issues may be overlooked. Although iterative development methodologies enable users to interact with the system early in the process, we have observed that project teams who follow these methodologies tend to devote less attention to the analysis of the complete problem domain than they might if they were using other methodologies.

### System Reliability

System reliability is usually an important factor in system development. After all, who wants an unreliable system? For some applications, reliability is truly critical (e.g., medical equipment, missile control systems), while for other applications, it is merely important (e.g., games, Internet video). The V-model is useful when reliability is important, due to its emphasis on testing. Throwaway prototyping excels when system reliability is a high priority because detailed analysis and design phases are combined with the ability for the project team to test many different approaches through design prototypes before completing the design. System prototyping is generally not a good choice when reliability is critical, due to the lack of careful analysis and design phases that are essential to dependable systems.

### Short Time Schedules

Projects that have short time schedules are well suited for RAD methodologies because those methodologies are designed to increase the speed of development. Iterative development, system prototyping, and agile methodologies are excellent choices when timelines are short because they best enable the project team to adjust the functionality in the system on the basis of a specific delivery date. If the project schedule starts to slip, it can be readjusted by removal

**YOUR TURN 2-2** || Selecting a Methodology

Suppose that you are an analyst for the ABC Company, a large consulting firm with offices around the world. The company wants to build a new knowledge management system that can identify and track the expertise of individual consultants anywhere in the world based on their education and the various consulting projects on which they have worked. Assume that this is a new idea that has never been attempted in ABC or elsewhere.

ABC has an international network, but the offices in each country may use somewhat different hardware and software. ABC management wants the system up and running within a year.

*Question*

1. What methodology would you recommend that ABC Company use? Why?

**CONCEPTS IN ACTION 2-E**

## || Where Agile Works and Does Not Work

British Airways (BA) experienced problems in software development despite a willing and capable development team. Mike Croucher, brought in as chief software engineer, recommended a move to agile development after studying BA's development process. The movement to agile was carefully conducted, recognizing that agile represents a huge cultural shift for the developers. BA development team members who were amenable to and suitable for agile methods were trained as agile mentors and coaches to help ease the transition.

Converting to agile methods enabled BA to substantially shorten the time requirements of certain projects. In some cases, a project that might have taken 9 months following a

traditional methodology was completed in 8 weeks. Only about 25% of the organization has changed to agile, however. BA recognized a continuing role for the waterfall methodology in certain areas of the organization and does not intend to force-fit agile everywhere. At BA, agile is used when the user base demands speed, flexibility, and customer-oriented design. Agile is ideal when an area requiring small functionality can be developed and deployed earlier, according to Croucher.

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Adapted from: Mondelo, Daniel J. "Where agile development works and where it doesn't: A user story." SearchSoftwareQuality.com. February 24, 2010.

of the functionality from the version or prototype under development. Waterfall-based methodologies are the worst choice when time is at a premium because they do not allow for easy schedule changes.

**Schedule Visibility**

One of the greatest challenges in systems development is knowing whether a project is on schedule. This is particularly true of the waterfall-based methodologies because design and implementation occur at the end of the project. The RAD methodologies move many of the critical design decisions to a position earlier in the project to help project managers recognize and address risk factors and keep expectations in check. Close user involvement in agile methodologies ensures that progress is well known.

One important item not discussed in Figure 2-9 is the development team's degree of experience. Many of the RAD and agile development methodologies require the use of new tools and techniques that have a significant learning curve. Often, these tools and techniques increase the complexity of the project and require extra time to learn and apply. Once they are adopted and the team becomes experienced, the tools and techniques can significantly decrease the time needed to deliver a final system.

## Staffing the Project

Project staffing decisions are complex and include determining how many people should be assigned to the project, matching people's skills with the needs of the project, motivating them to meet the project's objectives, and minimizing project team conflict that will occur over time. The deliverable for this part of project management is a staffing plan, which describes the number and kinds of people who will work on the project, the overall reporting structure, and the project charter, which describes the project's objectives and rules.

### Staffing Plan

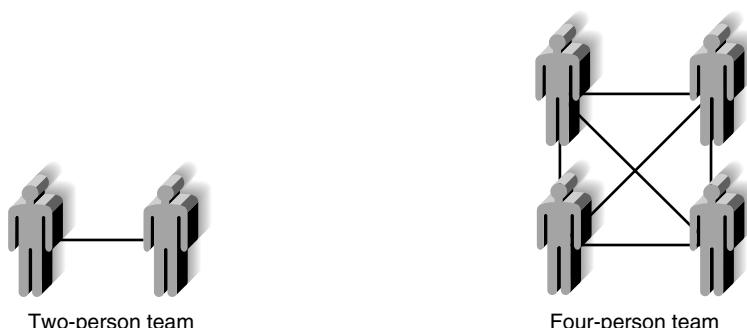
The first step to staffing is determining the average number of staff needed for the project. To calculate this figure, divide the total person-months of effort by the optimal schedule. So, to complete a 40 person-month project in 10 months, a team should have an average of four full-time staff members, although this may change over time as different specialists join and leave the team (e.g., business analysts, programmers, technical writers).

Many times, the temptation is to assign more staff to a project to shorten the project's length, but this is not a wise move. Adding staff resources does not translate into increased productivity; staff size and productivity share a disproportionate relationship, mainly because a large number of staff members is more difficult to coordinate. The more a team grows, the more difficult it becomes to manage. Imagine how easy it is to work on a two-person project team: the team members share a single line of communication. But adding two people increases the number of communication lines to six, and greater increases lead to more dramatic gains in communication complexity. Figure 2-10 and Your Turn 2-3 illustrate the impact of adding team members to a project team.

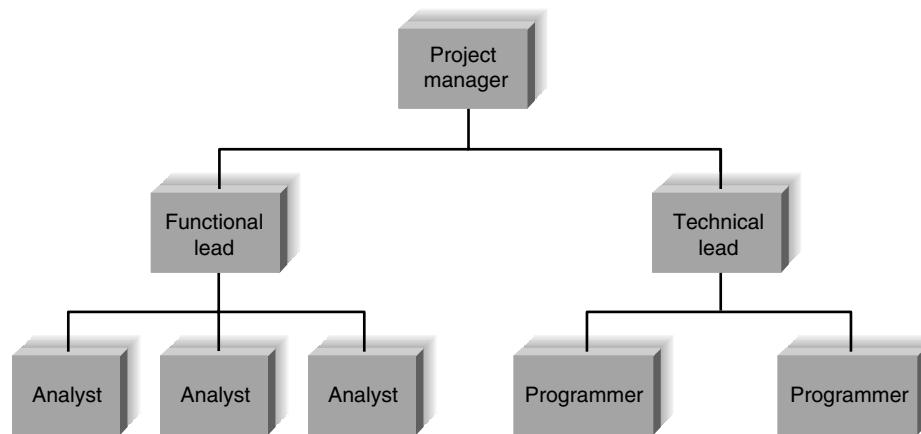
One way to reduce efficiency losses on teams is to understand the complexity that is created in numbers and to build in a **reporting structure** that tempers its effects. The rule of thumb is to keep team sizes under 8–10 people; therefore, if more people are needed, create subteams. In this way, the project manager can keep the communication effective within small teams, which in turn communicate to a contact at a higher level in the project.

After the project manager understands how many people are needed for the project, he or she creates a **staffing plan** that lists the roles that are required for the project and the proposed reporting structure for the project. Typically, a project will have one project manager who oversees the overall progress of the development effort, with the core of the team composed of the various types of analysts described in Chapter 1. A **functional lead** usually is assigned to manage a group of analysts, and a **technical lead** oversees the progress of a group of programmers and more technical staff members.

There are many structures for project teams; Figure 2-11 illustrates one possible configuration of a project team. After the roles are defined and the structure is in place, the project manager



**FIGURE 2-10**  
Increasing complexity  
with larger teams.



**FIGURE 2-11** Possible reporting structure.

needs to think about which people can fill each role. Often, one person fills more than one role on a project team.

When you make assignments, remember that people have **technical skills** and **interpersonal skills**, and both are important on a project. Technical skills are useful for working with technical tasks (e.g., programming in Java) and in trying to understand the various roles that technology plays in the project (e.g., how a Web server should be configured based on a projected number of hits from customers).

Interpersonal skills, on the other hand, include interpersonal and communication abilities that are used when dealing with business users, senior management executives, and other members of the project team. They are particularly critical for performing the requirements-gathering activities and when addressing organizational feasibility issues. Each project will require unique technical and interpersonal skills. For example, a Web-based project may require Internet experience or Java programming knowledge, or a highly controversial project may need analysts who are particularly adept at managing political or volatile situations.

Ideally, project roles are filled with people who have the right skills for the job; however, the people who fit the roles best may not be available; they may be working on other projects, or they may not exist in the company. Therefore, assigning project team members really is a combination of finding people with the appropriate skill sets and finding people who are available. When the skills of the available project team members do not match those required by the project, several options can be considered to improve the situation. First, people can be pulled off other projects, and resources can be shuffled around. This is the most disruptive approach from the organization's perspective. Another approach is to use outside help—such as a consultant or contractor—to train team members and start them off on the right foot. Training classes are generally available for both technical and interpersonal instruction if time is available. Mentoring may also be an option; a project team member can be sent to work on another similar project so that he or she can return with skills to apply to the current job.

### YOUR TURN 2-3 || Communication Complexity

Figure 2-10 shows the increasing number of communication channels that exist as a team grows from two members to four members. Using the figure as a guide, draw the number of communication channels that will be needed in a six-member team. Now, determine the number of communication channels that will be needed in an eight-person team.

#### Questions

- How many communication channels are there in the six-member team? The eight-member team?
- From your results, how effective do you think a 12-member team would be? A 16-member team?

## Motivation

Assigning people to tasks is not enough; the team members must be motivated to make the project a success. **Motivation** has been found to be the number-one influence on people's performance,<sup>15</sup> but determining how to motivate the team can be quite difficult. You may think that good project managers motivate their staff by rewarding them with money and bonuses, but most project managers agree that this is the last thing that should be done. The more often you reward team members with money, the more they expect it—and most times monetary motivation will not work.

Assuming that team members are paid a fair salary, technical employees on project teams are much more motivated by recognition, achievement, the work itself, responsibility, advancement, and the chance to learn new skills.<sup>16</sup> If you feel that you need to give a reward for motivational purposes, try a pizza or free dinner, or even a kind letter or award. These often have much more effective results. Figure 2-12 lists some other motivational don'ts that you should avoid, ensuring that motivation on the project is as high as possible.

## Handling Conflict

The third component of staffing is organizing the project to minimize conflict among group members. **Group cohesiveness** (the attraction that members feel to the group and to other members) contributes more to productivity than do project members' individual capabilities or experiences.<sup>17</sup> Clearly defining the roles on the project and holding team members accountable for their tasks is a good way to begin mitigating potential conflict on a project. Some project managers develop a *project charter* that lists the project's norms and ground rules. For example, the charter may describe when the project team should be at work, when staff meetings will be held, how the group will communicate with each other, and the procedures for progress reporting. Figure 2-13 lists additional techniques that can be used at the start of a project to keep conflict to a minimum.

Don'ts	Reasons
Assign unrealistic deadlines	Few people will work hard if they realize that a deadline is impossible to meet.
Ignore good efforts	People will work harder if they feel that their work is appreciated. Often, all it takes is public praise for a job well done.
Create a low-quality product	Few people can be proud of working on a project that is of low quality.
Give everyone on the project a raise	If everyone is given the same reward, then high-quality people will believe that mediocrity is rewarded—and they will resent it.
Make an important decision without the team's input	Buy-in is particularly important. If the project manager needs to make a decision that greatly affects the members of her team, she should involve them in the decision-making process.
Maintain poor working conditions	A project team needs a good working environment, or motivation will go down the tubes. This includes lighting, desk space, technology, privacy from interruptions, and reference resources.

**FIGURE 2-12**  
Motivational don'ts.

Adapted from: *Rapid Development*, Redmond, WA: Microsoft Press, 1996, by Steve McConnell.

<sup>15</sup> Barry W. Boehm, *Software Engineering Economics*, Englewood Cliffs, NJ: Prentice Hall, 1981. One of the best books on managing project teams is by Tom DeMarco and Timothy Lister, *Peopleware: Productive Projects and Teams*, New York: Dorset House, 1987.

<sup>16</sup> F. H. Herzberg, "One More Time: How Do You Motivate Employees?" *Harvard Business Review*, 1968, January–February.

<sup>17</sup> B. Lakhapal, "Understanding the Factors Influencing the Performance of Software Development Groups: An Exploratory Group-Level Analysis," *Information and Software Technology*, 1993, 35(8):468–473.

- Clearly define plans for the project.
- Make sure the team understands how the project is important to the organization.
- Develop detailed operating procedures and communicate these to the team members.
- Develop a project charter.
- Develop schedule commitments ahead of time.
- Forecast other priorities and their possible impact on the project.

Source: H. J. Thamhain and D. L. Wilemon, "Conflict Management in Project Life Cycles," *Sloan Management Review*, Spring 1975.

**FIGURE 2-13**  
Conflict avoidance  
strategies.

## Coordinating Project Activities

Like all project management responsibilities, the act of coordinating project activities continues throughout the entire project until a system is delivered to the project sponsor and end users. This step includes putting efficient development practices in place and mitigating risk. These activities occur over the course of the entire SDLC, but it is at this point in the project they should be established. Ultimately, these activities ensure that the project stays on track and that the chance of failure is kept at a minimum. The rest of this section will describe each of these activities in more detail.

### Computer-Aided Software Engineering Tools

CASE is a category of software that automates all or part of the development process. Some CASE software packages are primarily used during the analysis phase to create integrated diagrams of the system and to store information regarding the system components (often called **upper CASE**), whereas others are design-phase tools that create the diagrams and then generate code for database tables and system functionality (often called **lower CASE**). **Integrated CASE**, or I-CASE, contains functionality found in both upper-CASE and lower-CASE tools in that it supports tasks that happen throughout the SDLC. CASE comes in a wide assortment of flavors in terms of complexity and functionality, and there are many good programs available in the marketplace, such as Visible Analyst, Oracle Designer, Rational Rose, and the Logic Works suite.

The benefits of using CASE are numerous. With CASE tools, tasks are much faster to complete and alter; development information is centralized; and information is illustrated through diagrams, which typically are easier to understand. Potentially, CASE can reduce maintenance costs, improve software quality, and enforce discipline; and some project teams even use CASE to assess the magnitude of changes to the project.

Of course, like anything else, CASE should not be considered a silver bullet for project development. The advanced CASE tools are complex applications that require significant training and experience to achieve real benefits. Often, CASE serves only as a glorified diagramming tool that supports the practices described in Chapter 4 (process modeling) and Chapter 5 (data modeling). Our experience has shown that CASE is a helpful way to support the communication and

#### YOUR TURN 2-4

#### Computer-Aided Software Engineering Tool Analysis

Select a CASE tool—either one that you will use for class, a program that you own, or a tool that you can examine over the Web. Create a list of the capabilities that are offered by the CASE tool.

##### Question

1. Would you classify the CASE tool as upper CASE, lower CASE, or integrated CASE (I-CASE)? Why?

sharing of project diagrams and technical specifications—if it is used by trained developers who have applied CASE on past projects.

The central component of any CASE tool is the **CASE repository**, otherwise known as the information repository or data dictionary. The CASE repository stores the diagrams and other project information, such as screen and report design, and it keeps track of how the diagrams fit together. For example, most CASE tools will warn you if you place a field on a screen design that does not exist in your data model. As the project evolves, project team members perform their tasks by using CASE and have access to each project team member’s additions to the CASE repository. As you read through the textbook, we will indicate when and how the CASE tool can be used so that you can see how CASE supports the project tasks.

### Standards

Members of a project team need to work together, and most project management software and CASE tools provide access privileges to everyone working on the system. When people work together, however, things can get confusing. To make matters worse, people sometimes get reassigned in the middle of a project. It is important that their project knowledge does not leave with them and that their replacements can get up to speed quickly.

**Standards** are created to ensure that team members are performing tasks in the same way and following the same procedures. Standards can range from formal rules for naming files to forms that must be completed when goals are reached to programming guidelines. See Figure 2-14 for some examples of the types of standards that a project may include. When a team establishes standards and then follows them, the project can be completed faster because task coordination becomes less complex.

Standards work best when they are created at the beginning of the project and well communicated to the entire project team. As the team moves forward, new standards may be added when necessary. Some standards (e.g., file-naming conventions, status reporting) are applied to the entire SDLC, whereas others (e.g., programming guidelines) are appropriate only for certain tasks.

### Documentation

Another technique that project teams put in place during the planning phase is good **documentation**, which includes detailed information about the tasks of the SDLC. Often, the documentation is stored on a file server available to the entire team—a sort of electronic **project binder**. Stored in this location are all deliverables and all internal team notes and communication—the history of the project.

The project team should not wait until the last minute to create documentation. This typically leads to an undocumented system that no one understands. Good project teams learn to document the system’s history as it evolves, while the details are still fresh in their memory.

A simple way to set up your documentation is to create a folder hierarchy and use subfolders to separate content according to the major phases of the project. An additional subfolder should contain internal communication, such as the minutes from status meetings, written standards, memos to and from the business users, and a dictionary of relevant business terms. Then, as the project moves forward, place the deliverables from each task into the proper folder. Descriptive file names will help identify the purpose of each file. Also, keep a table of contents up to date with the content that is added. Documentation takes time up front, but it is a good investment that will pay off in the long run.

Types of Standards	Examples
Documentation standards	<p>The date and project name should appear as a header on all documentation.</p>
	<p>All margins should be set to 1 inch.</p>
	<p>All deliverables should be added to the project folder and recorded in its table of contents.</p>
Coding standards	<p>All modules of code should include a header that lists the programmer, last date of update, and a short description of the purpose of the code.</p>
	<p>Indentation should be used to indicate loops, if-then-else statements, and case statements.</p>
	<p>On average, every program should include one line of comments for every five lines of code.</p>
Procedural standards	<p>Record actual task progress in the work plan every Monday morning by 10 A.M.</p>
	<p>Report to project update meeting on Fridays at 3:30 P.M.</p>
	<p>All changes to a requirements document must be approved by the project manager.</p>
Specification requirement standards	<p>Name of the program to be created Description of the program's purpose Special calculations that need to be computed Business rules that must be incorporated into the program Pseudocode Due date</p>
User interface design standards	<p>Labels will appear in boldface text, left-justified, and followed by a colon. The tab order of the screen will move from top left to bottom right. Hot keys will be provided for all updatable fields.</p>

**FIGURE 2-14**  
A sampling of project standards.

### CONCEPTS IN ACTION 2-F

### Trade-Offs

I was once on a project to develop a system that should have taken a year to build. Instead, the business need demanded that the system be ready within 5 months—impossible!

On the first day of the project, the project manager drew a triangle on a white board to illustrate some trade-offs that he expected to occur over the course of the project. The corners of the triangle were labeled Functionality, Time, and Money. The manager explained, “We have too little time. We have an unlimited budget. We will not be measured by the bells and whistles that this system contains. So over the next several weeks, I want you as developers to keep this triangle in mind and do everything it takes to meet this 5-month deadline.”

At the end of the 5 months, the project was delivered on time; however, the project was incredibly over budget, and the final product was “thrown away” after it was used because it was unfit for regular usage. Remarkably, the business users felt that the project was highly successful because it met the very specific business needs for which it was built. They believed that the trade-offs that were made were worthwhile. *Barbara Wixom*

#### Questions

1. What are the risks in stressing only one corner of the triangle?
2. How would you have managed this project? Can you think of another approach that might have been more effective?

## Managing and Controlling the Project

The science (or art) of project management is in making **trade-offs** among three important concepts: the size of the system (in terms of what it does), the time to complete the project (when the project will be finished), and the cost of the project. Think of these three things as interdependent levers that the project manager controls throughout the SDLC. Whenever one lever is pulled, the other two levers are affected in some way. The project manager must work with the project sponsor to shift these levers appropriately as the project progresses. For example, if a deadline is moved up, then the only solution is to decrease the size of the system (by eliminating some of its functions) or to increase costs by adding more people or having team members work overtime.

Therefore, in the beginning of the project, the manager needs to estimate each of these levers and then continuously assess how to roll out the project in a way that meets the organization's needs.

Once the project begins, the project manager monitors the progress of the team on the project tasks as the project team members make periodic status reports. Gantt and PERT charts are valuable tools for the project manager to use to evaluate project progress and, if necessary, redirect resources. As the project proceeds, it may be necessary for the project manager to revise the original estimates made for the project. In addition, the manager must be on the watch for project scope increases, which can make completing the project on time and under budget exceedingly difficult. Finally, the project manager should constantly assess the risk profile of the project and take steps to manage those risks.

## Refining Estimates

The time and cost estimates that are produced during the planning phase will need to be refined as the project progresses. This does not necessarily mean that estimates were poorly done at the start of the project; it is virtually impossible to develop an exact assessment of the project's schedule before the analysis and design phases are conducted. A project manager should expect to be satisfied with broad estimate ranges that become more and more specific as the project's product becomes better defined.

In the planning phase, when a system is first requested, the project sponsor and project manager attempt to predict how long the SDLC will take, how much it will cost, and what the system will ultimately do when it is delivered (i.e., its functionality). However, the estimates are based on extremely limited knowledge of the system. As the project moves into the analysis phase, more information is gathered, the system concept is developed, and the estimates become even more accurate and precise. As the system moves closer to completion, the accuracy and precision increase until the final system is delivered.

According to one of the leading experts in software development,<sup>18</sup> a well-prepared project plan (prepared at the end of the planning phase) has a 100% margin of error for project cost and a 25% margin of error for schedule time. In other words, if a carefully done project plan predicts that a project will cost \$100,000 and take 20 weeks, the project may actually cost between \$0 and \$200,000 and take between 15 and 25 weeks. Figure 2-15 presents typical margins of error for other stages in the project. It is important to note that these margins of error apply only to well-prepared plans; a plan developed without much care has a much greater margin of error.

<sup>18</sup> Barry W. Boehm and colleagues, "Cost Models for Future Software Life Cycle Processes: COCOMO 2.0," in J. D. Arthur and S. M. Henry (eds.), *Annals of Software Engineering: Special Volume on Software Process and Product Measurement*, Amsterdam: J. C. Baltzer AG Science Publishers, 1995.

Typical Margins of Error for Well-Prepared Estimates			
Phase	Deliverable	Cost (%)	Schedule Time (%)
Planning phase	System request	400	60
	Project plan	100	25
Analysis phase	System proposal	50	15
Design phase	System specifications	25	10

Source: Barry W. Boehm and colleagues, "Cost Models for Future Software Life Cycle Processes: COCOMO 2.0," in J. D. Arthur and S. M. Henry (eds.), *Annals of Software Engineering Special Volume on Software Process and Product Measurement*, Amsterdam: J. C. Baltzer AG Science Publishers, 1995.

**FIGURE 2-15**  
Margins of error in cost and time estimates.

What happens if you overshoot an estimate (e.g., the analysis phase ends up lasting 2 weeks longer than expected)? There are several ways to adjust future estimates. If the project team finishes a step ahead of schedule, most project managers shift the deadlines sooner by the same amount but do not adjust the promised completion date. The challenge, however, occurs when the project team is late in meeting a scheduled date. Three possible responses to missed schedule dates are presented in Figure 2-16. We recommend that if an estimate proves too optimistic early in the project, do not expect to make up for lost time—very few projects end up working this way. Instead, change your future estimates to include an increase like the one that was experienced. For example, if the first phase was completed 10% over schedule, increase the rest of your estimates by 10%.



Assumptions	Actions	Level of Risk
If you assume that the rest of the project is simpler than the part that was late and is also simpler than believed when the original schedule estimates were made, you can make up lost time.	Do not change schedule.	High risk
If you assume that the rest of the project is simpler than the part that was late and is no more complex than the original estimate assumed, you cannot make up the lost time, but you will not lose time on the rest of the project.	Increase the entire schedule by the total amount of time that you are behind (e.g., if you missed the scheduled date by 2 weeks, move the rest of the schedule dates to 2 weeks later). If you included padded time at the end of the project in the original schedule, you may not have to change the promised system delivery date; you will just use up the padded time.	Moderate risk
If you assume that the rest of the project is as complex as the part that was late (your original estimates were too optimistic), then all the scheduled dates in the future underestimate the real time required by the same percentage as the part that was late.	Increase the entire schedule by the percentage of weeks that you are behind (e.g., if you are 2 weeks late on part of the project that was supposed to take 8 weeks, you need to increase all remaining time estimates by 25%). If this moves the new delivery date beyond what is acceptable to the project sponsor, the scope of the project must be reduced.	Low risk

**FIGURE 2-16**  
Possible actions when a schedule date is missed.

## Managing Scope

You may assume that your project will be safe from scheduling problems because of careful initial planning. The most common reason for schedule and cost overruns, however, occurs after the project is underway—*scope creep*.

Scope creep happens when new requirements are added to the project after the original project scope was defined. It can happen for many reasons: users may suddenly understand the potential of the new system and realize new functionality that would be useful; developers may discover interesting capabilities to which they become extremely attached; a senior manager may decide to let this system support a new strategy that was developed at a recent board meeting.

Unfortunately, after the project begins, it becomes increasingly difficult to address changing requirements. The ramifications of change become more extensive, the focus is removed from original goals, and there is at least some impact on the cost and schedule. Therefore, the project manager must actively work to keep the project tight and focused.

The key is to identify the requirements as well as possible in the beginning of the project and to apply analysis techniques effectively. For example, if needs are fuzzy at the project's onset, a combination of intensive meetings with the users and prototyping could be used so that users "experience" the requirements and better visualize how the system could support their needs. In fact, the use of meetings and prototyping has been found to reduce scope creep to less than 5% on a typical project.

Of course, some requirements may be missed no matter what precautions you take, but several practices can help to control additions to the task list. Members of the project team should carefully assess the ramifications of any requested change and present the assessment back to the users. For example, it may require two more person-months of work to create a newly defined feature, which would throw off the entire project deadline by several weeks. Any change that is implemented should be carefully tracked so that an audit trail exists to measure the change's impact.

Sometimes, changes cannot be incorporated into the present system even though they truly would be beneficial. In this case, these additions to scope should be recorded as future enhancements to the system. It may be possible to provide the functionality in future releases of the system, thus getting around telling someone no.

## Timeboxing

Up until now, we have described projects that are task oriented. In other words, we have described projects that have a schedule that is driven by the tasks that need to be accomplished, so the greater number of tasks and requirements, the longer the project will take. Some companies have little patience for development projects that take a long time, and these companies take a time-oriented approach that places meeting a deadline above delivering functionality.

Think about your use of word processing software. For 80% of the time, you probably use only 20% of the features, such as the spelling checker, boldfacing, and cutting and pasting. Other features, such as document merging and creation of mailing labels, may be nice to have, but they are not a part of your day-to-day needs. The same goes for other software applications; most users rely on only a small subset of their capabilities. Ironically, most developers agree that, typically, 75% of a system can be provided relatively quickly, with the remaining 25% of the functionality demanding most of the time.

To resolve this incongruity, a technique called **timeboxing** has become quite popular, especially when RAD methodologies are used. This technique sets a fixed deadline for a project and

1. Set the date for system delivery.
2. Prioritize the functionality that needs to be included in the system.
3. Build the core of the system (the functionality ranked as most important).
4. Postpone functionality that cannot be provided within the time frame.
5. Deliver the system with core functionality.
6. Repeat steps 3 through 5, to add refinements and enhancements.

**FIGURE 2-17** Steps for timeboxing.

delivers the system by that deadline no matter what, even if functionality needs to be reduced. Timeboxing ensures that project teams do not get hung up on the final “finishing touches” that can drag out indefinitely, and it satisfies the business by providing a product within a relatively fast time frame.

There are several steps to implementing timeboxing on a project (Figure 2-17). First, set the date of delivery for the proposed goals. The deadline should not be impossible to meet, so it is best to let the project team determine a realistic due date. Next, build the core of the system to be delivered; you will find that timeboxing helps create a sense of urgency and helps keep the focus on the most important features. Because the schedule is absolutely fixed, functionality that cannot be completed needs to be postponed. It helps if the team prioritizes a list of features beforehand to keep track of what functionality the users absolutely need. Quality cannot be compromised, regardless of other constraints, so it is important that the time allocated to activities is not shortened unless the requirements are changed (e.g., do not reduce the time allocated to testing without reducing features). At the end of the period, a high-quality system is delivered. Additional iterations will be needed to make changes and enhancements, and the timeboxing approach can be used once again.

## Managing Risk

One final facet of project management is **risk management**, the process of assessing and addressing the risks that are associated with developing a project. Many things can cause risks: weak personnel, scope creep, poor design, and overly optimistic estimates. The project team must be aware of potential risks so that problems can be avoided or controlled well ahead of time.

Typically, project teams create a **risk assessment**, or a document that tracks potential risks along with an evaluation of the likelihood of the risk and its potential impact on the project (Figure 2-18). A paragraph or two is included that explains potential ways that the risk can be addressed. There are many options: a risk could be publicized, avoided, or even eliminated by dealing with its root cause. For example, imagine that a project team plans to use new technology, but its members have identified a risk in the fact that its members do not have the right technical skills. They believe that tasks may take much longer to perform because of a steep learning curve. One plan of attack could be to eliminate the root cause of the risk—the lack of technical experience by team members—by providing time and resources to train the team.

Most project managers keep abreast of potential risks, even prioritizing them according to their magnitude and importance. Over time, the list of risks will change as some items are removed and others surface. The best project managers, however, work hard to keep risks from having an impact on the schedule and costs associated with the project.

**FIGURE 2-18**  
Sample risk assessment.  
A template for this figure is available on the student website.

RISK ASSESSMENT	
<b>RISK #1:</b>	The development of this system likely will be slowed considerably because project team members have not programmed in Java prior to this project.
<b>Likelihood of risk:</b>	High probability of risk
<b>Potential impact on the project:</b>	This risk likely will increase the time to complete programming tasks by 50%.
<b>Ways to address this risk:</b>	It is particularly important that time and resources are allocated to up-front training in Java for the programmers who are used for this project. Adequate training will reduce the initial learning curve for Java when programming begins. In addition, outside Java expertise should be brought in for at least some part of the early programming tasks. This person should be used to provide experiential knowledge to the project team so that Java-related issues (of which novice Java programmers would be unaware) are overcome.
<b>RISK #2:</b>	etc. . . .

### CONCEPTS IN ACTION 2-G || Poor Naming Standards

I once started on a small project (four people) in which the original members of the project team had not set up any standards for naming electronic files. Two weeks into the project, I was asked to write a piece of code that would be referenced by other files that had already been written. When I finished my piece, I had to go back to the other files and make changes to reflect my new work. The only problem was that the lead programmer decided to name the files using his initials (e.g., GG1.prg, GG2.prg, GG3.prg)—and there were over 200 files! I spent two days opening every one of those files because there was no way to tell what their contents were.

Needless to say, from then on, the team created a code for file names that provided basic information regarding the file's contents and they kept a log that recorded the file name, its purpose, the date of last update, and programmer for every file on the project. *Barbara Wixom*

*Question*

1. Think about a program that you have written in the past. Would another programmer be able to make changes to it easily? Why or why not?

## Applying the Concepts at DrōnTeq

Jiang Tsiao was excited about managing the Client Services project at DrōnTeq. Based on everything he learned while creating the system request and preparing the initial feasibility analysis, Jiang was most concerned about the unfamiliar aspects of the application and the need for a highly functional interface for the client and pilot user groups. Therefore, he decided that the project should follow the throwaway prototyping development methodology. In this way, he would explicitly devote project time to experimenting with multiple design alternatives. He also felt that some aspects of the parallel methodology could be useful since the client side and the pilot side of the system could be initially developed simultaneously and then integrated later in the project.

Although there was no urgency in the project's timetable, Jiang knew that Carmella Herrera and DrōnTeq's top managers wanted at least general ranges for a product delivery date. Based on his experience with other projects, Jiang estimated a 5-month timeframe for the project. Jiang's initial approach was to have one part of his team develop the client request portion of the system while other team members worked on the less familiar aspects of the pilot's side of the system.

DrōnTeq developed a throwaway prototyping methodology in-house that Jiang used to develop his project structure. Jiang expected to define the steps in much more detail at the beginning of each phase.

## Staffing the Project

Jiang next turned to the task of how to staff his project. According to his earlier estimates, it appeared that about five people would be needed to deliver the system.

First, he created a list of the various roles that he needed to fill. He thought he would need several analysts with strong business analysis skills to work with the analysis and design of the Client Services system, as well as an infrastructure analyst to manage the integration

### PRACTICAL TIP 2-1

### Avoiding Classic Planning Mistakes

As Seattle University's David Umphress has pointed out, watching most organizations develop systems is like watching reruns of *Gilligan's Island*. At the beginning of each episode, someone comes up with a cockamamie scheme to get off the island that seems to work for a while, but something goes wrong and the castaways find themselves right back where they started—stuck on the island. Similarly, most companies start new projects with grand ideas that seem to work, only to make a classic mistake and deliver the project behind schedule, over budget, or both. Here we summarize four classic mistakes in the planning and project management aspects of the project and discuss how to avoid them:

1. **Overly optimistic schedule:** Wishful thinking can lead to an overly optimistic schedule that causes analysis and design to be cut short (missing key requirements) and puts intense pressure on the programmers, who produce poor code (full of bugs).

**Solution:** Do not inflate time estimates; instead, explicitly schedule slack time at the end of each phase to account for the variability in estimates, using the margins of error from Figure 2-15.

2. **Failing to monitor the schedule:** If the team does not regularly report progress, no one knows if the project is on schedule.



**Solution:** Require team members to honestly report progress (or the lack of progress) every week. There is no penalty for reporting a lack of progress, but there are immediate sanctions for a misleading report.

3. **Failing to update the schedule:** When a part of the schedule falls behind (e.g., information gathering uses all of the slack in item 1 above plus 2 weeks), a project team often thinks it can make up the time later by working faster. It cannot. This is an early warning that the entire schedule is too optimistic.

**Solution:** Immediately revise the schedule and inform the project sponsor of the new end date or use timeboxing to reduce functionality or to move it into future versions.

4. **Adding people to a late project:** When a project misses a schedule, the temptation is to add more people to speed it up. This makes the project take longer because it increases coordination problems and requires staff to take time to explain what has already been done.

**Solution:** Revise the schedule, use timeboxing, throw away bug-filled code, and add people only to work on an isolated part of the project.

Role	Description	Assigned To
Project manager	Oversees the project to ensure that it meets its objectives on time and within budget	Jiang
Infrastructure analyst	Ensures that the system conforms to infrastructure standards at DrōnTeq; ensures that the DrōnTeq infrastructure can support the new system	Rahul
Systems analyst	Analysis and design—with a focus on design alternative for pilot-focused component	Jiang, Kenji
Systems analyst	Analysis and design—with a focus on the pilot-focused component	Dawn
Systems analyst	Analysis and design—with a focus on the client-focused component; integration of both components	Maria
Programmer	Codes system	Maria, Dawn, Kenji

**FIGURE 2-19**

Staffing plan for the client services system.

Reporting structure: All project team members will report to Jiang.

Special incentives: If the deadline for the project is met, all team members who contributed to this goal will receive a free day off, to be taken over the summer following project completion.

**FIGURE 2-20** Project charter for the client services system.

**Project objective:** The Client Services project team will create a Web-based system that supports the new Client Services business unit. This system enables clients to request drone services, and pilots to obtain and perform drone flights and data analyses for those clients.

The Client Services project team members will

1. Attend a staff meeting each Friday at 2 P.M. to report on the status of assigned tasks.
2. Update the work plan with actual data each Friday by 5 P.M.
3. Discuss all problems with Jiang as soon as they are detected.
4. Agree to support each other when help is needed, especially for tasks that could hold back the progress of the project.
5. Post important changes to the project on the team bulletin board as they are made.

of the system with DrōnTeq's existing technical environment. Jiang also needed people who had good programming skills and who could be responsible for ultimately implementing the system. Kenji, Dawn, and Maria are three analysts with strong interpersonal and technical skills (although Kenji is less balanced, having greater technical than interpersonal abilities), and they were available to bring onto this project. He was certain they had experience with the actual Web technology that would be used on the project. He planned that Rahul, an infrastructure analyst, would contribute when needed. Because the project was small, Jiang envisioned all the team members reporting to him since he would be serving as the project's manager as well as providing some systems analysis.

Jiang created a staffing plan that captured this information (Figure 2-19). He also drafted a project charter, to be fine-tuned after the team got together for its kick-off meeting (i.e., the first time the project team gets together). The charter listed several norms that Jiang wanted to put in place from the project's inception (Figure 2-20).

## Coordinating Project Activities

Jiang wanted the Client Services project to be well coordinated, so he immediately put several practices in place to support his responsibilities. First, he acquired the CASE tool used at DrōnTeq and set up the product so that it could be used for the analysis-phase tasks (e.g., drawing the data

flow diagrams). The team members would likely start creating diagrams and defining components of the system early on. He pulled out some standards that he uses on all development projects and made a note to review them with his project team at the kick-off meeting for the system. He also had his assistant set up an electronic project binder on the company LAN for the project deliverables that would start rolling in. Already, he was able to include the system request, feasibility analysis, staffing plan, project charter, standards list, and risk assessment.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Explain how the practice of project portfolio management may influence the selection of IS projects.
- Discuss the skills needed to be a successful systems analyst.
- List and explain the project characteristics that affect the selection of a project methodology.
- List and explain three methodologies that are based on the waterfall concept.
- List and explain three methodologies that are based on RAD.
- Explain the XP Agile methodology.
- For each methodology included in the chapter, summarize the project characteristics that make that methodology the best choice and the poorest choice. Explain why.
- Discuss the three main tasks involved when staffing a project.
- Describe various ways to influence the motivation of project team members.
- Explain the purpose and content of a project charter.
- Describe the role of CASE tools in coordinating the project.
- Describe the value of standards to the project team.
- Discuss the project manager's balancing act involving size, time, and cost.
- Describe how scope creep affects a project.
- Discuss the technique of timeboxing and how it affects a project team.

## KEY TERMS

Agile development	Feature creep	Parallel development	Risk assessment	Timeboxing
CASE repository	Functional lead	Project binder	Risk management	Trade-offs
Chief information officers (CIOs)	Group cohesiveness	Project management	Scope creep	Upper CASE
Computer-aided software engineering (CASE)	Integrated CASE	Project manager	Staffing plan	Versions
Design prototype	Interpersonal skills	Project portfolio	Standards	V-model
Documentation	Iterative development	management	System prototyping	Waterfall development
	Lower CASE	Rapid application	Technical lead	
	Methodology	development (RAD)	Technical skills	
	Motivation	Reporting structure	Throwaway prototyping	

## QUESTIONS

1. Describe how projects are selected in organizations.
2. Describe how project portfolio management is used by IT departments.
3. Describe the major elements and issues with waterfall development.
4. Describe the major elements and issues with parallel development.
5. Describe the major elements and issues with the V-model.
6. Describe the major elements and issues with iterative development.
7. Describe the major elements and issues with system prototyping.
8. Describe the major elements and issues with throwaway prototyping.
9. Describe the major elements and issues with agile development.
10. Compare and contrast structured design methodologies in general with rapid application development (RAD) methodologies in general.
11. Compare and contrast extreme programming and throwaway prototyping.

12. What are the key factors in selecting a methodology?
13. Why do many projects end up having unreasonable deadlines? How should a project manager react to unreasonable demands?
14. Describe two ways methodologies contribute to a project.
15. Some companies hire consulting firms to develop the initial project plans and manage the project but use their own analysts and programmers to develop the system. Why do you think some companies do this?
16. Describe the differences between a technical lead and a functional lead. How are they similar?
17. Describe three technical skills and three interpersonal skills that would be particularly important to have on any project.
18. What are the best ways to motivate a team? What are the worst ways?
19. List three techniques to reduce conflict.
20. What is the difference between upper CASE and lower CASE?
21. Describe three types of standards and provide examples of each.
22. What belongs in the electronic project binder? How is the electronic project binder organized?
23. What are the trade-offs that project managers must manage?
24. What is scope creep, and how can it be managed?
25. What is timeboxing, and why is it used?
26. Create a list of potential risks that could affect the outcome of a project.
27. Describe the factors that the project manager must evaluate when a project falls behind schedule.

## EXERCISES

- A. Suppose that you are a project manager using the waterfall development methodology on a large and complex project. Your manager has just read the latest article in *Computerworld* that advocates replacing the waterfall methodology with extreme programming (XP) and comes to your office requesting you to switch. What do you say?
- B. Suppose that you are an analyst developing a new information system to automate the sales transactions and manage inventory for each retail store in a large chain. The system would be installed at each store and would exchange data with a mainframe computer at the company's head office. What methodology would you use? Why?
- C. Suppose that you are an analyst developing a new executive information system (EIS) intended to provide key strategic information from existing corporate databases to senior executives to help in their decision making. What methodology would you use? Why?
- D. Suppose that you are an analyst working for a small company to develop an accounting system. What methodology would you use? Why?
- E. Visit a project management website, such as the Project Management Institute ([www.pmi.org](http://www.pmi.org)). Most have links to project management software products, white papers, and research. Examine some of the links for project management to better understand a variety of Internet sites that contain information related to this chapter.
- F. Select a specific project management topic like CASE, project management software, or timeboxing, and use the Web search for information on that topic. The URL listed in exercise E or any search engine (e.g., Yahoo!, Google) can provide a starting point for your efforts.
- G. Pretend that the career services office at your university wants to develop a system that collects student résumés and makes them available to students and recruiters over the Web. Students should be able to input their résumé information into a standard résumé template. The information then is presented in a résumé format, and it also is placed in a database that can be queried through an online search form. You have been placed in charge of the project. The project will be staffed by members of your class. Do your classmates have all the right skills to implement such a project? If not, how will you go about making sure that the proper skills are available to get the job done?
- H. Refer to the situation in exercise G. You have been told that recruiting season begins a month from today and that the new system must be used. How would you approach this situation? Describe what you can do as the project manager to make sure that your team does not burn out from unreasonable deadlines and commitments.
- I. Pretend that your instructor has asked you and two friends to create a Web page to describe the course to potential students and provide current class information (e.g., syllabus, assignments, readings) to current students. You have been assigned the role of leader, so you will need to coordinate your activities and those of your classmates until the project is completed. Describe how you would apply the project management techniques that you have learned in this chapter to this situation. Include descriptions of how you would create a work plan, staff the project, and coordinate all activities—yours and those of your classmates.
- J. A health insurance company had a computer problem that caused the company to overestimate revenue and underestimate

medical costs. Problems were caused by the migration of its claims processing system from an older operating system to a UNIX-based system that uses Oracle database software and hardware. As a result, the company's stock price plummeted, and fixing the system became the number-one priority

## MINICASES

1. Emily Pemberton is an IS project manager facing a difficult situation. Emily works for the First Trust Bank, which has recently acquired the City National Bank. Prior to the acquisition, First Trust and City National were bitter rivals, fiercely competing for market share in the region. Following the acrimonious takeover, numerous staff were laid off in many banking areas, including IS. Key individuals were retained from both banks' IS areas, however, and were assigned to a new consolidated IS department. Emily has been made project manager for the first significant IS project since the takeover, and she faces the task of integrating staffers from both banks on her team. The project they are undertaking will be highly visible within the organization, and the time frame for the project is somewhat demanding. Emily believes that the team can meet the project goals successfully, but success will require that the team become cohesive quickly and that potential conflicts are avoided. What strategies do you suggest that Emily implement to help ensure a successfully functioning project team?

*Note: If using the flipped classroom model, students should study the material on motivating teams before class. In class, divide the class into small groups. Each group should prepare a list of team motivational strategies they recommend. Then, compile a comprehensive list from all groups and have the class rank the strategies in order of importance.*

2. Marcus Weber, IS project manager at ICAN Mutual Insurance co., is reviewing the staffing arrangements for his next major project, the development of an artificial intelligence-based underwriters assistant. This new system will involve a whole new way for the underwriters to perform their tasks. The underwriter assistant system will function as sort of an underwriting supervisor, reviewing key elements of each application, checking for consistency in the underwriter's decisions, and ensuring that no critical factors have been overlooked. The goal of the new system is to improve the quality of the underwriters' decisions and to improve underwriter productivity. It is expected that the new system will substantially change the way the underwriting staff do their jobs.

Marcus is dismayed to learn that due to budget constraints, he must choose between one of two available staff members. Barry Filmore has had considerable experience and training

for the company. Pretend that you have been placed in charge of managing the repair of the claims processing system. Obviously, the project team will not be in good spirits. How will you motivate team members to meet the project's objectives?

in individual and organizational behavior. Barry has worked on several other projects in which the end users had to make significant adjustments to the new system, and Barry seems to have a knack for anticipating problems and smoothing the transition to a new work environment. Marcus had hoped to have Barry's involvement in this project.

Marcus's other potential staff member is Kim Danville. Before joining ICAN Mutual, Kim had considerable work experience with the expert system technologies that ICAN has chosen for this expert system project. Marcus was counting on Kim to help integrate the new expert system technology into ICAN's systems environment, and to provide on-the-job training and insights to the other developers on this team.

Given that Marcus's budget will permit him to add only Barry or Kim to this project team, but not both, he must anticipate how to manage the choice of each person.

- A. Assume that Marcus chooses Barry Filmore to join the team. Complete the risk assessment entry Marcus should make following that decision. Include the following elements:

- Risk description
- Likelihood of risk
- Potential impact on project
- Ways to address this Risk

- B. Now assume that Marcus chooses Kim Danville to join the team. Complete the risk assessment entry Marcus should make following that decision. Include the same elements as shown in part A.

*Note: If using the flipped classroom model, students should study the staffing and risk assessment material before class. In class, divide the class into small groups. Assign half the groups to answer part A and half to answer part B. Each group should prepare a risk assessment. Then, put the groups assigned to part A together and the groups assigned to part B together. Have the two larger groups compile a consolidated risk assessment from all subgroups. Have each group present their risk assessment to the class. Have the class vote on the best option for Marcus to take based on the risk assessment of each option.*

3. The IS department of the Dobbs Company currently has 10 system development projects underway. These projects are summarized here:

Project ID	Project Size	Strategic Importance	Project Risk
A	Large	High	High
B	Medium	Medium	High
C	Large	High	Medium
D	Small	Low	Low
E	Small	Medium	High
F	Medium	Medium	High
G	Small	Low	Low
H	Medium	Medium	Low
I	Small	Medium	Medium
J	Medium	High	High

Generally, large-sized projects have a multiyear time frame; medium-sized projects have a 6- to 18-month time frame; small-sized projects have a time frame of 6 months or less.

The IS Steering Committee is currently evaluating project proposals for the upcoming year. The committee has a budget of \$250,000 to allocate to new projects. Using the System

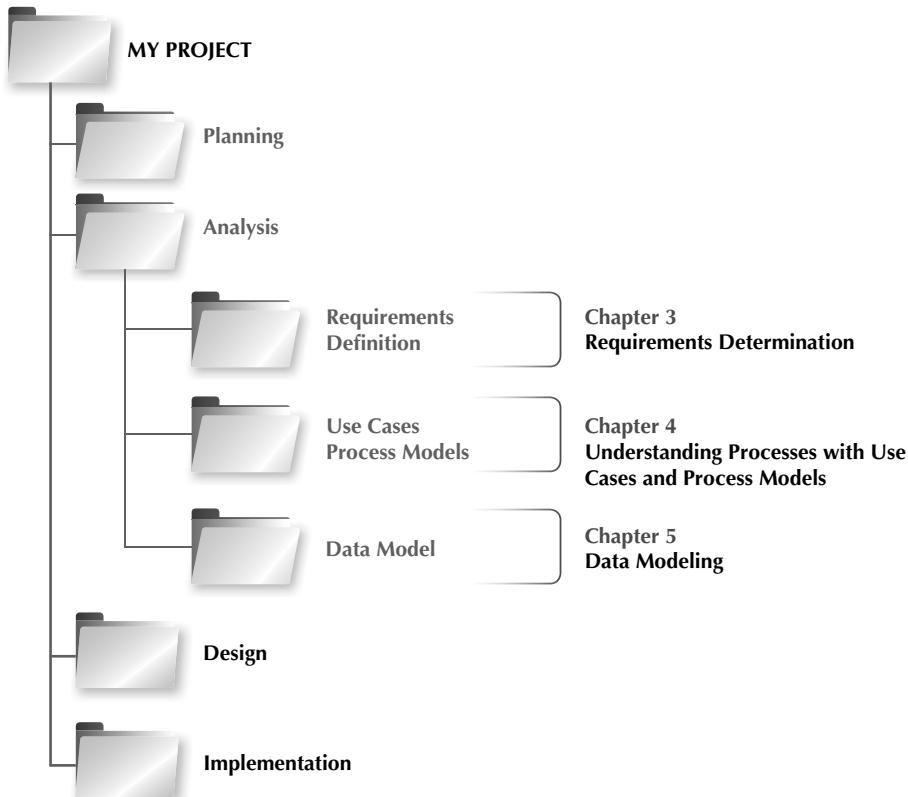
Request and Preliminary Feasibility Analysis for these proposals, their essential characteristics are summarized in the table here. Which projects should be selected? Why?

Project ID	Project Size	Strategic Importance	Project Risk	Cost
AA	Large	High	High	\$200,000
BB	Medium	High	High	100,000
CC	Medium	Low	Low	50,000
DD	Medium	Medium	High	100,000
EE	Medium	Medium	Medium	50,000
FF	Small	Medium	Medium	25,000
GG	Small	Low	Low	25,000
HH	Small	Medium	High	25,000

*Note: If using the flipped classroom model, students should study the project selection material before class. In class, have each student develop their own decision on project choice individually. Then divide the class into small groups. Each group should discuss their individual project choices and arrive at a group consensus. Then, compile a comprehensive set of choices from all groups and discuss the differences in choices.*

# ANALYSIS PHASE

PART 2



The Analysis Phase answers the questions of who uses the system, what the system does, and where and when it is used.

All deliverables are combined into the System Proposal. Management uses the System Proposal to decide if the project should continue.

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# Requirements Determination

# 3

## ANALYSIS

### TASK CHECKLIST

- Use requirements elicitation techniques (interview, JAD session, questionnaire, document analysis, or observation).
- Apply requirements analysis strategies as needed to discover underlying requirements.
- Develop requirements definition.
- Develop use cases.
- Develop data flow diagrams.
- Develop entity relationship model.
- Normalize entity relationship model.

During the analysis phase, the analyst determines the functional requirements for the new system. This chapter begins by describing the analysis phase and its primary deliverable, the system proposal. The concept of a requirement is explained, and several categories of requirements are defined. The purpose and structure of the requirements definition statement is outlined. Techniques to elicit requirements are discussed, including interviews, joint application development (JAD) sessions, questionnaires, document analysis, and observation. Finally, several requirements analysis strategies are described to help the analyst discover requirements.

### OBJECTIVES

- Explain the analysis phase of the SDLC.
- Describe the content and purpose of the requirements definition statement.
- Classify requirements correctly as business, user, functional, or nonfunctional requirements.
- Employ the requirement elicitation techniques of interviews, JAD sessions, questionnaires, document analysis, and observation.
- Define the role that each requirement elicitation technique plays in determining requirements.
- Describe several analysis strategies that can help the analyst discover requirements.

## Introduction

Part 2 of this textbook focuses on the analysis phase of the SDLC. The work performed in the analysis phase involves expanding the vision described in the system request into a thorough, detailed understanding of exactly what the new system needs to do. As the detailed understanding of what the new system must do evolves, those details will be expressed and documented in several ways, including a detailed requirements definition statement (this chapter), use cases and a process model (Chapter 4), and a data model (Chapter 5). Although the structure of a textbook requires that these topics be presented sequentially, in practice, the systems analyst uses all of the tools and techniques discussed in Chapters 3 through 5 throughout the analysis phase to define, clarify, and document the requirements for the new system.

## The Analysis Phase

The analysis phase is so named because the term **analysis** refers to breaking a whole into its parts with the intent of understanding the parts' nature, function, and interrelationships. In the context of the SDLC, the outputs of the planning phase (the system request, feasibility study, and project plan), outline the business goals for the new system, define the project's scope, assess project feasibility, and provide the initial work plan. These planning phase deliverables are the key inputs into the analysis phase. In the analysis phase, the systems analyst works extensively with the business users of the new system to understand their needs from the new system.

The basic process of *analysis* involves three steps:

- Understand the existing situation (the **as-is system**).
- Identify improvements.
- Define requirements for the new system (the **to-be system**).

Sometimes the first step (i.e., understanding the as-is system) is skipped or done in a limited manner. This happens when no current system exists, if the existing system and processes are irrelevant to the future system, or if the project team is using a RAD or agile development methodology in which the as-is system is not emphasized. Traditional methods such as waterfall and parallel development (see Chapter 2) typically allot significant time to understanding the as-is system and identifying improvements before moving to capture requirements for the to-be system. Newer RAD and agile methodologies, such as iterative development, system prototyping, throwaway prototyping, and extreme programming (see Chapter 2), focus almost exclusively on improvements and the to-be system requirements, and they devote little time for investigating the current as-is system. Experience shows that it is useful to study the current situation whenever possible. The insights gained from reviewing the existing system can be quite valuable to the project team.

To move the users "from here to there," an analyst needs strong **critical thinking skills**. Critical thinking is the ability to recognize strengths and weaknesses and recast an idea in an improved form. These skills are needed for the analyst to understand issues and develop new and improved business processes that are supported by information system technologies. These skills are essential in examining the results of requirements discovery and translating those requirements into a concept for the new system.

As an example, let us say that a user states that the new system should "eliminate inventory stock-outs." While this might be a worthy project goal, the analyst needs to think about it critically to formulate the statement in terms of useful requirements. The analyst could first have the users think about circumstances leading to stock-outs (e.g., supplier orders are not placed in a timely way), and then describe the actual business practices that lead to these circumstances

(e.g., on-hand inventory levels are updated only once a week; delays occur in identifying the best supply source for the items; delays occur in receiving approval of the supply order, etc.). By focusing on correcting these issues, the team is in a better position to develop new business processes that address these concerns. The new requirements will then be based on the issues that truly need to be fixed. In this case, the requirements might include, in part:

- The system will update on-hand inventory levels twice per day.
- The system will produce an out-of-stock notification immediately when an item quantity on hand reaches the item reorder point.
- The system will include a recommended supplier with every out-of-stock notification.
- The system will produce a supply purchase order that is sent to the appropriate manager for approval.
- The system will send an approved supply purchase order to the supplier via secure electronic communication.

As this example demonstrates, it is unrealistic to expect the true requirements to be delivered on a silver platter during a few conversations with the business users. The analyst must be prepared to dig into the situation and discover requirements. This is rarely an easy process.

A number of techniques and tools can be used by the analyst to facilitate this process of discovering requirements. In this chapter, we will describe those techniques and tools so that you can learn how to use them during the analysis phase. We will also explain the critical role that requirements play in defining the new system. As mentioned above, the analyst also employs additional tools during this phase to clarify and document the to-be system concept. These tools are the subject of complete chapters: use cases and the process model (Chapter 4) and the data model (Chapter 5).

The final deliverable of the analysis phase is the **system proposal**, a document compiling the detailed requirements definition statement, use cases, process models, and data model together with a revised feasibility analysis and work plan. At the conclusion of the analysis phase, the system proposal is presented to the approval committee, usually in the form of a system **walk-through**. The goal of the walk-through is to explain the system in moderate detail so that the users, managers, and key decision makers clearly understand it, can identify any needed modifications, and are able to decide about whether the project should continue. Before moving into the design phase, the project's **business value** should be reviewed to ensure it remains positive. If approved, the system proposal components (requirements definition, use cases, process model, and data model) are used as inputs to the steps in the design phase, which further refine them and define in much more detail how the system will be built.

The line between the analysis and design phases is very blurry because the deliverables created in the analysis phase are really the first step in the design of the new system. Many of the major design decisions for the new system are found in the analysis deliverables. In fact, a better name for the analysis phase would really be “analysis and initial design,” but because this name is rather long and because most organizations simply call this phase “analysis,” we will, too. Nonetheless, it is important to remember that the deliverables from the analysis phase are really the first step in the design of the new system.

In many ways, determining requirements is the single-most critical aspect of the entire SDLC. Although many factors contribute to the failure of systems development projects, failing to determine the correct requirements is a primary cause.<sup>1</sup> A 2014 survey of IT executive managers found

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<sup>1</sup>For example, see Kweku Ewusi-Mensah, *Software Development Failures: Anatomy of Failed Projects*, MIT Press, 2003.

that “clear statements of requirements” was one of the top project success factors (following “user involvement” and “executive management support”).<sup>2</sup> Therefore, analysts should devote considerable attention to the work performed in the analysis phase. It is here that the major elements of the system first begin to emerge. If the requirements are later found to be incorrect or incomplete, significant rework may be needed, adding substantial time and cost to the project.

During requirements determination, the to-be system concept is easy to change because little work has been done yet. As the system moves through the subsequent SDLC phases (design and implementation), it becomes harder and harder to return to requirements determination and make major changes because of all the rework that is involved. Therefore, the iterative approaches of many RAD and agile methodologies are so effective—small batches of requirements can be identified and implemented in incremental stages, allowing the overall system to change and evolve over time. Also, methodologies such as the V-model stress that tests for the system should be defined while the requirements are being defined. That way, testing is not just a last-minute, thrown-together process, but instead is based directly on the requirements of the system as they are being defined.

## Requirements Determination

**Requirements determination** is performed to transform the system request’s high-level statement of business requirements into a more detailed, precise list of what the new system must do to provide the needed value to the business. This detailed list of requirements is supported, confirmed, and clarified by the other activities of the analysis phase: creating use cases and building process and data models. We first explain what a requirement is and discuss the process of creating a requirements definition statement.

### What Is a Requirement?

A **requirement** is simply a statement of what the system must do or what characteristics it needs to have. During a systems development project, requirements are created that provide different perspectives. For example, we may describe what the business needs (**business requirements**); what the users need to do (**user requirements**); what the software should do (**functional requirements**); characteristics the system should have (**nonfunctional requirements**); and how the system should be built (**system requirements**). Although this list of requirement categories may seem intimidating at first, the categories merely reflect the purpose of the requirements and the stage in the SDLC in which they are defined.

We have already discussed the creation of the systems request in the planning phase of the SDLC. In the systems request, there are statements that describe the reasons for proposing the systems development project. These statements reflect the business requirements that this system, if built, will fulfill. These business requirements help define the overall goals of the system and help clarify the contributions it will make to the organization’s success. Examples of business requirements include: “Provide product search capabilities,” “Produce performance reports,” “Provide accurate project status reports,” and “Provide account access to mobile customers.” When the systems development project is complete, success will be measured by evaluating whether the stated business requirements have been achieved; therefore, they provide the overall direction for the project.

During the analysis phase, requirements are written from the perspective of the business, and they focus on *what* the system needs to do to satisfy business user needs. A good starting place

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<sup>2</sup>The Standish Report (2014).

### YOUR TURN 3-1 || Identifying Requirements

One of the most common mistakes made by new analysts is to confuse functional and nonfunctional requirements. Pretend that you received the following list of requirements for a sales system:

Requirements for the proposed system:

The system should . . .

1. be accessible to Web users.
2. include the company standard logo and color scheme.
3. restrict access to profitability information.
4. include actual and budgeted cost information.
5. provide management reports.
6. include sales information that is updated at least daily.
7. have 2-second maximum response time for predefined queries and 10-minute maximum response time for ad hoc queries.

8. include information from all company subsidiaries.
9. print subsidiary reports in the primary language of the subsidiary.
10. provide monthly rankings of salesperson performance.

#### Questions

1. Which requirements are functional business requirements? Provide two additional examples.
2. Which requirements are nonfunctional business requirements? What kind of nonfunctional requirements are they? Provide two additional examples.

is to concentrate on what the user really needs to accomplish with the system to fulfill a needed job or task. These user requirements describe tasks that the users perform as an integral part of the business' operations, such as: "Schedule a client appointment"; "Place a new customer order"; "Re-order inventory"; "Determine available credit"; and "Reconcile supplier shipment." Use cases (discussed in Chapter 4) are tools used to clarify the steps involved in performing these user tasks. By understanding what the user needs to do to complete a task, the analyst can then determine ways in which the new system can support the users' needs.

The system's functional requirements evolve from understanding how the new system can support user needs. A functional requirement relates directly to a process the system should perform as a part of supporting a user task and/or information it should provide as the user is performing a task. The International Institute of Business Analysis (IIBA) defines functional requirements as "the product capabilities, or things that a product must do for its users."<sup>3</sup> Functional requirements begin to define how the system will support the user in completing a task. For example, assume the user requirement is "Schedule a client appointment." The functional requirements associated with that task include: "Find available openings matching client availability," "Select desired appointment," "Record appointment," and "Confirm appointment." Notice how these functional requirements expand upon the user's task to describe capabilities and functions that the system will need to include, allowing the user to complete the task.

As the analyst works with the business users of the system to discover user and functional requirements, the user may reveal processes that will be needed or information that will be needed. For example, as shown in Figure 3-1, the user may state "The system must retain customer order history for 3 years" (an information need). The analyst should probe for the reasoning behind this statement, such as "The system should allow registered customers to review their own order history for the past 3 years" (a process need). Similarly, the user may state "The system should check incoming customer orders for inventory availability" (a process need). An alert analyst will recognize the related information need, "The system should maintain real-time inventory levels at all warehouses." All of these requirements are necessary to fully understand the system that is being developed.

<sup>3</sup>International Institute of Business Analysis, *Guide to Business Analysis Body of Knowledge® (BABOK®)*, 2nd ed.

Functional Requirement	Description	Examples
Process-oriented	A process the system must perform; a process the system must do	<ul style="list-style-type: none"> <li>The system must allow registered customers to review their own order history for the past 3 years.</li> <li>The system must check incoming customer orders for inventory availability.</li> <li>The system should allow students to view a course schedule while registering for classes.</li> </ul>
Information-oriented	Information the system must contain	<ul style="list-style-type: none"> <li>The system must retain customer order history for 3 years.</li> <li>The system must include real-time inventory levels at all warehouses.</li> <li>The system must include budgeted and actual sales and expense amounts for the current year and 3 previous years.</li> </ul>

**FIGURE 3-1** Functional requirements.

Process models (Chapter 4) are used to explain the relationship of functions/processes to the system users, how the functions/processes relate to each other, how data are entered and produced by functions/processes, and how functions/processes create and use stored data. Process models help clarify the software components that will be needed to accomplish the functional requirements. In addition, the information-oriented functional requirements begin to define the data that must be kept track of to accomplish the user tasks. The data component of the system is defined in the data model (Chapter 5).

User, functional, and nonfunctional requirements identified in the analysis phase will flow into the design phase, where they evolve to become more technical, describing *how* the system will be implemented. Requirements in the design phase reflect the developer's perspective, and they usually are called *system requirements*. These requirements focus on describing how to create the software product that will be produced from the project. More will be said about system requirements in Part 3 of the textbook.

Before we continue, we want to stress that it can be difficult to draw a black-and-white dividing line between these requirement categories. To add to the confusion, some companies use the terms interchangeably and do not distinguish between the types of requirements at all. The important thing to remember is that a requirement is a statement of what the system must do. The focus of requirements changes over time as the project moves from planning to analysis to design to implementation. Requirements evolve from broad overall goal statements to detailed statements of the business capabilities that a system should provide to detailed technical statements of the way in which the capabilities will be implemented in the new system.

The final category of requirements is *nonfunctional requirements*. The IIBA defines this group of requirements as “the quality attributes, design, and implementation constraints, and external interfaces which a product must have.”<sup>4</sup> Although the term “nonfunctional” is not very descriptive, this requirement category includes important behavioral properties that the system must have. For example, the ability to access the system through a mobile device would be considered a nonfunctional requirement. Nonfunctional requirements take center stage in the design phase when decisions are made about the user interface, the hardware and software, and the system’s underlying architecture. (We will revisit them in Chapter 7.) Many of these requirements will be discovered during interactions with users in the analysis phase, however, and should be recorded as they are identified.

Figure 3-2 lists different kinds of nonfunctional requirements and examples of each kind. Notice that the nonfunctional requirements describe a variety of system characteristics: operational, performance, security, and cultural and political. These characteristics do not describe

<sup>4</sup>Ibid.

Nonfunctional Requirement	Description	Examples
Operational	The physical and technical environments in which the system will operate	<ul style="list-style-type: none"> <li>The system will run on Android mobile devices.</li> <li>The system should be able to integrate with the existing inventory system.</li> <li>The system should be compatible with any Web browser.</li> </ul>
Performance	The speed, capacity, and reliability of the system	<ul style="list-style-type: none"> <li>Any interaction between the user and the system should not exceed 2 seconds.</li> <li>The system downloads new status parameters within 5 minutes of a change.</li> <li>The system should be available for use 24 hours per day, 365 days per year.</li> <li>The system supports 300 simultaneous users from 9–11 a.m.; 150 simultaneous users at all other times.</li> </ul>
Security	Who has authorized access to the system under what circumstances	<ul style="list-style-type: none"> <li>Only direct managers can see staff personnel records.</li> <li>Technicians can see only their own work assignments.</li> <li>The system includes all available safeguards from viruses, worms, Trojan horses, etc.</li> </ul>
Cultural and Political	Cultural and political factors and legal requirements that affect the system	<ul style="list-style-type: none"> <li>The system should be able to distinguish between US currency and currency from other nations.</li> <li>Company policy is to buy computers only from Dell.</li> <li>Country managers are permitted to authorize custom user interfaces within their units.</li> <li>Personal information is protected in compliance with the Data Protection Act.</li> </ul>

Source: The Atlantic Systems Guild, [www.systemsguild.com](http://www.systemsguild.com)

**FIGURE 3-2** Nonfunctional requirements.

business processes or information, but they are particularly important in understanding what the final system should be like. For example, the project team needs to know whether a system must be highly secure, requires sub-second response time, or must reach a multilingual customer base. The goal at this point is to identify any major issues. In addition, if the methodology in use includes developing test plans during analysis, then these requirements will be important in establishing testing benchmarks that will be needed later.

### CONCEPTS IN ACTION 3-A

### What Can Happen If You Ignore Nonfunctional Requirements

I once worked on a consulting project in which my manager created a requirements definition without listing nonfunctional requirements. The project was then estimated based on the requirements definition and sold to the client for \$5,000. In my manager's mind, the system that we would build for the client would be a very simple standalone system running on current technology. It should not take more than a week to analyze, design, and build.

Unfortunately, the client had other ideas. They wanted the system to be used by many people in three different departments, and they wanted the ability for any number of people to work on the system concurrently. The technology they had in

place was antiquated, but nonetheless they wanted the system to run effectively on the existing equipment. Because we did not set the project scope properly by including our assumptions about nonfunctional requirements in the requirements definition, we basically had to do whatever they wanted.

The capabilities they wanted took weeks to design and program. The project ended up taking 4 months, and the final project cost was \$250,000. Our company had to pick up the tab for everything except the agreed upon \$5,000. This was by far the most frustrating project situation I ever experienced. *Barbara Wixom*

## The Process of Determining Requirements

Both business and IT perspectives are needed to determine requirements during the analysis phase. Systems analysts may not understand the true business needs of the users, while the business users may not be aware of promising new technologies. Therefore, the most effective approach is to have both businesspeople and analysts working together to determine requirements. In fact, the analysis phase involves significant interactions with people who have an interest in the new system (often called stakeholders). One of the first tasks for the analyst is to identify the primary sources of requirements, including the project sponsor, project champion(s), all users of the system (both direct and indirect), and possibly others. It is important that all user perspectives are included.

The analyst must also consider how best to elicit the requirements from the stakeholders. There are a variety of elicitation techniques that can be used to acquire information, including interviews, questionnaires, observation, joint application development (JAD, as it is more commonly known), and document analysis. We will discuss these techniques in the next section. The information gathered by these techniques is critically analyzed and used to craft the requirements definition statement. The analyst works with the entire project team and the business users to verify, change, and complete the list of requirements and, if necessary, to prioritize the importance of the requirements that are identified. During this process, use cases, process models, and data models may be used to clarify and define the ideas for the new system. This process continues throughout the analysis phase, and the requirements definition evolves over time as new requirements are identified and as the project moves into later phases of the SDLC.

Beware, the evolution of the requirements definition must be carefully managed. Keeping the requirements list tight and focused is a key to project success. The project team cannot keep adding new items to the requirements definition or the system will keep growing and growing and never gets finished. Instead, the project team carefully identifies requirements and evaluates which ones fit within the system scope. When a requirement reflects a real business need but is not within the scope of the current system or current release, it should be evaluated in terms of its importance and impact on time and budget. It may be that the requirement is essential enough to add to the current project, along with appropriate adjustments to the project budget and time frame. We should expect that the requirements may change. However, sometimes requirements are deferred or given a low priority. The management of requirements (and system scope) is one of the hardest parts of managing a project!

## The Requirements Definition Statement

The requirements definition statement—usually just called the **requirements definition**—is a straightforward text report that simply lists the functional and nonfunctional requirements in an outline format. For example, the DrōnTeq IS department prepared a requirements definition statement when the current Drone Sales System was developed several years ago. Figure 3-3 shows the partial contents of this document.

As shown in Figure 3-3, requirements are typically identified by numbering. Assigning unique numbers enables each requirement to be tracked through the entire development process. For clarity, the requirements are typically grouped into functional and nonfunctional groupings. Then, within each of those groups, they are classified further by the type of requirement or by business area.

Sometimes, requirements are prioritized on the requirements definition statement. They can be ranked as having “high,” “medium,” or “low” importance in the new system, or they can be labeled with the version of the system that will address the requirement (e.g., release 1, release 2, release 3). This practice is particularly important with RAD methodologies that deliver requirements in batches by developing incremental versions of the system.

## Functional Requirements

### 1. Drone Sales Management

- 1.1 The system will enable drone sales order creation.
- 1.2 The system will determine if the requested drone model is in stock.
- 1.3 The system will display all available customization options for a specific drone.
- 1.4 The system will create a final approved sales order.
- 1.5 The system will prepare a shop work order based on final approved configuration.
- 1.6 The system will process a customer deposit.
- 1.7 The system will process a customer final payment.

### 2. Drone Customization Shop Management

- 2.1 The system will send a Parts Request for needed drone components on an order to Drone Inventory department.
- 2.2 The system enables assignment of a work order to a specific technician.
- 2.3 The system records the arrival of component parts as they arrive in the shop parts room.
- 2.4 The system notifies the assigned technician when all required components are available for a shop work order.
- 2.5 The system enables the technician to record work start time on a work order.
- 2.6 The system allows the technician to record when shop order is completed.
- 2.7 The system notifies the customer of the order completion.

## Nonfunctional Requirements

### 1. Operational

- 1.1 The system should run on tablet devices to be used by salespeople.
- 1.2 The system should be Web-based and run on any browser.
- 1.3 The system should connect to printers wirelessly.

### 2. Performance

- 2.1 The system should provide response times of 3 seconds or less.
- 2.2 The system should be updated with new customer orders and drone inventory levels every 5 minutes.

### 3. Security

- 3.1 Customer accounts should be maintained securely.
- 3.2 Only the customization shop supervisor may approve non-standard customizing options.
- 3.3 Use of each tablet device should be restricted to the salesperson to whom it is assigned.

### 4. Cultural and Political

- 4.1 Company policy says that all computer equipment is purchased from Dell.

**FIGURE 3-3**  
Sample requirements definition.

The most *obvious* purpose of the requirements definition is to provide a clear statement of what the new system should do in order to achieve the system vision described in the system request. The use cases, process models, and data models provide additional explanatory content in different formats. A critically *important* purpose of the requirements definition, however, is to define the scope of the system. The document describes to the analysts exactly what the final system needs to do. In addition, it serves to establish the users' expectations for the system.

If and when discrepancies or misunderstandings arise, the document serves as a resource for clarification.

## Requirements Elicitation Techniques

An analyst is very much like a detective (and business users sometimes are like elusive suspects). He or she knows that there is a problem to be solved and therefore must look for clues that uncover the solution. Unfortunately, the clues are not always obvious (and often are missed), so the analyst needs to notice details, talk with witnesses, and follow leads, just as Sherlock Holmes would have done. The best analysts will thoroughly search for requirements using a variety of techniques and make sure that the current business processes and the needs for the new system are well understood before moving into design. You do not want to discover later that you have key requirements wrong—surprises like this late in the SDLC can cause all kinds of problems.

### Requirements Elicitation in Practice

Before discussing the five requirements elicitation techniques in detail, a few practical tips are in order. First, the analyst should recognize that important side effects of the requirements definition process include building political support for the project and establishing trust and rapport between the project team and the ultimate users of the system. Every contact and interaction between the analyst and a potential business user or manager is an opportunity to generate interest, enthusiasm, and commitment to the project. Therefore, the analyst should be prepared to make good use of these opportunities as they arise during the requirements definition process.

Second, the analyst should carefully determine who is included in the requirements definition process. The choice to include (or exclude) someone is significant; involving someone in the process implies that the analyst views that person as an important resource and values his or her opinions. You *must* include all the key **stakeholders** (the people who can affect the system or who will be affected by the system). This might include managers, employees, staff members, and even some customers and suppliers. Also, be sensitive to the fact that some people may have significant influence within the organization even if they do not rank high in the formal organizational hierarchy. If you do not involve a key person, that individual may feel slighted, causing problems during implementation (e.g., saying “I could have told them this might happen, but they didn’t ask *me!*”).

Finally, do everything possible to respect the time commitment that you are asking the participants to make. The best way to do this is to be fully prepared and to make good use of all the types of requirements elicitation techniques. Although, as we will see, interviewing is the most used technique, other indirect methods may help the analyst develop a basic understanding of the business domain so that the direct techniques are more productive. In general, a useful strategy for the analyst to employ is to begin requirements gathering by interviewing senior managers to gain an understanding of the project and get the “big picture.” These preliminary interviews can then be followed by document analysis and, possibly, observation of business processes to learn more about the business domain, the vocabulary, and the as-is system. More interviews may then follow to collect the rest of the information needed to understand the as-is system.

In our experience, identifying improvements is commonly done through JAD sessions because these sessions enable the analysts, users, and other key stakeholders to work together and create a shared understanding of the possibilities for the to-be system. Occasionally, these JAD sessions are followed by questionnaires sent to a much larger group of users or potential users to get a broad range of opinions. The concept for the to-be system is frequently developed through interviews with senior managers, followed by JAD sessions with users of all levels, to make sure that the key requirements of the new system are well understood.

In this section, we focus on the five most common requirements elicitation techniques: interviews, JAD sessions, questionnaires, document analysis, and observation.

## Interviews

The **interview** is the most common requirements elicitation technique. After all, it is natural—usually if you need to know something, you ask someone. In general, interviews are conducted one on one (one interviewer and one interviewee), but sometimes, due to time constraints, several people are interviewed at the same time. There are five basic steps to the interview process: selecting interviewees, designing interview questions, preparing for the interview, conducting the interview, and postinterview follow-up.<sup>5</sup>

### Selecting Interviewees

An **interview schedule** should be created, listing who will be interviewed, the purpose of the interview, and where and when it will take place (Figure 3-4). The people who appear on the interview schedule are selected based on the analyst's information needs. The project sponsor, key business users, and other members of the project team can help the analyst find the best candidates to provide important information about requirements.

People at different levels of the organization will have different viewpoints on the business area. It is important to include both managers who oversee the processes and staff who perform the processes to gain both high-level and low-level perspectives. Also, the kinds of interview subjects that you need may change over time. For example, at the start of the project, the analyst has a limited understanding of the as-is business process. It is common to begin by interviewing one or two senior managers to get a strategic view and then move to mid-level managers who can provide broad, overarching information about the business process and the expected role of the system being developed. Once the analyst has a good understanding of the big picture, lower-level managers and staff members can fill in the exact details of how the process works. Like most other things about systems analysis, this is an iterative process—starting with senior managers, moving to mid-level managers, then staff members, back to mid-level managers, and so on, depending upon what information is needed along the way.

It is quite common for the list of interviewees to grow, often by 50–75%. As you interview people, you likely will identify more information that is needed and additional people who can provide the information.

Name	Position	Purpose of Interview	Meeting
Andria McClellan	Director, Accounting	Strategic vision for new accounting system	Mon, March 1 8:00–10:00 a.m.
Jennifer Draper	Manager, Accounts Receivable	Current problems with accounts receivable process; future goals	Mon, March 1 2:00–3:15 p.m.
Mark Goodin	Manager, Accounts Payable	Current problems with accounts payable process; future goals	Mon, March 1 4:00–5:15 p.m.
Anne Asher	Supervisor, Data Entry	Accounts receivable and payable processes	Wed, March 3 10:00–11:00 a.m.
Fernando Merce	Data Entry Clerk	Accounts receivable and payable processes	Wed, March 3 1:00–3:00 p.m.

**FIGURE 3-4** Sample interview schedule.

<sup>5</sup>A good book on interviewing is Brian James, *The Systems Analysis Interview*, Manchester: NCC Blackwell, 1989.

### **CONCEPTS IN ACTION 3-B** || Selecting the Wrong People

In 1990, I led a consulting team for a major development project for the US Army. The goal was to replace eight existing systems used on virtually every Army base across the United States. The as-is process and data models for these systems had been built, and our job was to identify improvement opportunities and develop to-be process models for each of the eight systems.

For the first system, we selected a group of mid-level managers (captains and majors) recommended by their commanders as being the experts in the system under construction.

These individuals were the first- and second-line managers of the business function. The individuals were experts at managing the process but did not know the exact details of how the process worked. The resulting to-be process model was very general and nonspecific. *Alan Dennis*

*Question*

1. Suppose you oversaw the project. Create an interview schedule for the remaining seven projects.

### Designing Interview Questions

Typically, interviews include closed-ended questions, open-ended questions, and probing questions. **Closed-ended questions** require a specific answer. You can think of them as being like multiple-choice or arithmetic questions on an exam (Figure 3-5). Closed-ended questions are used when the analyst is looking for specific, precise information (e.g., how many credit card requests are received per day). In general, precise questions are best. For example, rather than asking “Do you handle a lot of requests?” it is better to ask, “How many requests do you process per day?”

Closed-ended questions enable analysts to control the interview and obtain the information they need. However, these types of questions do not uncover *why* the answer is the way it is, nor do they uncover information that the interviewer does not think to ask ahead of time.

**Open-ended questions** seek a more wide-ranging response from the interviewee. They are similar in many ways to essay questions that you might find on an exam. (See Figure 3-5 for examples.) Open-ended questions are designed to gather rich information and give the interviewee more control over the information that is revealed during the interview. Sometimes the subjects the interviewee chooses to discuss uncover information that is just as important as the answer (e.g., if the interviewee talks only about other departments when asked about problems, it may suggest that he or she is reluctant to admit his or her own department’s problems).

**Probing questions** follow up on what has just been discussed so that the interviewer can learn more. They encourage the interviewee to expand on or to confirm information from a previous

Types of Questions	Examples
Closed-Ended Questions	<ul style="list-style-type: none"> <li>• How many telephone orders are received per day?</li> <li>• How do customers place orders?</li> <li>• What information is missing from the monthly sales report?</li> </ul>
Open-Ended Questions	<ul style="list-style-type: none"> <li>• What do you think about the way invoices are currently processed?</li> <li>• What are some of the problems you face on a daily basis?</li> <li>• What are some of the improvements you would like to see in the way invoices are processed?</li> </ul>
Probing Questions	<ul style="list-style-type: none"> <li>• Why?</li> <li>• Can you give me an example?</li> <li>• Can you explain that in a bit more detail?</li> </ul>

**FIGURE 3-5** Three types of questions.

response, and they are a signal that the interviewer is listening and interested in the topic under discussion. Many beginning analysts avoid probing questions because they are afraid that the interviewee might be offended at being challenged or because they believe it shows that they did not understand what the interviewee said. When done politely, probing questions can be a powerful tool in requirements discovery.

In general, you should not ask questions about information that is readily available from other sources. For example, rather than asking what information is used to perform to a task, it is more effective to show the interviewee a form or report (see document analysis later) and ask what information on it is used. This helps focus the interviewee on the task and saves time, because he or she does not need to describe the information in detail—he or she just needs to point it out on the form or report.

Your interview questions should anticipate the type of information the interviewee is likely to know. Managers are often somewhat removed from the details of daily business processes and so might be unable to answer questions about them, whereas lower-level staff members could readily respond. Conversely, lower-level employees may not be able to answer broad, policy-oriented questions, while managers could. Since no one wants to appear ignorant, avoid confounding your interviewees with questions outside their areas of knowledge.

No type of question is better than another, and usually a combination of questions is used during an interview. At the initial stage of an IS development project the as-is process can be unclear, so the interview process begins with **unstructured interviews**, interviews that seek a broad and roughly defined set of information. In this case, the interviewer has a general sense of the information needed, but few closed-ended questions to ask. These are the most challenging interviews to conduct because they require the interviewer to ask open-ended questions and probe for important information “on the fly.”

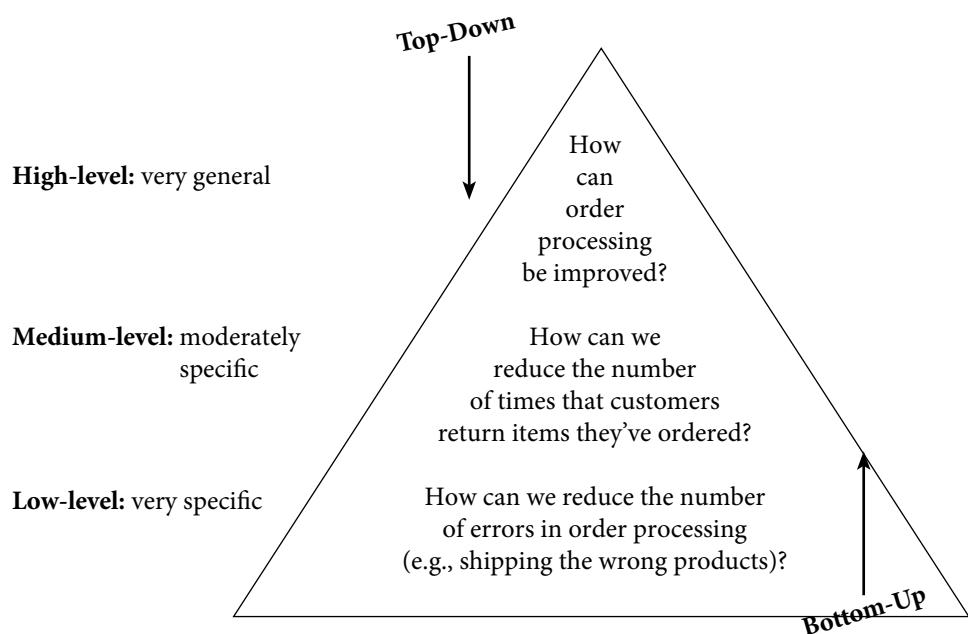
As the project progresses, the analyst comes to understand the business process much better, and he or she needs specific information about how business processes are performed (e.g., exactly how a customer credit request is approved). At this time, the analyst conducts **structured interviews** in which specific sets of questions are developed prior to the interviews. There usually are more closed-ended questions in a structured interview than in the unstructured approach.

No matter what kind of interview is being conducted, interview questions must be organized into a logical sequence so that the interview flows well. For example, when trying to gather information about the current business process, the analyst will find it useful to move in logical order through the process or from the most important issues to the least important.

There are two fundamental approaches to organizing the interview questions: top-down or bottom-up; see Figure 3-6. With the **top-down interview**, the interviewer starts with broad, general issues and gradually works towards more specific ones. With the **bottom-up interview**, the interviewer starts with specific questions and moves to broad questions. In practice, analysts mix the two approaches, starting with broad general issues, moving to specific questions, and then back to general issues.

The top-down approach is an appropriate strategy for most interviews. (It is certainly the most common approach.) The top-down approach enables the interviewee to become accustomed to the topic before he or she needs to provide specifics. It also enables the interviewer to understand the issues before moving to the details, because the interviewer may not have sufficient information at the start of the interview to ask specific questions. Perhaps most importantly, the top-down approach enables the interviewee to raise a set of big-picture issues before becoming enmeshed in details, so the interviewer is less likely to miss important issues.

One case in which the bottom-up strategy may be preferred is when the analyst already has gathered a lot of information about issues and just needs to fill in some holes with details. Or



**FIGURE 3-6**  
Top-down and  
bottom-up questioning  
strategies.

bottom-up may be appropriate if lower-level staff members feel threatened or are unable to answer high-level questions. For example, “How can we improve customer service?” may be too broad a question for a customer service clerk, whereas a specific question is readily answerable (e.g., “How can we speed up customer returns?”). In any event, all interviews should begin with noncontroversial questions first and then gradually move into more contentious issues after the interviewer has developed some rapport with the interviewee.

### Preparing for the Interview

It is important to prepare for the interview in the same way that you would prepare to give a presentation. You should have an interview plan that lists the topics/issues that you will ask in the appropriate order; anticipates possible answers and provides how you will follow up with them; and identifies segues between related topics. Figure 3-7 shows a typical format for an interview plan and illustrates a helpful way to prepare for an upcoming interview focused on ideas for consultant performance measures from a human resources director.

Confirm the areas in which the interviewee has knowledge so you do not ask questions that he or she cannot answer. Review the topic areas, the questions, and the interview plan, and clearly decide which ones have the greatest priority in case you run out of time.

In general, structured interviews with closed-ended questions take more time to prepare than unstructured interviews. So, some beginning analysts prefer unstructured interviews, thinking that they can “wing it.” This is extremely dangerous and often counterproductive because any information not gathered in the first interview would have to be obtained by follow-up efforts, and most people do not like to be interviewed repeatedly about the same issues.

Be sure to prepare the interviewee as well. When you schedule the interview, inform the interviewee of the reason for the interview and the areas you will be discussing far enough in advance so that he or she has time to think about the issues and organize his or her thoughts. This is particularly important when you are an outsider to the organization and for interviewing lower-level employees who often are not asked for their opinions and who may be uncertain about why you are interviewing them.

**Interviewee:** Paul H., Human Resources Director

**Interview purpose/goals:** Understand Paul's requirements for the new performance measures and reporting of measures to be used to monitor the staff of consultants.

**Interview strategy:** Top-down design. Begin with general discussion of his need for performance measures. Ask open-ended questions about what he is currently missing from the performance measures he has. Explore ideas for new metrics he thinks would help him. Finish with closed-ended questions to confirm understanding of specific metric ideas. Discuss any other areas of concern such as confidentiality issues.

**Behavioral issues to expect (if any are known):** Expect Paul to be supportive and enthusiastic. He has been asking for these improvements for quite a while.

**Interview topics and outline:**

General introduction, discuss purpose and goals of meeting

Understand his current approach to understanding the performance of consulting staff

- Current metrics (if any)
- How are these metrics collected and reported (if at all)?
- How are these measures inadequate?

Ideas for improved performance measures

- Develop list of items he thinks would be useful
- Understand the underlying data source of each item—need to know exactly what each one means and how the relevant data is or could be collected

How would he like to receive these metrics?

- Regular reports? If so, how often?
- Dashboard?
- Queries?

Other concerns:

- Are metrics confidential?
  - If yes, identify which ones are confidential and who is allowed to view them.
  - If no, how widely shared will these metrics be?

**FIGURE 3-7**

Sample interview preparation form. A template for this figure is available on the student website.

## Conducting the Interview

When you start the interview, the first goal is to build rapport with the interviewee so that he or she trusts you and is willing to tell you the whole truth, not just give the answers that he or she thinks you want. You should appear to be professional and an unbiased, independent seeker of information. The interview should start with an explanation of why you are there and why you have chosen to interview the person, and then move into your planned interview questions.

It is critical to carefully record all the information that the interviewee provides. In our experience, the best approach is to take careful notes—write down *everything* the interviewee says, even if it does not appear immediately relevant. Do not be afraid to ask the person to slow down or to pause while you write, because this is a clear indication that the interviewee's information is important to you. One potentially controversial issue is whether to tape-record the interview. Recording ensures that you do not miss important points, but it can be intimidating for the interviewee. Most organizations have policies or generally accepted practices about the recording of interviews, so find out what they are before you start an interview. If you are worried about missing information and cannot tape the interview, then bring along a second person to take detailed notes.

As the interview progresses, it is important that you understand the issues that are discussed. If you do not understand something, be sure to ask. Do not be afraid to ask “dumb questions,” because the only thing worse than appearing “dumb” is to *be* “dumb” by not understanding something that you could have cleared up by questioning. If you do not understand something during the interview, you certainly will not understand it afterward. Try to recognize and define jargon and be sure to clarify jargon you do not understand. One good strategy to increase your

understanding during an interview is to periodically summarize the key points that the interviewee is communicating. This avoids misunderstandings and demonstrates that you are listening.

Finally, be sure to separate facts from opinion. The interviewee may say, for example, “We process too many credit card requests.” This is an opinion, and it is useful to follow this up with a probing question requesting support for the statement (e.g., “Oh, how many do you process in a day?”). It is helpful to check the facts because any differences between the facts and the interviewee’s opinions can point out key areas for improvement. Suppose that the interviewee complains about a high or increasing number of errors, but the logs show that errors have been decreasing. This suggests that errors are viewed as a particularly important problem that should be addressed by the new system, even if they are declining.

As the interview draws to a close, be sure to give the interviewee time to ask questions or provide information that he or she thinks is important but was not part of your interview plan. In most cases, the interviewee will have no additional concerns or information, but in some cases, this will lead to unanticipated, but important information. Likewise, it can be useful to ask the interviewee if there are other people who should be interviewed. Make sure that the interview ends on time. (If necessary, omit some topics or plan to schedule another interview.)

As a last step in the interview, briefly explain what will happen next (see the Post-interview Follow-up section). You do not want to prematurely promise certain features in the new system or a specific delivery date, but you do want to reassure the interviewee that his or her time was well spent and extremely helpful to the project.

Beginning systems analysts may naively think that conducting an interview is as easy as conversing with a friend. Unfortunately, this is almost never true. Interviewees often are not able or willing to hand over the needed information in a neat, organized fashion. In some cases, they may not want to share what they know at all. Analysts should hone their interpersonal skills to improve their interviewing success. (See Practical Tip 3-1.)



### PRACTICAL TIP 3-1

### Developing Interpersonal Skills

**Interpersonal skills** are those that enable you to develop rapport with others, and they are very important for interviewing. They help you to communicate with others effectively. Some people develop good interpersonal skills at an early age; they simply seem to know how to communicate and interact with others. Other people are less “lucky” and need to work hard to develop their skills.

Interpersonal skills, like most skills, can be learned. Here are some tips:

- **Don’t worry, be happy.** Happy people radiate confidence and project their feelings on others. Try interviewing someone while smiling and then interviewing someone else while frowning and see what happens!
- **Pay attention.** Pay attention to what the other person is saying (which is harder than you might think). See how many times you catch yourself with your mind on something other than the conversation at hand.
- **Summarize key points.** At the end of each major theme or idea that someone explains, you should repeat the key

points back to the speaker (e.g., “Let me make sure I understand. The key issues are . . .”). This demonstrates that you consider the information important—and also forces you to pay attention. (You cannot repeat what you did not hear.)

- **Be succinct.** When you speak, be succinct. The goal in interviewing (and in much of life) is to learn, not to impress. The more you speak, the less time you give to others.
- **Be honest.** Answer all questions truthfully, and if you do not know the answer, say so.
- **Watch body language (yours and theirs).** The way a person sits or stands conveys much information. In general, a person who is interested in what you are saying sits or leans forward, makes eye contact, and often touches his or her face. A person leaning away from you or with an arm over the back of a chair is disinterested. Crossed arms indicate defensiveness or uncertainty, while “steeping” (sitting with hands raised in front of the body with fingertips touching) indicates a feeling of superiority.

## Post-interview Follow-up

After the interview is over, the analyst needs to prepare an **interview report** that describes the information from the interview (Figure 3-8). The report contains **interview notes**, information that was collected over the course of the interview and is summarized in a useful format. In general, the interview report should be written within 48 hours of the interview, because the longer you wait, the more likely you are to forget information.

Often, the interview report is sent to the interviewee with a request to read it and inform the analyst of clarifications or updates. Make sure the interviewee is convinced that you genuinely want his or her corrections to the report. Usually, there are few changes, but the need for any significant changes suggests that a second interview will be required. Never distribute someone's information without prior approval.

### INTERVIEW NOTES APPROVED BY: LINDA ESTEY

**Person Interviewed:** Linda Estey,

Director, Human Resources

**Interviewer:** Barbara Wixom

**Purpose of Interview:**

- Understand reports produced for human resources (HR) by the current system.
- Determine information requirements for future system.

**Summary of Interview:**

- Sample reports of all current HR reports are attached to this report. The information that is not used and missing information are noted on the reports.
- Two biggest problems with the current system are:
  1. The data are too old. (The HR department needs information within 2 days of month end; currently information is provided to them after a 3-week delay.)
  2. The data are of poor quality. (Often, reports must be reconciled with the HR departmental database.)
- The most common data errors found in the current system include incorrect job-level information and missing salary information.

**Open Items:**

- Get current employee roster report from Mary Skudrna (extension 4355).
- Verify calculations used to determine vacation time with Mary Skudrna.
- Schedule interview with Jim Wack (extension 2337) regarding the reasons for data quality problems.

**Detailed Notes:** See attached transcript.

**FIGURE 3-8**  
Interview report.  
A template for this figure is available on the student website.

### CONCEPTS IN ACTION 3-C

### The Reluctant Interviewee

Early in my consulting career, I was sent to a client organization with the goal of interviewing the only person in the organization who knew how the accounts receivable system worked and developing documentation for that system (non-existent at the time). The interviewee was on time, polite, and told me absolutely nothing of value about the accounts receivable system, despite my best efforts over several

interview sessions. Eventually, my manager called me off this project, and our attempt to document this system was abandoned. *Roberta Roth*

*Questions*

1. Why do you suppose the interviewee was so uncooperative?
2. Can you think of any ways to avoid this failed outcome?

## Joint Application Development (JAD)

**Joint Application Development (JAD)** is an information gathering technique that allows the project team, users, and management to work together to identify requirements for the system. IBM developed the JAD technique in the late 1970s, and it is an especially useful method for collecting information from users.<sup>6</sup> Capers Jones claims that JAD can reduce scope creep by 50%, and it prevents the requirements for a system from being too specific or too vague, both of which can cause trouble during later stages of the SDLC.<sup>7</sup> JAD is a structured process in which 10–20 users meet under the direction of a **facilitator** skilled in JAD techniques. The facilitator is a person who sets the meeting agenda and guides the discussion but does not join in the discussion as a participant. He or she does not provide ideas or opinions on the topics under discussion and remains neutral during the session. The facilitator must be an expert in both group process techniques and systems analysis and design techniques. Ideally, the facilitator will have experience with the business under discussion. In many cases, the JAD facilitator is an outside consultant. Organizations may not have a regular day-to-day need for JAD or e-JAD expertise and developing and maintaining this expertise in-house can be expensive. One or two **scribes** assist the facilitator by recording notes, making copies, and so on. Often, the scribes will use computers and CASE tools to record information as the JAD session proceeds.

The JAD group meets for several hours, several days, or several weeks until all the issues have been discussed and the needed information is collected. Most JAD sessions take place in a specially prepared meeting room, away from the participants' offices, so that they are not interrupted. The meeting room is usually arranged in a U shape so that all participants can easily see each other (Figure 3-9). At the front of the room (the open part of the "U"), there is a whiteboard, flip chart, and/or projector for use by the facilitator, who leads the discussion.

One problem with JAD is that it suffers from the traditional problems associated with groups: sometimes people are reluctant to challenge the opinions of others (particularly their boss), a few people often dominate the discussion, and not everyone participates. In a 15-member group, for example, if everyone participates equally, then each person can talk for only 4 minutes each hour and must listen for the remaining 56 minutes—not a very efficient way to collect information.

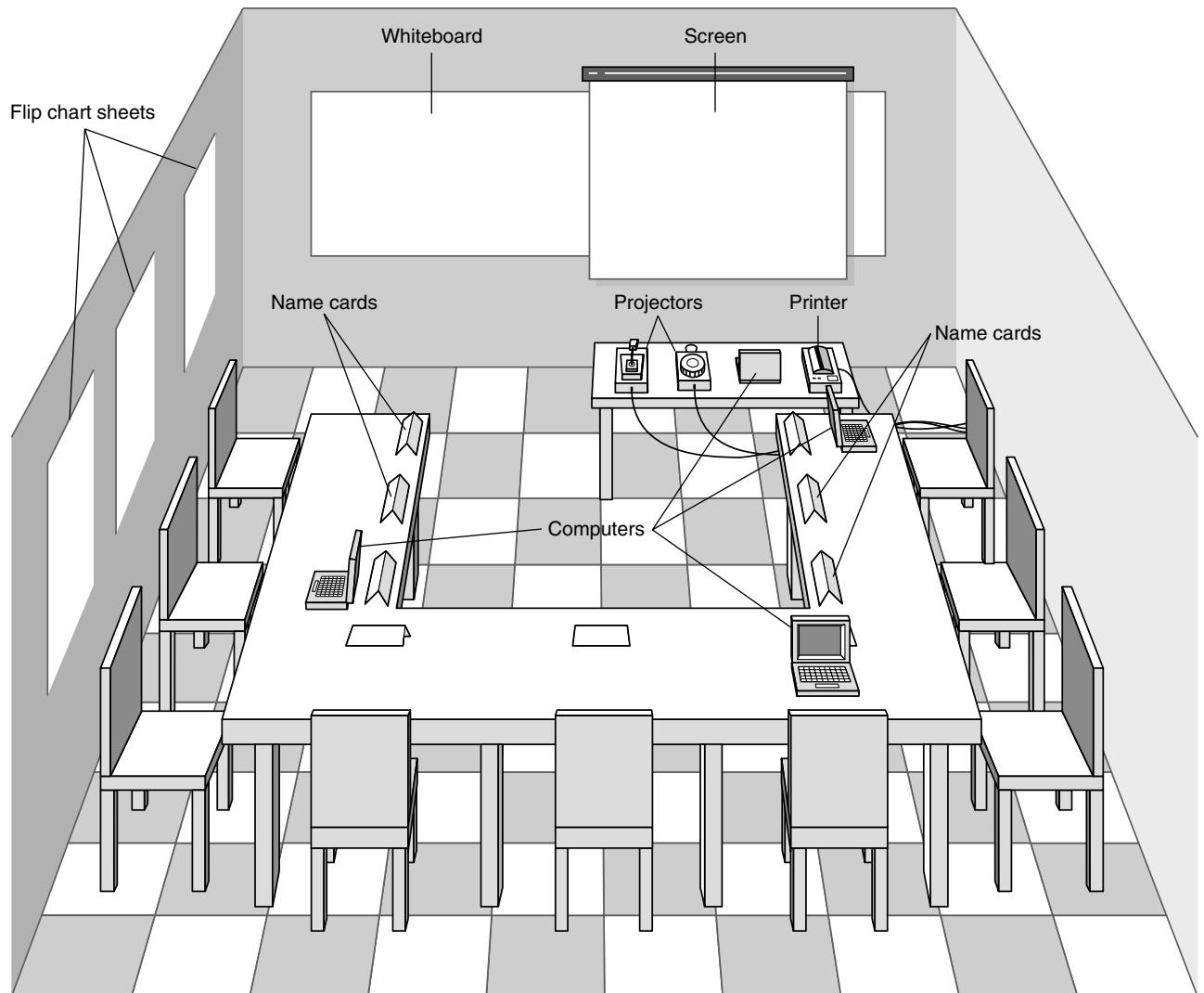
**Electronic JAD, or e-JAD**, attempts to overcome these problems by the use of groupware. In an e-JAD meeting room, each participant uses special software on a networked computer to anonymously submit ideas, view all ideas generated by the group, and rate and rank ideas through voting. The facilitator uses the electronic tools of the e-JAD system to guide the group process, for maintaining anonymity and enabling the group to focus on each idea's merits and not the power or rank of the person who contributed the idea. In this way, all participants can contribute at the same time, without fear of reprisal from people with differing opinions. Initial research suggests that e-JAD can reduce the time required to run JAD sessions by 50–80%.<sup>8</sup>

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<sup>6</sup>More information on JAD can be found in J. Wood and D. Silver, *Joint Application Development*, New York: John Wiley & Sons, 1989; and Alan Cline, "Joint Application Development for Requirements Collection and Management," <http://www.carolla.com/wp-jad.htm>.

<sup>7</sup>See Kevin Strehlo, "Catching up with the Jones and 'Requirement' Creep," *InfoWorld*, July 29, 1996; and Kevin Strehlo, "The Makings of a Happy Customer: Specifying Project X," *Infoworld*, November 11, 1996.

<sup>8</sup>For more information on e-JAD, see A. R. Dennis, G. S. Hayes, and R. M. Daniels, "Business Process Modeling with Groupware," *Journal of Management Information Systems*, 1999, 15(4); 115–142.



**FIGURE 3-9** Joint application development meeting room.

### YOUR TURN 3-2

### Interview Practice

Interviewing is not as simple as it first appears. Select two people from class to go to the front of the room to demonstrate an interview. (This also can be done in groups.) Have one person be the interviewer, and the other the interviewee. The interviewer should conduct a 5-minute interview regarding the school course registration system. Gather information about the existing system and how the system can be improved. If there is time, repeat with another pair.

#### Questions

1. Describe the body language of the interview pair.
2. What kind of interview was conducted?
3. What kinds of questions were asked?
4. What was done well? How could the interview be improved?

## Selecting Participants

Selecting JAD participants is done in the same basic way as selecting interview participants. Participants are selected on the basis of information they can contribute, to provide a broad mix of organizational levels, and to build political support for the new system. The need for all JAD participants to be away from their offices at the same time can be a major problem. The office may need to be closed or run with a skeleton staff until the JAD sessions are complete.

Ideally, the participants who are released from regular duties to attend the JAD sessions should be the very best people in that business unit. However, without strong management support, JAD sessions can fail, because those selected to attend the JAD session are people who are less likely to be missed (i.e., the least competent people).

## Designing the JAD Session

JAD sessions can run from as little as a half day to several weeks, depending upon the size and scope of the project. In our experience, most JAD sessions tend to last 5–10 days spread over a 3-week period. Most e-JAD sessions tend to last 1–4 days in a 1-week period.

As with interviewing, JAD success depends upon a careful plan. JAD sessions usually are designed and structured along the same principles as interviews. Most JAD sessions are designed to collect specific information from users, and this requires the development of a set of questions before the meeting. A difference between JAD and interviewing is that all JAD sessions are structured—they *must* be carefully planned. In general, closed-ended questions are seldom used, because they do not spark the open and frank discussion that is typical of JAD. In our experience, it is better to proceed top-down in JAD sessions when gathering information. Typically, 30 minutes is allocated to each separate agenda item, and frequent breaks are scheduled throughout the day because participants tire easily.

## Preparing for the JAD Session

As with interviewing, it is important to prepare the analysts and participants for the JAD session. Because the sessions can go beyond the depth of a typical interview and usually are conducted off-site, participants can be more concerned about how to prepare. It is important that the participants understand what is expected of them. If the goal of the JAD session, for example, is to develop an understanding of the current system, then participants can bring procedure manuals and documents with them. If the goal is to identify improvements for a system, then they can think about how they would improve the system prior to the JAD session.

## Conducting the JAD Session

Most JAD sessions try to follow a formal agenda, and most have formal **ground rules** that define appropriate behavior. Common ground rules include following the schedule, respecting others' opinions, accepting disagreement, and ensuring that only one person talks at a time.

The role of the JAD facilitator can be challenging. Many participants come to the JAD session with strong feelings about the system being discussed. Channeling these feelings so that the session moves forward in a positive direction and getting participants to recognize and accept—but not necessarily agree on—opinions and situations different from their own requires significant expertise in systems analysis and design, JAD, and interpersonal skills. Few systems analysts attempt to facilitate JAD sessions without being trained in JAD techniques, and most apprentice with a skilled JAD facilitator before they attempt to lead their first session.

The JAD facilitator performs three key functions. First, he or she ensures that the group sticks to the agenda. The only reason to digress from the agenda is when it becomes clear to the facilitator, project leader, and project sponsor that the JAD session has produced some new

information that is unexpected and requires the JAD session (and perhaps the project) to move in a new direction. When participants attempt to divert the discussion away from the agenda, the facilitator must be firm, but polite, in leading the discussion back to the agenda and getting the group back on track.

Second, the facilitator must help the group understand the technical terms and jargon that surround the system development process and help the participants understand the specific analysis techniques used. Participants are experts in their business area, but they probably are not experts in systems analysis. The facilitator must therefore minimize the learning required and teach participants how to effectively provide the right information.

Third, the facilitator records the group's input on a public display area, which can be a whiteboard, flip chart, or computer display. He or she structures the information that the group provides and helps the group recognize key issues and important solutions. Under no circumstance should the facilitator insert his or her opinions into the discussion. The facilitator *must* always remain neutral and simply help the group through the process. The moment the facilitator offers an opinion on an issue, the group will no longer see him or her as a neutral party, but rather as someone who could be attempting to sway the group into some predetermined solution.

However, this does not mean that the facilitator should not try to help the group resolve issues. For example, if two items appear to be the same to the facilitator, the facilitator should not say, "I think these may be similar." Instead, the facilitator should ask, "Are these similar?" If the group decides that they are, the facilitator can combine them and move on. However, if the group decides that they are not similar (despite what the facilitator believes), the facilitator should accept the decision and move on. The group is *always* right, and the facilitator has no opinion.

It is common for the JAD participants to make use of several tools during the JAD session to fully define the new system. Use cases may be created to describe how the users will interact with the new system. Prototypes are commonly created to understand the user interface or navigation through the system more fully. Process models can be constructed to understand the software that will be developed, while a data model can be used to describe the data that will be captured and maintained. The facilitator and the analysts on the project team should use every tool at their disposal to help the participants clarify and define their needs for the new system.

### Post-JAD Follow-Up

As with interviews, a **JAD post-session report** is prepared and circulated among session attendees. The post-session report is essentially the same as the interview report in Figure 3-8. Since the JAD sessions are longer and provide more information, it usually takes a week or two after the JAD session before the report is complete.

#### YOUR TURN 3-3

#### JAD Practice

Organize yourselves into groups of four to seven people and pick one person in each group to be the JAD facilitator. Using a blackboard, whiteboard, or flip chart, gather information about how the group performs some process (e.g., working on a class

assignment, making a sandwich, paying bills, getting to class). How did the JAD session go? Based on your experience, what are some pros and cons of using JAD in a real organization?

## Questionnaires

A **questionnaire** is a set of written questions for obtaining information from individuals. Questionnaires often are used when there are many people from whom information and opinions are needed. In our experience, questionnaires are commonly used for systems intended for use outside of the organization (e.g., by customers or vendors) or for systems with business users spread across many geographic locations. Today, most questionnaires are being distributed in electronic form, either via e-mail or on the Web.

### Selecting Participants

As with interviews and JAD sessions, the first step is to select the individuals to whom the questionnaire will be sent. Typically, a **sample**, or subset, of people are selected who are representative of the entire group. Sampling guidelines are discussed in most statistics books, and most business schools include courses that cover the topic, so we will not discuss it here. The important point in selecting a sample, however, is to realize that not everyone who receives a questionnaire will complete it. On average, only 30–50% of paper and e-mail questionnaires are returned. Response rates for Web-based questionnaires tend to be significantly lower (often, only 5–30%).

### Designing the Questionnaire

Developing good questions is critical for questionnaires because the information on a questionnaire cannot be immediately clarified for a confused respondent. Questions on questionnaires must be very clearly written and must leave little room for misunderstanding; therefore, closed-ended questions tend to be most common. Questions must enable the analyst to clearly separate facts from opinions. Opinion questions often ask the respondent the extent to which they agree or disagree (e.g., “Are network problems common?”), while factual questions seek more precise values (e.g., “How often does a network problem occur: once an hour, once a day, or once a week?”). See Figure 3-10 for guidelines on questionnaire design.

Perhaps the most obvious issue—but one that is sometimes overlooked—is to have a clear understanding of how the information collected from the questionnaire will be analyzed and used. You must address this issue before you distribute the questionnaire because it is too late afterward.

Questions should be relatively consistent in style so that the respondent does not have to read instructions for each question before answering it. It is generally a good practice to organize related questions together to make them simpler to answer. Some experts suggest that questionnaires should start with questions important to respondents, so that the questionnaire immediately grabs their interest and induces them to answer it. Perhaps the most important step is to have several colleagues review the questionnaire and then pretest it with a few people drawn from the groups to whom it will be sent. It is surprising how often seemingly simple questions can be misunderstood.

- Begin with nonthreatening and interesting questions.
- Group items into logically coherent sections.
- Do not put important items at the very end of the questionnaire.
- Do not crowd a page with too many items.
- Avoid abbreviations.
- Avoid biased or suggestive items or terms.
- Number questions to avoid confusion.
- Pretest the questionnaire to identify confusing questions.
- Provide anonymity to respondents.

**FIGURE 3-10**  
Good questionnaire design.



### PRACTICAL TIP 3-2 || Managing Problems in JAD Sessions

I have run more than a hundred JAD sessions and have learned several standard “facilitator tricks.” Here are some common problems and some ways to deal with them.

- **Reducing domination.** The facilitator should ensure that no one person dominates the group discussion. The only way to deal with someone who dominates is head on. During a break, approach the person, thank him or her for their insightful comments, and ask them to help you make sure that others also participate.
- **Encouraging noncontributors.** Drawing out people who have participated very little is challenging because you want to bring them into the conversation so that they will contribute again. The best approach is to ask a direct factual question that you are *certain* they can answer. And it helps to ask the question using some repetition to give them time to think. For example, “Pat, I know you’ve worked shipping orders a long time. You’ve probably been in the Shipping Department longer than anyone else. Could you help us understand exactly what happens when an order is received in Shipping?”
- **Side discussions.** Sometimes participants engage in side conversations and fail to pay attention to the group. The easiest solution is simply to walk close to the people and continue to facilitate right in front of them. Few people will continue a side conversation when you are 2 feet from them, and the entire group’s attention is on you and them.
- **Agenda merry-go-round.** The merry-go-round occurs when a group member keeps returning to the same issue every few minutes and will not let go. One solution is to let the person have 5 minutes to ramble on about the issue while you carefully write down every point on a flip chart or computer file. This flip chart or file is then posted conspicuously on the wall. When the person brings up the issue again, you interrupt them, walk to the paper, and ask them what to add. If they mention something already on the list, you quickly interrupt, point out that it is there, and ask what other information to add. Do not let them repeat the same point but write any new information.
- **Violent agreement.** Some of the worst disagreements occur when participants really agree on the issues but do not realize that they agree because they are using different terms. An example is arguing whether a glass is half empty or half full; they agree on the facts but cannot agree on the words. In this case, the facilitator has to translate the terms into different words and find common ground, so the parties recognize that they really agree.
- **Unresolved conflict.** In some cases, participants do not agree and cannot understand how to determine what alternatives are better. You can help by structuring the issue. Ask for criteria by which the group will identify a good alternative (e.g., “Suppose this idea really did improve customer service. How would I recognize the improved customer service?”). Then once you have a list of criteria, ask the group to assess the alternatives using them.
- **True conflict.** Sometimes, despite every attempt, participants just cannot agree on an issue. The solution is to postpone the discussion and move on. Document the issue as an “open issue” and list it prominently on a flip chart. Have the group return to the issue hours later. Often the issue will resolve itself by then and you have not wasted time on it. If the issue cannot be resolved later, move it to the list of issues to be decided by the project sponsor or some other more senior member of management.
- **Use humor.** Humor is one of the most powerful tools a facilitator has and thus must be used judiciously. The best JAD humor is always in context; never tell jokes but take the opportunity to find the humor in the situation. *Alan Dennis*

### Administering the Questionnaire

The key issue in administering the questionnaire is getting participants to complete the questionnaire and send it back. Dozens of marketing research books have been written about ways to improve response rates. Commonly used techniques include clearly explaining why the questionnaire is being conducted and why the respondent has been selected; stating a date by which the questionnaire is to be returned; offering an inducement to complete the questionnaire (e.g., a free pen); and offering to supply a summary of the questionnaire responses. Systems analysts have

**YOUR TURN 3-4****Questionnaire Practice**

Organize yourselves into small groups. Have each person develop a short questionnaire to collect information about the frequency in which group members perform some process (e.g., working on a class assignment, making a sandwich, paying bills, getting to class), how long it takes them, how they feel about the process, and opportunities for improving the process.

Once everyone has completed his or her questionnaire, ask each member to pass it to the right and then complete his or her neighbor's questionnaire. Pass the questionnaire back to the creator when it is completed.

*Questions*

1. How did the questionnaire you completed differ from the one you created?
2. What are the strengths of each questionnaire?
3. How would you analyze the survey results if you had received 50 responses?
4. What would you change about the questionnaire that you developed?

additional techniques to improve responses rates inside the organization, such as personally handing out the questionnaire and personally contacting those who have not returned them after a week or two, as well as requesting the respondents' supervisors to administer the questionnaires in a group meeting.

**Questionnaire Follow-Up**

It is helpful to process the returned questionnaires and develop a questionnaire report soon after the questionnaire deadline. This ensures that the analysis process proceeds in a timely fashion and that respondents who requested copies of the results receive them promptly.

**Document Analysis**

Project teams often use **document analysis** to understand the as-is system. Under ideal circumstances, the project team that developed the existing system will have produced documentation, which was then updated by all subsequent projects. In this case, the project team can start by reviewing the documentation and examining the system itself.

Unfortunately, most systems are not well documented, because project teams fail to document their projects along the way, and when the projects are over, there is no time to go back and document. Therefore, there may not be much technical documentation about the current system available, or it may not contain updated information about recent system changes. However, there are many helpful documents that do exist in the organization: paper reports, memorandums, policy manuals, user training manuals, organization charts, and forms. Problem reports filed by the system users can be another rich source of information about issues with the existing system.

But these documents (forms, reports, policy manuals, organization charts) only tell part of the story. They represent the **formal system** that the organization uses. Quite often, the "real," or **informal system** differs from the formal one, and these differences, particularly large ones, give strong indications of what needs to be changed. For example, forms or reports that are never used likely should be eliminated. Likewise, boxes or questions on forms that are never filled in (or are used for other purposes) should be rethought. See Figure 3-11 for an example of how a document can be interpreted.

The most powerful indication that the system needs to be changed is when users create their own forms or add additional information to existing ones. Such changes clearly demonstrate the need for improvements to existing systems. Thus, it is useful to review both blank and completed

The customer made a mistake. This should be labeled **Owner's Name** to prevent confusion.

The staff had to add additional information about the type of animal and the animal's date of birth and gender. This information should be added to the new form in the to-be system.

**CENTRAL VETERINARY CLINIC  
Patient Information Card**

Name: Buffy Pat Smith

Pet's Name: Buffy Collie 7/6/17 Male

Address: 100 Central Court. Apartment 10

Toronto, Ontario K7L 3N6

Phone Number: 416- 555-3400 Cell: 416-567-1369

Do you have insurance: yes

Insurance Company: Pet's Mutual

Policy Number: KA-5493243

The customer did not include area code in the phone number. This should be made more clear.

The form does not allow for this fact. It should be added to the to-be system.

**FIGURE 3-11**  
Performing a document analysis.

### CONCEPTS IN ACTION 3-D || Publix Credit Card Forms

At my neighborhood Publix grocery store, the cashiers always handwrite the total amount of the charge on every credit card charge form, even though it is printed on the form. Why? Because the “back office” staff people who reconcile the cash in the cash drawers with the amount sold at the end of each shift find it hard to read the small print on the credit card forms. Writing in large print makes it easier for them to add the values up. However, cashiers sometimes make mistakes

and write the wrong amount on the forms, which causes problems. *Barbara Wixom*

#### Questions

1. What does the credit card charge form indicate about the existing system?
2. How can you make improvements with a new system?

forms to identify these deviations. Likewise, when users must access multiple reports to satisfy their information needs, it is a clear sign that new information or new information formats are needed.

## Observation

**Observation**, the act of watching processes being performed, is a powerful tool to gain insight into the as-is system. Observation enables the analyst to see the reality of a situation, rather than listening to others describe it in interviews or JAD sessions. Several research studies have shown that many managers really do not remember how they work and how they allocate their time. (Quick, how many hours did you spend last week on each of your courses?) Observation is a good way to check the validity of information gathered from other sources such as interviews and questionnaires.

In many ways, the analyst becomes an anthropologist as he or she walks through the organization and observes the business system as it functions. The goal is to keep a low profile, to not interrupt those working, and to not influence those being observed. Nonetheless, it is important to understand that what analysts observe may not be the normal day-to-day routine because people tend to be extremely careful in their behavior when they are being watched.<sup>9</sup> Even though normal practice may be to break formal organizational rules, the observer is unlikely to see this. (Remember how carefully you drove the last time a police car was behind you?) Thus, what you see may *not* be what you really want.

Observation is often used to supplement interview information. The location of a person's office and its furnishings gives clues as to their power and influence in the organization, and such clues can be used to support or refute information given in an interview. For example, an analyst might become skeptical of someone who claims to use the existing computer system extensively if the computer is never turned on while the analyst visits. In most cases, observation will support the information that users provide in interviews. When it does not, it is an important signal that extra care must be taken in analyzing the business system.

## Selecting the Appropriate Techniques

Each of the requirements elicitation techniques just discussed has strengths and weaknesses. No one technique is always better than the others, and in practice, most projects benefit from a combination of techniques. Thus, it is important to understand the strengths and weaknesses of each technique and when to use each (Figure 3-12). One issue not discussed is that of the analysts' experience. In general, document analysis and observation require the least amount of training, while JAD sessions are the most challenging.

### YOUR TURN 3-5

### Observation Practice

Visit the library at your college or university and observe how the book check-out process occurs. First, watch several students checking books out, and then check one out yourself. Prepare a brief summary report of your observations.

When you return to class, share your observations with others. You may notice that not all the reports present the same information. Why? How would the information be different had you used the interview or JAD technique?

<sup>9</sup>This illustrates the Hawthorne effect: an increase in worker productivity produced by the psychological stimulus of being singled out and made to feel important. See R. H. Frank and J. D. Kaul, "The Hawthorne Experiments: First Statistical Interpretation," *American Sociological Review*, 1978, 43: 623–643.

	<b>Interviews</b>	<b>Joint Application Design</b>	<b>Questionnaires</b>	<b>Document Analysis</b>	<b>Observation</b>
Type of information	As-is, improvements, to-be	As-is, improvements, to-be	As-is, improvements	As-is	As-is
Depth of information	High	High	Medium	Low	Low
Breadth of information	Low	Medium	High	High	Low
Integration of information	Low	High	Low	Low	Low
User involvement	Medium	High	Low	Low	Low
Cost	Medium	Low-Medium	Low	Low	Low-Medium

**FIGURE 3-12** Comparison of requirements elicitation techniques.

### Type of Information

The first characteristic is the type of information. Some techniques are more suited for use at different stages of the analysis process, whether understanding the as-is system, identifying improvements, or developing the to-be system. Interviews and JAD are commonly used in all three stages. In contrast, document analysis and observation usually are most helpful for understanding the as-is system, although they occasionally provide information about improvements. Questionnaires are often used to gather information about the as-is system, as well as general information about improvements.

### Depth of Information

The depth of information refers to how rich and detailed the information is that the technique usually produces and the extent to which the technique is useful at obtaining not only facts and opinions, but also an understanding of *why* those facts and opinions exist. Interviews and JAD sessions are especially useful at providing a good depth of rich and detailed information and helping the analyst to understand the reasons behind them. At the other extreme, document analysis and observation are useful for obtaining facts, but little beyond that. Questionnaires can provide a medium depth of information, soliciting both facts and opinions with little understanding of why.

### Breadth of Information

Breadth of information refers to the range of information and information sources that can be easily collected by that technique. Questionnaires and document analysis both are easily capable of soliciting a wide range of information from many information sources. In contrast, interviews and observation require the analyst to visit each information source individually and, therefore, take more time. JAD sessions are in the middle because many information sources are brought together at the same time.

### Integration of Information

One of the most challenging aspects of requirements gathering is the integration of information from different sources. Simply put, different people can provide conflicting information. Combining this information and attempting to resolve differences in opinions or facts is usually very time consuming because it means contacting each information source in turn, explaining the discrepancy, and attempting to refine the information. In many cases, the individual wrongly perceives that the analyst is challenging his or her information, when in fact the source of conflict is another user in the organization. This can make the user defensive and make it hard to resolve the differences.

All techniques suffer integration problems to some degree, but JAD sessions are designed to improve integration because all information is integrated when it is collected, not afterward. If two users provide conflicting information, the conflict becomes immediately obvious, as does the source of the conflict. The immediate integration of information is the single-most important benefit of JAD that distinguishes it from other techniques, and therefore many organizations use JAD for important projects.

### User Involvement

User involvement refers to the amount of time and energy the intended users of the new system must devote to the analysis process. It is generally agreed that, as users become more involved in the analysis process, the chance of success increases. However, user involvement can have a significant cost, and not all users are willing to contribute valuable time and energy. Questionnaires, document analysis, and observation place the least burden on users, while JAD sessions require the greatest effort.

### Cost

Cost is always an important consideration. In general, questionnaires, document analysis, and observation are low-cost techniques (although observation can be quite time consuming). The low cost does not imply that they are more or less effective than the other techniques. We regard interviews and JAD sessions as having moderate costs. In general, JAD sessions are much more expensive initially, because they require many users to be absent from their offices for significant periods, and they often involve highly paid consultants. However, JAD sessions significantly reduce the time spent in information integration and thus cost less in the long term.

## Requirements Analysis Strategies

The previous section discussed five essential techniques that analysts will use to interact with stakeholders in the system development project to elicit and define requirements. As we discussed earlier in the chapter, the analyst often must encourage the stakeholders to think critically about the needs for the new system and discover the true underlying requirements. In this section, we present several strategies that the analyst can employ with the stakeholders to accomplish this goal.

### Problem Analysis

The most straightforward (and probably the most common) requirements analysis strategy is **problem analysis**. Problem analysis means asking the users and managers to identify problems with the as-is system and to describe how to solve them in the to-be system. Most users have a good idea of the changes they would like to see, and most will be quite vocal about suggesting them. Most changes tend to solve problems rather than capitalize on opportunities, but that is possible, too. Improvements from problem analysis tend to be small and incremental (e.g., add a field to store the customer's cell phone number; provide a new report that currently does not exist).

This type of improvement often effectively improves a system's efficiency or ease of use. However, it often provides only minor improvements in business value—the new system is better than the old, but it may be hard to identify significant monetary benefits from the new system.

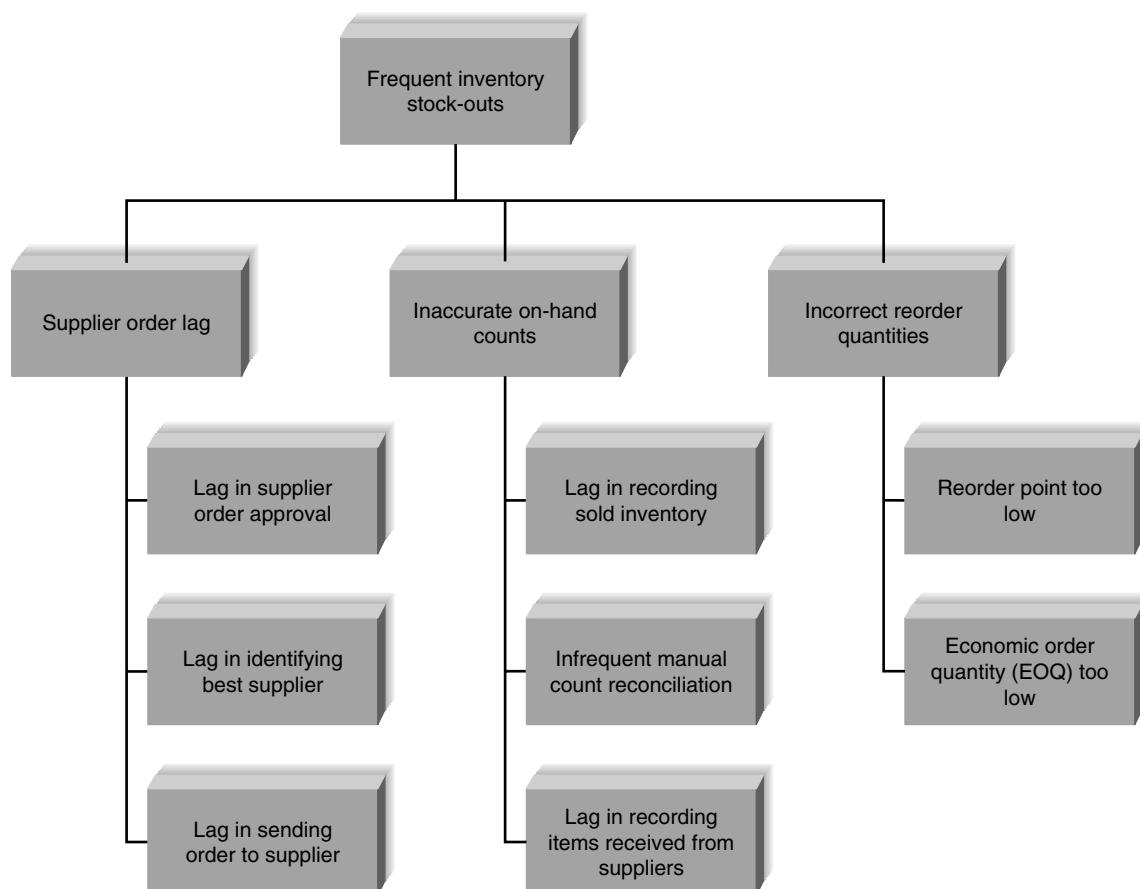
### Root Cause Analysis

The ideas produced by problem analysis tend to be *solutions* to problems. All solutions make assumptions about the nature of the problem, assumptions that may or may not be valid. In our

experience, users (and most people in general) tend to jump quickly to solutions without fully considering the nature of the problem. Sometimes the solutions are appropriate, but many times they address a **symptom** of the problem, not the true problem or **root cause** itself.<sup>10</sup>

For example, suppose that the users report that “inventory stock-outs happen frequently.” Inventory stock-outs are not good, of course, and one obvious way to reduce their occurrence is to increase the quantity of items kept in stock. This action incurs costs, however, so it is worthwhile to investigate the underlying cause of the frequent stock-outs instead of jumping to a quick-fix solution. The solutions that users propose (or systems that analysts consider) may address either symptoms or causes, but without careful analysis, it is difficult to tell which one. Finding out later that you have just spent millions of dollars and have not fixed the *true* underlying problem is a horrible feeling!

**Root cause analysis** focuses on problems first rather than solutions. The analyst starts by having the users generate a list of problems with the current system, then prioritizes the problems in order of importance. Starting with the most important, the users and/or analysts generate all possible root causes for the problem. As shown in Figure 3-13, the problem of “too frequent stock-outs” has several potential root causes (inaccurate on-hand counts; incorrect reorder points; lag in placing supplier orders). Each possible root cause is investigated, and additional



**FIGURE 3-13** Root cause analysis for inventory stock outs.

<sup>10</sup>Two good books that discuss the problems in finding the root causes to problems are E. M. Goldratt and J. Cox, *The Goal*, Croton-on-Hudson, NY: North River Press, 1986; and E. M. Goldratt, *The Haystack Syndrome*, Croton-on-Hudson, NY: North River Press, 1990.

root causes are identified. As Figure 3-13 shows, it is sometimes useful to display the potential root causes in a tree-like hierarchy. Ultimately, the investigation process reveals the true root cause or causes of the problem, enabling the team to design the system to correct the problem with the right solution. The key point in root cause analysis is to always challenge the obvious and dig into the problem deeply enough that the true underlying cause(s) is revealed.

## Duration Analysis

**Duration analysis** requires a detailed examination of the amount of time it takes to perform each process in the current as-is system. The analysts begin by determining the total amount of time it takes, on average, to perform a set of business processes for a typical input. They then time each of the individual steps (or subprocesses) in the business process. The time to complete the basic steps are then totaled and compared with the total for the overall process. A significant difference between the two—and, in our experiences, the total time often can be 10 or even 100 times longer than the sum of the parts—indicates that this part of the process is badly in need of a major overhaul.

For example, suppose that the analysts are working on a home mortgage system and discover that, on average, it takes 30 days for the bank to approve a mortgage. They then look at each of the basic steps in the process (e.g., data entry, credit check, title search, appraisal, etc.) and find that the total amount of time actually spent on each mortgage is about 8 hours. This is a strong indication that the overall process is badly broken because it takes 30 days to perform 1 day's work.

These problems likely occur because the process is badly fragmented. Many different people must perform different activities before the process is complete. In the mortgage example, the application probably sits on many peoples' desks for long periods of time before it is processed. Processes in which many different people work on small parts of the inputs are prime candidates for **process integration** or **parallelization**. Process integration means changing the fundamental process so that fewer people work on the input, which often requires changing the processes and retraining staff to perform a wider range of duties. Process parallelization means changing the process so that all the individual steps are performed at the same time. In the mortgage application example, there is probably no reason that the credit check cannot be performed at the same time as the appraisal and title check.

## Activity-Based Costing

**Activity-based costing** is a similar analysis that examines the cost of each major process or step in a business process rather than the time taken.<sup>11</sup> The analysts identify the costs associated with each of the basic functional steps or processes, identify the costliest processes, and focus their improvement efforts on them.

Assigning costs is conceptually simple. You just examine the direct cost of labor and materials for each input. Materials costs are easily assigned in a manufacturing process, while labor costs are usually calculated based on the amount of time spent on the input and the hourly cost of the staff. However, as you may recall from a managerial accounting course, there are indirect costs such as rent, depreciation, and so on that also can be included in activity costs.

## Informal Benchmarking

**Benchmarking** refers to studying how other organizations perform a business process to learn how your organization can do something better. Benchmarking helps the organization by introducing ideas that employees may never have considered, but that have the potential to add value.

<sup>11</sup>Many books have been written on activity-based costing. Useful ones include K. B. Burk and D. W. Webster, *Activity-Based Costing*, Fairfax, VA: American Management Systems, 1994; and D. T. Hicks, *Activity-Based Costing: Making It Work for Small and Mid-Sized Companies*, New York: John Wiley, 1998. The two books by Eli Goldratt mentioned previously (*The Goal* and *The Haystack Syndrome*) also offer unique insights into costing.

**Informal benchmarking** is common for “customer-facing” business processes (i.e., those processes that interact with the customer). With informal benchmarking, the managers and analysts think about other organizations, or visit them as customers to watch how the business process is performed. In many cases, the business studied may be a known leader in the industry or simply a related firm. For example, suppose that the team is developing a website for a car dealer. The project sponsor, key managers, and key team members would likely visit the website of competitors, those of others in the car industry (e.g., manufacturers, accessories suppliers), and those of other industries that have won awards for their websites.

## Outcome Analysis

**Outcome analysis** focuses on understanding the fundamental outcomes that provide value to customers. While these outcomes sound as though they should be obvious, they often are not. For example, suppose that you are an insurance company and one of your customers has just had a car accident. What is the fundamental outcome from the *customer's* perspective? Traditionally, insurance companies have answered this question by assuming that the customer wants to receive the insurance payment quickly. To the customer, however, the payment is only a *means* to the real outcome: a repaired car. The insurance company might benefit by extending its view of the business process past its traditional boundaries to include, not simply paying for repairs, but performing the repairs or contracting with an authorized body shop to do them.

With this approach, the system analysts encourage the managers and project sponsor to pretend that they are customers and to think carefully about what the organization's products and services enable the customers to do—and what they *could* enable the customer to do.

## Technology Analysis

Many major changes in business over the past decade have been enabled by new technologies. **Technology analysis** therefore starts by having the analysts and managers develop a list of important and interesting technologies. Then the group systematically identifies how each technology could be applied to the business process and identifies how the business would benefit.

For example, one useful technology might be the Internet. A manufacturer could develop an extranet application for its suppliers. Rather than ordering parts for its products, the manufacturer makes its production schedule available electronically to its suppliers, who ship the needed parts so that they arrive at the plant just in time. This saves significant costs because it eliminates the need for people to monitor the production schedule and issue purchase orders.

### CONCEPTS IN ACTION 3-E

### A Process in Need of Improvement

A group of executives from a Fortune 500 company used duration analysis to discuss their procurement process. Using a huge wall of Velcro and a handful of placards, a facilitator proceeded to map out the company's process for procuring a \$50 software upgrade. Having quantified the time, it took to complete each step, she then assigned costs based on the salaries of the employees involved. The 15-minute exercise left

the group stunned. Their procurement process had gotten so convoluted that it took 18 days, countless hours of paperwork, and nearly \$22,000 in people time to get the product ordered, received, and up and running on the requester's desktop.

Adapted from: “For Good Measure,” *CIO Magazine*, March 1, 1999, by Debby Young.

**CONCEPTS IN ACTION 3-F****IBM Credit**

IBM Credit was a wholly owned subsidiary of IBM responsible for financing mainframe computers sold by IBM. While some customers bought mainframes outright or obtained financing from other sources, financing computers provided significant additional profit.

When an IBM sales representative made a sale, he or she would immediately call IBM Credit to obtain a financing quote. The call was received by a credit officer who would record the information on a request form. The form would then be sent to the credit department to check the customer's credit status. This information would be recorded on the form, which was then sent to the business practices department, which would write a contract (sometimes reflecting changes requested by the customer). The form and the contract would then go to the pricing department, which used the credit information to establish an interest rate and record it on the form. The form and contract were then sent to the clerical group, where an administrator would prepare a cover letter quoting the interest rate and send the letter and contract via Federal Express to the customer.

The problem at IBM Credit was a major one. Getting a financing quote took anywhere from 4 to 8 days (6 days, on average), giving the customer time to rethink the order or find financing elsewhere. While the quote was being prepared, sales representatives would often call to find out where the quote was in the process, so that they could tell the customer when to expect it. However, no one at IBM Credit could answer the question, because the paper forms could be in any department and it was impossible to locate one without physically walking

through the departments and going through the piles of forms on everyone's desk.

IBM Credit examined the process and changed it so that each credit request was logged into a computer system so that each department could record an application's status as soon as it was completed and sent it to the next department. In this way, sales representatives could call the credit office and quickly learn the status of each application. IBM used some sophisticated management science queuing theory analysis to balance workloads and staff across the different departments so that no applications would be overloaded. They also introduced performance standards for each department (e.g., the pricing decision had to be completed within 1 day after that department received an application).

However, process times got worse, even though each department was achieving almost 100% compliance on its performance goals. After some investigation, managers found that when people got busy, they conveniently found errors that forced them to return the credit request to the previous department for correction, thereby removing it from their time measurements.

*Question*

1. What techniques can you use to identify improvements? Choose one technique and apply it to this situation—what improvements did you identify?

Adapted from: *Reengineering the Corporation*, New York: Harper Business, 1993, by M. Hammer and J. Champy.

## Activity Elimination

**Activity elimination** is exactly what it sounds like. The analysts and managers work together to identify how the organization could eliminate each and every activity in the business process, how the function could operate without it, and what effects are likely to occur. Initially, managers are reluctant to conclude that processes can be eliminated, but this is a “force-fit” exercise in that they must eliminate each activity. In some cases, the results are silly; nonetheless, participants must address each and every activity in the business process.

For example, in the home mortgage approval process discussed earlier, the managers and analysts would start by eliminating the first activity, entering the data into the mortgage company's computer. This leads to one of two obvious possibilities: (1) Eliminate the use of a computer system or (2) make someone else do the data entry (e.g., the customer, over the Web). They would then eliminate the next activity, the credit check. Silly, right? After all, making sure the applicant has good credit is critical in issuing a loan, isn't it? Not really. The real answer depends upon how many times the credit check identifies bad applications. If all or almost all applicants have good

credit and are seldom turned down by a credit check, then the cost of the credit check may not be worth the benefit of the few bad loans it prevents. Eliminating it may result in lower costs, even with the cost of bad loans, unless the number of applicants with poor credit greatly increases.

## Comparing Analysis Strategies

Each of the requirements analysis strategies discussed here has its own purpose. No one technique is inherently better than the others. Remember that an organization will likely have a wide range of projects in its portfolio; the requirements analysis strategy should be chosen to fit the nature of the project. Problem analysis and root cause analysis tend to be most useful in situations with a narrow focus where efficiency gains are sought. Duration analysis and activity-based costing strategies help the team find the most “broken” business processes so that those processes can be redesigned and improved. Outcome analysis, technology analysis, and informal benchmarking help the team think “outside the box” and are very useful when the team is trying to create completely new ways of accomplishing the business processes.

## Applying the Concepts at DrōnTeq

Once the DrōnTeq IS project approval committee approved the system request and feasibility analysis and the project was planned, the project team began performing analysis activities. These included gathering requirements by a variety of techniques and analyzing the requirements that were gathered. Some highlights of the project team’s activities are presented next.

### Eliciting and Analyzing Requirements

Since there is no existing Client Services system in place, Jiang did not spend much time on understanding the current system and processes. He did believe, however, that it would be important to understand the existing Web-based drone sales processes and systems already used by the Sales department to ensure consistency between the two systems. Two requirements-gathering techniques improved the understanding of the current systems and processes—document analysis and interviews.

First, the project team collected existing reports (e.g., sales forms, screen shots of the online sales screens) and system documentation (requirements definition (Figure 3-3), data model, process models) that explained the as-is Sales system. They were able to gather a good amount of information about the existing order processes and systems in this way. When questions arose, they conducted short interviews with the person who provided the documentation, for clarification.

Next, Jiang interviewed the senior analysts for the current Sales system to get a better understanding of how those systems worked. He asked whether they had any ideas for the new system, particularly some of the trickier aspects that he anticipated. Jiang also interviewed a contact from the ISP and the IT person who supported DrōnTeq’s current website—both provided information about the existing communications infrastructure at DrōnTeq and its Web capabilities.

Carmella suggested that the project team conduct several JAD sessions with Eric Chen and Peter Lyons (top DrōnTeq executives), Carmella Herrera, and several other senior managers in the new business unit, members of the IT staff, plus several drone pilots and potential clients who may use the new system. Together, the group would brainstorm and clarify the features desired in the Client Services system.

Jiang facilitated three JAD sessions that were conducted over the course of a week. Jiang's past facilitation experience helped the eight-person meetings run smoothly and stay on track. Because this project introduces new business processes, Jiang used the techniques of informal benchmarking, outcome analysis, and technology analysis in his JAD design. The JAD sessions generated ideas about how DrōnTeq could apply technology to provide value to the primary users of the Client Services system. Jiang had the group categorize the ideas into three sets: "definite" ideas that would have a good probability of providing business value, "possible" ideas that might add business value, and "unlikely" ideas.

Because of the importance of the user interface to the future users of the new system (clients and pilots), several prototypes were created during the JAD session. These prototypes helped clarify the desired interactions between the users and the system.

## Requirements Definition

Throughout these activities, the project team collected information and compiled requirements for the system from the information. As the project progressed, requirements were added to the requirements definition and grouped by requirements type. When questions arose, the team worked with Carmella and Jiang to confirm that requirements were in scope. The requirements that fell outside of the scope of the current system were stored in a separate document that would be saved for future use.

At the end of the analysis phase, the requirements definition was distributed to Eric, Peter, Carmella, two Client Services managers who would work with the system on the business side, and several pilot and customer system users. This group then met for a 2-day JAD session to clarify, finalize, and prioritize the requirements and to create use cases (Chapter 4) to show how the system would be used. During this session, additional prototyping took place so that the team could evaluate several different approaches to the way in which prospective drone assignments could be communicated to the pilots and pilots could "bid" on the assignments they wanted. In this way, the group clarified how to use their technology options to provide the best experience for the future users of the system.

After the JAD session, the project team also spent time creating a process model (Chapter 4) and a data model (Chapter 5) to depict the processes and data in the future system. Client Services managers and the IS department reviewed the documents during interviews with the project team. Figure 3-14 shows a portion of the final requirements definition.

## System Proposal

Jiang reviewed the requirements definition and the other deliverables that the project team created during the analysis phase. He reviewed the work plan and made some slight changes. He also conferred with Carmella and her Client Services managers to review the feasibility analysis. He felt strongly that the analysis phase work had reduced much of the uncertainty about several technical and organizational feasibility factors. All deliverables from the project were then combined into a system proposal and submitted to the IS project approval committee. Figure 3-15 shows the outline of the DrōnTeq system proposal. Carmella and Jiang met with the approval committee and presented the highlights of what was learned during the analysis phase and the final concept of the new system. Based on the proposal and presentation, the approval committee decided that it would continue to fund the Client Services system.

**Functional Requirements (Clients):**

1. Learn about DrōnTeq Services
  - 1.1. The system allows clients to review drone services by predefined categories.
  - 1.2. The system allows clients to search the range of drone flight services and data analyses by keywords.
  - 1.3. The system allows clients to view samples of drone flight service results and data analyses.
2. Create DrōnTeq Account
  - 2.1. The system enables clients to create a client account storing client data and (optional) payment information.
  - 2.2. The system enables clients to specify and store one or more geographic flight service areas.
  - 2.3. The system enables clients to add drone flight service and data analysis options to a "desired services" list.
3. Request Drone Flight Service
  - 3.1. The system allows clients to create a request for a drone flight over a specific geographic flight service area.
  - 3.2. The system allows clients to add one or more data analyses to a drone flight request.
  - 3.3. The system sends notification of acceptance of the flight request by a pilot to the client.
  - 3.4. The system enables clients to confirm the drone flight and authorize payment for the flight and analyses.
4. Manage Flight Requests
  - 4.1. The system provides status messages on open drone flight requests.
  - 4.2. The system notifies clients of completed drone flight and completed data analyses.
  - 4.3. The system allows clients to view/download output produced by completed drone flight sensors.
  - 4.4. The system allows clients to view/download data analysis results from a completed drone flight.
  - 4.5. The system allows clients to request new data analyses of a previous drone flight.

**Functional Requirements (Pilots):**

5. Learn about DrōnTeq Pilot Partnership
  - 5.1. The system allows pilots to review partnership information.
  - 5.2. The system allows pilots to review drone models available for special leasing rates within pilot partnership.
6. Become a DrōnTeq Pilot Partner
  - 6.1. The system enables a pilot to create partnership agreement application.
  - 6.2. The system notifies the pilot of DrōnTeq's acceptance/denial of pilot partnership application.
  - 6.3. The system allows approved pilots to order drone.
  - 6.4. The system allows approved pilots to create pilot account.
  - 6.5. The system provides approved pilots with pilot partner instructions and guidelines.
7. Bid on Drone Flight
  - 7.1. The system notifies pilots of drone flight request including suggested price range for requested service.
  - 7.2. The system allows pilots to enter a bid on a flight with bid price and proposed flight date/time.
  - 7.3. The system uses flight assignment algorithm at close of bidding window to select the winning bid, based on pilot capability, bid price, and date/time factors.
  - 7.4. The system notifies all bidding pilots of the final flight assignment decision, assigning specific pilot to specific flight.
8. Complete a Drone Flight
  - 8.1. The system allows pilots to upload data from drone sensors following the drone flight for a specific flight request.
  - 8.2. The system allows pilots to initiate data analysis for drone flight results.
  - 8.3. The system allows pilots to change the status of a drone flight request from 'open' to 'complete.'

**Nonfunctional Requirements:**

1. Operational
  - 1.1. The system will run on any Web browser.
  - 1.2. Native apps will be developed for iOS and Android mobile and tablet devices.
2. Performance
  - 2.1. Download speeds of drone flight results and data analyses will be monitored and kept at an acceptable level.
3. Security
  - 3.1. Customer information will be secured.
  - 3.2. Payment information will be encrypted and secured.
4. Cultural and political  
No special cultural and political requirements are expected.

**FIGURE 3-14** DrōnTeq requirements definition.

<b>1. Table of Contents</b>
<b>2. Executive Summary</b>
A summary of all the essential information in the proposal so that a busy executive can read it quickly and decide what parts of the plan to read in more depth.
<b>3. System Request</b>
The revised system request form. (See Chapter 1.)
<b>4. Work plan</b>
The original work plan revised after having completed the analysis phase. (See Chapter 2.)
<b>5. Feasibility Analysis</b>
A revised feasibility analysis, using the information from the analysis phase. (See Chapter 1.)
<b>6. Requirements Definition</b>
A list of the functional and nonfunctional business requirements for the system (this chapter).
<b>7. Use Cases</b>
A set of use cases that illustrate the basic processes that the system needs to support. (See Chapter 4.)
<b>8. Process Model</b>
A set of process models and descriptions for the to-be system. (See Chapter 4.) This may include process models of the current as-is system that will be replaced.
<b>9. Data Model</b>
A set of data models and descriptions for the to-be system. (See Chapter 5.) This may include data models of the as-is system that will be replaced.
<b>Appendices</b>
These contain additional material relevant to the proposal, often used to support the recommended system. This might include results of a questionnaire survey or interviews, industry reports and statistics, etc.

**FIGURE 3-15**  
Outline of the DrōnTeq  
system proposal.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Explain the purpose of the analysis phase. Discuss how its purpose differs from the design phase.
- Discuss the contents and purpose of the system proposal.
- Explain the concept of a requirement in an IS development project.
- Discuss the difference between a functional requirement and a nonfunctional requirement. Explain how both contribute to our understanding of the new information system.
- Discuss how to use interviews when eliciting requirements.
- Discuss how to use JAD when eliciting requirements.
- Discuss how to use questionnaires when eliciting requirements.
- Discuss how to use document analysis when eliciting requirements.
- Discuss how to use observation when eliciting requirements.
- Describe the problem analysis strategy and how it contributes to the analysis phase.
- Describe the root cause analysis strategy and how it contributes to the analysis phase.
- Describe the duration analysis strategy and how it contributes to the analysis phase.
- Describe the activity-based costing strategy and how it contributes to the analysis phase.
- Describe the informal benchmarking strategy and how it contributes to the analysis phase.
- Describe the outcome analysis strategy and how it contributes to the analysis phase.
- Describe the technology analysis strategy and how it contributes to the analysis phase.
- Describe the activity elimination strategy and how it contributes to the analysis phase.

## KEY TERMS

Activity-based costing	Electronic JAD, or e-JAD	Interview schedule	Process integration	Symptom
Activity elimination		Joint Application Development (JAD)	Questionnaire	System proposal
Analysis	Facilitator	Nonfunctional requirements	Requirement	System requirements
As-is system	Formal system	Observation	Requirements definition	Technology analysis
Benchmarking	Functional requirements	Open-ended questions	Requirements determination	To-be system
Bottom-up interview	Ground rule	Outcome analysis	Root cause	Top-down interview
Business requirements	Informal benchmarking	Parallelization	Root cause analysis	Unstructured interview
Business value	Informal system	Post-session report	Sample	User requirements
Closed-ended questions	Interpersonal skills	Probing questions	Scribe	Walk-through
Critical thinking skills	Interview	Problem analysis	Stakeholder	
Document analysis	Interview notes		Structured interview	
Duration analysis	Interview report			

## QUESTIONS

- What is the meaning of analysis? What is the purpose of the analysis phase of the SDLC?
- What are the key elements of the system proposal?
- A system development project may be approached in one of two ways: as a single, monolithic project in which all requirements are considered at once or as a series of smaller projects focusing on smaller sets of requirements. Which approach seems to be more successful? Why do you suppose that this is true?
- Distinguish between business, user, and functional requirements.
- Explain what is meant by a functional requirement. What are the two types of functional requirements? Give two examples of each.
- Explain what is meant by a nonfunctional requirement. What are the primary types of nonfunctional requirements? Give two examples of each. What role do nonfunctional requirements play in the project overall?
- What is the value of producing a requirements definition and having the project sponsor and key users review and approve it?
- What are the three basic steps of the analysis process? Is each step performed in every project? Why or why not?
- Discuss the appropriate way to set up and conduct interviews to elicit requirements.
- Give an example of a closed-ended question, an open-ended question, and a probing question. When would each type of question be used?
- “Interviews should always be conducted as structured interviews.” Do you agree with this statement? Why or why not?
- Discuss the considerations that should be made when determining who to include in interviews and/or JAD sessions.
- Is the primary purpose of requirements determination to discover facts or to discover opinions? Explain your answer.
- Describe the five major steps in conducting JAD sessions.
- Describe the primary roles involved in JAD sessions. What is the major contribution made by the person(s) fulfilling each role?
- Discuss the reasons that question design for questionnaires is so difficult.
- Why is document analysis useful? What insights into the organization can it provide?
- Outline suggestions to make observation a useful, reliable requirements elicitation technique.
- Describe a strategy for using the various requirements elicitation techniques in a project.
- Discuss problem analysis as an analysis strategy. What are the strengths and limitations of this technique?
- Discuss root cause analysis as an analysis strategy. What are the strengths and limitations of this technique?
- Compare and contrast duration analysis and activity-based costing. What role do these activities play as analysis strategies?
- How can informal benchmarking contribute to requirements determination?
- Compare and contrast outcome analysis, technology analysis, and activity elimination. What general contribution do these strategies play in determining requirements?

**EXERCISES**

- A. Go to a website of your choice that sells products (a retail site). Develop a list of functional and nonfunctional requirements that the website provides. Now, go to a news-oriented site and develop a similar list. How do your two lists compare? What are the key differences between requirements for the two sites?
- B. Pretend that you are going to build a new system that automates or improves the interview process for the career services department of your school. Develop a requirements definition for the new system. Include both functional and nonfunctional system requirements. Pretend that you will release the system in three different versions. Prioritize the requirements accordingly.
- C. Describe in very general terms the as-is business process for registering for classes at your university. Collaborate with another student in your class and evaluate the process using problem analysis and root cause analysis. Based on your work, list some example improvements that you identified.
- D. Describe in very general terms the as-is business process for applying for admission at your university. Collaborate with another student in your class and evaluate the process using informal benchmarking. Based on your work, list some example improvements that you identified.
- E. Describe in very general terms the as-is business process for registering for classes at your university. Collaborate with another student in your class and evaluate the process using activity elimination. Based on your work, list some example improvements that you identified.
- F. Suppose that your university is having a dramatic increase in enrollment and is having difficulty finding enough seats in courses for students so that they can take courses required for graduation. Perform a technology analysis to identify new ways to help students complete their studies and graduate.
- G. Suppose that you are the analyst charged with developing a new system for the university bookstore with which students can order books online and have them delivered to their dorms and off-campus housing. What requirements-gathering techniques will you use? Describe in detail how you would apply the techniques.
- H. Suppose that you are the analyst charged with developing a new system to help senior managers make better strategic decisions. What requirements-gathering techniques will you use? Describe in detail how you would apply the techniques.
- I. Find a partner and interview each other about what tasks you/ they did in the last job held (full-time, part-time, past, or current). If you have not worked before, then assume that your job is being a student. Before you do this, develop a brief interview plan. After your partner interviews you, identify the type of interview, interview approach, and types of questions used.
- J. Find a group of students and run a 60-minute JAD session on improving alumni relations at your university. Develop a brief JAD plan, select two techniques that will help identify improvements, and then develop an agenda. Conduct the session, using the agenda, and write your post-session report.
- K. Find a questionnaire on the Web that has been created to capture customer information. Describe the purpose of the survey, the way questions are worded, and how the questions have been organized. How can the questionnaire be improved? How will the responses be analyzed?
- L. Develop a questionnaire that will help gather information regarding processes at a popular restaurant or the college cafeteria (e.g., ordering, customer service). Give the questionnaire to 10–15 students, analyze the responses, and write a brief report that describes the results.
- M. Contact the career services department at your university and find all the pertinent documents designed to help students find permanent and/or part-time jobs. Analyze the documents and write a brief report.

**MINICASES**

1. The state firefighters' association has a membership of 15,000. The purpose of the organization is to provide some financial support to the families of deceased member firefighters and to organize a conference each year bringing together firefighters from all over the state. Annually, members are billed dues and calls. "Calls" are additional funds required to take care of payments made to the families of deceased members. The bookkeeping work for the association is handled by the elected treasurer, Bob Smith, although it is widely known that his wife, Laura, does all the work. Bob runs unopposed each year

at the election since no one wants to take over the tedious and time-consuming job of tracking memberships. Bob is paid a stipend of \$12,000 per year, but his wife spends well over 20 hours per week on the job. The organization, however, is not happy with their performance.

A computer system is used to track the billing and receipt of funds. This system was developed in 1994 by a computer science student and his father. The system is simple system developed in Access. The most immediate problem facing the treasurer and his wife is the fact that there is no

one around who knows how to maintain the system. One query in particular takes 7 hours to run. Over the years, they have just avoided running this query, although the information in it would be quite useful. Questions from members concerning their statements cannot easily be answered. Usually, Bob or Laura just jots down the inquiry and returns a call with the answer. Sometimes, it takes 3–5 hours to find the information needed to answer the question. Often, they must perform calculations manually since the system was not developed to handle certain types of queries. When member information is entered into the system, the input form is poorly organized. This makes data entry slow and error-prone. Sometimes a new member is entered but disappears from the records. The report of membership used in the conference materials does not alphabetize members by city. Only cities are listed in the correct order.

- A. What requirements analysis technique or techniques would you recommend for this situation? Explain your answer.
- B. Prepare an Interview Plan for your first interview with Laura Smith in which you want to discover as many of the problems in this system as you can and find out Laura's opinions on the priority of correcting these problems.

*Note: If using the flipped classroom model, students should study the requirements analysis strategy and interview preparation material before class. Divide the class into small groups. Each group should determine their choice of the best requirements analysis technique. Then, have the groups prepare an Interview Plan for Laura's interview. Have each group present their Interview Plan and discuss as a class the strengths and weaknesses of each plan.*

2. Brian Callahan, IS project manager, is just about ready to depart for an urgent meeting called by Joe Campbell, manager of manufacturing operations. A major BPI project, sponsored by Joe, recently cleared the approval hurdle, and Brian helped bring the project through project initiation. Now that the approval committee has given the go-ahead, Brian has been working on the project's analysis plan.

One evening, while playing golf with a friend who works in the manufacturing operations department, Brian learned that Joe wants to shorten the project's time frame from Brian's original estimate of 13 months. Brian's friend overheard Joe say, "I can't see why that IS project team needs to spend all that time 'analyzing' things. They've got two weeks scheduled just to look at the existing system! That seems like a real waste. I want that team to get going on building my system."

Because Brian has a little inside knowledge about Joe's agenda for this meeting, he has been considering how to handle Joe. What do you suggest that Brian tell Joe?

3. Barry has recently been assigned to a project team that will be developing a new retail store management system for a chain of submarine sandwich shops. Barry has several years of experience in programming but has not done much analysis

in his career. He was a little nervous about the new work he would be doing but was confident that he could handle any assignment he was given.

One of Barry's first assignments was to visit one of the submarine sandwich shops and prepare an observation report on how the store operates. Barry planned to arrive at the store around noon, but he chose a store in an area of town he was unfamiliar with, and due to traffic delays and difficulty in finding the store, he did not arrive until 1:30 PM. The store manager was not expecting him and refused to let a stranger behind the counter until Barry had him contact the project sponsor (the director of store management) back at company headquarters to verify who he was and what his purpose was.

After finally securing permission to observe, Barry stationed himself prominently in the work area behind the counter so that he could see everything. The staff had to maneuver around him as they went about their tasks; however, there were only occasional minor collisions. Barry noticed that the store staff seemed to be going about their work very slowly and deliberately, but he supposed that was because the store was not very busy. At first, Barry questioned each worker about what he or she was doing, but the store manager eventually asked him not to interrupt their work so much—he was interfering with their service to the customers.

By 3:30, Barry was a little bored. He decided to leave, figuring that he could get back to the office and prepare his report before 5:00 PM that day. He was sure that his team leader would be pleased with his quick completion of his assignment. As he drove, he reflected, "There really won't be much to say in this report. All they do is take the order, make the sandwich, collect the payment, and hand over the order. It's really simple!" Barry's confidence in his analytical skills soared as he anticipated his team leader's praise.

Back at the store, the store manager shook his head, commenting to his staff, "He comes here at the slowest time of day on the slowest day of the week. He never even looked at all the work I was doing in the back room while he was here—summarizing yesterday's sales, checking inventory on hand, making up resupply orders for the weekend . . . plus he never even considered our store opening and closing procedures. I hate to think that the new store management system is going to be built by someone like that. I'd better contact Chuck (the director of store management) and let him know what went on here today." Evaluate Barry's conduct of the observation assignment.

4. The following set of questions were developed to administer to the customers of a food catering business. Put yourself in the position of a customer who has ordered food from this catering business at least one time in the past. You have just received this survey in an e-mail from the catering company. The e-mail contains a link that takes you to a Web-based survey process (such as Google Forms or SurveyMonkey).

As you read each question, evaluate it carefully. Is it easy to answer? Do you understand how to answer? Is there any confusion in your mind about what response is expected? Do you think your answer will be meaningful and useful to the system development team?

- What is your company's name?
- On a scale from 1 to 10, how easy do you find the ordering process?

0-----10

- How long does it take to place a catering request?
- In your opinion, what is the biggest problem with the current system of placing a catering order?
- How do you feel the process could be simplified?
- What features would you like to see in the new system?
- Do you value convenience and speed or accuracy and a detailed description when placing an order?
- How often do you use our catering services?
- On a scale from 1 to 10, how often are you satisfied with the delivered products?

0-----10

- On a scale from 1 to 10, how likely are you to choose our catering again?

0-----10

*Note: If using the flipped classroom model, students should study the questionnaire design material before class. This question works well as a discussion vehicle for the entire class. Present each question and challenge the class to identify weaknesses and faulty assumptions underlying the question. Then have class members revise the question into a more useful form.*

5. Anne has been given the task of conducting a survey of sales-clerks who will be using a new order entry system being developed for a household products catalog company. The goal of the survey is to identify the clerks' opinions on the strengths and weaknesses of the current system. There are about 50 clerks who work in three different cities, so a survey seemed like an ideal way of gathering the needed information from the clerks.

Anne developed the questionnaire carefully and pretested it on several sales supervisors who were available at corporate

headquarters. After revising it according to their suggestions, she sent a paper version of the questionnaire to each clerk, asking that it be returned within 1 week. After 1 week, she had only three completed questionnaires returned. After another week, Anne received just two more completed questionnaires. Feeling somewhat desperate, Anne then sent out an e-mail version of the questionnaire, again to all the clerks, asking them to respond to the questionnaire by e-mail as soon as possible. She received two e-mail questionnaires and three messages from clerks who had completed the paper version expressing annoyance at being bothered with the same questionnaire a second time. At this point, Anne has just a 14% response rate, which she is sure will not please her team leader. What suggestions do you have that could have improved Anne's response rate to the questionnaire?

6. Central City Community College recently authorized a system development project focused on the college's Career Center. A job posting capability is in the existing system, but there is no way for students to upload resumes or schedule interviews with recruiters. The Career Center director wants to add several new features to make the system more useful and valuable to both students and recruiters. The following Business Needs were drawn from the System Request document.

#### **Business Needs:**

Expansion and enhancements are needed to improve the existing system and correct several deficiencies. Most critically:

- Students are unable to upload resumes
  - Recruiters cannot easily search student resumes for candidates
  - Recruiters cannot post interview schedules for on-campus recruiting
  - Students are unable to schedule recruiting interviews
- A. List the features/capabilities that will correct problems and/or exploit opportunities (the Business Requirements).
- B. List the things the users need/want to do (the User Requirements).
- C. List the things the software should do/include, both processes and information (the Functional Requirements).

# Understanding Processes with Use Cases and Process Models

4

## ANALYSIS

### TASK CHECKLIST

- Use requirements elicitation techniques (interview, JAD session, questionnaire, document analysis, and observation).
- Apply requirements analysis strategies as needed to discover underlying requirements.
- Develop the requirements definition.
- Develop use cases.
- Develop data flow diagrams.
- Develop entity relationship model.
- Normalize entity relationship model.

Information systems support people who use the system to perform activities and tasks. Use cases and process models are used to help understand and describe the tasks the system must support (functional requirements) and how those tasks will be organized into processes that complete the response to an event. Use cases are used to explain and document the interaction that is required between the user and the system to accomplish the user's task. Use cases are created to help the development team understand the steps that are involved in accomplishing the user's goals more fully. Once created, use cases often are the basis for detailed, new system functional requirements. Process models graphically describe business processes—the activities that people do.

### OBJECTIVES

- Explain the purpose of use cases in the analysis phase of the SDLC.
- Describe the various parts of a use case and the purpose of each part.
- Describe how use cases contribute to the functional requirements.
- Describe how use cases inform the development of test plans.
- Explain the process used to create a use case.
- Explain the rules and style guidelines for data flow diagrams.
- Describe the process used to create data flow diagrams.
- Create data flow diagrams.

## Introduction

Chapter 3 discussed the overall process of the analysis phase of the SDLC, resulting in the system proposal deliverable. Within the system proposal is the requirements definition, defining exactly what the new system should do. A key aspect of determining the requirements for the new system is understanding the **user requirements**: the things the users need to accomplish with the new system. In this chapter, we discuss **use cases** as a means of expressing user requirements. We also discuss how the requirements definition and use cases may be further clarified through a **process model**.

Since one of our goals in the systems development project is to create usable software, it is imperative to know what the users must do with it. Use cases help us understand and clarify the users' required interactions with the system and can help us more fully understand the functional requirements of the new system. Process models graphically illustrate the processes or activities that are performed and how data move among them. Consequently, use cases and process models are used extensively in the analysis phase when working with the users in interviews and workshop settings as a means of discovering and depicting user and functional requirements.

A use case represents how a system interacts with its environment by illustrating the activities that are performed by the users of the system and the system's responses. The goal is to create a set of use cases that describe all the tasks that users need to perform using the system. Use cases are often thought of as an external or functional view of a business process, showing how the users view the process rather than the internal mechanisms by which the process operates. Since use cases describe the system's activities from the user's perspective in words, it is essential to involve users in their development. Therefore, creating use cases helps ensure that users' insights are explicitly incorporated into the new system.

Use cases are especially valuable for business system applications and websites. Both types of systems commonly involve extensive user interactions, so the use case is particularly helpful. Use cases are not as useful in certain other settings, such as batch processes, computationally intensive applications, or data warehousing. These settings have extensive "internal" complexity but limited user interactions. Therefore, the use case is not necessarily the best tool to use in these applications. As always, the analyst needs to be skilled in using an array of tools and must be able to select and apply the appropriate ones for the situation.

Once the team has created a set of use cases that describe the things the users need to accomplish with the new system, there will be several important contributions to the analysis phase. First, the use cases will help the analysts develop a more detailed understanding of the new system's functional requirements. System developers commonly find that a well-constructed set of use cases includes most of the functional requirements. Second, use cases are helpful in understanding exceptions, special cases, and error handling requirements in the new system. These requirements are easy to overlook but creating use cases helps to discover them. Finally, the text-based use case is easy for the users to understand and flows easily into the creation of process models and the data model (Chapter 5), which are used by the analysts to more fully define the software that will be developed in the new system.

Process models have been a part of structured systems analysis and design techniques for many years. Today, with use cases gaining favor due to their ability to clarify user requirements in an understandable way, you may see that organizations place less emphasis on process modeling than in the past. We find, however, that graphically depicting the system that will be developed in a set of well-organized diagrams is a particularly useful approach. Remember that our goal is to be able to employ an array of tools and techniques that will help us understand and clarify what the new system must do before the new system is constructed. We focus on one of the most common process modeling techniques: data flow diagramming.<sup>1</sup>

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<sup>1</sup> Another commonly used process modeling technique is IDEF0. IDEF0 is used extensively throughout the US Government. For more information about IDEF0, see FIPS 183: *Integration Definition for Function Modeling (IDEF0)*, Federal Information Processing Standards Publications, Washington, DC: US Department of Commerce, 1993.

In this chapter, we first explain the use case through several examples, describe their basic elements, and show alternative formats. We then illustrate the process of creating use cases with another example and apply the concepts to the DrōnTeq running case. We then explain how to read DFDs and describe their basic syntax. Then we describe the process used to build DFDs that draw information from the use cases and from additional requirements information gathered from the users. We conclude with illustrations of DFDs based on the DrōnTeq running case.

## What Is a Use Case?

A use case depicts a set of activities performed to produce some output result. Each use case describes how an **event triggers** actions performed by the system and the user. With this type of **event-driven modeling**, everything in the system can be thought of as a response to some trigger event. When there are no events, the system is at rest, patiently waiting for the next event to trigger it. When a trigger event occurs, the system (and the people using it) responds, performs the actions defined in the use case, and then returns to the waiting state.

## The Use Case Concept in a Nutshell

The easiest way to appreciate the role of a use case is to follow along with this brief example. Imagine you have accompanied a friend to your local post office to purchase postage stamps. When you arrive at the post office, the service window is closed, but there is an automated postage vending kiosk to use. While your friend makes the purchase, you put your observation skills to work (Chapter 3). Your notes on your observation of the user/system interaction are as follows:

- System:** Displays Welcome message and flashes “Start” button
- User:** Presses “Start” button
- System:** Displays list of options (buy stamps, mail package, etc.)
- User:** Presses “Buy Stamps” button
- System:** Displays list of stamp-buying options (type, denomination, quantity)
- User:** Selects desired stamps by pressing button next to choice
- System:** Displays dollar amount of purchase and asks for purchase confirmation
- User:** Presses “Yes” button to confirm purchase
- System:** Asks user to swipe card and flashes light next to card reader
- User:** Swipes debit card in card reader
- System:** Displays keypad for PIN entry and requests PIN
- User:** Types in PIN on keypad
- System:** Confirms payment transaction and asks if user wants a printed receipt
- User:** Presses “Yes” button to request receipt
- System:** Prints receipt and asks user to take receipt
- User:** Takes receipt
- System:** Displays message to wait while it prints the purchased stamps
- User:** Takes stamps when printing is done
- System:** Displays Thank You Message for 10 seconds, then displays Welcome message

As you can see from this user–system dialog, the postage purchase transaction is accomplished through a coordinated series of prompts, user entries, and system actions. The user–system dialog tells a lot about what the user does to complete the desired task while working with the system, and that is its primary purpose. We use the description of user and system actions and responses to understand the user’s perspective on the system more fully. Any user who reads through this brief dialog should be able to fully grasp how he/she will accomplish the purchase of stamps with the kiosk.

Now let us change the situation slightly. Assume that the vending kiosk has not been developed. As the analysts are defining what this kiosk should do, a functional requirement stating “The kiosk system will provide the option to purchase postage stamps” was included in the requirements definition. This statement clearly specifies a function of the system but provides few details about how the system should support the user’s performance. If a systems analyst works with a user and together they create the user–system dialog just shown, we get a much clearer understanding of how the system can support the user in accomplishing this task. In essence, we have created a use case.

Although we do not know much at all about what is going on “behind the scenes” of the system, we can now create a much more complete description of functional requirements:

The kiosk system will:

- enable the user to begin a transaction
- display a list of purchase transaction options that are available on the kiosk
- enable the user to specify the type of purchase transaction desired
- display a list of options for the purchase type
- enable the user to specify the desired type of postage and quantity desired
- display the amount due for the purchase
- enable the user to confirm the purchase
- enable the user to pay for the purchase with credit/debit card
- complete the credit/debit card transaction securely
- print receipt if requested by user
- print stamps purchased

This list shows that we are well on the way to clarifying the functional requirements for this system. This brief example displays the role of the use case in a nutshell—to define the expected interaction between user and system and use that interaction to clarify and more fully describe the system’s functional requirements.

## Use Case Formats and Elements

Use cases can vary considerably from one organization to another in terms of the content included, the format followed, and the degree of formality employed. In this section, we show the casual use case format.

### Casual Use Case Format

To illustrate a use case in the casual style, we will employ a use case from the already completed Sales System at DrōnTeq. The Sales System was created several years ago to allow DrōnTeq

customers to place orders for the commercial-grade drones that DrōnTeq manufactures. In this example use case, customers order a base model drone and then may add or modify various features on the drone, such as batteries, motors, cameras, and other sensors. The process of ordering the customized drone involves four main steps: authenticating the customer (because DrōnTeq provides commercial-grade drones and sells to commercial drone operators, it requires its customers to create an account before ordering); creating the preliminary order; getting shop manager approval for the requested optional features; and transmitting the approved order to the drone customization shop. The example use case focuses on the second step of this overall process: create a preliminary custom drone order. Refer to Figure 4-1 as we describe the sections of the use case. There are numerous pieces of information in the use case, each with an important role to play in describing the response to the triggering event. We will describe each section starting at the top.

## Basic Information

Each use case has a name and number. The name should be as simple, yet descriptive, as possible. The number is simply a sequential number that serves to reference each use case (e.g., UC-6). The description briefly conveys the use case's purpose.

The **priority** may be assigned to indicate the relative significance of the use case in the overall system. Some use cases will describe essential activities that the system must perform and hence will have a high priority level. Other use cases may describe activities that are less critical, having medium or low priority. Classifying the priority level is especially useful with a methodology that implements the system in a series of versions so that the most essential system features can be targeted first.

The **actor** refers a person, another software system, or a hardware device that interacts with the system to achieve a useful goal. Some organizations use the term **user role** rather than actor

<b>Use Case Name:</b> Create preliminary custom drone order	<b>ID:</b> UC-6	<b>Priority:</b> High
<b>Actor:</b> Customer		
<b>Description:</b> The customer selects and customizes a commercial drone to purchase		
<b>Trigger:</b> Customer wants to purchase a commercial drone		
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal		
<b>Preconditions:</b>		
1. The customer is authenticated by logging in to his account 2. The Sales System Order Processing application is online		
<b>Normal Course:</b>		
1.0 Order a customized drone 1. The customer selects a base model drone from a list of models 2. The system provides availability status for that model (in stock, out of stock) 3. For out of stock status, system displays expected date available a. Customer accepts future availability date; proceed to step 4 b. Customer rejects future availability date; return to step 1 4. The system displays a list of options and upgrades for the selected model 5. The customer selects desired model options and upgrades 6. Preliminary order with cost estimate is created and displayed 7. Customer may return to step 4, confirm order, save for future consideration, or exit without saving 8. Unconfirmed orders are stored in Unconfirmed Custom Order datastore 9. Confirmed orders are saved in Confirmed Custom Order datastore 10. Shop manager is notified of Confirmed Order requiring approval		
<b>Postconditions:</b>		
1. Unconfirmed order is stored in Unconfirmed Custom Order datastore 2. Confirmed order is stored in Confirmed Custom Order datastore 3. Shop manager sent notice of Confirmed Order requiring approval		

**FIGURE 4-1** Create preliminary custom drone order use case—casual format.

A template for this figure is available on the student website.

because there may be several different user groups who interact with the system in the same way. For example, an order entry use case could be performed with either customers or order entry clerks performing the user role. In our example, the actor is the customer wanting to purchase a customized drone from DrōnTeq.

Another element of basic information is the **trigger** for the use case—the event that causes the use case to begin. A trigger can be an **external trigger**, such as a customer placing an order, the fire alarm ringing, or inventory levels reaching the reorder point. A trigger can also be a **temporal trigger**, where the event is time-based, such as ebook becoming overdue at the library or it's time to process the weekly payroll.

### Preconditions

Use cases are often performed in a sequence to accomplish an overall business task. When this practice is followed, it is important to define clearly what needs to be accomplished before each use case begins. These **preconditions** define the state the system must be in before the use case commences. In our example, you can see that for a customer to place an order, he must be authenticated, and the Sales System Order Processing application is online. These tasks are taken care of in a different use case prior to the performance of this use case. Once these preconditions are established, the customer can perform the *Create preliminary custom drone order* use case.

### Normal Course

The next major section of a use case is the description of the major steps that are performed to execute the response to the event, the inputs used for the steps, and the outputs produced by the steps. The normal course lists the steps that are performed when everything flows smoothly in the system. This is sometimes called the “**happy path**” because there are no problems or issues that arise when the steps can be followed normally.

As you read through the steps, you can clearly understand the interactions that occur between the user and the system. The steps are listed in the order in which they are performed, and you can see the “bird’s-eye” perspective illustrated in the steps, describing what an outsider could observe while watching the user and system interact.

Notice step 2, where a branching logical condition occurs. In this case, if the selected drone is out of stock, the customer is given the option of accepting the future availability date and continuing the order process. If that choice is rejected, the customer returns to step 1 to select a different drone model.

### Postconditions

In this section of the use case, we define the final products of this use case. In our example, a confirmed order is stored in the Confirmed Custom Order datastore; an unconfirmed order is stored in the Unconfirmed Custom Order data store; and the shop manager is notified of a confirmed order requiring approval. These **postconditions** also serve to define the preconditions for the next use case in the series. In our example, that would be the use case that describes the Shop Manager’s custom order approval process.

### Exceptions

To be complete, a use case should describe any error conditions or exceptions that may occur as the use case steps are performed. These are not normal branches in decision logic but are unusual occurrences or errors that could potentially be encountered and will lead to an unsuccessful result. As the use case is written and reviewed, the analyst should ask the user if there are any special situations or errors that could occur with each step. If there are, they should be explained as an exception. We want to be sure that the system does not fail while in use because of an error that no one thought about. As you probably know, in many systems, handling exceptions can require more coding effort than the normal and alternative courses. It is essential to try to identify

these trouble spots during the analysis phase, so we do not encounter unexpected error conditions and crashes during testing and implementation.

In our example, there are no exception conditions that have been identified.

## Use Cases in Sequence

While it might be possible to describe everything in one large use case, that use case could become unwieldy. Therefore, it is common practice to create smaller, more focused use cases breaking the whole process down into parts.

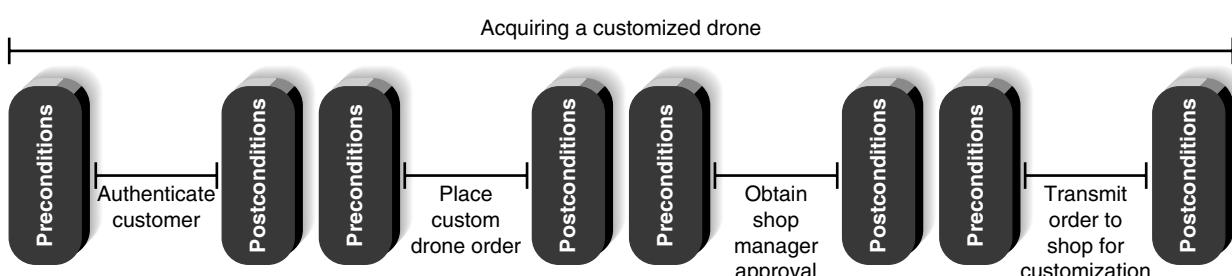
Consequently, it is important to know exactly what state the system should be in before the use case can begin and exactly what state the system should be in when the use case is complete. That is the purpose of the precondition and postcondition sections of the use case. In our example scenario, the use case depicted in Figure 4-1 was a part of the larger user goal of acquiring a customized drone. We chose to divide that major task into four use cases that are performed in a series so that each use case is less complex and does not become confusingly large. When we take this approach, the preconditions and postconditions are essential, since the state at the conclusion of Use Case 1 (its postconditions) are also the preconditions for Use Case 2 (our example use case), and the postconditions for Use Case 2 are the preconditions for Use Case 3. As Figure 4-2 shows, postconditions of a use case define the required system state (preconditions) for the subsequent use case, essentially establishing the boundaries of each use case.

We often separate the overall user task into individual use cases to take advantage of the potential reusability of a use case. In our example, the need to authenticate the customer probably occurs in several places throughout the system. We do not need to develop new use cases each time this task is needed; we can simply reuse the use case we have already created. In situations like this, it is a good idea to add a notation on the use case describing the multiple places in the system that will utilize this use case.

## Additional Use Case Issues

Some organizations may choose to include additional sections on their use case forms. If appropriate, it may be helpful to include sections devoted to:

- Alternative paths
- Summary of inputs and outputs
- Frequency of use
- Business rules
- Special requirements
- Assumptions
- Notes and issues



**FIGURE 4-2** Chain of use cases with boundaries.

These sections enable more detail to be listed about the use case as it is learned. More elaborate use cases are especially valuable when:

- User representatives are not actively engaged with the development team throughout the project.
- The application is complex and has a high risk associated with system failures.
- Comprehensive test cases will be based on the user requirements.
- Collaborating remote teams need a detailed, shared understanding of the user requirements.<sup>2</sup>

## Applying Use Cases

The use cases shown here are **essential use cases**, written to depict the user–system interactions as abstract, technology-independent steps. For example, in the first step of the Normal Course shown in Figure 4-1, “The customer selects base model drone from a list of models,” nothing is said about the specific way this is done. This phrasing keeps our options open in terms of how this task will be implemented. In the analysis phase, this is the correct perspective to take since we do not want our users to limit their thinking to just one way for the system to work too early in the process.

## Use Case Practical Tips

Realistically, you should not expect to create a perfect use case on the first try. The process of building use cases is one of gradual refinement: As users and analysts work through the parts of the use case, they often return to previous parts to correct them. As you gain experience, the creation of use cases will become more intuitive. Being detailed and thorough will get you a long way toward a use case that contributes a significant understanding of the system that we are developing. Your focus should be on describing the user’s objectives in working with the system completely and accurately so that we will not have to rework the system later as it is being developed.

Also, keep in mind that use cases are read and used by two quite different groups of people, the user/business experts and the system development experts. It is hard to find a middle ground writing style that will provide the precision needed by the development experts without overwhelming the users/business experts. Many organizations have found that use case writing teams are helpful. On the team, there should be at least one person who has a programming perspective to ensure adequate precision and accuracy in the use case; another person who has deep knowledge of the business rules that the system must enforce; and another person who is thoroughly familiar with how the system will actually be used.

We create use cases when they are likely to help us better understand the situation and help convey the required user–system interactions. For simple processes that are well explained in the requirements definition, it is not necessary to create a use case. The information in the requirements definition itself is sufficient to describe what the system should do. It is important, however, to create use cases whenever we are reengineering processes or making any changes to business processes that will significantly alter the way people work. Remember that the use case describes what the system will do from the user’s perspective. Therefore, it is critical to involve

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<sup>2</sup> Karl E. Weigers, *Software Requirements*, 2nd ed. (Redmond, WA: Microsoft Press, 2003).

the user in the creation of the use case so that the user understands the interactions planned for the new system. Also, the user helps to ensure that no essential steps or tasks are omitted from the use case and that rare, special circumstances are included.

## Use Cases and Functional Requirements

As we stated earlier in the chapter, use cases are helpful tools to use to understand user requirements. It is tempting for novice analysts, however, to incorrectly assume that the use case is all that is needed to fully define what the system must do. Use cases do explain the user's interaction with the system, but they omit a lot of details that are necessary to know before the system can be developed. Use cases only convey the user's point of view. Behind the scenes processing details are probably not included in the use case. Transforming the user's view into the developer's view by creating functional requirements is one of the important contributions that the systems analyst makes to the development project. Figure 4-3 lists functional requirements based on the Normal Course in the Place Custom Drone Order use case. As you can see, these requirements give more information to the developer about what the system must do to allow the user to accomplish his goals.

## Use Cases and Testing

Many organizations develop test plans early in the development process. This strategy has many advantages, including giving the testing/quality assurance personnel an early understanding of the system under development. By studying the use cases and the functional requirements derived from them, the testing personnel can readily identify elements of the tests they will want to perform when the system enters testing. When the time comes to perform the tests, the testing personnel are well prepared and not forced to develop and perform the tests in a rush. In addition, the quality assurance personnel often can make helpful suggestions about the system and it is valuable to gain this feedback early in the development process.

- The system displays a list of base drone models
- The system accepts customer selection of base drone model
- The system displays in stock/out of stock status for selected drone model
- For an out-of-stock model,
  - The system displays the expected date of availability
  - The system asks customer to accept future date available and continue or to select a different drone model
- The system displays optional features for the selected drone model (batteries, motors, cameras, sensors, etc.)
- The system accepts user choices of options
- The system displays summary and price of selected drone configuration
- The system allows user to continue modifying the drone configuration, save the order for later, confirm the order, or exit without saving.
- For orders saved without confirming, the system stores the order in the Unconfirmed Custom Order datastore
- For confirmed orders,
  - The system displays a completed order summary for the customer
  - The system stores the order in the Confirmed Custom order
  - The system sends a notice of new Confirmed Custom order to the Shop Manager for approval

**FIGURE 4-3** Place custom drone order (normal course) functional requirements.

## Creating Use Cases

The most common ways to gather information for the use cases are through the same requirement determination techniques discussed in the previous chapter, especially interviews and JAD sessions. Observation also is sometimes used for as-is use cases. Regardless of whether interviews or JAD sessions are used, research shows that some ways to gather the information for use cases are better than others. The most effective process has four steps<sup>3</sup> (Figure 4-4). These four steps are performed in order, but, of course, the analyst often cycles among them in an *iterative* fashion as he or she moves from use case to use case.

### Identify the Major Use Cases

As stated previously, use cases document one or more functional requirements outlined in the requirements definition. Therefore, use cases are intricately linked with the requirements definition. The process-oriented functional requirements—things the system must do—suggest a direct action resulting from an external or temporal event. The information-oriented functional requirements—content the system must have—suggest things that happen involving information or time triggers to collect or produce information.

Step	Activities	Typical Questions Asked <sup>a</sup>
1. Identify the use cases.	Start a use case report form for each use case by filling in the name, description, and trigger. If there are more than nine use cases, group them into packages.	Ask who, what, when, and where about the use cases (or tasks). What are the major tasks that are performed? What triggers this task? What tells you to perform this task?
2. Identify the major steps within each use case.	For each use case, fill in the major steps needed to complete the task.	Ask how about each use case. What information/forms/reports do you need to perform this task? Who gives you these information/forms/reports? What information/forms/report does this produce and where do they go? How do you produce this report? How do you change the information on the report? How do you process forms? What tools do you use to do this step (e.g., paper, e-mail, phone)?
3. Identify elements within steps.	For each step, identify its triggers and its inputs and outputs.	Ask how about each step. How does the person know when to perform this step? What forms/reports/data does this step produce? What forms/reports/data does this step need? What happens when this form/report/data is not available?
4. Confirm the use case.	For each use case, validate that it is correct and complete.	Ask the user to execute the process, using the written steps in the use case—that is, have the user role-play the use case.

**FIGURE 4-4**  
Steps for writing  
for use cases.

<sup>a</sup>We have used the typical questions for the as-is model (e.g., “What are the . . .”). These same questions can be used for the to-be model, but they would be phrased in the future tense (e.g., “What should be the . . .”).

<sup>3</sup> The approach in this section is based on the work of George Marakas and Joyce Elam, “Semantic Structuring in Analyst Acquisition and Representation of Facts in Requirements Analysis,” *Information Systems Research*, 1998, 9(1), 37–63, as well as our own: Alan Dennis, Glenda Hayes, and Robert Daniels, “Business Process Modeling with Group Support Systems,” *Journal of Management Information Systems*, 1999, 15(4): 115–142.

We will illustrate the process of creating use cases using the DrōnTeq Drone Sales System scenario. We have already seen a partial requirements definition for this situation (Figure 3-3). How was this information obtained? When the project to create this system began, the owners of DrōnTeq met with Sarah, a systems analyst for the company. This interview took place early in the project when Sarah was just getting familiar with the organization and Peter and Eric were envisioning how they wanted to conduct the business of selling their commercial drones.

As Sarah conducted the interview with Peter and Eric, she looked for things that happen that cause activities to be performed. These things will be the major events of the system. Once an event is identified, try to discover the major response(s) to the event and how the response(s) are produced. Chances are, the details are obscure at this stage, but they can be discovered later by digging deeper.

The interview gave Sarah quite a bit of information about the way the drone sales department should operate. The events she discovered suggest the primary things the users must accomplish with the system, and the responses describe the results of the activities performed when the event occurs. The event-response list prepared by Sarah is shown in Figure 4-5. In this example, we focus on the Drone Customization Shop Management area of the business.

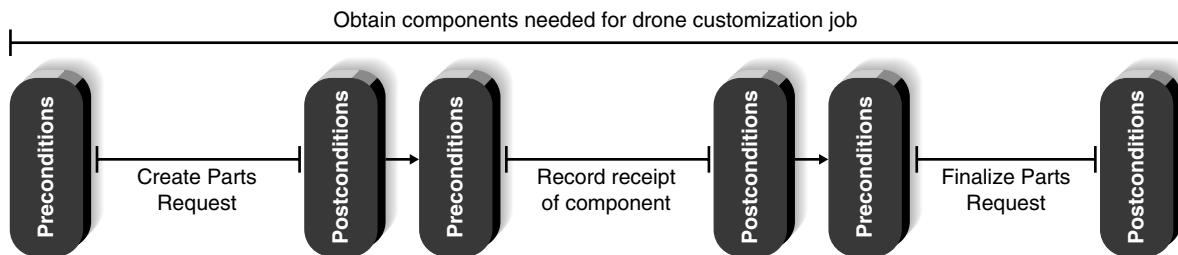
As shown in Figure 4-5, Sarah identified seven major events from her initial conversation with Peter and Eric. The first two events deal with receiving the shop work order from the Sales System and assigning the work order to a qualified technician. Events 3, 4, and 5 are associated with obtaining all needed components for the custom drone from the Inventory department. Finally, events 6 and 7 are focused on recording the start and completion times for the technician's work on the drone. Sarah has also listed, in the Response column, the things that signify that the response to an event is concluded.

As she reflected on events 3, 4, and 5, Sarah could see that these events are three parts of the overall user goal of obtaining all needed components for a drone customization work order. As shown in Figure 4-6, each event is an independent, but related part of the overall goal.

After the use cases are identified, the top parts of the use case form should be filled in with name, ID, primary actor, short description, and trigger—it may be too early to assign the importance level of the use case. The goal is to develop a set of major use cases with the major information about each, rather than jumping into one use case and describing it completely. This prevents the users and analysts from forgetting key use cases and helps the users explain the overall set of business processes for which they are responsible. It also helps users understand how to describe the use cases and reduces the chance of overlap between use cases. In this step, the analysts and users identify a set of major use cases that could benefit from additional definition beyond the requirements definition.

Event	Response
1) New shop work order is received	<ul style="list-style-type: none"> <li>Shop work order arrival time is recorded</li> </ul>
2) Shop work order is assigned to qualified technician	<ul style="list-style-type: none"> <li>Work order added to technician's work assignment</li> </ul>
3) Parts Request for base model drone and additional components generated	<ul style="list-style-type: none"> <li>Parts request stored</li> <li>Inventory department receives Parts Request</li> </ul>
4) Requested parts arrive in Shop Parts room	<ul style="list-style-type: none"> <li>Parts arrival recorded on Parts Request</li> </ul>
5) All parts on a Parts Request are available	<ul style="list-style-type: none"> <li>Technician notified that all parts are available</li> </ul>
6) Technician records date/time work begins on work order	<ul style="list-style-type: none"> <li>Shop work order updated with start date/time</li> </ul>
7) Technician records completion of work on work order	<ul style="list-style-type: none"> <li>Shop work order updated with completion date/time</li> <li>Customer is notified of order completion</li> </ul>

**FIGURE 4-5** Sample event-response list. A template for this figure is available on the student website.



**FIGURE 4-6** Chain of use cases for obtaining drone components.

Identifying use cases is an iterative process, with users often changing their minds about what a use case is and what it includes. It is quite easy to get trapped in the details at this point, so you need to remember that the goal at this step is to just identify the major use cases. The trick is to select the right size so that you end up with the major use cases that need additional explanation beyond the requirements definition. This does get easier with experience and practice. Remember that a use case is a set of end-to-end activities that starts with a trigger event and continues through many possible paths until some output has been produced and the system is again at rest.

If the project team discovers more than eight or nine major use cases, this suggests that the system is complex (or that the use cases are not defined at the right level of detail). If there really are more than eight or nine major use cases, the use cases are grouped together into **use case packages**. For example, if we were to do a more thorough study of the Customization shop at DrönTeq, we would likely find more than the seven events discussed in our example. The events leading to use cases could be grouped logically together in packages, such as all use cases for work orders, all use cases for parts requests, all use cases for work in process, etc. These packages are then treated as the major processes for the top level of the process model, with the use cases appearing on lower levels, or are treated as separate systems and modeled as separate systems. (Process modeling will be described next.)

Since Sarah was focusing on three use cases, she prepared use case forms for each with the basic information on the top of the forms (Figure 4-7). She then began to complete the use cases by working with the customization shop manager.

## Identify the Major Steps for Each Use Case

The next step is to complete the main body of the use case form. The users and analysts work together to describe the envisioned interactions between the user and the system to complete the response to the event.

Before beginning a discussion of the steps, the analyst should ask the users what tasks need to be completed before the use case steps can begin. This helps clarify the preconditions that are necessary for the use case. Remember that the preconditions help define the starting state of the system. Record the preconditions in the proper section on the use case form.

Next, the user–system interactions should be outlined as a series of steps in the Normal Course section of the form. The steps focus on what an independent observer would see the user and system do in response to the event. The users should concentrate on the steps that are followed when everything flows smoothly; however, make note of places where branches in logic may occur. In general, the steps should be listed in the order in which they are performed, from first to last, but there also may be steps that are performed only occasionally, have no formal sequence in which they are done, or loop back and forth. The order of steps implies a sequence but does not require it. It is fine to list steps that have no sequence in any order you like, but if there is a sequence, you should list the steps in that way.

Each step should be about the same size as the others. For example, if we were writing steps for preparing a meal, steps such as “Take fork out of drawer” and “Put fork on table” are much

<b>Use Case Name:</b> Create Parts Request	<b>ID:</b> UC-3	<b>Priority:</b> High
<b>Actor:</b> Shop Manager		
<b>Description:</b> This use case describes how the Shop Manager creates a Parts Request.		
<b>Trigger:</b> Shop manager receives notice of new shop work order arrival from Sales System.		
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal		
<b>Preconditions:</b> Shop manager is authenticated Parts Request application is available and online Inventory application is available and online		
<b>Use Case Name:</b> Record Receipt of Component	<b>ID:</b> UC-4	<b>Priority:</b> High
<b>Actor:</b> Shop Parts Room Clerk		
<b>Description:</b> This use case describes how the Parts Room Clerk Records delivery of drone component from Inventory Department.		
<b>Trigger:</b> Drone component arrives in Parts Room from Inventory Department.		
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal		
<b>Preconditions:</b> Parts Room Clerk is authenticated Parts Request application is available and online		
<b>Use Case Name:</b> Finalize Parts Request	<b>ID:</b> UC-5	<b>Priority:</b> High
<b>Actor:</b> Parts Room Clerk		
<b>Description:</b> This use case describes how the Parts Room Clerk finalizes a Parts Request.		
<b>Trigger:</b> Notification received that all parts are available for a Parts Request.		
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal		
<b>Preconditions:</b> Parts Room Clerk is authenticated All components listed on Parts Request have arrived in Parts Room		

**FIGURE 4-7** Major use cases with basic information.

smaller than “Prepare cake, using mix.” If you end up with more than nine steps or steps that vary greatly in size, you must go back and adjust the steps. Recognizing the size of the steps takes practice but will become natural in time.

One good approach to producing the steps for a use case is to have the users visualize themselves performing the use case and write down the steps as if they were writing a recipe for a cookbook. In most cases, the users will be able to quickly define what they do in as-is use cases. Defining the steps for to-be use cases may take a bit more coaching. In our experience, the descriptions of the steps change greatly as the users work through a use case. Our advice is to use an erasable blackboard or whiteboard (or paper with pencil) to develop the list of steps. Once the set of steps is fairly well defined, only then do you write it on the use case form.

Occasionally, a use case is so simple that further refinement is not needed. The analyst simply writes a brief description and does not bother to develop the steps within the use case. The information at the top of the use case form is sufficient because the use case need not be explained in more detail. Some of the use cases presented in the exercises at the end of this chapter are simple enough that they do not need information beyond what is at the top of the use case form.

Once the steps have been outlined at the proper level of detail, the postconditions can be completed. Ask the users how they know they are finished with a task. What are the tangible results of performing the steps just listed? Record these in the Postconditions section of the form.

Sarah decided that the best way to understand the use case steps for this part of the system was to hold a JAD-type workshop involving the shop manager, the inventory department manager, and two clerks from the parts room. In the workshop, the participants began by describing the initial state of the system. Sarah asked them to think about what needed to be accomplished before the use case steps could begin. Then, she asked them to describe how they envisioned working with the system to complete the task. Sarah was careful to guide them to think in terms of essential steps that did not assume a particular form of system implementation. Since the goal was to describe the user–system interactions in a new system, Sarah also helped the participants think of what could be done using technology. After several revisions, the team settled on the partial use cases shown in Figure 4-8. Notice as you look at the examples in Figure 4-8

<b>Use Case Name:</b> Create Parts Request	<b>ID:</b> UC-3	<b>Priority:</b> High
<b>Actor:</b> Shop Manager		
<b>Description:</b> This use case describes how the Shop Manager creates a Parts Request		
<b>Trigger:</b> Shop Manager receives notice of new shop work order arrival from Sales System		
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal		
<b>Preconditions:</b>		
1. Shop manager is authenticated 2. Parts Request application is available and online 3. Inventory application is available and online		
<b>Normal Course:</b>	<b>Information for Steps</b>	
1.0 Create Parts Request		
1. Shop manager opens the shop work order 2. Shop manager opens a blank Parts Request 3. For each required component part		
a. Shop manager enters component part and quantity needed b. System queries the inventory datastore and records part status: (In stock/ Out of stock with expected date available)		
4. Shop manager verifies Parts Request is complete 5. System stores new Parts Request 6. System transmits notice of Parts Request to be filled to Inventory Department		
<b>Postconditions:</b>		
1. New Parts Request record created and stored 2. Inventory Department notified of Parts Request to be filled		

<b>Use Case Name:</b> Record Receipt of Component	<b>ID:</b> UC-4	<b>Priority:</b> High
<b>Actor:</b> Shop Parts Room Clerk		
<b>Description:</b> This use case describes how the Shop Parts Room clerk records delivery of component from Inventory department.		
<b>Trigger:</b> Drone component arrives in Parts Room from Inventory department		
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal		
<b>Preconditions:</b>		
1. Parts room clerk is authenticated 2. Parts Request application is available and online		
<b>Normal Course:</b>	<b>Information for Steps</b>	
1.0 Record Receipt of Component		
1. Parts Room clerk retrieves correct Parts Request 2. Parts Room clerk verifies part is correct and undamaged 3. System records date/time part is received 4. Parts Room clerk records the Parts Room location where the part will be stored until pickup 5. System stores updated Parts Request 6. System checks to see if all parts on the Parts Request are available; if they are, the Parts Room clerk is notified to perform Finalize Parts Request use case		
<b>Postconditions:</b>		
1. Parts request updated with received part		

FIGURE 4-8 Major use cases with steps completed.

<b>Use Case Name:</b> Finalize Parts Request	<b>ID:</b> UC-5	<b>Priority:</b> High
<b>Actor:</b> Shop Parts Room clerk		
<b>Description:</b> This use case describes how the Parts Room clerk finalizes a Parts Request		
<b>Trigger:</b> Notification received that all parts are available for a Parts Request		
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal		
<b>Preconditions:</b>		
1. Parts room clerk is authenticated 2. All components listed on Parts Request have arrived in Parts Room		
<b>Normal Course:</b>	<b>Information for Steps</b>	
1.0 Finalize Parts Request		
1. Parts room clerk opens the Parts Request and the associated Shop Work Order 2. Parts room clerk verifies that all listed components are currently in the Parts Room 3. Parts room clerk changes the Parts Request Status to "complete" 4. System records the completion date/time in the Shop Work Order 5. System notifies the assigned technician that job is ready		
<b>Postconditions:</b>		
1. Parts Request status is complete 2. Date/time all parts are available recorded in Shop Work Order 3. Technician notified that job is ready		

**FIGURE 4-8** *Continued*

that Sarah has opted for a style that is not quite as casual as the use case in Figure 4-1. Sarah's chosen use case style is suitable for her situation and is sufficient to provide the detail that her team requires.

## Identify Elements within Steps

The use case forms in Figure 4-8 require some final work before they are complete. The last column ("Information for Steps") must be completed, and arrows may be drawn to describe **inputs** and **outputs** from the steps.

The goal at this point is to identify the major inputs and outputs for each **step**. One could identify the inputs and outputs in detail, but this would make it difficult to list them concisely in the summary area at the bottom of this use case form. In our example, we have chosen to refer to the inputs and outputs in broad terms. For example, if a step needs the customer name, address, and phone number, we might note these in the step description but list only "customer information" as the major input at the bottom of the form.

The users and analysts now return to the steps in the use case and begin tracing the flow of the steps. Typically, this means asking what inputs (e.g., information, forms, reports) are used by each step or what outputs it produces. These are written in the last column on the use case form, with an arrow pointing into or out of a step (Figure 4-9). Sometimes, forms, reports, and information will flow from one step to the next to the next; these can be shown by arrows pointing from step to step.

It is not unusual at this point for users to discover that they forgot to list the entire steps during their first time through the use case. These previously omitted steps are simply added to a revised use case. Our experience has shown that users can forget to include seldom-used activities that occur in special cases (e.g., when data is not available or when something unexpected

<b>Use Case Name:</b> Create Parts Request	<b>ID:</b> UC-3	<b>Priority:</b> High	
<b>Actor:</b> Shop Manager			
<b>Description:</b> This use case describes how the Shop Manager creates a Parts Request			
<b>Trigger:</b> Shop Manager receives notice of new shop work order arrival from Sales System			
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal			
<b>Preconditions:</b>			
1. Shop manager is authenticated 2. Parts Request application is available and on-line 3. Inventory application is available and on-line			
<b>Normal Course:</b>			
1.0 Create Parts Request 1. Shop manager retrieves the shop work order 2. Shop manager opens a blank Parts Request 3. For each required component part a. Shop manager enters component part and quantity needed b. System queries the inventory datastore and records part status: (In stock/ Out of stock with expected date available) 4. Shop manager verifies Parts Request is complete 5. System stores new Parts Request 6. System transmits notice of Parts Request to be filled to Inventory Department	<b>Information for Steps</b>  Shop work order ID → Shop work order Part ID, quantity needed → Part status in inventory Part Request status → New Parts Request record Parts Request to fill → Shop work order		
<b>Postconditions:</b>			
1. New Parts Request record created and stored 2. Inventory Department notified of Parts Request to be filled			
Summary Inputs	Source	Summary Outputs	Destination
Shop work order ID Part ID and quantity Part request status	Shop manager Shop manager Shop manager	Shop work order Part inventory status New part request record Parts Request to fill	Shop manager Inventory system Parts Request datastore Inventory department

<b>Use Case Name:</b> Record Receipt of Component	<b>ID:</b> UC-4	<b>Priority:</b> High	
<b>Actor:</b> Shop Parts Room Clerk			
<b>Description:</b> This use case describes how the Shop Parts Room clerk records delivery of component from Inventory department.			
<b>Trigger:</b> Drone component arrives in Parts Room from Inventory department			
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal			
<b>Preconditions:</b>			
1. Parts room clerk is authenticated 2. Parts Request application is available and on-line			
<b>Normal Course:</b>			
1.0 Record Receipt of Component 1. Parts Room clerk retrieves correct Parts Request 2. Parts Room clerk verifies part is correct and undamaged a. For incorrect part, enter "Incorrect part-returned" on Delivery slip and return to Inventory department b. For damaged part, enter "Damaged part-rejected" on Delivery slip and return to Inventory department c. Close Part Request and exit use case 3. System records date/time part is received 4. Parts Room clerk records the Parts Room location where the part will be stored until pickup 5. System stores updated Parts Request 6. System checks to see if all parts on the Parts Request are available; if they are, the Parts Room clerk is notified to perform Finalize Parts Request use case	<b>Information for Steps</b>  Part Request ID → Part Request record Part Request record → Part return to Inventory Department Part return to Inventory Department → Part rejection to Inventory Department Date/time received → Parts room storage location Updated Parts Request → Part Request Complete notification		
<b>Postconditions:</b>			
1. Parts request updated with received part 2. Returned/rejected parts sent back to Inventory department			
Summary Inputs	Source	Summary Outputs	Destination
Part Request ID Parts room storage location	Parts room clerk Parts room clerk	Part Request record Updated Parts Request Parts Request Complete notice	Parts room clerk Parts Request datastore Parts room clerk

**FIGURE 4-9** Major use cases with information for steps completed.

<b>Use Case Name:</b> Finalize Parts Request	<b>ID:</b> UC-5	<b>Priority:</b> High	
<b>Actor:</b> Shop Parts Room clerk			
<b>Description:</b> This use case describes how the Parts Room clerk finalizes a Parts Request			
<b>Trigger:</b> Notification received that all parts are available for a Parts Request			
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal			
<b>Preconditions:</b> 1. Parts room clerk is authenticated 2. All components listed on Parts Request have arrived in Parts Room			
<b>Normal Course:</b> 1.0 Finalize Parts Request 1. Parts room clerk opens the Parts Request and the associated Shop Work Order 2. Parts room clerk verifies that all listed components are currently in the Parts Room 3. Parts room clerk changes the Parts Request Status to "complete" 4. System records the completion date/time in the Shop Work Order 5. System notifies the assigned technician that job is ready		<b>Information for Steps</b> 	
<b>Postconditions:</b> 1. Parts Request status is complete 2. Date/time all parts are available recorded in Shop Work Order 3. Technician notified that work order is ready			
Summary Inputs	Source	Summary Outputs	Destination
Final parts verification Date/time completion	Parts room clerk Parts room clerk	Parts request record Shop work order record Work order ready notice	Parts room clerk Shop work order datastore Technician

**FIGURE 4-9** *Continued*

occurs), so it is helpful to carefully challenge the user about each step to make sure that nothing has been omitted. Remember our process of gradual refinement; it applies to the creation of the use cases. In our example shown in Figure 4-9, you will notice some steps added in Use Case UC-4, step 2. Here, some steps were added to show how to handle receipt of an incorrect or damaged part.

The Summary area for inputs and outputs found at the end of the use case form is completed once the team is satisfied with the steps, inflows, and outflows listed previously. In this section, all the input flows are listed in the left-most column and their source is specified in the adjacent column. In the third column, all the output flows are listed, and their destination is specified in the right-most column. As we have mentioned, this summary area allows the team to easily view all the inputs that must be included to complete the use case and all the outputs that will be produced by the use case. This area of the use case form will be especially useful if the team decides to depict the system with data flow diagrams.

**YOUR TURN 4-1****Campus Housing**

Create a set of use cases for the following high-level requirements in a housing system run by the Campus Housing Service. The Campus Housing Service helps students find apartments. Owners of apartments fill in information forms about the rental units they have available (e.g., location, number of bedrooms, monthly rent), which are entered into a database. Students can search through this database via the Web to find apartments that meet their needs (e.g., a two-bedroom

apartment for \$800 or less per month within ½ mile of campus). They then contact the apartment owners directly to see the apartment and possibly rent it. Apartment owners call the service to delete their listing when they have rented their apartment(s).

In building the major use cases, follow the four-step process: identify the use cases, identify the steps within them, identify the elements within the steps, and confirm the use cases.

## Confirm the Use Case

The final step is for the users to confirm that the use case is correct as written. Review the use case with the users to make sure that each step and each input and output are correct and that the result of the use case is consistent with the result in the event-response list. The most powerful approach is to ask the user to **role-play** or execute the use case by using the written steps in the use case. The analyst will hand the user pieces of paper labeled as the major inputs to the use case. The user follows the written steps like a recipe to make sure that those steps and inputs really can produce the outputs and result defined for the use case.

### YOUR TURN 4-2

### Functional Requirements for DrōnTeq Create a Parts Request

Review the initial DrōnTeq Customization Shop Management functional requirement 2-1 in Figure 3-3. Now, based on your study of UC-3 in Figure 4-9, revise the list of functional

requirements to provide more clarity and detail for the task of preparing a Parts Request.

### CONCEPTS IN ACTION 4-A

### Building a Bad System?

Several years ago, a well-known national real estate company built a computer-based system to help its real estate agents sell houses more quickly. The system, which worked in many ways like an early version of realtor.com, enabled its agents to search the database of houses for sale to find houses matching the buyer's criteria using a much easier interface than the traditional system. The system also enabled the agent to show the buyer a virtual tour of selected houses listed by the company itself. It was believed that by more quickly finding a small set of houses more closely matching the buyer's desires, and by providing a virtual tour, the buyers (and the agent) would waste less time looking at unappealing houses. This would result in happier buyers and in agents who were able to close sales more quickly, leading to more sales for the company and higher commissions for the agent.

The system was designed with input from agents from around the country and was launched with great hoopla. The initial training of agents met with a surge of interest and satisfaction among the agents, and the project team received many congratulations.

Six months later, satisfaction with the system had dropped dramatically, absenteeism had increased by 300%, and agents were quitting in record numbers; turnover among agents had

risen by 500%, and in exit interviews, many agents mentioned the system as the primary reason for leaving. The company responded by eliminating the system—with great embarrassment.

One of an agent's key skills was the ability to find houses that match the buyer's needs. The system destroyed the value of this skill by providing a system that could enable less skilled agents to perform almost as well as highly skilled ones. Worse still—from the viewpoint of the agent—the buyer could interact directly with the system, thus bypassing the “expertise” of the agent.

#### Questions

1. How were the problems with the system missed?
2. How might these problems have been foreseen and possibly avoided?
3. In perfect hindsight, given the widespread availability of such systems on the Internet today, what should the company have done?

Adapted from: “The Hidden Minefields in Sales Force Automation Technologies,” *Journal of Marketing*, July 2002, by C. Speier and V. Venkatesh.

### YOUR TURN 4-3

### Functional Requirements for DrōnTeq Obtain Component Parts

Review the initial DrōnTeq Customization Shop Management System functional requirement 2.3 in Figure 3-3. Now, based on your study of UC-4 and UC-5 in Figure 4-9, revise the list

of functional requirements to provide more clarity and detail for the task of obtaining all components parts for a shop work order.

## Revise Functional Requirements Based on Use Cases

We have stressed in our discussion that developing use cases enables the project team to clarify and outline in detail the user–system interaction that is needed in the new system. As a result, the system to be developed is better understood. The functional requirements in the requirements definition may be modified to reflect this more detailed understanding and to provide insight to the development team on some “back-end” processing that will be needed that may not be obvious from the use cases alone.

## Applying the Concepts at DrōnTeq

### Identifying the Major Use Cases

The first step in creating the use cases is to identify the major use cases according to the requirements definition, which was developed in the last chapter and shown in Figure 3-12. Take a minute and carefully read the requirements definition. Identify the major use cases that you think need additional definition before you continue reading.

It is important that you think about the use cases before you read what we have to say about them. So, if you have not tried to do this, take five minutes now and do it. We will wait.

The information in the functional requirements definition sometimes just flows into the use cases, but it usually requires some thought as to how to structure the use cases. Creating an event-response list often helps to clarify the number and scope of the use cases (Figure 4-10).

Looking closely about these requirements, we can see the first two deal with clients and pilots who wish to learn more about the flight services DrōnTeq offers and the Pilot partnership program, respectively. The third and fourth events deal with establishing formal client and pilot relationships with DrōnTeq. While these events are essential to the Client Services business unit, none of them are inherently complex. The remaining five events on the list deal with specific aspects of flight request operations. Jiang wants to focus on these elements carefully, for these will be the operational foundation for the new business unit.

Event	Response	Requirements
• Client wants to learn about services	• Flight services and data analyses displayed	1.1–1.3
• Pilots wants to learn about Pilot Partnership program	• Pilot Partnership details displayed	5.1–5.2
• Client creates account	• New client account and profile created	2.1–2.3
• Pilot creates Pilot Partnership Agreement	• Pilot Partnership completed	6.1–6.4
• Client requests drone flight	• Open Drone Flight Request created	3.1–3.2
• Pilot receives drone flight assignment	• Flight assigned to pilot	7.1–7.4, 3.3
• Client wants to view status of open flight requests	• Flight request status displayed	4.1
• Flight is completed	• Flight sensor data uploaded; data analyses initiated; customer notified; flight request closed • Data analyses initiated	8.1–8.3, 4.2 4.5
• Client requests more data analysis for completed flights		

**FIGURE 4-10**  
DrōnTeq Client Services event-response list.

Jiang scheduled a meeting with Carmella to discuss her ideas on how these five events should be handled in the new system. Carmella was able to create outlines of three of the event handling processes easily. Together, she and Jiang created brief descriptions of how clients would request a drone flight, how clients would review the status of open flight requests, and how clients could request additional data analyses for a completed drone flight. The ways to handle events dealing with the assignment of flights to pilots and the completion of a flight were less clear, however, and Jiang and Carmella decided to use a JAD session to further clarify those aspects of the new system. Carmella invited DrōnTeq owners, Eric and Peter, to the JAD session, along with her assistant manager and two commercial drone pilots who were expected to participate in the new Client Services program.

## Elaborating on the Use Cases

During the JAD sessions, the team followed the steps of the process we outlined earlier in the chapter. For each use case, the **primary actor** and trigger were identified, and a brief description was written. The next step was to define the major steps for each use case. The goal at this point is to describe how the use case operates. Jiang asked the JAD team to visualize how each of these events would be handled with the support of an information system, individually, and then collectively as a group. The team also considered experiences they had with other systems to get ideas for how to handle these events. The techniques of visualizing your interaction with the process and thinking about how other systems work (informal benchmarking) are important techniques that help analysts and users understand how processes work and how to write the use cases. Both **visualization** and informal benchmarking are commonly used in practice.

As the JAD team discussed the process to assign a flight request to a pilot, they realized that this event encompassed three events with narrower scope that are performed in sequence. First, the new flight request triggers an event to notify pilots of the new flight request and open the bidding process. Second, pilots submit bids for the flight request until the bidding window closes. Third, when the bidding window closes, the bids are analyzed, and the winning bid is selected and awarded the flight.

As the team discussed this process, they also recognized that awarding the winning bid would not be a fully automatic process as originally conceived. Eric, Peter, and Carmella felt that it would be important to have a human involved in reviewing all pilot bids to ensure that the winning bid was awarded to a pilot/drone that were fully capable of providing all the services associated with a flight request. For example, a client might request a drone flight using an infrared sensor, and not all drones are equipped with such sensors. In addition, several “Exception” conditions were discovered that needed human intervention. Based on this discussion, the role of Flight Operations Manager was developed. This position will play a key role in the final assignment of a flight to a pilot, with considerable assistance from the information system being developed.

Creating the Flight Operations Manager role was a direct outcome of the JAD team working through use case development for this new business area. By thinking carefully about the process needed to respond to a business event, the team recognized areas where human/system interaction was needed. Prior to the JAD session, there was uncertainty about the exact nature of this process. That uncertainty was resolved because of the JAD team’s work.

The team added more detail to the use case steps by identifying their inputs and outputs. This means identifying the inputs needed to complete the step (e.g., information, forms, reports) and the outputs produced by each step. Alternative branches in logic were discussed and the team looked for error conditions that might occur. As the inputs and outputs were described, they were written in the summary area at the end of the form. Once all the use cases had been defined, the final step in the JAD session was to confirm that they were accurate. The project team had the users role-play the use cases. A few minor problems were discovered and easily fixed.

The JAD team also considered the way the system should handle the flight completion event. With considerable input from the two pilots on the team, an outline of the response process was developed for this event. The formality of a use case was not required after all, as the team determined that the steps needed to record completing a flight were straightforward.

Figure 4-11 shows the completed use cases. We limit the focus here to the three use cases that, together, enable a flight request to be assigned to a pilot. Refer to these use cases as you read the remaining material in this chapter. Can you follow the steps? Do they seem logical? If you find something that you think may be missing, remember that use cases are created with gradual refinement, and errors and omissions can be corrected as they are discovered. Also, we have purposely tried to avoid getting lost in the details. Our goal is to include the major activities that are performed, but not necessarily every tiny detail at this point.

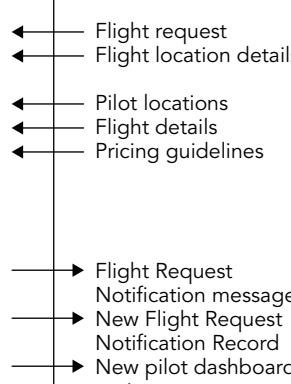
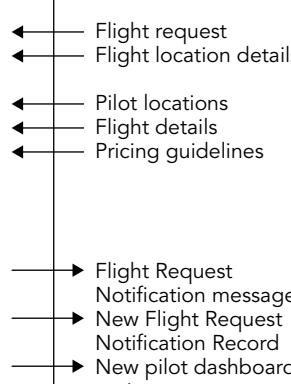
Use Case Name:	Notify Pilots of New Flight Request	ID:	UC-2A	Priority:	High
Actor:	Flight Request system				
Description:	This use case describes how the system notifies pilots of new flight request				
Trigger:	New Flight Request is submitted by client (described in UC-1 (Create Flight Request)				
Type:	<input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal				
Preconditions:	1. New Flight Request is submitted and confirmed by client 2. Flight Assignment application is available and online				
Normal Course:	1.0 Notify pilots of new flight request 1. System obtains the flight request 2. System uses the latitude/longitude of the flight area to define the flight proximity region 3. System develops a list of pilots in the flight proximity region 4. System develops price guidelines for the flight based on the characteristics of the flight request 5. System prepares a flight request notification for all pilots in the flight proximity region, including location, requested flight features, price guidelines, and opening/closing date/time of the pilot bidding window. ↓ 6. System transmits flight request notification to all pilots in the flight proximity region ↓ 7. System stores new flight request notification 8. Pilot dashboards for all pilots receiving the flight notification are modified to include the flight request notification with a bidding window countdown clock.				Information for Steps
					Information for Steps
					
Postconditions:	1. New flight request notification record created and stored 2. Pilots in the flight proximity region receive flight notification message 3. Pilot dashboards for the notified pilots are modified				
Exceptions:	E1. No pilots are found in the flight proximity region (occurs at step 3) 1. System increases the radius of the distance from the flight location by 25 miles 2. Return to step 2, Normal Course, to recalculate the flight proximity region				
Summary Inputs	Source	Summary Outputs	Destination		
Flight Request	Create Flight Request use case	Flight Request Notification message	Pilots		
Flight location	Flight request	New Flight Request Notification record	Flight Request Notification datastore		
Pilot locations	Pilot datastore	Pilot dashboard update	Dashboard of notified pilots		
Flight details	Flight request				
Pricing guidelines	Price guideline datastore				

FIGURE 4-11 DrōnTeq use cases.

<b>Use Case Name:</b> Pilot Submits Bid	<b>ID:</b> UC-2B	<b>Priority:</b> High	
<b>Actor:</b> Pilot			
<b>Description:</b> This use case describes how a pilot submits a bid for an open flight request			
<b>Trigger:</b> Pilot received notification of new flight request			
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal			
<b>Preconditions:</b>			
1. Pilot is authenticated and signed in to his/her dashboard 2. Open flight request is displayed on pilot dashboard 3. Flight Request application is available and online			
<b>Normal Course:</b>		<b>Information for Steps</b>	
1.0 Submit Pilot Bid 1. Pilot selects the new flight request displayed on dashboard 2. System displays details of the flight request including location, requested flight features, price guidelines, and opening/closing date/time of the pilot bidding window. 3. Pilot selects "Submit a bid" option 4. System displays Flight bid form 5. Pilot enters bid price and planned date/time for flight 6. System verifies that the bid meets the terms of the flight request If no errors, continue; if errors, display error message and return to step 5 7. System requests pilot confirmation of the bid 8. System stores new Flight Bid record		<pre> sequenceDiagram     participant S     participant P     Note over S: Flight Request     Note over S: Flight request notification details     Note over P: Flight Bid details     Note over P: Flight Request details     Note over P: Pilot confirmation     Note over P: New flight bid record     S-&gt;&gt;P: Flight Request     S-&gt;&gt;P: Flight request notification details     P--&gt;&gt;S: Flight Bid details     P--&gt;&gt;S: Flight Request details     P--&gt;&gt;S: Pilot confirmation     S--&gt;&gt;P: New flight bid record   </pre>	
<b>Postconditions:</b>			
1. New flight bid is stored			
<b>Exceptions:</b>			
E1: Bidding window is closed (occurs at step 7) 1. Date/time of pilot confirmation is after the closing date/time of the bidding window 2. Modify status of flight bid to "invalid/late" 3. Save flight bid record 4. Notify pilot of late submission bid status			
Summary Inputs	Source	Summary Outputs	Destination
Flight Request record Flight request notification details Flight bid details Bid confirmation	Flight request datastore Flight request notification datastore Pilot Pilot	Flight bid record Flight bid status	Flight bid datastore Pilot

**FIGURE 4-11** *Continued*

### Notify Pilots of New Flight Request (UC-2A)

For this use case, the trigger is the submission of a new Flight Request by a client (described in a separate use case for that event). The system uses the details of the new flight request to create a flight proximity region, which is defined as a circular area with a radius of 75 miles from the flight's geographic location. The system then uses pilot geographic location data to identify all pilots within the flight proximity region. If no pilots are found within the flight proximity area, the system extends the radius by 25 miles and recalculates the flight proximity region until the region includes one or more pilots. The system sends notification of the new Flight Request to these pilots and their dashboards are updated with the flight information and bidding window. The Flight Request notification record is saved and stored.

### Pilot Submits Bid (UC-2B)

This use case is performed by a pilot who wants to submit a bid for a flight request. The pilot uses the pilot dashboard to review the details of the flight request. A Flight Bid form can be completed and submitted by the pilot, listing the details of the pilot's bid on the flight. Assuming the

<b>Use Case Name:</b> Select Winning Flight Bid	<b>ID:</b> UC-2C	<b>Priority:</b> High	
<b>Actor:</b> Flight Operations Manager			
<b>Description:</b> This use case describes how the Flight Operations Manager finalizes the selection of the winning pilot bid on a flight			
<b>Trigger:</b> A flight bid window has closed			
<b>Type:</b> <input type="checkbox"/> External <input checked="" type="checkbox"/> Temporal			
<b>Preconditions:</b>			
1. Flight Operations Manager is authenticated 2. Bidding window on a flight request has closed			
<b>Normal Course:</b>			
1.0 Select Winning Flight Bid			
1. System posts "closed to bid" message on pilot's dashboard	→ Pilot dashboard update		
2. Flight Operations manager requests list of all bids for the flight	→ Flight Bid List Request		
3. System displays list of all bids	← Flight Bid records		
4. For each bid,	← Pilot's drone details		
a. The flight manager verifies the drone's capability to perform the flight	← Flight Request details		
b. Bids based on drone without required equipment are marked "Not Qualified," updated, and removed from bid list	→ Updated Flight Bid record		
5. System sorts and ranks remaining bids based on flight completion time and bid price	← Qualified Flight Bid records		
6. Flight Operations Manager selects bid that optimizes flight completion time and bid price	→ Updated Flight Bid record		
7. System changes status of all unselected flight bids	→ Updated Flight Bid records		
8. System sends notification message to selected bid pilot	→ Bid Award Notification		
9. System posts flight details on selected pilot's dashboard	→ Awarded flight details		
10. System notifies all other bidding pilots of the final selection	→ Unsuccessful bid notice		
11. System notifies customer that flight has been assigned to a pilot	→ Flight Assigned notice		
12. System updates Flight Request with flight assignment details.	→ Updated Flight Request		
<b>Postconditions:</b>			
1. Pilot of selected bid is notified			
2. Selected pilot's dashboard is updated with flight details			
3. Pilots' bids not selected are notified			
4. Flight bid records selection status is updated			
5. Client notified of flight assignment			
6. Flight Request record updated with flight assignment			
<b>Exceptions:</b>			
E1: No bids submitted (occurs at Step 2)			
1. Flight operations manager modifies flight proximity area and/or price guidelines			
2. Flight operations manager performs Use Case 2A to re-post modified Flight Request			
3. If Flight Request has been posted twice with no bids, the Flight Operations manager will contact the client; exit the use case			
Summary Inputs	Source	Summary Outputs	Destination
Flight Bid records Pilot drone details Flight Request details Qualified Flight Bids	Flight Bid datastore Pilot drone datastore Flight Request datastore Flight Bid datastore	Bidding window closed Updated Flight Bids Bid Award Notification Awarded Flight details Unsuccessful bid notice Assigned flight notice Assigned Flight Request	Pilot dashboards Flight Bid datastore Selected Pilot Selected Pilot dashboard Unselected pilots Flight Client Flight Request datastore

**FIGURE 4-11** *Continued*

bid is received before the flight bidding window closes, the new flight bid record is saved and stored.

### Select Winning Flight Bid (UC-2C)

This use case is triggered by the closing of the flight bid window. The flight bid window is opened when pilots are notified of a new flight request (UC-2A) and remains open for a specific time period. When that time period has elapsed, this use case is performed; hence, this is an example of a temporal event.

Pilot dashboards are immediately updated when the bidding windows closes. The Flight Operations Manager then reviews the list of bids and eliminates any bids that came in from pilots who do not have drones with the required capabilities for the flight. The system then ranks the remaining flight bids based on an optimal combination of time frame and price. The Flight Operations Manager selects the more favorable bid. The system then updates the Flight Bid records and the Flight Request record and notifies pilots and the customer of the results of the bidding process. If no bids were received during the bidding window, the Flight Operations Manager can perform UC-2A, modifying the flight proximity area and/or the pricing guidelines for the Flight Request and reposting the Flight Request.

## Data Flow Diagrams

Data flow diagramming is a technique that diagrams the business **processes** and the data that pass among them. We use **data flow diagrams (DFDs)** to describe the to-be system's interactions with its environment, processes, flows of data, and data stores. In this section, we first describe the basic syntax rules and illustrate how they are used to draw simple one-page DFDs. Then we describe how to create more complex multipage diagrams.

Although the name DFD implies a focus on data, this is not the case. The focus is mainly on the processes or activities that are performed. Data modeling, discussed in the next chapter, describes how the data created and used by processes are organized. Process modeling—and creating DFDs in particular—is one of the most important skills needed by systems analysts.

In this section, we focus on **logical process models**, which are models that describe processes, without suggesting how they are conducted. When reading a logical process model, you will not be able to tell whether a process is computerized or manual, whether a piece of information is collected by paper form or via the Web, or whether information is placed in a filing cabinet or a large database. These physical details are defined during the design phase when these logical models are refined into **physical models**, which provide information that is needed to ultimately build the system. (See Chapter 9.) By focusing on logical processes first, analysts can focus on how the business should run, without being distracted by implementation details.

In this chapter, we first explain how to read DFDs and describe their basic syntax. Then we describe the process used to build DFDs that draws information from the use cases and from additional requirements information gathered from the users.

## Reading Data Flow Diagrams

Figure 4-12 shows a DFD for an event we introduced earlier in the chapter, that of the shop manager approving a custom drone order. By examining the DFD, an analyst can understand the process by which the shop manager assesses the custom drone order. Take a moment to examine the diagram before reading on. How much do you understand?

Most people from Western cultures start reading diagrams from left to right, top to bottom. So, whenever possible, this is where most analysts try to make the DFD begin. The item on the left side of Figure 4-12 is the “Shop Manager” external entity, which is a rectangle that represents the person/role responsible for approving custom drone orders. This symbol has five arrows pointing away from it to rounded rectangular symbols. These arrows represent data flows and show that the external entity (shop manager) provides five “**bundles**” of data to processes that use the data. Also, there are several arrows arriving at the shop manager external entity from the rounded rectangles, representing bundles of data that the processes produce to flow back to the shop manager. A use case for the Approve Custom Drone Order event would show these same input/output data bundles with the source/destination listed as the shop manager.

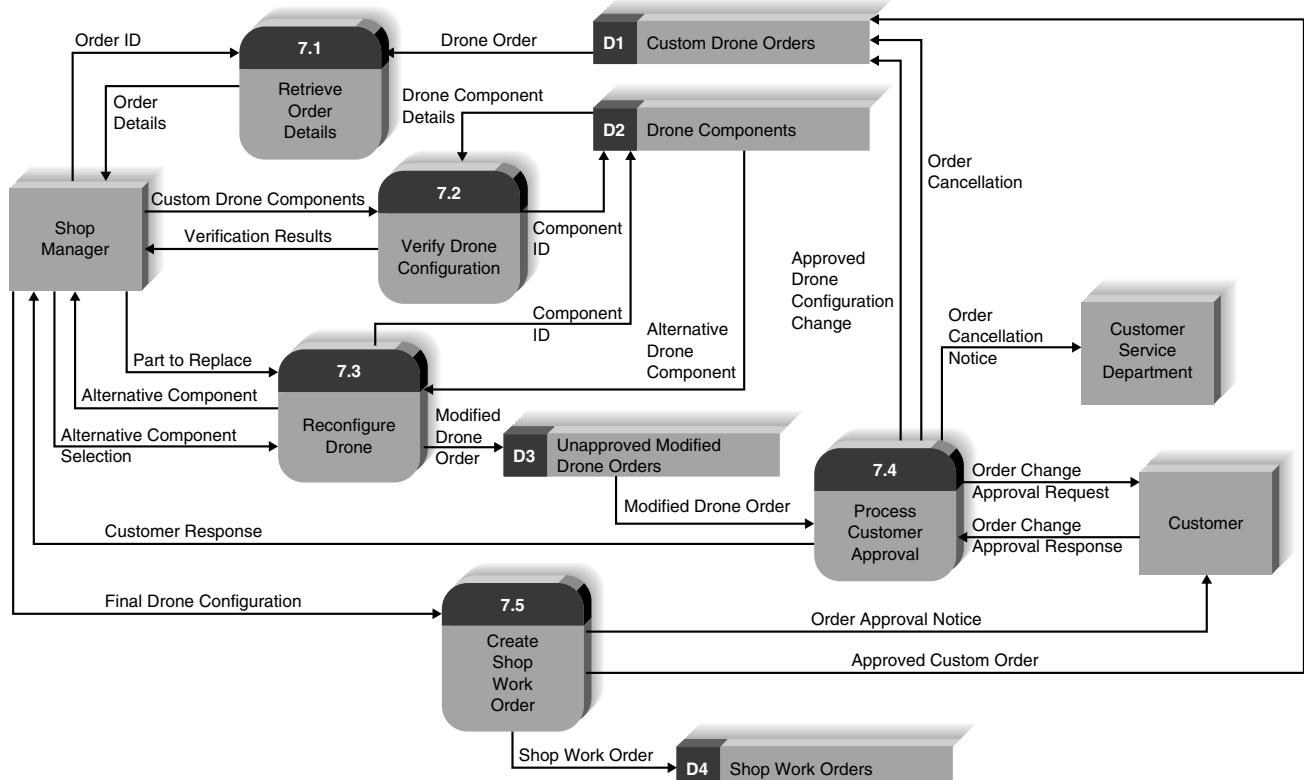


FIGURE 4-12 Shop manager approval of custom drone order level 1 DFD.

Now look at the arrow that flows in to the “Retrieve Order Details” process from the right side. To approve the custom drone order, the process must retrieve some information from data storage. The open-ended rectangle labeled “Custom Drone Orders” is called a data store, and it represents a collection of stored data. The “Retrieve Order Details” process uses an identifier for the custom drone order to find the order details and provide them to the shop manager. Note that every major input listed in a use case flows into a process from an external entity or stored data. Also notice that every major output listed in a use case flows out to a destination (an external entity or data storage) on the DFD.

The Major Steps Performed section of a use case provides insight to the processes that are needed to respond to the event. On the DFD, these steps have been organized into five major processes, each performing one main component of the interactions included on the use case. On the DFD (Figure 4-12), as you follow the arrows starting with “Order ID” from the shop manager to the “Retrieve Order Details” process, imagine the shop manager specifying the ID for the order he must approve. The system retrieves the order details. Using the custom components on the drone order, the shop manager submits the drone configuration to the “Verify Drone Configuration” process. Information about the custom drone components is retrieved from data storage and used to perform the weight and balance check and the battery check for the custom drone. The system returns the results of these verification checks to the shop manager. If problems are found, the shop manager can search for alternative components. He can rerun the “Verify Drone Configuration” process as needed until the modified custom configuration passes those verification checks. After making changes to the drone configuration that pass the verification checks, the modified drone order is stored temporarily while the customer is contacted for approval of the order change. If the customer accepts the change, the changes are recorded in the custom drone order data store and the shop manager is notified of the customer’s approval. If the customer does not approve the change, the order is canceled, and the Customer Service Department is notified of the cancellation so that a follow-up contact can be made.

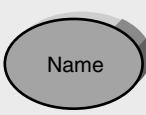
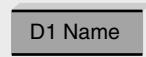
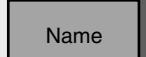
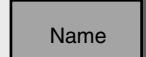
Look at the remaining process symbol in the DFD and examine its inflows and outflows. Based on the data flowing in and flowing out, try to understand what the process is doing. You probably recognized that the “Create Shop Work Order” process (7.5) uses the final drone configuration to create and store a new Shop Work Order. The customer is notified of the shop manager’s approval and the custom drone order data store is updated with the approval status.

As you learn to read DFDs, it is important to remember that these diagrams are not the same as program flowcharts. On a DFD, the processes are performed by the actor as needed. In most cases, the custom drone configurations will successfully pass the verification checks in process 7.2 and the shop manager will immediately create the shop work order using process 7.5. Processes 7.3 and 7.4 are only used when a custom drone configuration fails a verification check and requires modification.

An event’s use case and a DFD (such as Figure 4-12) are purposefully related. A well-constructed use case makes developing a DFD quite straightforward, although the analyst will have to make some decisions about how much detail to depict in the DFD. The steps outlined in a use case can be organized into logical processes on a DFD. The Major Inputs and Major Outputs listed on the use case provide a list of the sources and destinations, respectively, of the inflows and outflows of the processes. The Information for Steps section shows the data flowing in or produced by each step of the use case, and these correspond to the data flows that enter or leave each process on the DFD.

## Elements of Data Flow Diagrams

Now that you have had a glimpse of a DFD, we will present the language of DFDs, which includes a set of symbols, naming conventions, and syntax rules. There are four symbols in the

Data Flow Diagram Element	Typical Computer-Aided Software Engineering Fields	Gane and Sarson Symbol	DeMarco and Yourdon Symbol
Every <i>process</i> has a number a name (verb phase) a description at least one output data flow at least one input data flow	Label (name) Type (process) Description (what is it) Process number Process description (structured English) Notes		
Every <i>data flow</i> has a name (a noun) a description one or more connections to a process	Label (name) Type (flow) Description Alias (another name) Composition (description of data elements) Notes		
Every <i>data store</i> has a number a name (a noun) a description one or more input data flows one or more output data flows	Label (name) Type (store) Description Alias (another name) Composition (description of data elements) Notes		
Every <i>external entity</i> has a name (a noun) a description	Label (name) Type (entity) Description Alias (another name) Entity description Notes		

**FIGURE 4-13** Data flow diagram elements.

DFD language (processes, data flows, data stores, and external entities), each of which is represented by a different graphic symbol. There are two commonly used styles of symbols, one set developed by Chris Gane and Trish Sarson and the other by Tom DeMarco and Ed Yourdon<sup>4</sup> (Figure 4-13). Neither is better than the other; some organizations use the Gane and Sarson style of symbols, and others use the DeMarco/Yourdon style. We will use the Gane and Sarson style in this book.

## Process

A **process** is an activity or a function that is performed for some specific business reason. Processes can be manual or computerized. Every process should be named starting with a verb and ending with a noun (e.g., “Create shop work order”). Names should be short yet contain enough information so that the reader can easily understand exactly what they do. In general,

<sup>4</sup> See Chris Gane and Trish Sarson, *Structured Systems Analysis: Tools and Techniques*, Englewood Cliffs, NJ: Prentice Hall, 1979; Tom DeMarco, *Structured Analysis and System Specification*, Englewood Cliffs, NJ: Prentice-Hall, 1979; and E. Yourdon and Larry L. Constantine, *Structured Design: Fundamentals of a Discipline of Computer Program and Systems Design*, Englewood Cliffs, NJ: Prentice-Hall, 1979.

each process performs only one activity, so most systems analysts avoid using the word “and” in process names because it suggests that the process performs several activities. In addition, every process must have at least one input data flow and at least one output data flow.

Figure 4-13 shows the basic elements of a process and how they are usually named in CASE tools. Every process has a unique identification number, a name, and a description, all of which are noted in the CASE repository. Descriptions clearly and precisely describe the steps and details of the processes; ultimately, they are used to guide the programmers who need to write the software that implements the processes (or the writers of procedure manuals for noncomputerized processes). The process descriptions become more detailed as information is learned about the process through the analysis phase. Many process descriptions are written as simple text statements about what happens. More complex processes use more formal techniques such as structured English, decision tables, or decision trees, which are discussed in a later section.

### Data Flow

A **data flow** is a single fact, such as Order ID (sometimes called a data element), or a logical collection of several facts (e.g., new shop work order). Every data flow should be named with a noun. The description of a data flow lists exactly what data elements the flow contains. For example, the order details data flow would list customer information, order date, base model drone, and the custom components included in the order as its data elements.

Data flows are the glue that holds the processes together. One end of every data flow will always come from or go to a process, with the arrow showing the direction into or out of the process. Data flows show what inputs go into each process and what outputs each process produces. Every process must create at least one output data flow, because if there is no output, the process does not do anything. Likewise, each process has at least one input data flow, because it is difficult, if not impossible, to produce an output with no input.

### Data Store

A **data store** is a collection of data that is stored in some way (which is determined later when creating the physical model). Every data store is named with a noun and is assigned an identification number and a description. Data stores form the starting point for the data model (discussed in the next chapter) and form the logical connection between the process model and the data model.

Data flows coming out of a data store indicate that information is retrieved from the data store. Looking at Figure 4-12, you can see that process 7.1 (Retrieve Order Details) retrieves the Order Details data flow from the Custom Drone Orders data store. Similarly, process 7.2 (Verify Drone Configuration) retrieves the Drone Component Details data flow from the Drone Components data store. Data flows going into a data store indicate that information is added to the data store. For example, process 7.5 adds a Shop Work Order data flow to the Shop Work Orders data store. Finally, data flows going both into and out of a data store indicate that information in the data store is changed (e.g., by retrieving data from a data store, changing it, and storing it back). In Figure 4-12, we can see that process 7.4 (Process Customer Approval) modifies the existing content of the Custom Drone Orders data store with configuration changes that were approved by the customer.

All data stores must have at least one input data flow (or else they never contain any data) unless they are created and maintained by another information system or on another page of the DFD. In Figure 4-12, the Drone Components data store supplies data to two processes (7.2 and 7.3) but its content is not changed. This is perfectly fine, but before the system analyst is finished, it is important to ensure that processes are included somewhere that allow data to be added, modified, and deleted from this data store. Likewise, data stores must have at least one output data flow on some page of the DFD. (Why store data if you never use it?) In cases in which the same

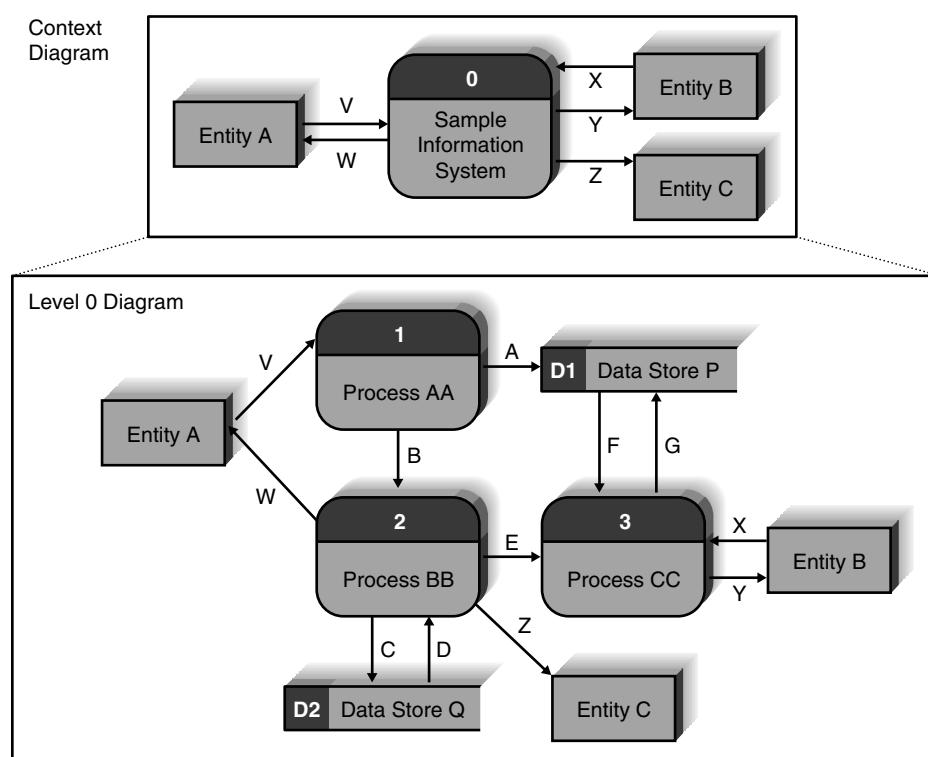
process both stores data and retrieves data from a data store, there is a temptation to draw one data flow with an arrow on both ends. This practice is incorrect, however. The data flow that stores data and the data flow that retrieves data should always be shown as two separate data flows.

### External Entity

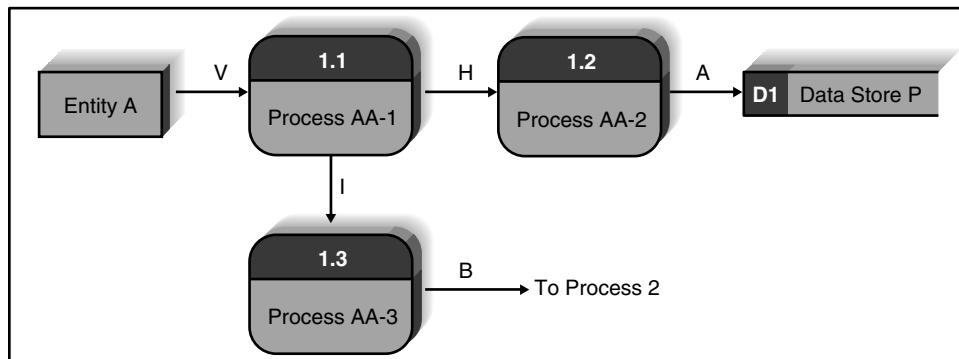
An **external entity** is a person, organization, organization unit, or system that is external to the system, but interacts with it (e.g., customer, clearinghouse, government organization, accounting system). The external entity typically corresponds to the primary actor identified in the use case. External entities provide data to the system or receive data from the system and serve to establish the system boundaries. Every external entity has a name and a description. The key point to remember about an external entity is that it is external to the system but may or may not be part of the organization. People who use the information from the system to perform other processes or who decide what information goes into the system are documented as external entities (e.g., managers, staff).

## Using Data Flow Diagrams to Define Business Processes

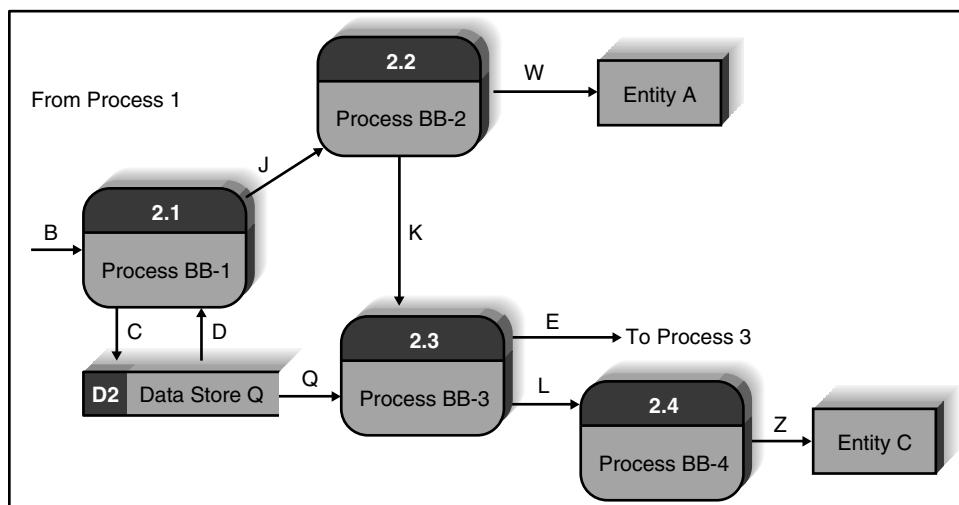
Most business processes are too complex to be explained in one DFD. Most process models are therefore composed of a set of DFDs. The first DFD provides a summary of the overall system, with additional DFDs providing more and more detail about each part of the overall business process. Thus, one important principle in process modeling with DFDs is the **decomposition** of the business process into a hierarchy of DFDs, with each level down the hierarchy consisting of diagrams with less scope but more detail. Figures 4-14 and 4-15 show how one business process can be decomposed into several levels of DFDs.



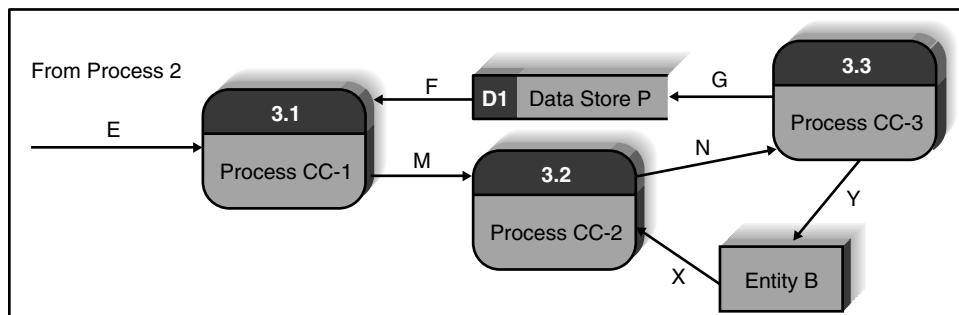
**FIGURE 4-14**  
Context diagram  
decomposed into level 0  
diagram.



Process 1 Level 1 Diagram



Process 2 Level 1 Diagram



Process 3 Level 1 Diagram

**FIGURE 4-15**  
Processes 1, 2,  
and 3 level 1 diagrams.

### Context Diagram

The top-level DFD in every business process model, whether a manual system or a computerized system, is the **context diagram** (Figure 4-14). As the name suggests, the context diagram shows the entire system in context with its environment. All process models have one context diagram.

The context diagram shows the overall business process as a single process (i.e., the system itself) and shows the data flows to and from external entities. Data stores are not included on the context diagram. If the system uses data from or supplies data to another independent information system, that system should be shown as an external entity, not a data store.

### Level 0 Diagram

The next level in the DFD hierarchy is the diagram called the **level 0 diagram** or **level 0 DFD** (Figure 4-14). The level 0 diagram shows all the major processes at the first level of numbering (i.e., processes numbered 1 through 3), the data stores, external entities, and data flows among them. The purpose of the level 0 DFD is to show all the major high-level processes of the system and how they relate to each other and to stored data. All process models have one and only one level 0 DFD.

The three processes, two data stores, and seven data flows shown in the level 0 diagram are contained within process 0. They were not shown on the context diagram because they are internal components of process 0. The context diagram deliberately hides some of the system's complexity in order to make it easier for the reader to understand. Only after the reader understands the context diagram does the analyst "open up" process 0 to display its internal operations by decomposing the context diagram into the level 0 DFD, which shows more detail about the processes, data stores, and data flows inside the system.

Another key principle in creating sets of DFDs is **balancing**. Balancing means ensuring that all information presented in a DFD at one level is accurately represented in the next-level DFD. This does not mean that the information is identical, but that it is shown appropriately. There is a subtle difference in meaning between these two words that will become apparent shortly, but for the moment, let us compare the context diagram with the level 0 DFD in Figure 4-14 to see how the two are balanced. In this case, we see that the external entities (A, B, C) are identical between the two diagrams and that the data flows to and from the external entities in the context diagram (V, W, X, Y, Z) also appear on the level 0 DFD. The level 0 DFD replaces the context diagram's single process (always numbered 0) with three processes (1, 2, 3), adds two data stores (D1, D2), and includes several additional data flows that were not on the context diagram (look for data flows A, B, C, D, E, F, and G).

### Level 1 Diagrams

In the same way that the context diagram deliberately hides some of the system's complexity, so, too, does the level 0 DFD. The level 0 DFD shows only how the major high-level processes in the system interact. Each process on the level 0 DFD must be decomposed into a more explicit DFD, called a **level 1 diagram**, or **level 1 DFD**, which shows how it operates in greater detail. The DFD illustrated in Figure 4-12 is a level 1 DFD.

In general, all process models have as many level 1 diagrams as there are processes on the level 0 diagram; every process in the level 0 DFD would be *decomposed* into its own level 1 DFD. Therefore, the level 0 DFD in Figure 4-14 would have three level 1 DFDs (one for process 1, one for process 2, one for process 3). In Figure 4-15, we show three new diagrams, the level 1 DFDs for each process that was shown in the level 0 diagram.

The processes in the level 1 diagram are the **children** of the **parent** process in the level 0 diagram. The set of children and the parent are identical; they are simply different ways of looking at the same thing. When a parent process is decomposed into children processes, its children must completely perform all its functions, in the same way that cutting up a pie produces a set of slices that wholly and completely make up the pie. Even though the slices may not be the same size, the set of slices is identical to the entire pie; nothing is omitted by slicing the pie.

You can appreciate the value of the hierarchy of diagrams in this simple example. We have shown that the entire system can be represented by three major processes. These three major

processes are further decomposed into ten smaller processes represented on the three level 1 diagrams. Ten processes on one diagram would be messy and difficult to understand, but carefully decomposing in the hierarchy of diagrams keeps each diagram less complex and easier to understand. That is the essence of the hierarchy of DFDs found in the process model.

Once again, it is important to ensure that the level 0 and level 1 DFDs are balanced. For example, the level 0 DFD shows that process 1 receives data flow V from Entity A and produces two output data flows. One output data flow (A) is sent to data store D1 and the other (B) is sent to process 2. A check of the level 1 DFD shows the same entity, data store, and data flows. We also see that two new data flows have been added (H, I) at this level. These data flows are contained within process 1 and therefore are not documented in the level 0 DFD. Only when we decompose or open up process 1 via the level 1 DFD do we see that they exist.

The level 1 DFD shows more precisely which process uses the input data flow V (process 1.1) and which produces the output data flows A and B (processes 1.2 and 1.3). Take a moment and look carefully at the data flows surrounding process 2 and process 3 in the level 0 diagram. Verify that these data flows have been carried down to the respective level 1 diagrams correctly. Also note the new level of detail that can be seen in these two level 1 diagrams that was hidden in the level 0 diagram.

When decomposing a process into its child level DFD, some CASE and drawing tools carry only the input and output data flows down to the child diagram. To find the exact source and destination of data flows, one often must follow the data flow across several DFDs on different diagrams. To simplify reading the diagrams, we like to show the external entities on all levels of the DFDs and commonly add a text notation that explains a data flow's destination to another process.

### Level 2 Diagrams and Below

If any of the processes in the level 1 diagram appear to be “busy” with multiple inflows and outflows, it may be appropriate to decompose that process into a child diagram. The next level under level 1 would be labeled as level 2, and so forth. The ultimate goal is to decompose a process so that each child process performs one essential task, not multiple tasks.

It is sometimes difficult to remember which DFD level is which. It may help to remember that the level numbers refer to the number of periods in the process numbers on the DFD. A level 0 DFD has process numbers with no periods (e.g., 1, 2), whereas a level 1 DFD has process numbers with one period (e.g., 2.3, 5.1), a **level 2 DFD** has numbers with two periods (e.g., 1.2.5, 3.3.2), and so on.

### Alternative Data Flows

Suppose that a process produces two different data flows under different circumstances. For example, a quality-control process could produce a quality-approved widget or a defective widget, or in Figure 4-12, the customer may or may not approve the order modification. How do we show these alternative paths in the DFD? The answer is that we show both data flows and use the process description to explain that they are alternatives. Nothing on the DFD itself shows that the data flows are mutually exclusive. For example, in Figure 4-15, process 2.3 on the level 1 DFD produces two output data flows (E and L). Without reading the underlying process description of process 2.3, we do not know whether these are produced simultaneously or whether they are mutually exclusive. The process description shown in Figure 4-16 reveals that these two data flows are indeed alternative data flows.

### Process Descriptions

The purpose of process descriptions is to explain what the process does and provide additional information that the DFD does not provide (see Figure 4-16). As we move through the SDLC, we

The diagram illustrates a data flow process involving several components:

- Process BB-1 (2.1):** Receives input from "From Process 1" (flow B) and sends output to Process BB-3 (flow K).
- Data Store D2 (Q):** Associated with Process BB-3, it receives flow Q and provides flow L to Process BB-4.
- Process BB-2 (2.2):** Receives flow J from Process BB-1 and sends output to Entity A (flow W).
- Process BB-3 (2.3):** Receives flows K and Q; sends flow E to "To Process 3" and flow L to Process BB-4.
- Process BB-4 (2.4):** Receives flow L from Data Store D2 and sends output to Entity C (flow Z).
- Entity A:** Receives flow W from Process BB-2.
- Entity C:** Receives flow Z from Process BB-4.

**Entry Description**

**Name:** Process BB-3

**Entry Type:** Process

**Process #:** 2.3

**Short Description:** This process calculates Result1 and provides Result1 to process 3, or calculates Result2 and provides Result2 to process 2.4

**Process Description:**

```

Receive data flow K from process 2.2
Using data flow K, retrieve correct record (data flow Q) from
data store D2
If record meets all selection criteria,
  Compute Result1
  Provide Result1 to process 3 as data flow E
Else
  Compute Result2
  Provide Result2 to process 2.4 as data flow L
Endif
  
```

**Notes:** Detailed calculations for Result1 and Result2 will be provided by Jeff Essex in the Marketing Dept.

**Buttons:** Save, Clear, Copy, Previous, Next, Exit

FIGURE 4-16 Process description entry in data dictionary.

gradually move from the general text descriptions of requirements into more and more precise descriptions that are eventually translated into very precise programming languages. In most cases, a process is straightforward enough that the requirements definition, a use case, and a DFD with a simple text description together provide sufficient detail to support the activities in the design phase. Sometimes, however, the process is sufficiently complex that it can benefit from a more detailed process description that explains the logic that occurs inside the process. Three techniques are commonly used to describe more complex processing logic: structured English, decision trees, and decision tables. Complex processes may use a combination of structured English and either decision trees or decision tables.

**Structured English** uses short sentences to describe the work that a process performs. **Decision trees** display decision logic (**IF statements**) as a set of nodes (questions) and branches (answers). **Decision tables** represent complex policy decisions as rules that link various conditions with actions. Since these techniques are commonly discussed in programming texts, we will not elaborate on them here. They are useful to the systems analyst in conveying the proper understanding of what goes on “inside” a process.

## Creating Data Flow Diagrams

Data flow diagrams start with the information in the use cases and the requirements definition. Although the use cases are created by the users and project team working together, the DFDs typically are created by the project team and then reviewed by the users. The set of DFDs that make up the process model simply integrates the individual use cases (and adds in any processes in the requirements definition not selected as use cases). The project team takes the use cases and rewrites them as DFDs. However, because DFDs have formal rules about symbols and syntax that use cases do not, the project team sometimes must revise some of the information in the use cases to make them conform to the DFD rules. The most common types of changes are to the names of the use cases that become processes and the inputs and outputs that become data flows. The second most common type of change is to combine several small inputs and outputs in the use cases into larger data flows in the DFDs (e.g., combining three separate inputs, such as “customer name,” “customer address,” and “customer phone number,” into one data flow, such as “customer information”).

Project teams usually use process modeling tools or CASE tools to draw process models. Simple tools such as Visio contain DFD symbol sets and enable easy creation and modification of diagrams. Other process modeling tools such as BPWin understand the DFD and can perform simple syntax checking to make sure that the DFD is at least somewhat correct. A full CASE tool provides many capabilities in addition to process modeling (e.g., data modeling as discussed in the next chapter). CASE tools tend to be complex, and while they are valuable for large and complex projects, they often cost more than they add for simple projects. Figure 4-16 shows how a process description is created within a CASE tool.

Building a process model that has many levels of DFDs usually entails several steps. While there is no one right way to begin, we have found it useful to first build the context diagram showing all the external entities and the data flows that originate from or terminate in them. Second, the team creates a DFD fragment for each use case that shows how the use case exchanges data flows with the external entities and data stores. Third, these DFD fragments are organized into a level 0 DFD. Fourth, the team develops level 1 DFDs for each process in the level 0 diagram, based on the steps within each use case, to better explain how they operate. Some level 1 processes may be further decomposed into level 2 DFDs; some level 2 processes are decomposed into level 3 DFDs, and so on. Fifth, the team validates the set of DFDs to make sure that they are complete and correct.

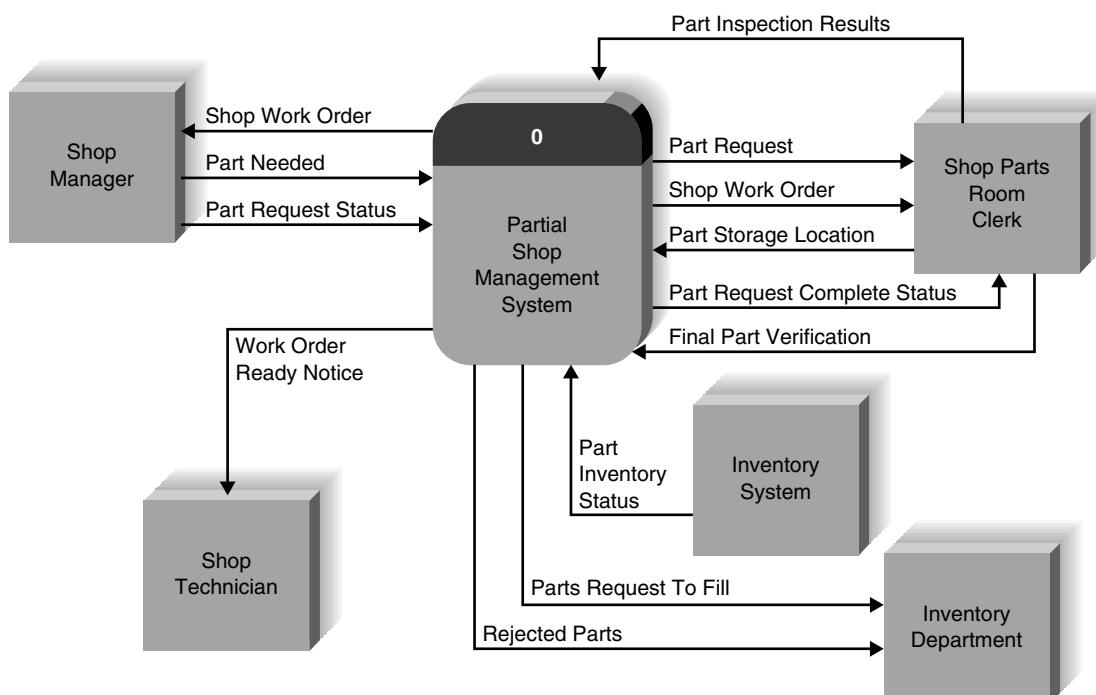
In the following sections, process modeling is illustrated with the DrönTeq Drone Customization Shop Management system.

## Creating the Context Diagram

The context diagram defines how the business process or computer system interacts with its environment—primarily the external entities. To create the context diagram, you simply draw one process symbol for the business process or system being modeled (numbered 0 and named for the process or system). You read through the use cases and add the inputs and outputs listed on the form, as well as their sources and destinations. Usually, all the inputs and outputs will come from or go to external entities such as a person, organization, or other information system. If any inputs and outputs connect directly to data stores in an external system, it is best practice to create an external entity that is named for the system that owns the data store. None of the data stores inside the process/system are included in the context diagram because they are “within” the system. Because there are sometimes so many inputs and outputs, we often combine several small data flows into one larger data flow.

Figure 4-17 shows the context diagram for the DrōnTeq Drone Customization Shop Management system. Take a moment to review this system as described previously in this chapter. Recall that seven events were described in the event response list shown in Figure 4-5. Since three events were emphasized in the use cases shown in Figure 4-9, however, we will focus on those three events again in this section. The context diagram includes the entities and major inflows and outflows associated with those three events and excludes the entities and flows associated with the other events.

You can see from the Major Inputs and Outputs sections in Figure 4-9 use cases that the system has interactions with the Shop Manager and Shop Parts Room Clerk external entities. In addition, the system obtains information needed from the DrōnTeq Inventory System, shown as an external entity because it is a system outside the scope of the system under study. Finally, the system supplies information to the Shop Technician entity and the Inventory Department entity, the final external entities shown in this partial context diagram.



**FIGURE 4-17** DrōnTeq partial shop management system context diagram.

## Creating Data Flow Diagram Fragments

A **DFD fragment** is one part of a DFD that eventually will be combined with other DFD fragments to form a new DFD. In this step, each use case is converted into one DFD fragment. You start by taking each use case and drawing a DFD fragment, using the information given on the top of the use case: the name, ID number, and major inputs and outputs. The information about the major steps that make up each use case is ignored at this point; it will be used in a later step. Figure 4-18 shows a use case and the DFD fragment that was created from it.

Once again, some subtle, but important changes are often made in converting the use case into a DFD. The two most common changes are modifications to the process names and the addition of data flows. There were no formal rules for use case names, but there are formal rules for naming processes on the DFD. All process names must be a verb phrase—they must start with a verb and include a noun (Figure 4-13). If the use case names were not named in this way, we must change them now. It is also important to have a consistent **viewpoint** when naming processes. For example, the DFD in Figure 4-18 is written from the viewpoint of the drone customization shop, not of the customer who is buying the drone. All the process names and descriptions are

<b>Use Case Name:</b> Create Parts Request	<b>ID:</b> UC-3	<b>Priority:</b> High	
<b>Actor:</b> Shop Manager			
<b>Description:</b> This use case describes how the Shop Manager creates a Parts Request			
<b>Trigger:</b> Shop Manager receives notice of new shop work order arrival from Sales System			
<b>Type:</b> <input checked="" type="checkbox"/> External <input type="checkbox"/> Temporal			
Summary Inputs	Source	Summary Outputs	Destination
Part ID and quantity Part inventory status Part request status Shop work order	Shop manager Inventory System Shop manager Shop work order data store	Shop work order New part request record Parts Request to fill	Shop manager Parts Request datastore Inventory department

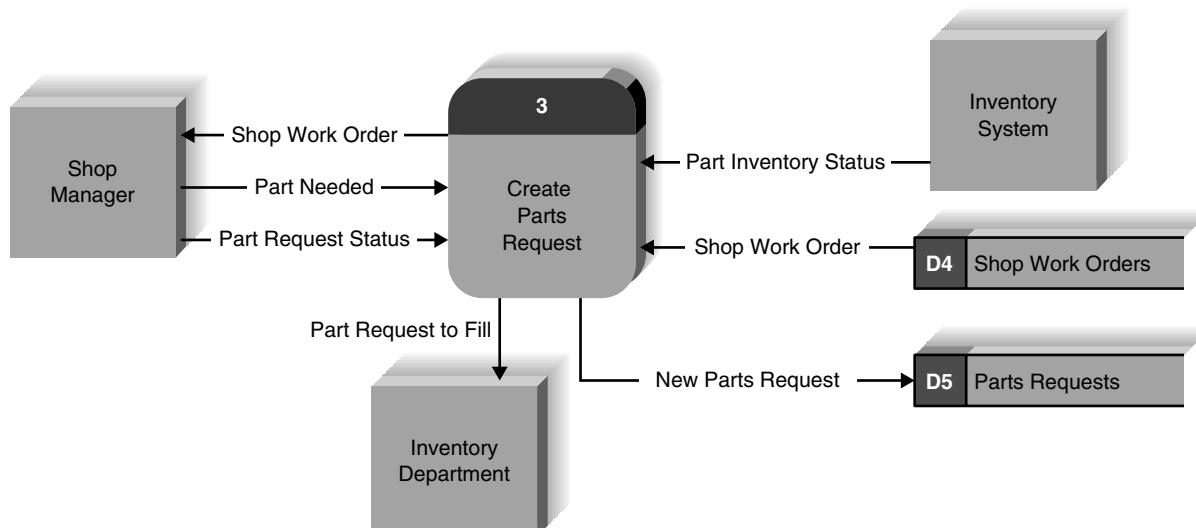


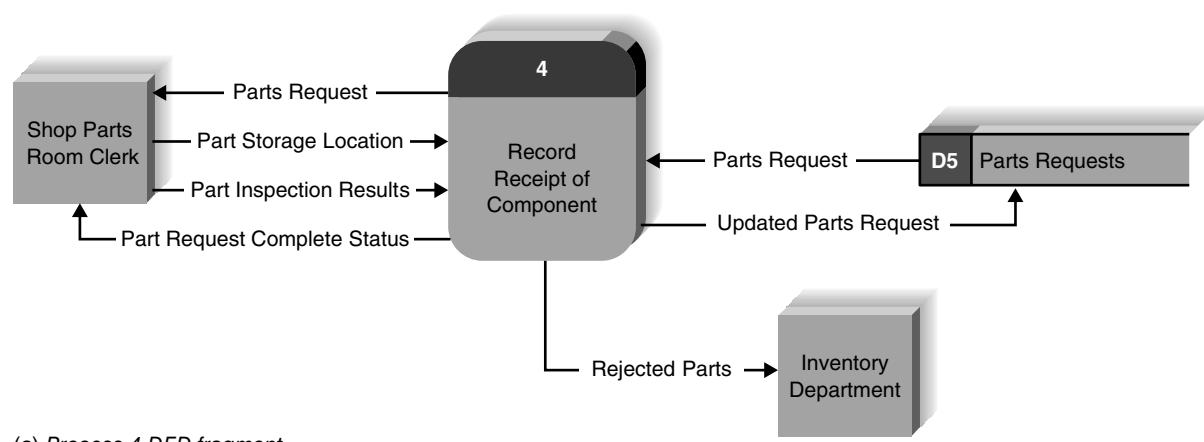
FIGURE 4-18 DrönTeq customization shop management process 3 (Create Parts Request) DFD fragment.

written as activities that the staff performs. It is traditional to design the processes from the viewpoint of the organization running the system, so this sometimes requires some additional changes in names.

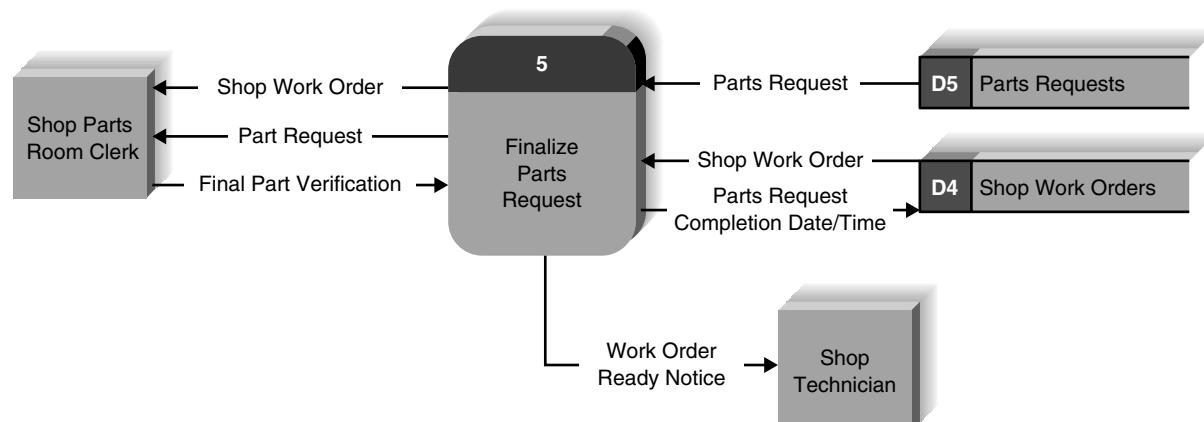
The second common change is the addition of data flows. Use cases are written to describe how the system and user interact. They may not describe how the system obtains data, so the use case often omits data flows read from a data store. When creating DFD fragments, it is important to make sure that any information given to the user is obtained from a data store. The easiest way to do this is to first create the DFD fragment with the major inputs and outputs listed on the use case and then verify that all outputs have sufficient inputs to create them.

There are no formal rules covering the **layout** of processes, data flows, data stores, and external entities within a DFD. Most systems analysts try to put the process in the middle of the DFD fragment, with the major inputs starting from the left side or top entering the process and outputs leaving from the right or the bottom. Data stores are often written below the process.

Take a moment and draw a DFD fragment for the two other use cases shown in Figure 4-9 (Record Receipt of Component and Finalize Parts Request). We have included possible ways of drawing these fragments in Figure 4-19. (Do not look until you have attempted the drawings on your own!)



(a) Process 4 DFD fragment



(b) Process 5 DFD fragment

FIGURE 4-19 Additional DFD fragments for DrönTeq customization shop management system.

## Creating the Level 0 Data Flow Diagram

Once you have the set of DFD fragments (one for each of the major use cases), you combine them into one DFD drawing that becomes the level 0 DFD. As mentioned earlier, there are no formal layout rules for DFDs. Most systems analysts try to put the process that is first chronologically in the upper left corner of the diagram and work their way from top to bottom, left to right (e.g., Figure 4-12). Most analysts try to reduce the number of times that data flow lines cross or to ensure that when they do cross, they cross at right angles so that there is less confusion. (Many give one line a little “hump” to imply that one data flow jumps over the other without touching it.) Minimizing the number of data flows that cross is challenging.

**Iteration** is the cornerstone of good DFD design. Even experienced analysts seldom draw a DFD perfectly the first time. In most cases, they draw it once to understand the pattern of processes, data flows, data stores, and external entities and then draw it a second time on a fresh sheet of paper (or in a fresh file) to make it easier to understand and to reduce the number of data flows that cross. Often, a DFD is drawn many times before it is finished.

Figure 4-20 combines the DFD fragments in Figures 4-18 and 4-19. Take a moment to examine Figure 4-20 and find the DFD fragments from Figures 4-18 and 4-19 contained within it.

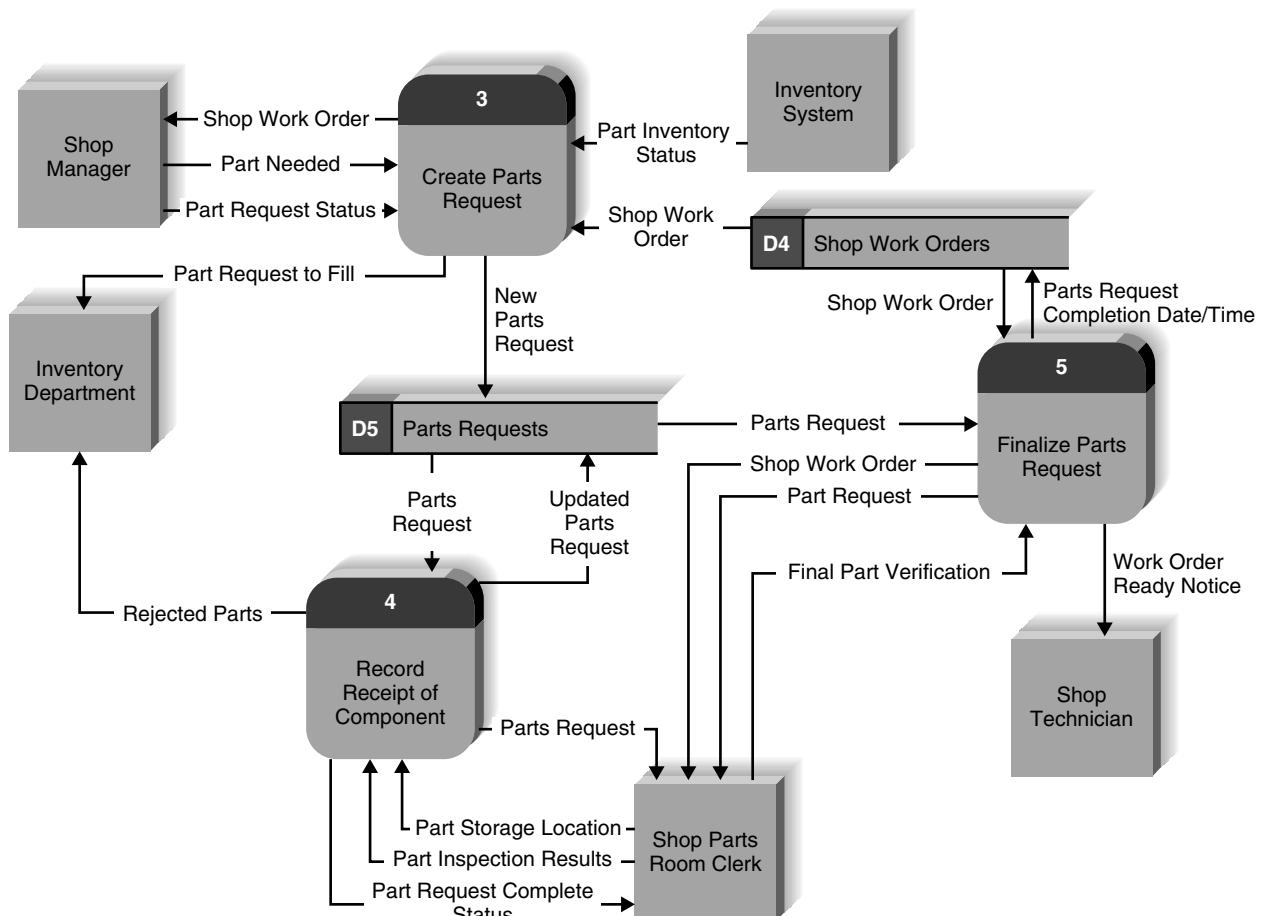


FIGURE 4-20 DrönTeq customization shop management system level 0 DFD.

## Creating Level 1 Data Flow Diagrams (and Below)

The team now begins to create lower-level DFDs for each process in the level 0 DFD that needs a level 1 DFD. Each one of the use cases is turned into its own DFD. The process for creating the level 1 DFDs is to take the steps as written on the use cases and convert them into a DFD in much the same way as for the level 0 DFD. Usually, each major step in the use case becomes a process on the level 1 DFD, with the inputs and outputs becoming the input and output data flows. Once again, however, sometimes subtle changes are required to go from the informal descriptions in the use case to the more formal process model, such as adding input data flows that were not included in the use case. And because the analysts are now starting to think more deeply about how the processes will be supported by an information system, they sometimes slightly change the use case steps to make the process easier to use.

In some approaches to creating DFDs, no source and destination are given on the level 1 DFD (and lower) for the inputs that come and go between external entities (or other processes outside of this process). We believe, however, that including external entities in level 1 and lower DFDs dramatically simplifies the readability of DFDs, with little downside. In our work in several dozen projects with the US Department of Defense, several other federal agencies, and the military of two other countries, we came to understand the value of this approach and converted the powers that be to our viewpoint. Because DFDs are not completely standardized, each organization uses them slightly differently. So, the ultimate decision of whether or not to include external entities on level 1 DFDs is yours—or your instructor’s! In this book, we will include them.

Ideally, we try to keep the data stores in the same general position on the page in the level 1 DFD as they were in the level 0 DFD, but this is not always possible. We try to draw input data flows arriving from the left edge of the page and output data flows leaving from the right edge. For example, see the level 1 DFD in Figure 4-12.

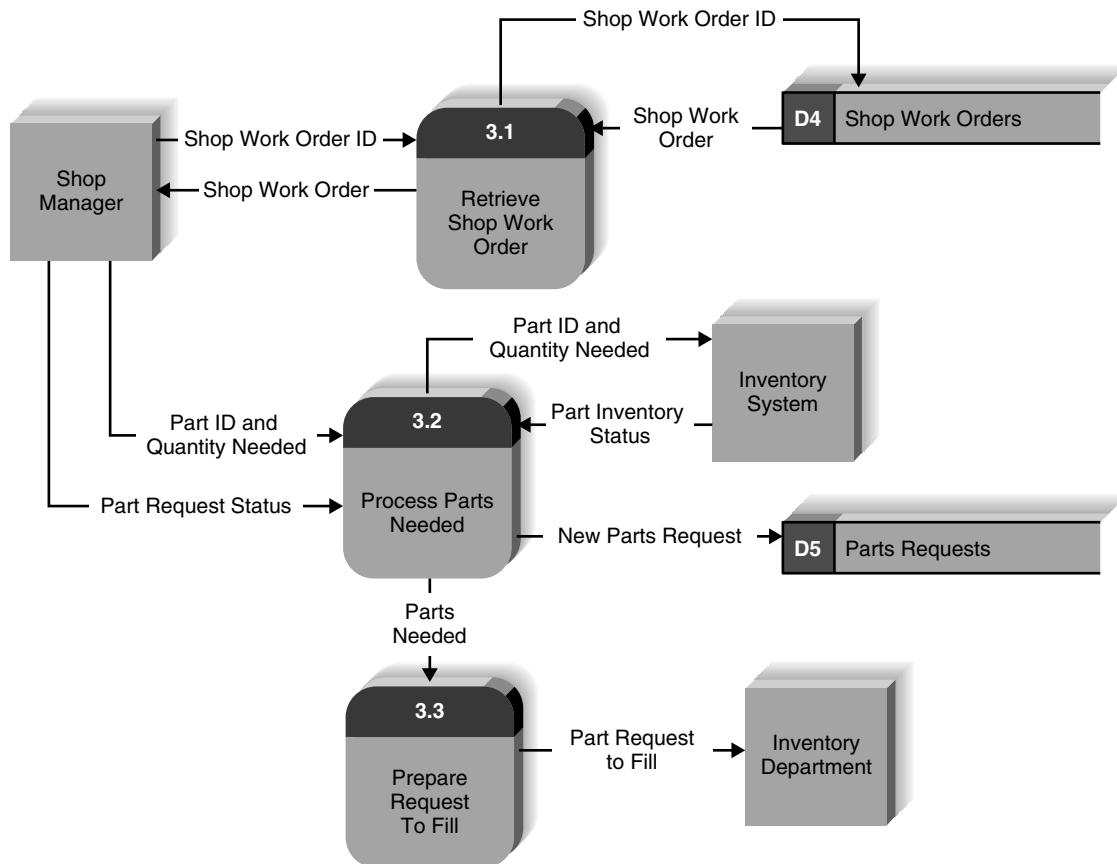
One of the most challenging design questions is when to decompose a process on a level 1 DFD into a child diagram. The decomposition of DFDs can be taken to almost any level, so for example, we could decompose process 1.2 on the level 1 DFD into processes 1.2.1, 1.2.2, 1.2.3, and so on in the level 2 DFD. This can be repeated to any level of detail, so one could have level 4 or even level 5 DFDs.

There is no simple answer to the “ideal” level of decomposition because it depends on the complexity of the system or business process being modeled. In general, you decompose a process into a lower-level DFD whenever that process is sufficiently complex that additional decomposition can help explain the process. Most experts believe that there should be at least three, and no more than seven to nine, processes on every DFD, so if you begin to decompose a process and end up with only two processes on the lower-level DFD, you probably do not need to decompose it. There seems little point in decomposing a process and creating another lower-level DFD for only two processes; you are better off simply showing two processes on the original higher level DFD. Likewise, a DFD with more than nine processes becomes difficult for users to read and understand, because it is very complex and crowded. Some of these processes should be combined and explained on a lower-level DFD.

One guideline for reaching the ideal level of decomposition is to decompose until you can provide a detailed description of the process in no more than one page of process descriptions: structured English, decision trees, or decision tables. Another helpful rule of thumb is that each lowest level process should be no more complex than what can be realized in about 25–50 lines of code.

In Figures 4-21, 4-22, and 4-23, we have provided level 1 DFDs for the parts request processes we have focused on for the DrōnTeq Customization Shop Management System. As we describe each figure, take a moment to look back at the Major Steps section of their respective use cases in Figure 4-9.

Figure 4-21 depicts the level 1 DFD for the process of Creating a Parts Request (process 3). The shop manager retrieves the shop work order from data storage. Based on the custom components

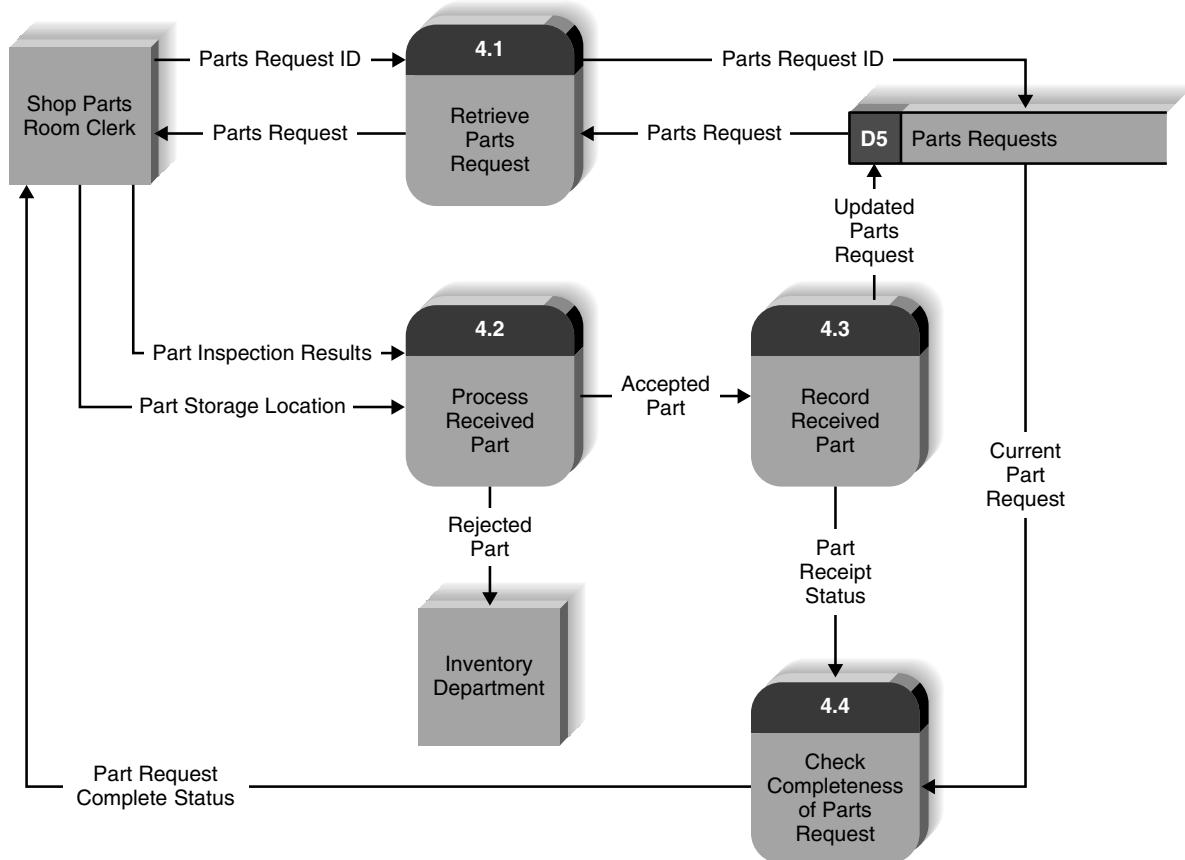


**FIGURE 4-21** DrōnTeq customization shop management system process 3 (Create Parts Request) level 1 DFD.

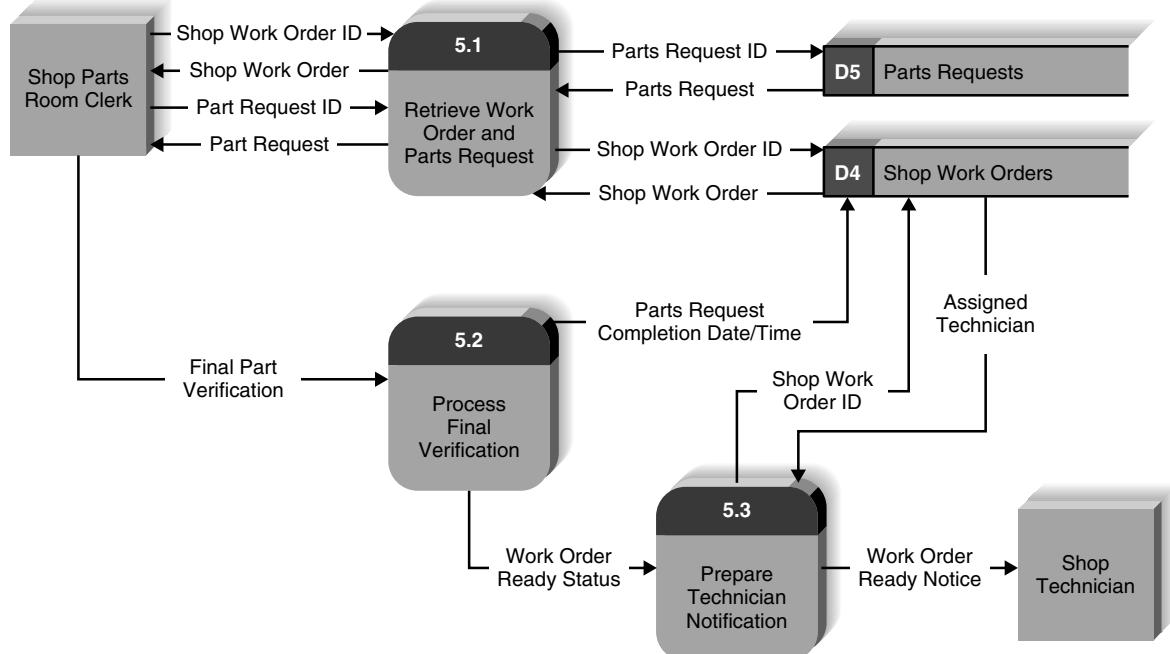
listed on the shop work order, the shop manager begins the process of querying the inventory system to determine the availability status of the needed parts. When the shop manager has entered all the needed parts, he indicates the parts request is complete. At this point, the new parts request record is added to data storage and the list of parts needed is used to create a request to fill that is sent to the inventory department. The request to fill will cause work to be performed in the inventory department to gather up the listed parts and deliver them to the shop parts room.

Figure 4-22 describes the process of Recording Receipt of a Component. This process is performed by the shop parts room clerk whenever the inventory department delivers a batch of components that will be used in building a custom drone. The shop parts room clerk uses the Parts Request ID that is listed with the delivered component to retrieve the correct parts request record. The part is then inspected to ensure it is the correct part and is undamaged. If the part is incorrect or damaged, it will be rejected by the shop parts room clerk and returned to the inventory department. If the part is the correct part and is undamaged, the shop parts room clerk enters the location in the part room where the part will be stored until pickup by the shop technician. The date/time of the part receipt and the storage location are recorded in the parts request record. Following the update of the parts request record, a process will review the status of all parts listed on the parts request. If all parts have been received, the shop parts clerk is notified that the parts request is complete.

Figure 4-23 depicts the third of the use cases from Figure 4-10 (Finalize Parts Request). The shop parts room clerk retrieves the shop work order and the associated parts request from data storage and verifies that all parts are available to meet the work order requirements. This



**FIGURE 4-22** DrōnTeq customization shop management system process 4 (Record Receipt of Components) level 1 DFD.



**FIGURE 4-23** DrōnTeq customization shop management system process 5 (Finalize Parts Request) Level 1 DFD.

verification is submitted by the clerk and the shop work order is updated with the date/time that the work order was ready. Finally, the technician assignment is retrieved from the shop work order so that the correct technician can be notified that the components may be picked up and assembly of the custom drone can begin.

The process model is more likely to be drawn to the lowest level of detail for a to-be model if a traditional development process is used [i.e., not rapid application development (RAD); see Chapter 2] or if the system will be built by an external contractor. Without the complete level of detail, it may be hard to specify in a contract exactly what the system should do. If a RAD approach, involving a lot of interaction with the users and, typically, prototypes, is being used, we would be less likely to go to as low a level of detail, because the design will evolve through interaction with the users. In our experience, most systems go to only level 2 at most.

There is no requirement that all parts of the system must be decomposed to the same level of DFDs. Some parts of the system may be very complex and require many levels, whereas other parts of the system may be simpler and require fewer.

## Validating the Data Flow Diagrams

Once you have created a set of DFDs, it is important to check them for quality. Figure 4-24 provides a quick checklist for identifying the most common errors. There are two fundamentally different types of problems that can occur in DFDs: **syntax errors** and **semantics errors**. “Syntax,” refers to the structure of the DFDs and whether the DFDs follow the rules of the DFD language. Syntax errors can be thought of as grammatical errors made by the analyst when he or she creates the DFD. “Semantics” refers to the meaning of the DFDs and whether they accurately describe the business process being modeled. Semantics errors can be thought of as misunderstandings by the analyst in collecting, analyzing, and reporting information about the system.

In general, syntax errors are easier to find and fix than are semantics errors, because there are clear rules that can be used to identify them (e.g., a process must have a name). Most CASE tools have syntax checkers that will detect errors within one page of a DFD in much the same way that word processors have spelling checkers and grammar checkers. Finding syntax errors that span several pages of a DFD (e.g., from a level 1 to a level 2 DFD) is slightly more challenging, particularly for consistent viewpoint, decomposition, and balance. Some CASE tools can detect balance errors, but that is about all. In most cases, analysts must carefully and painstakingly review every process, external entity, data flow, and data store on all DFDs by hand to make sure that they have a consistent viewpoint and that the decomposition and balance are appropriate.

Each data store is required to have at least one input and one output on some page of the DFD. In our example DFDs, you may see a data store with only outputs and others that have only inputs. This situation is not necessarily an error. The analyst should check elsewhere in the DFDs to locate places in which the data store has inputs or outputs. All data stores should have at least one inflow and one outflow, but the flows may not be on the same diagram, so check other parts of the system. Another issue that arises is when the data store is utilized by other systems. In that case, data may be added to or used by a separate system. This is perfectly fine, but the analyst should investigate to verify that the required flows in and out of data stores exist somewhere.

In our experience, the most common syntax error that novice analysts make in creating DFDs is violating the law of conservation of data.<sup>5</sup>

The first part of the law states the following:

1. *Data at rest stays at rest until moved by a process.*

In other words, data cannot move without a process. Data cannot go to or come from a data store or an external entity without having a process to push it or pull it.

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<sup>5</sup> This law was developed by Prof. Dale Goodhue at the University of Georgia.

## Syntax

### Within DFD

Process	<ul style="list-style-type: none"> <li>Every process has a unique name that is an action-oriented verb phrase, a number, and a description.</li> <li>Every process has at least one input data flow.</li> <li>Every process has at least one output data flow.</li> <li>Output data flows usually have different names than input data flows because the process changes the input into a different output in some way.</li> <li>There are between three and seven processes per DFD.</li> </ul>
Data Flow	<ul style="list-style-type: none"> <li>Every data flow has a unique name that is a noun, and a description.</li> <li>Every data flow connects to at least one process.</li> <li>Data flows only in one direction (no two-headed arrows).</li> <li>A minimum number of data flow lines cross.</li> </ul>
Data Store	<ul style="list-style-type: none"> <li>Every data store has a unique name that is a noun, and a description.</li> <li>Every data store has at least one input data flow (which means to add new data or change existing data in the data store) on some page of the process model.</li> <li>Every data store has at least one output data flow (which means to read data from the data store) on some page of the process model.</li> </ul>
External Entity	<ul style="list-style-type: none"> <li>Every external entity has a unique name that is a noun, and a description.</li> <li>Every external entity has at least one input or output data flow.</li> </ul>

### Across DFDs

Context diagram	<ul style="list-style-type: none"> <li>Every set of DFDs must have one context diagram.</li> </ul>
Viewpoint	<ul style="list-style-type: none"> <li>There is a consistent viewpoint for the entire set of DFDs.</li> </ul>
Decomposition	<ul style="list-style-type: none"> <li>Every process is wholly and completely described by the processes on its children DFDs.</li> </ul>
Balance	<ul style="list-style-type: none"> <li>Every data flow, data store, and external entity on a higher-level DFD is shown on the lower-level DFD that decomposes it.</li> </ul>

### Semantics

Appropriate Representation	<ul style="list-style-type: none"> <li>User validation</li> <li>Role-play processes</li> </ul>
Consistent Decomposition	<ul style="list-style-type: none"> <li>Examine lowest-level DFDs</li> </ul>
Consistent Terminology	<ul style="list-style-type: none"> <li>Examine names carefully</li> </ul>

**FIGURE 4-24** Data flow diagram quality checklist.

### CONCEPTS IN ACTION 4-B

### US Army and Marine Corps Battlefield Logistics

Shortly after the Gulf War in 1991 (Desert Storm), the US Department of Defense realized that there were significant problems in its battlefield logistics systems that provided supplies to the troops at the division level and below. During the Gulf War, it had proved difficult for army and marine units fighting together to share supplies back and forth because their logistics computer systems would not easily communicate. The goal of the new system was to combine the army and marine corps logistics systems into one system to enable units to share supplies under battlefield conditions.

The army and marines built separate as-is process models of their existing logistics systems that had 165 processes for the army system and 76 processes for the marines. Both process models were developed over a 3-month period and cost several million dollars to build, even though they were not intended to be comprehensive.

I helped them develop a model for the new integrated battlefield logistics system that would be used by both services (i.e., the to-be model). The initial process model contained 1,500 processes and went down to level 6 DFDs in many places. It took 3,300 pages to print. They realized that this model was too large to be useful. The project leader decided that level 4 DFDs was as far as the model would go, with additional information contained in the process descriptions. This reduced the model to 375 processes (800 pages) and made it far more useful. *Allan Dennis*

#### Questions

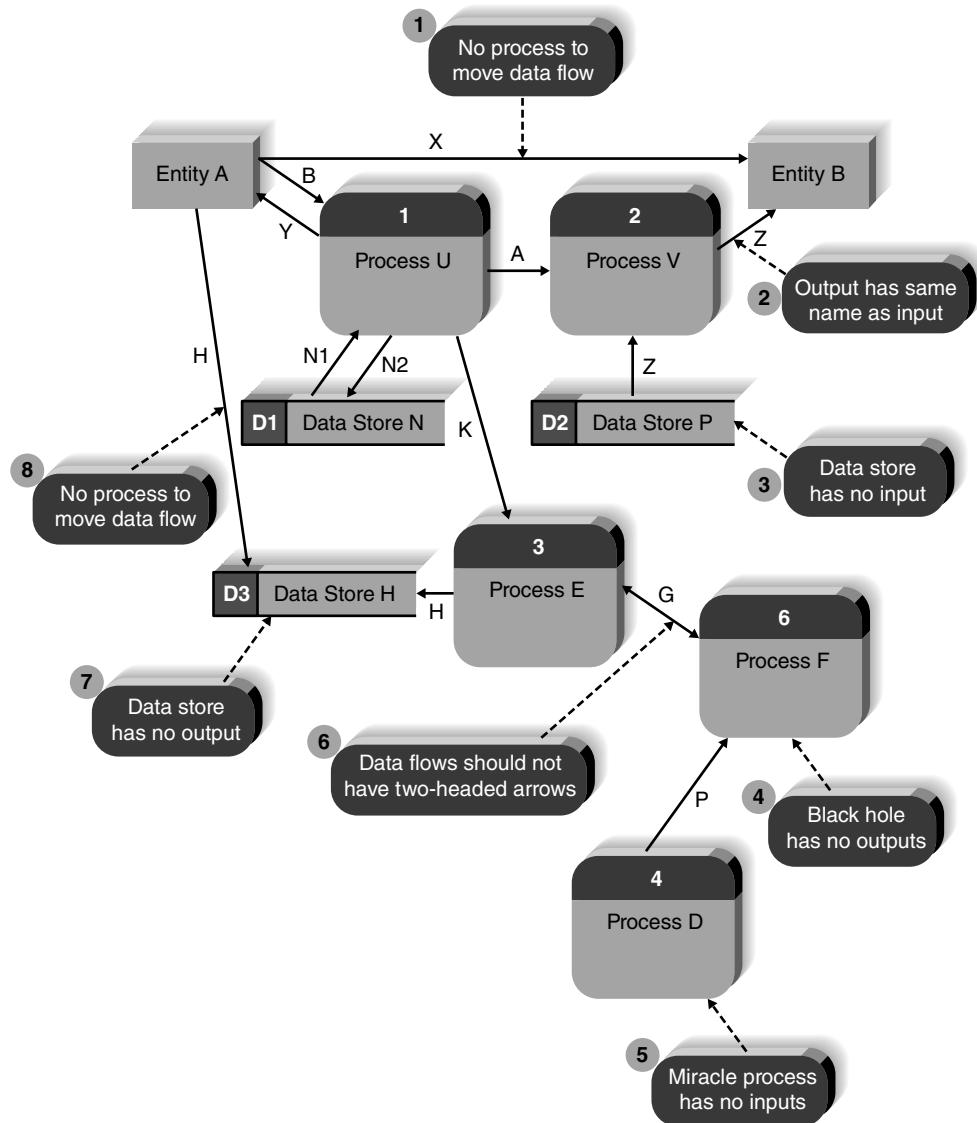
- What are the advantages and disadvantages to setting a limit for the maximum depth for a DFD?
- Is a level 4 DFD an appropriate limit?

The second part of the law states the following:

*2. Processes cannot consume or create data.*

In other words, data only enters or leaves the system by way of the external entities. A process cannot destroy input data; all processes must have outputs. Drawing a process without an output is sometimes called a “black hole” error. Likewise, a process cannot create new data; it can transform data from one form to another, but it cannot produce output data without inputs. Drawing a process without an input is sometimes called a “miracle” error (because output data miraculously appear). There is one exception to the part of the law requiring inputs, but it is so rare that most analysts never encounter it.<sup>6</sup>

Figure 4-25 shows some common syntax errors.



**FIGURE 4-25** Some common errors.

<sup>6</sup> The exception is a temporal process that issues a trigger output based on an internal time clock. Whenever some predetermined period elapses, the process produces an output. The timekeeping process has no inputs because the clock is internal to the process.

Looking at Figure 4-25, we will discuss each error in turn.

1. Data flow X is drawn directly from Entity A to Entity B. Remember that a data flow must either originate or terminate at a process; therefore, a process is needed between the two entities.
2. Data flow Z is retrieved from Data Store P and sent to Entity B. Processes should exist to transform the data in some way, so we usually modify the data flow names to reflect the changes made in the process.
3. Data Store P has outputs but has no inputs. This is not necessarily an error but does deserve the analyst's investigation. Make sure that a process that adds data to Data Store P exists somewhere in the DFDs of the entire process model.
4. Process F receives data from two processes but has no outputs. This is considered a black hole since data are received but nothing is produced.
5. Process D produces a data flow but has no inputs. This is termed a miracle process.
6. A two-headed arrow is drawn on Data Flow G between Process E and Process F. Data flows should not be drawn this way but should flow only in one direction. If data flows in both directions each flow should be drawn as a separate data flow.
7. Data Store H receives Data Flow H as an input but has no outputs. This issue may not be an error but should be followed up by the analyst to ensure that the data that are stored in Data Store H are used some place in the process model; otherwise, there is no reason to store it.
8. A process is needed between Entity A and Data Store H.

Semantics errors cause the most problems in system development. Semantics errors are much harder to find and fix because doing so requires a good understanding of the business process. And even then, what may be identified as an error may be a misunderstanding by the person reviewing the model. There are three useful checks to help ensure that models are semantically correct (Figure 4-24).

The first check to ensure that the model is an appropriate representation is to ask the users to validate the model in a walk-through (i.e., the model is presented to the users, and they examine it for accuracy). A more powerful technique is for the users to role-play the process from the DFDs in the same way in which they role-played the use case. The users pretend to execute the process exactly as it is described in the DFDs. They start at the first process and attempt to perform it by using only the inputs specified and producing only the outputs specified. Then they move to the second process, and so on.

One of the most subtle forms of semantics error occurs when a process creates an output but has insufficient inputs to create it. For example, to create water ( $H_2O$ ), we need to have both hydrogen (H) and oxygen (O) present. The same is true of computer systems, in that the outputs of a process can be only combinations and transformations of its inputs. Suppose, for example, that we want to record an order; we need the customer's name and mailing address and the quantities and prices for the items the customer is ordering. We need information from the customer data store (e.g., address) and information from the items data store (e.g., price). We cannot draw a process that produces an output order data flow without inputs from these two data stores. Role-playing with strict adherence to the inputs and outputs in a model is one of the best ways to catch this type of error.

A second semantics error check is to ensure consistent decomposition, which can be tested by examining the lowest-level processes in the DFDs. In most circumstances, all processes

should be decomposed to the same level of detail—which is not the same as saying the same number of levels. For example, suppose that we were modeling the process of driving to work in the morning. One level of detail would be to say the following: (1) enter car; (2) start car; (3) drive away. Another level of detail would be to say the following: (1) unlock car; (2) sit in car; (3) buckle seat belt; and so on. Still another level would be to say the following: (1) remove key from pocket; (2) insert key in door lock; (3) turn key; and so on. None of these is inherently better than another, but barring unusual circumstances, it is usually best to ensure that all processes at the very bottom of the model provide the same consistent level of detail.

Likewise, it is important to ensure that the terminology is consistent throughout the model. The same item may have different names in different parts of the organization, so one person’s “sales order” may be another person’s “customer order.” Likewise, the same term may have different meanings; for example, “ship date” may mean one thing to the sales representative taking the order (e.g., promised date) and something else to the warehouse (e.g., the actual date shipped). Resolving these differences before the model is finalized is important in ensuring that everyone who reads the model or who uses the information system built from the model has a shared understanding.

## Applying the Concepts at DrōnTeq

### Developing the Process Model

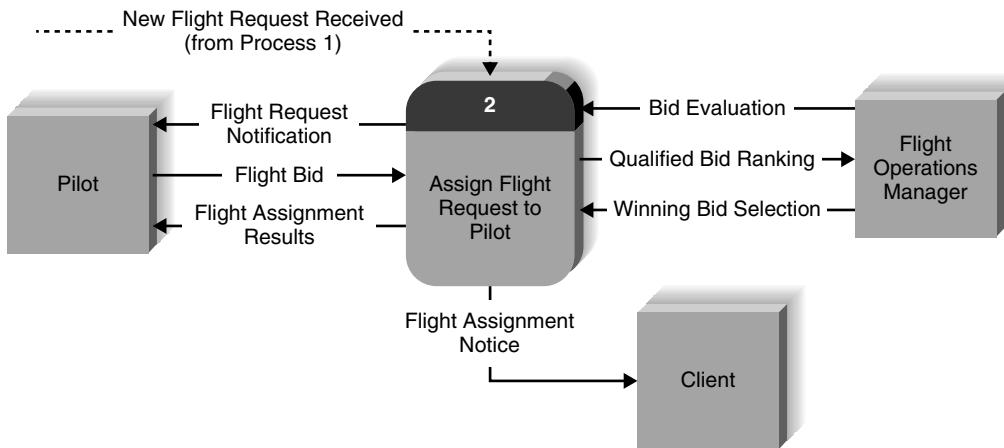
As discussed previously, not all the events associated with the Client Services system under development were complex enough to warrant creating use cases. Jiang did employ use cases to help clarify one particularly thorny aspect of the new system, however, that of assigning flights to pilots. These use cases are shown in Figure 4-11. You should refer to those use cases as you study this section of the book.

To add more clarity to his understanding of these events, Jiang decided to develop a set of data flow diagrams. While he decided not to prepare DFDs for the entire Client Services system, he felt that the DFDs would prove to be useful for this smaller segment of the system.

Jiang began by creating a DFD fragment for the event handling process, Assign Flight Request to Pilot. This fragment is akin to a context diagram for a single, complex event. We label the process as number 2 in this diagram, since we are looking at a single event-handling process in our event list. The DFD fragment is shown in Figure 4-26. You will notice a control flow entering the process with the notation that a New Flight Request is received from Request Flight (process 1). This notation conveys that process 2 is triggered following the submission of a flight request in another part of the system.

### Creating Data Flow Diagram Fragments

Following the practice of decomposing our process model to expand on the details, Jiang next focused on drawing a level 1 diagram. Jiang began by drawing DFD fragments for each of the three use cases depicted in Figure 4-11. This was done by drawing the process in the middle of the page, making sure that the process number and name were appropriate, and connecting all the input and output data flows to it. Unlike the parent diagram shown in Figure 4-25, the DFD fragments include data flows to external entities and to internal data stores.



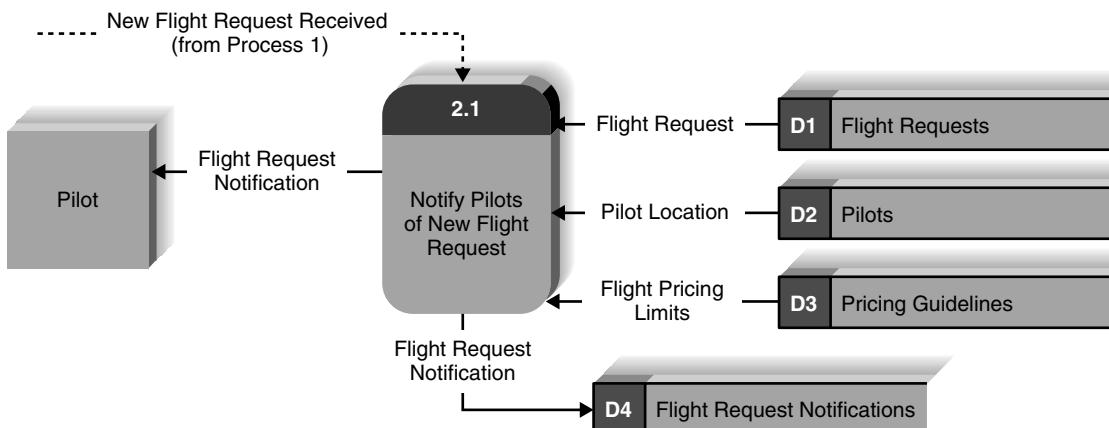
**FIGURE 4-26** DFD fragment for event 2, assign flight request to pilot.

The completed DFD fragments are shown in Figure 4-27. Before looking at the figure, take a minute and draw them on your own by referring to Figure 4-11. There are many good ways to draw these fragments. In fact, there are many “right” ways to create use cases and DFDs. Notice that on the DFD fragment for process 2.3, we have shown a dotted line inflow labeled “Bidding Window on Flight Request Closes” entering the process. Recall that we specified that the use case, Select Winning Flight Bid, was a temporal use case, triggered when the time to place bids on a flight request expires. The dotted line flow into process 2.3 in Figure 4-27 illustrates the way a control flow can represent a time-based trigger for an event.

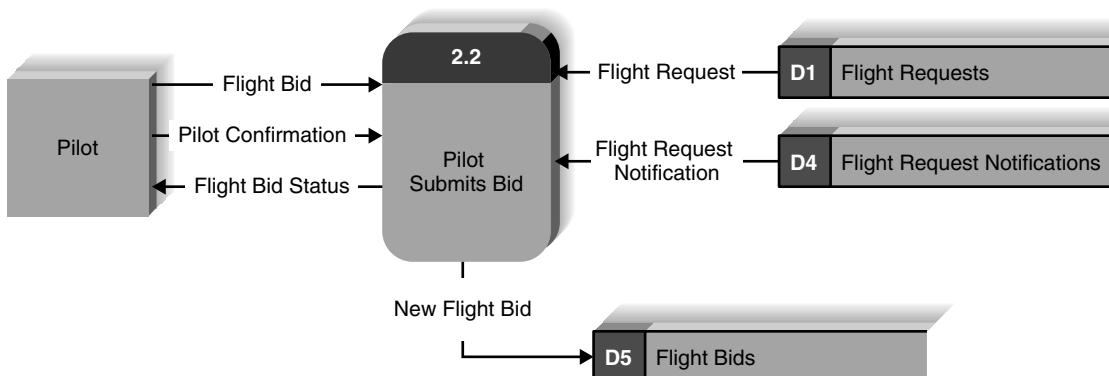
## Creating the Level 1 Data Flow Diagram

The next step was to create the level 1 DFD by integrating the DFD fragments, which proved to be anticlimactic. Jiang simply took the DFD fragments and drew them together on one piece of paper. Although it sometimes is challenging to arrange all the DFD fragments on one piece of paper, it was primarily a mechanical exercise (Figure 4-28). Compare the level 1 diagram with the parent diagram in Figure 4-26. Are the two DFDs balanced? Notice the additional detail contained in the level 1 diagram.

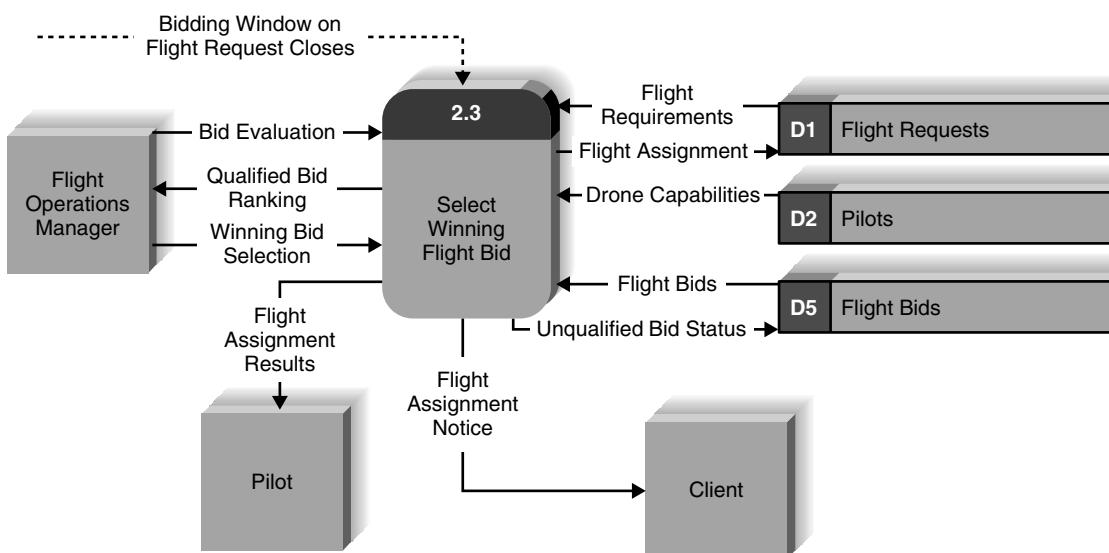
A careful review of the data stores in Figure 4-27 reveals that only two of the data stores have both an inflow and an outflow (D4: Flight Request Notifications and D5: Flight Bids). Data stores D2: Pilots and D3: Pricing Guidelines are used only to provide data to these processes. Data store D1: Flight Requests provides data and is updated by a process. We know that the Flight Request data store contents are created in Process 1, Create Flight Requests, and the contents of D2: Pilots is probably created when pilots create a contract with DrōnTeq to participate in the Pilot Partnership program. The source of data store D3: Pricing Guidelines is unclear. These violations of DFD syntax need to be investigated by the team because it may be a serious oversight. We need to create processes specifically for adding, modifying, and deleting data in all our data stores. “Administrative” processes such as this are often overlooked, as we initially focus on business requirements only, but will need to be added before the system is complete.



(a) Notify pilots of New Flight Request Process 2.1 DFD fragment

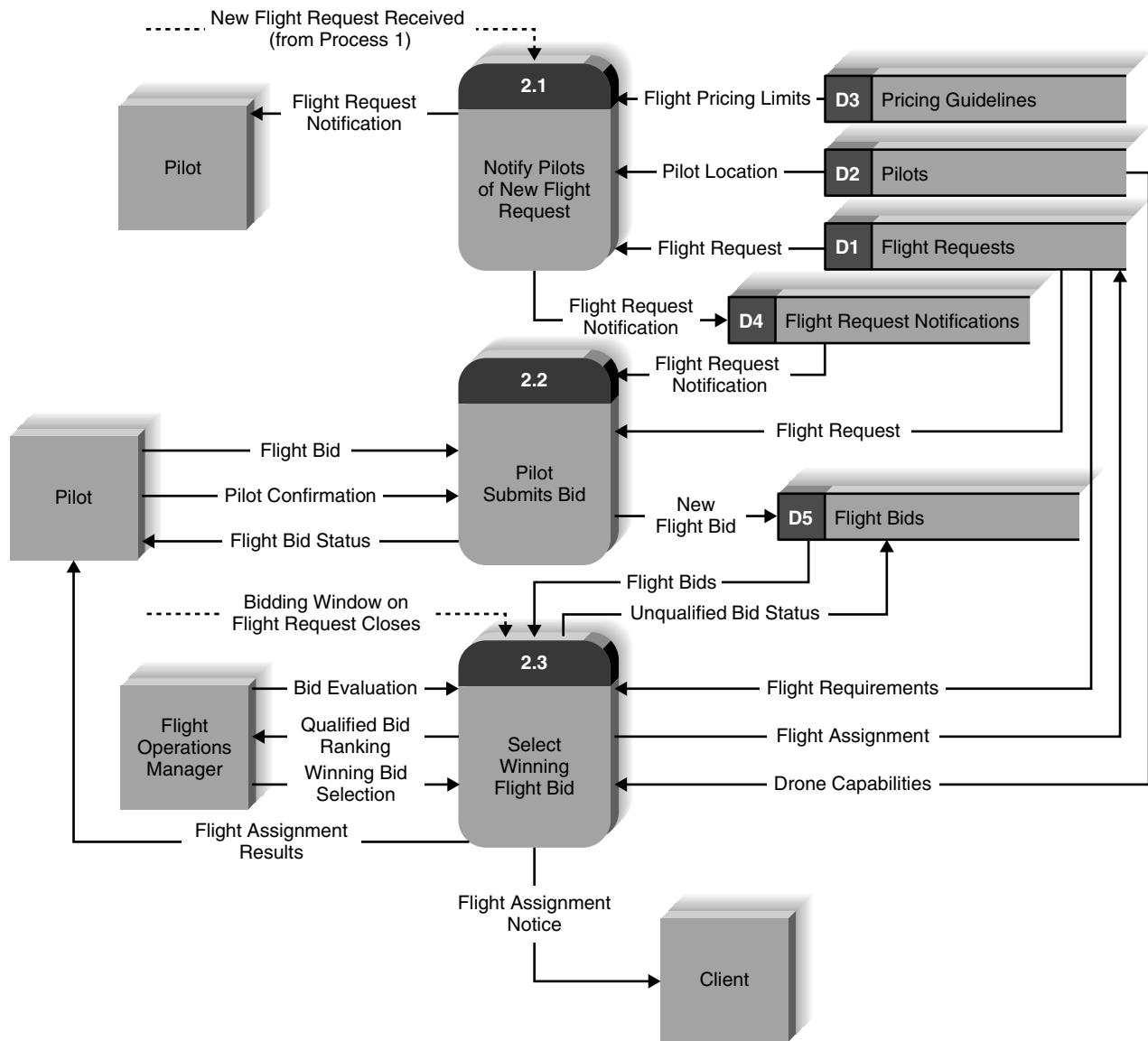


(b) Pilot submits Bid Process 2.2 DFD fragment



(c) Select Winning Flight Bid Process 2.3 DFD fragment

**FIGURE 4-27** Event 2, assign flight request to pilot DFD fragments.

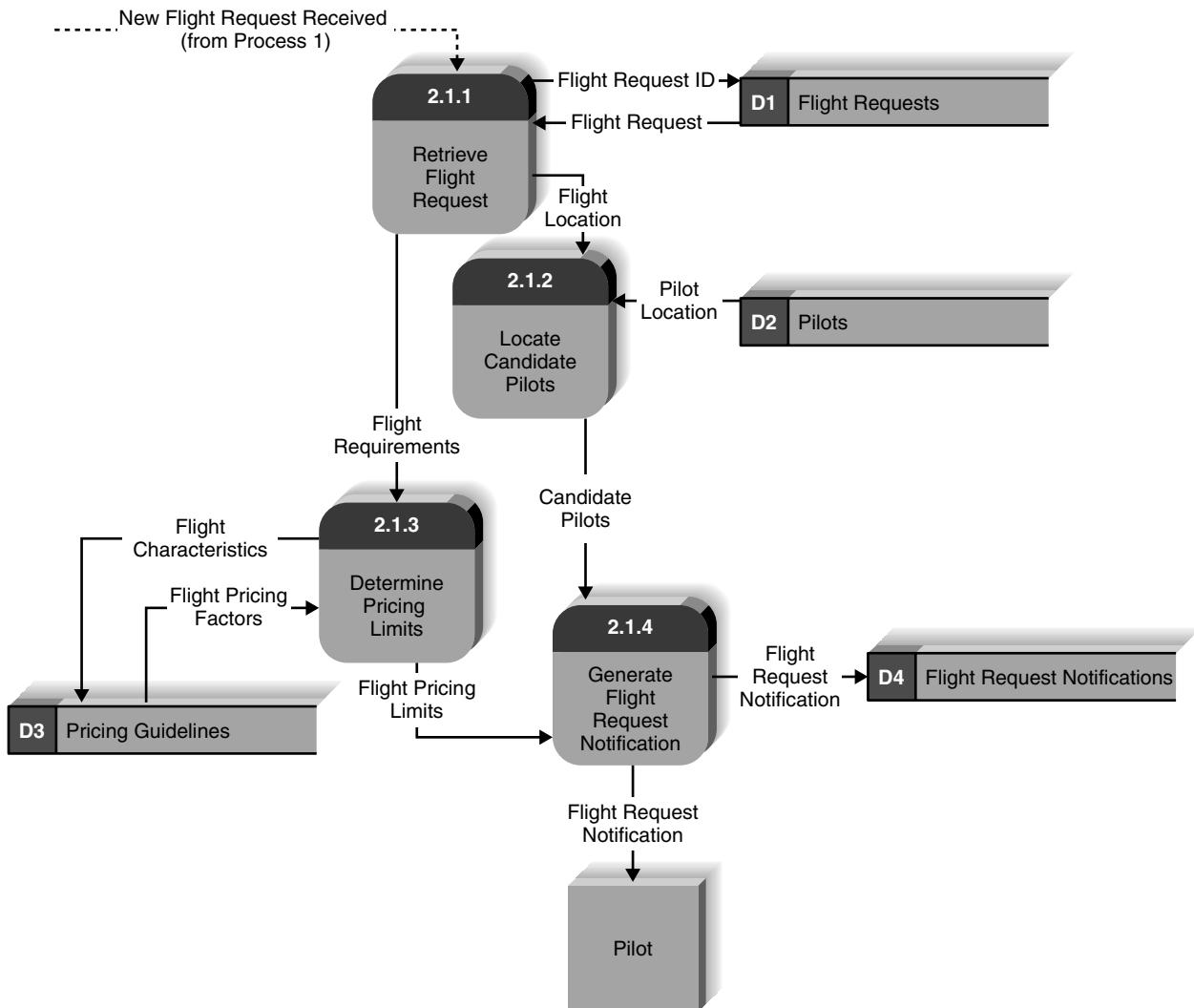


**FIGURE 4-28** Assign flight request to pilot level 1 DFD.

## Creating Level 2 Data Flow Diagrams (and Below)

The next step was to create the level 2 DFDs for those processes that could benefit from them. The analysts started with the first use case (notify pilots of new flight request) and started to draw a DFD for the individual steps it contained. The steps in the use case were straightforward, but as is common, the team had to choose names and numbers for the processes and to add data flows between subprocesses. See Figure 4-29.

The team also developed level 2 diagrams for the other processes, using the major steps outlined in their respective use cases. Some adjustments were made from the steps as shown in the use cases, but the team followed the steps fairly closely. See Figures 4-30 and 4-31 and compare them with their use cases shown in Figure 4-11.



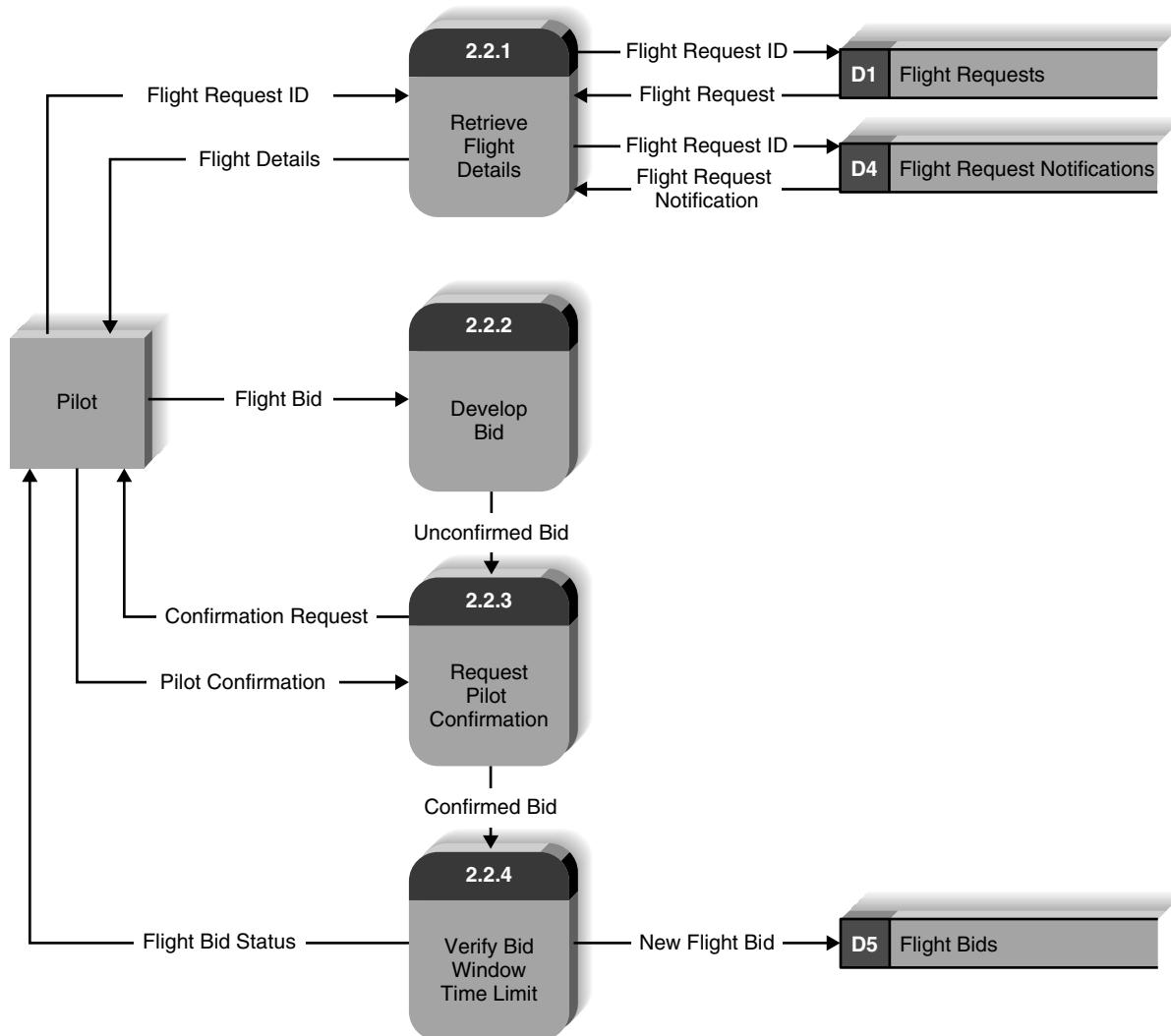
**FIGURE 4-29** Level 2 DFD for process 2.1 notifies pilots of new flight request.

#### YOUR TURN 4-3 || Campus Housing

Draw a context diagram, a level 0 DFD, and a set of level 1 DFDs (where needed) for the campus housing use cases that you developed for the Your Turn 4-1 box.

## Validating the Data Flow Diagrams

The final set of DFDs was validated by the project team and then by Carmella and her management team in a final JAD meeting. There was general approval of the processes outlined and the team felt very satisfied that a complex process had been made clear and would support this important aspect of the business processes of the Client Services business unit.



**FIGURE 4-30** Level 2 DFD for process 2.2 pilot submits bid.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Explain the purpose of a use case in the analysis phase of the SDLC.
- Explain why use cases are commonly used in the analysis phase.
- Discuss the various sections found in a use case form and the purpose and content of each section.
- Explain how use cases help the systems analyst create a more in-depth understanding of the system's functional requirements.
- Describe how use cases can contribute to the development of test plans for the new system.
- Discuss the four steps of the process used to create use cases.
- Define the meaning and purpose of the four basic symbols found on a data flow diagram.
- Explain the meaning and purpose of a process model's context diagram.
- Explain the meaning and purpose of a process model's level 0 diagram.
- Explain the meaning and purpose of a process model's level 1 diagrams.
- Explain the concept of decomposition and why process models are created as a hierarchy of DFDs.
- Describe several common syntax and semantic errors found on DFDs.
- Discuss the process used to create a process model.
- Discuss how the process model contributes to the development of the new information system.

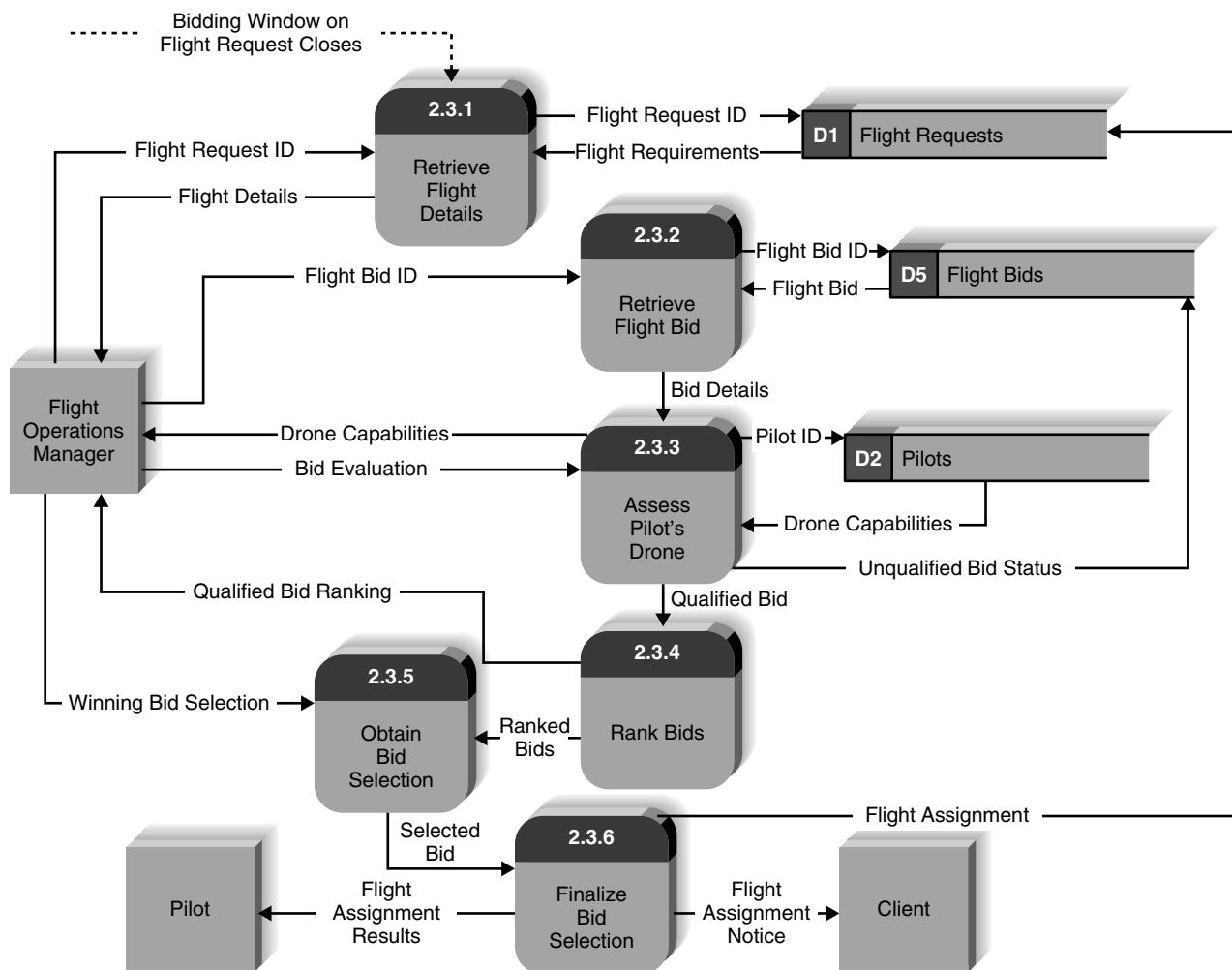


FIGURE 4-31 Level 2 DFD for process 2.3 selects winning flight bid.

## KEY TERMS

Actor	Decomposition	Layout	Preconditions	Temporal trigger
Balancing	DFD fragment	level 0 diagram or level 0 DFD	Primary actor	Trigger
Bundle	Essential use cases	level 1 diagram, or level 1 DFD	Priority	Use case
Children	Event-driven modeling	Level 2 DFD	Process	Use case packages
Context diagram	event triggers	Logical process model	Processes	User requirements
Data flow	External entity	Outputs	Process model	User role
Data flow diagram (DFD)	External trigger	Parent	Role-play	Viewpoint
	Happy path	Physical model	Semantics error	Visualization
	IF statements	Postconditions	Step	
Decision tables	Inputs		Structured English	
Decision trees	Iteration		Syntax error	

## QUESTIONS

1. What is the purpose of developing use cases during systems analysis?
2. How do use cases relate to the requirements stated in the requirements definition?
3. Describe the elements of the use case's basic information section.
4. What is the purpose of the inputs and outputs section of the use case?
5. What is the purpose of stating the primary actor for the use case?
6. Why is it important to state the priority level for a use case?
7. What is the distinction between an external trigger and a temporal trigger? Give two examples of each.
8. Why do we outline the major steps performed in the use case?
9. What is the purpose of an event-response list in the process of developing use cases?
10. Should a use case be prepared for every item on the event-response list? Why or why not?
11. Describe two ways to handle a situation in which there are many use cases.
12. What role does iteration play in developing use cases?
13. Describe the best way to validate the content of the use cases.
14. What is a process model? What is a data flow diagram (DFD)? Are the two related? If so, how?
15. Distinguish between logical process models and physical process models.
16. Define what is meant by a *process* in a process model. How should a process be named? What information about a process should be stored in the CASE repository?
17. Define what is meant by a *data flow* in a process model. How should a data flow be named? What information about a data flow should be stored in the CASE repository?
18. Define what is meant by a *data store* in a process model. How should a data store be named? What information about a data store should be stored in the CASE repository?
19. Define what is meant by an *external entity* in a process model. How should an external entity be named? What information about an external entity should be stored in the CASE repository?
20. Why is a process model typically composed of a set of DFDs? What is meant by decomposition of a business process?
21. Explain the relationship between a DFD context diagram and the DFD level 0 diagram.
22. Explain the relationship between a DFD level 0 diagram and DFD level 1 diagram(s).
23. Discuss how the analyst knows how to stop decomposing the process model into more and more levels of detail.
24. Suppose that a process on a DFD is numbered 4.3.2. What level diagram contains this process? What is this process's parent process?
25. Explain the use of structured English in process descriptions.
26. Why would one use a decision tree and/or decision table in a process description?
27. Explain the process of balancing a set of DFDs.
28. How are mutually exclusive data flows (i.e., alternative paths through a process) depicted in DFDs?
29. Discuss several ways to verify the correctness of a process model.
30. Identify three typical syntax errors commonly found in DFDs.
31. What is meant by a DFD semantic error? Provide an example.
32. Creating use cases when working with users is a recent development in systems analysis practice. Why is the trend today to employ use cases in user interviews or JAD sessions?
33. How can you make a DFD easier to understand? (Think first about how to make one difficult to understand.)
34. Suppose that your goal is to create a set of DFDs. How would you begin an interview with a knowledgeable user? How would you begin a JAD session?

## EXERCISES

- A. Create a set of use cases for the process of buying glasses from the viewpoint of the patient, but do not bother to identify the steps within each use case. (Just complete the information at the top of the use case form.) The first step is to see an eye doctor who will give you a prescription. Once you have a prescription, you go to a glasses store, where you select your frames and place the order for your glasses. Once the glasses have been made, you return to the store for a fitting and pay for the glasses.
- B. Draw a level 0 data flow diagram (DFD) for the process of buying glasses in Exercise A.
- C. Create a set of use cases for the accompanying dentist office system, but do not bother to identify the steps within each use case. (Just complete the information at the top of the use case form.) When new patients are seen for the first time, they complete a patient information form that asks for their name, address, phone number, and brief medical history, which are

- stored in the patient information file. When a patient calls to schedule a new appointment or change an existing appointment, the receptionist checks the appointment file for an available time. Once a good time is found for the patient, the appointment is scheduled. If the patient is a new patient, an incomplete entry is made in the patient file; the full information will be collected when the patient arrives for the appointment. Because appointments are often made far in advance, the receptionist usually mails a reminder postcard to each patient 2 weeks before the appointment.
- D. Draw a level 0 DFD for the dentist office system in Exercise C.
- E. Complete the use cases for the dentist office system in exercise C by identifying the steps and the data flows within the use cases.
- F. Create a set of use cases for an online university registration system. The system should enable the staff of each academic department to examine the courses offered by their department, add and remove courses, and change the information about them (e.g., the maximum number of students permitted). It should permit students to examine currently available courses, add and drop courses to and from their schedules, and examine the courses for which they are enrolled. Department staff should be able to print a variety of reports about the courses and the students enrolled in them. The system should ensure that no student takes too many courses and that students who have any unpaid fees are not permitted to register. (Assume that a fees data store is maintained by the university's financial office, which the registration system accesses but does not change.)
- G. Draw a level 0 DFD for the university system in Exercise E.
- H. Create a set of use cases for the following system: A Real Estate, Inc. (AREI), sells houses. People who want to sell their houses sign a contract with AREI and provide information on their house. This information is kept in a database by AREI, and a subset of this information is sent to the citywide multiple listing service used by all real estate agents. AREI works with two types of potential buyers. Some buyers have an interest in one specific house. In this case, AREI prints information from its database, which the real estate agent uses to help show the house to the buyer (a process beyond the scope of the system to be modeled). Other buyers seek AREI's advice in finding a house that meets their needs. In this case, the buyer completes a buyer information form that is entered into a buyer database, and AREI real estate agents use its information to search AREI's database and the multiple listing service for houses that meet their needs. The results of these searches are printed and used to help the real estate agent show houses to the buyer.
- I. Draw a level 0 DFD for the real estate system in Exercise H.
- J. Create a set of use cases for the following system: a Video Store (AVS) runs a series of fairly standard video stores. Before a video can be put on the shelf, it must be catalogued and entered into the video database. Every customer must have a valid AVS customer card in order to rent a video. Customers rent videos for 3 days at a time. Every time a customer rents a video, the system must ensure that this customer does not have any overdue videos. If so, the overdue videos must be returned and an overdue fee paid before the customer can rent more videos. Likewise, if the customer has returned overdue videos, but has not paid the overdue fee, the fee must be paid before new videos can be rented. Every morning, the store manager prints a report that lists overdue videos; if a video is two or more days overdue, the manager calls the customer to remind him or her to return the video. If a video is returned in damaged condition, the manager removes it from the video database and may sometimes charge the customer.
- K. Draw a level 0 DFD for the video store system in Exercise J.
- L. Create a set of use cases for the following health club membership system: when members join the health club, they pay a fee for a certain length of time. Most memberships are for 1 year, but memberships as short as 2 months are available. Throughout the year, the health club offers a variety of discounts on its regular membership prices (e.g., two memberships for the price of one for Valentine's Day). It is common for members to pay different amounts for the same length of membership. The club wants to mail out reminder letters to members asking them to renew their memberships 1 month before their memberships expire. Some members have become angry when asked to renew at a much higher rate than their original membership contract, so that the club wants to track the price paid so that the manager can override the regular prices with special prices when members are asked to renew. The system must track these new prices so that renewals can be processed accurately. One of the problems in the health club industry is the high turnover rate of members. While some members remain active for many years, about half of the members do not renew their memberships. This is a major problem because the health club spends a lot in advertising to attract each new member. The manager wants the system to track each time a member comes into the club. The system will then identify the heavy users and generate a report so that the manager can ask them to renew their memberships early, perhaps offering them a reduced rate for early renewal. Likewise, the system should identify members who have not visited the club in more than a month so that the manager can call them and attempt to reinterest them in the club.
- M. Draw a level 0 DFD for the health club system in Exercise L.
- N. Create a set of use cases for the following system: picnics R Us (PRU) is a small catering firm with five employees. During

a typical summer weekend, PRU caters 15 picnics with 20 to 50 people each. The business has grown rapidly over the past year, and the owner wants to install a new computer system for managing the ordering and buying process. PRU has a set of 10 standard menus. When potential customers call, the receptionist describes the menus to them. If the customer decides to book a picnic, the receptionist records the customer information (e.g., name, address, phone number, etc.) and the information about the picnic (e.g., place, date, time, which one of the standard menus, total price) on a contract. The customer is then faxed a copy of the contract and must sign and return it along with a deposit (often by credit card or check) before the picnic is officially booked. The remaining money is collected when the picnic is delivered. Sometimes, the customer wants something special (e.g., birthday cake). In this case, the receptionist takes the information and gives it to the owner who determines the cost; the receptionist then calls the customer back with the price information. Sometimes the customer accepts the price; other times, the customer requests some changes, which have to go back to the owner for a new cost estimate. Each week, the owner looks through the picnics scheduled for that weekend and orders the supplies (e.g., plates) and food (e.g., bread, chicken) needed to make them. The owner would like to use the system for marketing as well. It should be able to track how customers learned about PRU and identify repeat customers so that PRU can mail special offers to them. The owner also wants to track the picnics on which PRU sent a contract, but the customer never signed the contract or actually booked a picnic.

- O. Draw a level 0 DFD for the Picnics R Us system in Exercise H.
- P. Create a set of use cases for the following system: Of-the-Month Club (OTMC) is an innovative young firm that sells memberships to people who have an interest in certain products. People pay membership fees for 1 year and each month receive a product by mail. For example, OTMC has a coffee-of-the-month club that sends members one pound of special coffee each month. OTMC currently has six memberships (coffee, wine, beer, cigars, flowers, and computer games), each of which costs a different amount. Customers usually

belong to just one, but some belong to two or more. When people join OTMC, the telephone operator records the name, mailing address, phone number, e-mail address, credit card information, start date, and membership service(s) (e.g., coffee). Some customers request a double or triple membership (e.g., 2 pounds of coffee, three cases of beer). The computer game membership operates a bit differently from the others. In this case, the member must also select the type of game (action, arcade, fantasy/science fiction, educational, etc.) and age level. OTMC is planning to greatly expand the number of memberships it offers (e.g., video games, movies, toys, cheese, fruit, vegetables), so the system needs to accommodate this future expansion. OTMC is also planning to offer 3-month and 6-month memberships.

- Q. Draw a level 0 DFD for the Of-the-Month Club system in Exercise P.
- R. Create a set of use cases for a university library borrowing system. (Do not worry about catalogue searching, etc.) The system will record the books owned by the library and will record who has borrowed what books. Before someone can borrow a book, he or she must show a valid ID card that is checked to ensure that it is still valid against the student database maintained by the registrar's office (for student borrowers), the faculty/staff database maintained by the personnel office (for faculty/staff borrowers), or against the library's own guest database (for individuals issued a "guest" card by the library). The system must also check to ensure that the borrower does not have any overdue books or unpaid fines before he or she can borrow another book. Every Monday, the library prints and mails postcards to those people with overdue books. If a book is overdue by more than 2 weeks, a fine will be imposed and a librarian will telephone the borrower to remind him or her to return the book(s). Sometimes, books are lost or are returned in damaged condition. The manager must then remove them from the database and will sometimes impose a fine on the borrower.
- S. Draw a level 0 DFD for the university library system in Exercise R.

## MINICASES

1. Williams Specialty Company is a small printing and engraving organization. When Pat Williams, the owner, brought computers into the business office 8 years ago, the business was very small and very simple. Pat was able to utilize an inexpensive PC-based accounting system to handle the basic information processing needs of the firm. As time has gone on, however, the business has grown and the work being performed has become significantly more complex. The simple accounting software still in

use is no longer adequate to keep track of many of the company's sophisticated deals and arrangements with its customers.

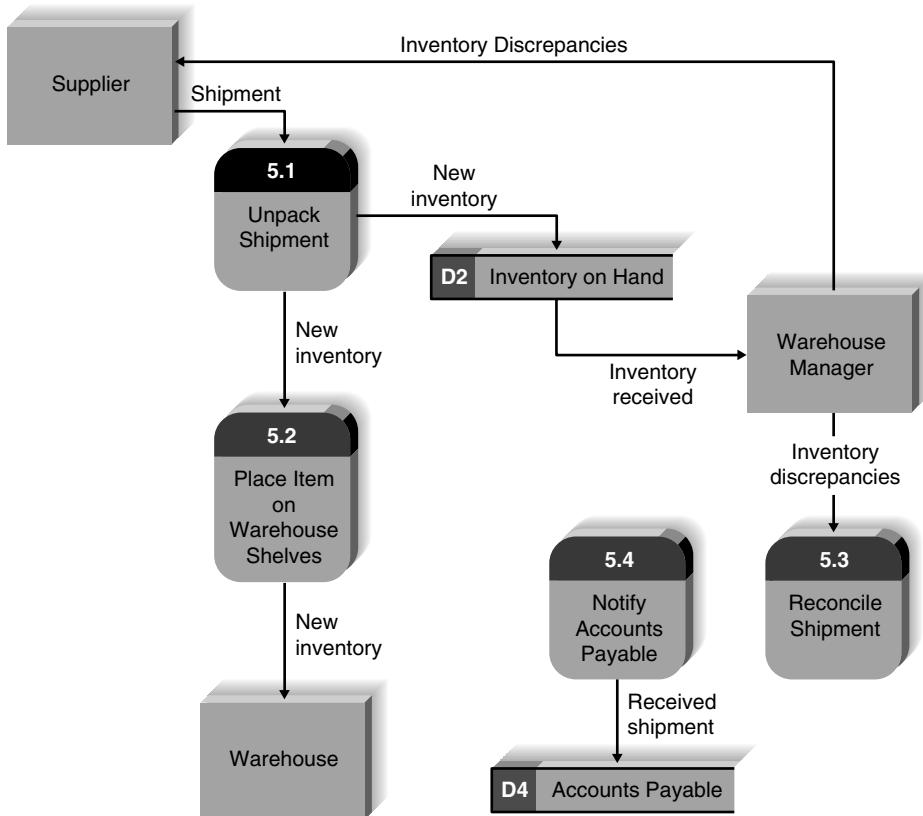
Pat has a staff of four people in the business office who are familiar with the intricacies of the company's record-keeping requirements. Pat recently met with her staff to discuss her plan to hire an IS consulting firm to evaluate their information system needs and recommend a strategy for upgrading their computer system. The staff are excited about the prospect of

a new system, since the current system causes them much aggravation. No one on the staff has ever done anything like this before, however, and they are a little wary of the consultants who will be conducting the project.

Assume that you are a systems analyst on the consulting team assigned to the Williams Specialty Co. engagement. At your first meeting with the Williams staff, you want to be sure that they understand the work that your team will be performing and how they will participate in that work.

- Explain, in clear, nontechnical terms, the goals of the analysis phase of the project.
- Explain, in clear, nontechnical terms, how use cases will be used by the project team. Explain what these models are, what they represent in the system, and how they will be used by the team.

- The Hatcher Company is in the process of developing a new inventory management system. One of the event handling processes in that system is Receive Supplier Shipments. The (inexperienced) systems analyst on the project has spent time in the warehouse observing this process and developed the following list of activities that are performed: getting the new order in the warehouse, unpacking the boxes, making sure that all the ordered items were actually received, putting the items on the correct shelves, dealing with the supplier to reconcile any discrepancies, adjusting the inventory quantities on hand, and passing along the shipment information to the accounts payable office. He also created the accompanying level 1 data flow diagram for this process. Unfortunately, this DFD has numerous syntax and semantic errors. Identify the errors. Redraw the DFD to more correctly represent the Receive Supplier Shipments process.

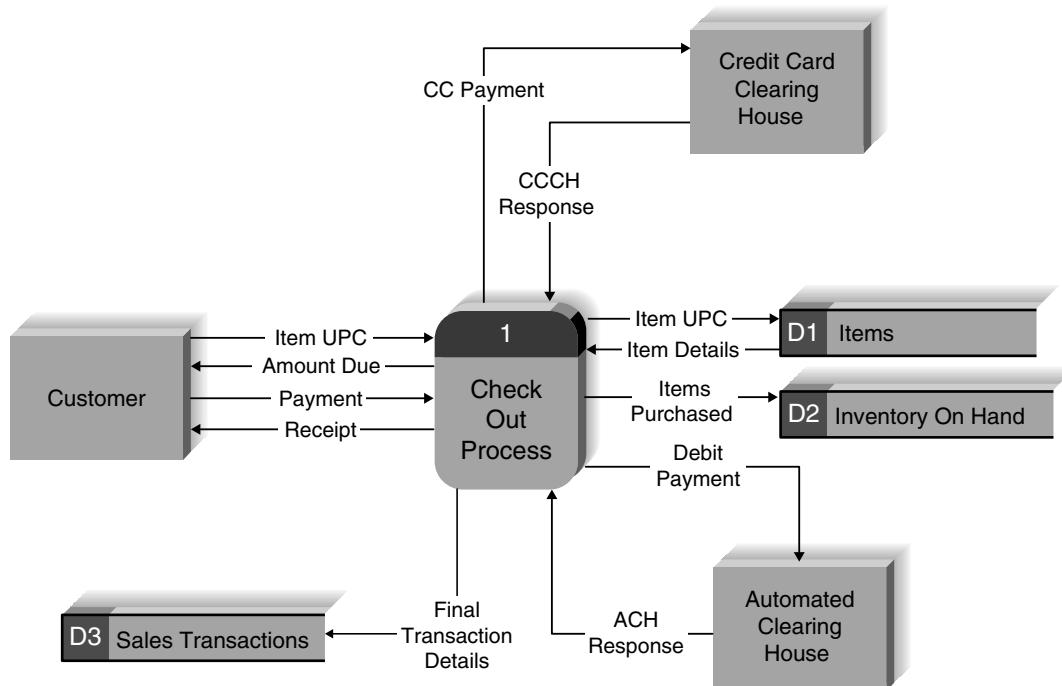


Hatcher Company inventory management system level 1 DFD.

- In this exercise, you will “explode” an event handling process into a level 1 DFD. The exercise focuses on the process used to complete a purchase at the “self-checkout lane” at a retail store. The basic process should be familiar to you. To simplify

the scenario, we assume that only credit/debit card payments are allowed in this lane (no cash, checks, or food stamps).

We start with a DFD fragment that has been created for this situation. This fragment shows one event-handling



process and the data flows it receives and sends to external entities and data stores. This fragment was extracted from the Level 0 diagram to help us focus just on this event.

The event handling process includes four subprocesses:

- 1.1. Process purchase items
- 1.2. Update inventory on hand
- 1.3. Process payment
- 1.4. Record sales transaction details

Draw the level 1 diagram for Process 1. Use the suggested subprocesses listed above as the process components of the level 1 diagram. Remember that all data flows and data stores on the parent diagram must also appear on the child diagram, but you will likely add more data flows on the child diagram.

4. Professional and Scientific Staff Management (PSSM) is a unique type of temporary staffing agency. Many organizations today hire highly skilled technical employees on a short-term, temporary basis to assist with special projects or to provide a needed technical skill. PSSM negotiates contracts with its client companies in which it agrees to provide temporary staff in specific job categories for a specified cost. For example, PSSM has a contract with an oil and gas exploration company, in which it agrees to supply geologists with at least a master's degree for \$5,000 per week.

PSSM has contracts with a wide range of companies and can place almost any type of professional or scientific staff members, from computer programmers to geologists to astrophysicists.

When a PSSM client company determines that it will need a temporary professional or scientific employee, it issues a staffing request against the contract it had previously negotiated with PSSM. When a staffing request is received by PSSM's contract manager, the contract number referenced on the staffing request is entered into the contract database. Using information from the database, the contract manager reviews the terms and conditions of the contract and determines whether the staffing request is valid. The staffing request is valid if the contract has not expired, the type of professional or scientific employee requested is listed on the original contract, and the requested fee falls within the negotiated fee range. If the staffing request is not valid, the contract manager sends the staffing request back to the client with a letter stating why the staffing request cannot be filed, and a copy of the letter is filed. If the staffing request is valid, the contract manager enters the staffing request into the staffing request database, as an outstanding staffing request. The staffing request is then sent to the PSSM placement department.

In the placement department, the type of staff member, experience, and qualifications requested on the staffing request are checked against the database of available professional and scientific staff. If a qualified individual is found, he or she is marked “reserved” in the staff database. If a qualified individual cannot be found in the database or is not immediately available, the placement department creates a memo that explains the inability to meet the staffing request and attaches it to the staffing request. All staffing requests are then sent to the arrangements department.

In the arrangement department, the prospective temporary employee is contacted and asked to agree to the placement. After the placement details have been worked out and agreed to, the staff member is marked “placed” in the staff database. A copy of the staffing request and a bill for the placement fee is sent to the client. Finally, the staffing

request, the “unable to fill” memo (if any), and a copy of the placement fee bill is sent to the contract manager. If the staffing request was filled, the contract manager closes the open staffing request in the staffing request database. If the staffing request could not be filled, the client is notified. The staffing request, placement fee bill, and “unable to fill” memo are then filed in the contract office.

- a. Develop a use case for each of the major processes just described.
- b. Create the context diagram for the system just described.
- c. Create the DFD fragments for each of the four use cases outlined in part a, and then combine them into the level 0 DFD.
- d. Create a level 1 DFD for the most complicated use case.

# Data Modeling

5

PLANNING	
TASK CHECKLIST	
<input checked="" type="checkbox"/>	Use requirements elicitation techniques (interview, JAD session, questionnaire, document analysis, and observation).
<input checked="" type="checkbox"/>	Apply requirements analysis strategies as needed to discover underlying requirements.
<input checked="" type="checkbox"/>	Develop the requirements definition.
<input checked="" type="checkbox"/>	Develop use cases.
<input checked="" type="checkbox"/>	Develop data flow diagrams.
<input type="checkbox"/>	Develop entity relationship model.
<input type="checkbox"/>	Normalize entity relationship model.

A data model describes the data that flow through the business processes in an organization. During the analysis phase, the data model presents the logical organization of data without indicating how the data are stored, created, or manipulated so that analysts can focus on the business without being distracted by technical details. Later, during the design phase, the data model is changed to reflect exactly how the data will be stored in databases and files. This chapter describes entity relationship diagramming, one of the most common data modeling techniques used in industry.

## OBJECTIVES

- Explain the rules and style guidelines for creating entity relationship diagrams (ERDs).
- Create an ERD.
- Describe the use of a data dictionary and metadata.
- Explain how to balance ERDs and data flow diagrams.
- Describe the process of normalization.

## Introduction

During the analysis phase, analysts create process models to represent how the business system will operate. At the same time, analysts need to understand the information that is used and created by the business system (e.g., customer information, order information). In this chapter, we discuss how the data that flow through the processes are organized and presented.

A **data model** is a formal way of representing the data that are used and created by a business system; it illustrates people, places, or things about which information is captured and how they are related to each other. The data model is drawn by an iterative process in which the model becomes more detailed and less conceptual over time. During analysis, analysts draw a **logical data model**, which shows the logical organization of data without indicating how data are stored, created, or manipulated. Because this model is free of any implementation or technical details, the analysts can focus more easily on matching the diagram to the real business requirements of the system.

In the design phase, analysts draw a **physical data model** to reflect how the data will physically be stored in databases and files. At this point, the analysts investigate ways to store the data efficiently and to make the data easy to retrieve. The physical data model and performance tuning are discussed in Chapter 10.

Project teams usually use CASE tools to draw data models. Some of the CASE tools are data modeling packages, such as ER *win* by Platinum Technology, that help analysts create and maintain logical and physical data models; they have a wide array of capabilities to aid modelers, and they can automatically generate many kinds of databases from the models that are created. Other CASE tools (e.g., Oracle Designer) come bundled with database management systems (e.g., Oracle), and they are particularly good for modeling databases that will be built in their companion database products. A full-service CASE tool, in which data modeling is one of many capabilities, may be used with many different databases. A benefit of the full-service CASE tool is that it integrates the data model information with other relevant parts of the project. If a CASE tool is not available, there are numerous software drawing tools that support data modeling, including Visio, Visual Paradigm, and Lucid chart.

In this chapter, we focus on creating a logical data model. Although there are several ways to model data, we will present one of the most commonly used techniques: entity relationship diagramming, a graphic drawing technique developed by Peter Chen<sup>1</sup> that shows all the data components of a business system. We will first describe how to create an entity relationship diagram (ERD) and discuss some style guidelines. Then, we will present a technique called normalization that helps analysts validate the data models that they draw. The chapter ends with a discussion of how data models balance, or interrelate, with the process models that you learned about in Chapter 4.

## The Entity Relationship Diagram

An **entity relationship diagram (ERD)** is a picture which shows the information that is created, stored, and used by a business system. An analyst can read an ERD to discover the individual pieces of information in a system and how they are organized and related to each other. On an ERD, similar kinds of information are listed together and placed inside boxes called entities. Lines are drawn between entities to represent relationships among the data, and special symbols are added to the diagram to communicate high-level **business rules** that need to be supported by the system. The ERD implies no order, although entities that are related to each other are usually placed close together.

<sup>1</sup>P. Chen, "The Entity-Relationship Model—Toward a Unified View of Data," *ACM Transactions on Database Systems*, 1976, 1, 9–36.

For example, consider the process of a customer creating a preliminary custom drone order described in Chapter 4. Although this system is just a small part of the information system for DrönTeq's Custom Drone Sales system, we will use it for our discussion on how to read an ERD. First, go back and look at the use case shown in Figure 4-1, describing the preliminary custom drone order creation process. Although we understand how the user/system interaction works from studying the use case description, we have little detailed understanding of the information itself that flows through the system. What exactly is a “preliminary custom order”? What pieces of data are included in a “drone base model” or a “drone component”?

## Reading an Entity Relationship Diagram

The analyst can answer these questions and more by using an ERD. We have included a partial ERD for the Create Preliminary Custom Drone Order scenario in Figure 5-1. First, we have organized the data into five main categories: Customer, Custom Drone Order, Drone Base Model, Ordered Drone Component, and Drone Component. The Customer data describe the organizations which are purchasing a DrönTeq commercial drone who wish to customize that drone to meet their needs. The Custom Drone Order data capture information about every order for a custom drone. The Drone Base Model data describe the characteristics of the base drone model specified in the order. The Ordered Drone Component data describe each Drone Component the customer wishes to add to the custom drone or to replace standard components on the Drone Base Model. Finally, the Drone Component data describe the custom components.

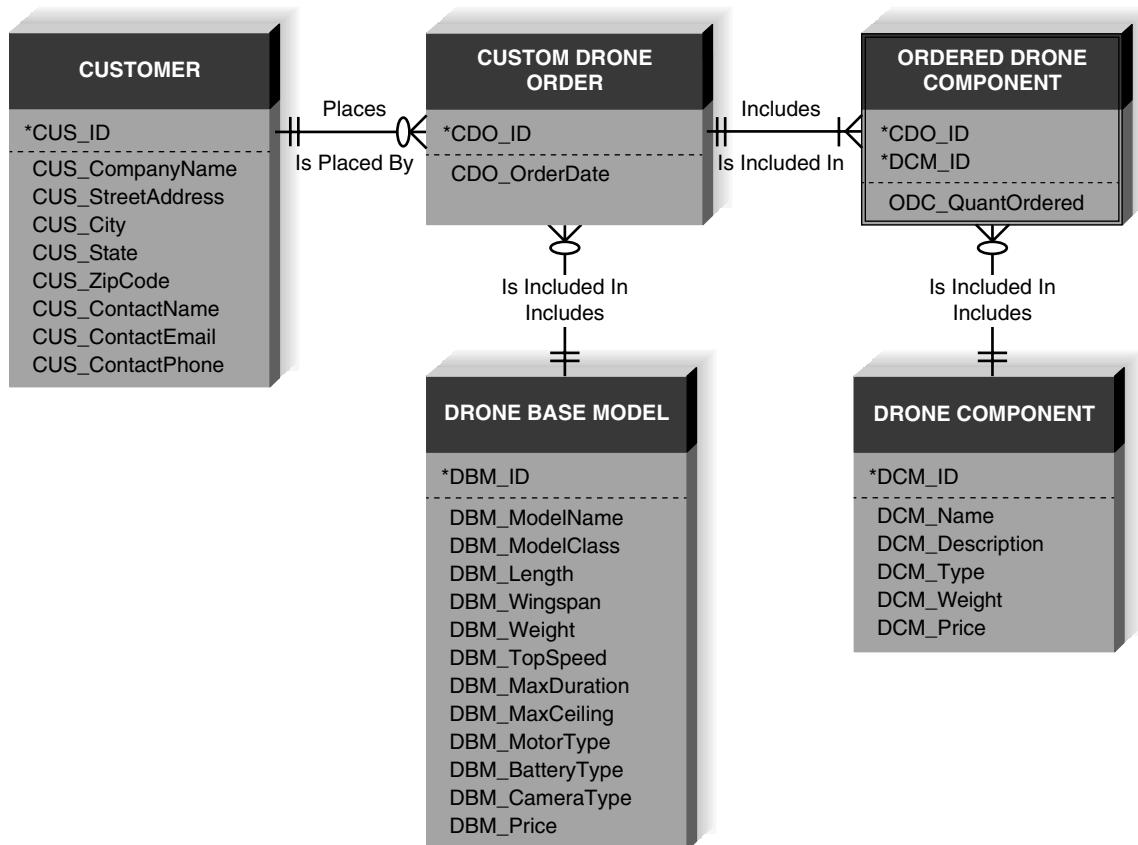


FIGURE 5-1 Partial DrönTeq sales system ERD.

We can see the specific facts that describe each of the five categories. In this figure, a representative list of characteristics for each category have been listed. For example, a Drone Component is described by its ID number, name, description, type, weight, and price.

We can also see what can be used to uniquely identify each Customer, Custom Drone Order, Drone Base Model, Ordered Drone Component, and Drone Component, by looking at the notation placed next to the data elements. When we are developing a logical data model, an asterisk is used to indicate the uniquely identifying data element(s). We term this data element, or several elements grouped together, the **identifier**. A unique ID data element has been created to identify every Customer, Custom Drone Order, Drone Base Model, and every Drone Component. An Ordered Drone Component is uniquely identified by a combination of the Custom Drone Order ID (CDO\_ID) and the Drone Component ID (CDM\_ID).

The lines connecting the five categories of information communicate the relationships that the categories share. By reading the relationship lines, the analyst understands that a Customer places a Custom Drone Order and a Custom Drone order includes a Drone Base Model. We also see that a Custom Drone Order includes Ordered Drone Components, and an Ordered Drone Component includes a specific Drone Component.

The ERD also communicates high-level business rules. Business rules are constraints or guidelines that are followed during the operation of the system; they are rules such as “A payment can be cash, check, debit card, credit card, coupon(s), or food stamps,” “A sale is paid for by one or more payments,” or “A customer may place many orders.” Over the course of a workday, people are constantly applying business rules to do their jobs, and they know the rules through training or knowing where to look them up. If a situation arises where the rules are not known, workers may have to refer to a policy guide or written procedure to determine the proper business rules.

On a data model, business rules are communicated by the relationships that the categories share and the nature of those relationships. On the ERD shown in Figure 5-1, for example, the “crow’s foot” placed on the line closest to Custom Drone Order indicates that Customer may place many Custom Drone Orders. The two vertical bars placed on the line closest to the Customer indicates that a Custom Drone Order is placed by exactly one Customer. Ultimately, the new system should support the business rules we just described, and it should ensure that users do not violate the rules when performing the processes of the system. Therefore, in our example, the system should not permit a Custom Drone Order to be placed that does not involve a specific Customer. Similarly, the system should not allow a Custom Drone Order to involve more than one Customer.

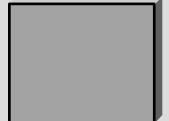
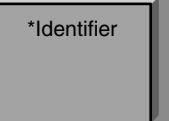
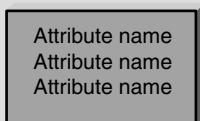
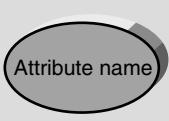
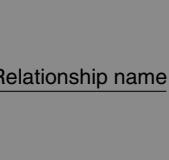
Now that you have seen an ERD, let us step back and learn the ERD basics. In the following sections, we will first describe the syntax of the ERD, using the diagram in Figure 5-1. Then we will teach you how to create an ERD by using an example from DrönTeq.

## Elements of an Entity Relationship Diagram

There are three basic elements in the data modeling language (entities, attributes, and relationships), each of which is represented by a different graphic symbol. There are many different sets of symbols that can be used on an ERD. No one set of symbols dominates industry use, and none is necessarily better than another. We will use crow’s foot notation in this book. Figure 5-2 summarizes the three basic elements of ERDs. The symbols we will use are shown in the right-hand column.

### Entity

The **entity** is the basic building block for a data model. It is a person, place, event, or thing about which data is collected—for example, an employee, an order, or a product. An entity is depicted

	IDEF1X	Chen	Crow's Foot
An ENTITY ✓ is a person, place, or thing. ✓ has a singular name spelled in all capital letters. ✓ has an identifier. ✓ should contain more than one instance of data.	ENTITY NAME 	ENTITY NAME 	ENTITY NAME 
An ATTRIBUTE ✓ is a property of an entity. ✓ should be used by at least one business process. ✓ is broken down to its most useful level of detail.	ENTITY NAME 		ENTITY NAME 
A RELATIONSHIP ✓ shows the association between two entities. ✓ has a parent entity and a child entity. ✓ is described with a verb phrase. ✓ has cardinality (1 : 1, 1 : N, or M : N). ✓ has modality (null, not null). ✓ is dependent or independent.	Relationship name 		Relationship name 

**FIGURE 5-2** Data modeling symbol sets.

by a rectangle, and it is described by a singular noun spelled in capital letters. All entities have a name, a short description that explains what they are, and an identifier that is the way to locate information in the entity (which is discussed later). In Figure 5-1, the entities are Customer, Custom Drone Order, Drone Base Model, Ordered Drone Component, and Drone Component.

Entities represent something for which there exist multiple **instances**, or occurrences. For example, for a retail store, John Smith and Susan Jones could be instances of the customer entity (Figure 5-3). We would expect the customer entity to stand for all the people with whom we have done business, and each of them would be an instance in the customer entity. If there is just one instance, or occurrence, of a person, place, event, or thing, then it should not be included as an entity in the data model. For example, think a little more broadly about DrönTeq's sales information system. Figure 5-1 focuses on just a small part of that information system. We assumed that the company sells more than one type of Drone Base Model, because we included a Drone Base Model entity to capture specific facts about each one. If the company offered just one drone base model, however, there would be no need to set up a Drone Base Model entity in the overall data model. There is no need to capture data in the system about something having just a single instance.

### Attribute

An **attribute** is some type of information that is captured about an entity. For example, last name, home address, and e-mail address are all attributes of an employee. It is easy to come up with

Entity	Example Instances
Customer	John Smith Susan Jones Peter Todd Dale Turner Pat Turner

**FIGURE 5-3** Entities and instances.

hundreds of attributes for an entity (e.g., an employee has a specific eye color, a favorite hobby, a religious affiliation), but only those that will be used by a business process should be included in the model.

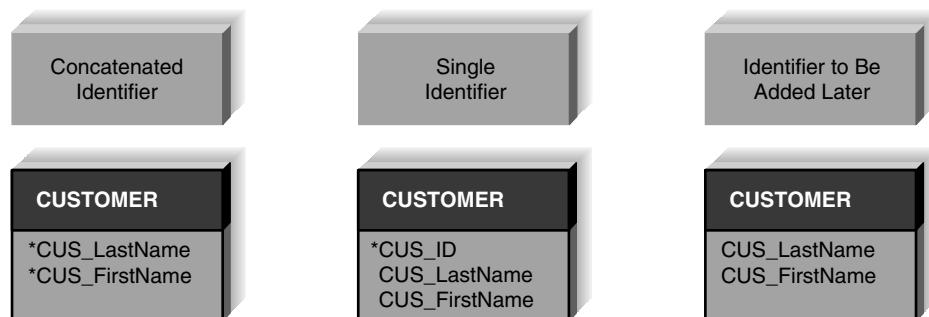
Attributes are nouns that are listed within an entity. Usually, some form of the entity name is appended to the beginning of each attribute to make it clear as to what entity it belongs (e.g., CUS\_CompanyName, CUS\_StreetAddress). Without doing this, you can get confused by multiple entities that have the same attributes—for example, a Drone Base Model and a Drone Component both can have an attribute called “Weight.” DBM\_Weight and DC\_Weight are much clearer ways to name attributes on the data model.

One or more attributes can serve as the identifier—the attribute(s) that can uniquely identify one instance of an entity—and the attributes that serve as the identifier are noted by an asterisk or other symbol next to the attribute name. If a retail store had no customers with the same last name, then last name can be used as the identifier of the customer entity. In this case, if we need to locate John Brown, the name Brown would be sufficient to identify the one instance of the Brown last name.

Suppose that the retail store adds a customer named Sarah Brown. Now we have a problem: using the name Brown would not uniquely lead to one instance—it would lead to two (i.e., John Brown and Sarah Brown). You have three choices at this point, and all are acceptable solutions. First, you can use a combination of multiple fields to serve as the identifier (last name and first name). This is called a **concatenated identifier** because several fields are combined, or concatenated, to uniquely identify an instance. Second, you can find a field that is unique for each instance, like the customer ID number. Third, you can wait to assign an identifier (like a randomly generated number that the system will create) until the design phase of the SDLC (Figure 5-4). Many data modelers do not believe that randomly generated identifiers belong on this data model, because they do not logically exist in the business process.

### Relationships

**Relationships** are associations between entities, and they are shown by lines that connect the entities together. Every relationship has a **parent entity** and a **child entity**, the parent being the first



**FIGURE 5-4** Choices for identifiers.

entity in the relationship, and the child being the second. To help you think about this, generally, the parent entity is on the “one” side of the relationship line, and the child entity is on the “many” side.

Relationships should be clearly labeled with active verbs so that the connections between entities can be understood. If one verb is given to each relationship, it is read in two directions. For example, we could write the verb “places” alongside the relationship for the Customer and Custom Drone Order entities, and this would be read as “a Customer places a Custom Drone Order” and “a Custom Drone Order is placed by a Customer.” In Figure 5-1, we included words for both directions of the relationship line; the top words are read from parent to child, and the bottom words are read from child to parent. Notice that the Customer is the parent entity in the Customer/Custom Drone Order relationship because a single Customer can place many Custom Drone Orders. Look carefully at the remaining entity pairings in Figure 5-1. Can you identify the parent entity in each pair? [Hint: Drone Base Model is the parent entity in the Drone Base Model/Custom Drone Order pair; Drone Component is the parent in the Drone Component/Ordered Drone Component pair; and Custom Drone Order is the parent in the Custom Drone Order/Ordered Drone Component pair.] How well did you do?

## Cardinality

Relationships have two properties that convey meaning about the nature of the entity relationship. First, a relationship has **cardinality**, which is the ratio of parent instances to child instances. To determine the cardinality for a relationship, we ask ourselves: “How many instances of one entity are associated with an instance of the other?” (Remember that an instance is one occurrence of an entity, such as Customer “Precision Wings Drone Services” or Drone Base Model “DrōnTeq QuadMax Raptor V2.”) We ask, a Customer places how many Custom Drone Orders? A Drone Base Model is included in how many Custom Drone Orders? The cardinality for binary relationships (i.e., relationships between two entities) is 1:1, 1:N, or M:N, and we will discuss each in turn.

The 1:1 (read as “one to one”) relationship means that one instance of the parent entity is associated with exactly one instance of the child entity. There are no examples of **1:1 relationships** in Figure 5-1. So, imagine for a moment that, as a reward, a company assigns a specific reserved parking place to the employee who is honored as the “employee of the month.” One reserved parking place is assigned to the honored employee, and the honored employee is assigned one reserved parking place. If we were to draw these two entities, we would place a bar next to the Employee entity and a bar next to the Reserved Parking Place entity. The cardinality is clearly 1:1 in this case, because the honored employee is assigned exactly one reserved parking place, and the reserved parking place is assigned to exactly one employee.

More often, relationships are 1:N (read as “one to many”). In this kind of relationship, a single instance of a parent entity is associated with many instances of a child entity; however, the child entity instance is related to only one instance of the parent. For example, a specific Customer instance (parent entity) can place many Custom Drone Order instances (child entity), but a specific Custom Drone Order instance is placed by just one specific Customer instance. Similarly, a specific instance of the Drone Base Model entity is included in many Custom Drone Order instances; a specific Custom Drone Order instance includes just one Drone Base Model instance. The character resembling a crow’s foot is placed closest to the Custom Drone Order entity for each of these example entity pairings to show the “many” (child) sides of the relationship. The parent entity is always on the “1” side of the relationship; hence, a bar is placed on the relationship line next to the Customer and the Drone Base Model entities. Can you identify other **1:N relationships** in Figure 5-1?

A third kind of relationship is the M:N (read as “many to many”) relationship. In this case, many instances of an entity can relate to many instances of another entity. As a result, it is difficult to determine the parent and the child entities in the relationship. There are no M:N relationships shown in Figure 5-1 because we specifically eliminated them (more on this later). For now, look at Figure 5-5. This figure shows an early draft version of the partial DrōnTeq Sales System ERD. In

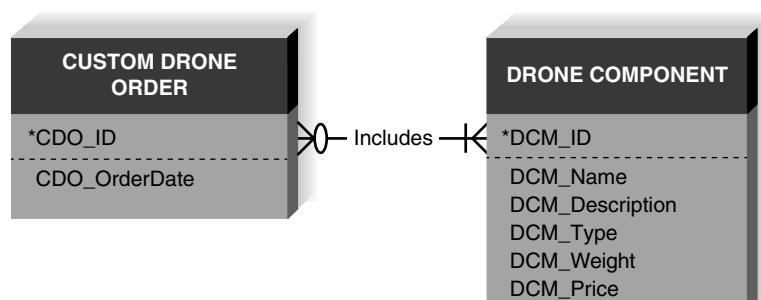
this version, an M:N relationship is shown between the Custom Drone Order entity and the Drone Component entity. Reading this figure, we see that a specific Custom Drone Order can include many different Drone Components, and a specific Drone Component can be included in many different Custom Drone Orders. M:N relationships are depicted on an ERD by placing crow's feet symbols at both ends of the relationship line. We will learn later that there are advantages to eliminating M:N relationships from an ERD, so that is why it was removed from Figure 5-1 by creating the Ordered Drone Component entity between Custom Drone Order and Drone Component. The process of “resolving” an M:N relationship will be explained later in the chapter.

### Modality

The second important property that characterizes the nature of the relationship between two entities is termed **modality**. Relationships have a modality of either “required” or “optional,” which refers to whether an instance of an entity can exist without a related instance in the related entity. Basically, the modality of a relationship indicates whether one entity instance is required to participate in the relationship. It forces you to ask questions such as, “Can you have a Customer instance without a related Custom Drone Order instance?” and “Can you have a Custom Drone Order instance without a related Customer instance?” The answer to the first question is “yes,” it is possible to have a Customer instance without having a related Custom Drone Order instance. Based on DrōnTeq’s business rules, Customer instances could exist in the Customer entity without having placed any Custom Drone Orders; the relationship is optional. The answer to the second question is “no,” an instance of a Custom Drone Order requires a related Customer instance. DrōnTeq’s business rules want to ensure that a Custom Drone Order cannot be placed without a related Customer instance.

Using more formal data modeling terminology, modality indicates whether the relationship between an entity instance and an instance of the related entity is “null” (optional) or “not null” (required). Modality is depicted by placing a zero on the relationship line next to the parent entity if nulls are allowed. A bar is placed on the relationship line next to the parent entity if nulls are not allowed.

Let us explore the modality of the relationship between the Custom Drone Order entity and the Drone Base Model entity. Can an instance of a Drone Base Model exist without a related instance in the Custom Drone Order entity? The answer to this question is “yes,” an instance of a Custom Drone Order is not required for an instance of a Drone Base Model. The correct modality is “null.” Think of it this way: if DrōnTeq offers a new drone base model, it will need to describe the facts about that new model in a new instance in the Drone Base Model entity. DrōnTeq should be able to add this new entity instance without regard to whether an order has been placed for that new model. Checking Figure 5-1, we see the zero on the relationship line next to the Custom Drone Order entity to document the “null” modality. Now consider if an instance of the Custom Drone Order can exist without a related instance of a Drone Base Model. DrōnTeq would never want to allow a customer to place a Custom Drone Order without specifying the Drone Base Model for that order; therefore, the modality of this relationship is “not null.” Check for the bar on the relationship line next to the Drone Base Model entity that indicates that this is a required relationship.



**FIGURE 5-5** M:N Relationship.

**YOUR TURN 5-1****Applying the Concepts of Cardinality and Modality**

We have described the purpose and meaning of the relationship properties of cardinality and modality. Referring to the ERD in Figure 5-1, answer the following questions.

*Questions*

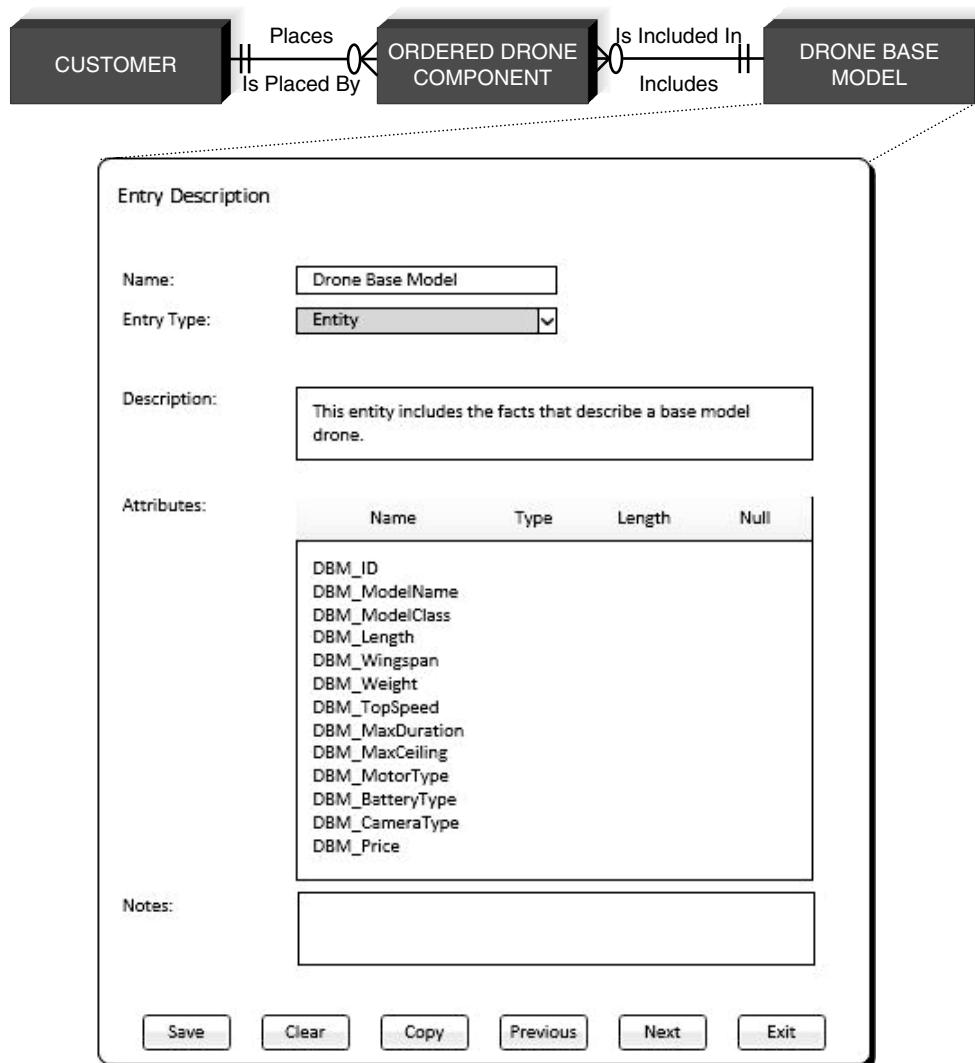
- Focus on the relationship between entities Custom Drone Order and Ordered Drone Component. Describe, in words, the meaning of the cardinality/modality symbols on each end of the relationship line. What do the cardinality/modality

symbols tell us about the business rules associated with Custom Drone Orders and Ordered Drone Components?

- Focus on the relationship between entities Ordered Drone Component and Drone Component. Describe, in words, the meaning of the cardinality/modality symbols on each end of the relationship line. What do the cardinality/modality symbols tell us about the business rules associated with Ordered Drone Components and Drone Components?

## The Data Dictionary and Metadata

As we mentioned earlier, a CASE tool is often used to help build ERDs. Every CASE tool has something called a **data dictionary**, which quite literally is where the analyst goes to define or look up information about the entities, attributes, and relationships on the ERD. Figures 5-6, 5-7,



**FIGURE 5-6** Data dictionary entry for entity.

**Entry Description**

Name:	DBM_ModelClass
Entry Type:	Data Element
Description:	This data element specifies the model classification for the base model drone. Model classes are based on the number of motors.
Values & Meanings:	Quad – drone has four motors Hex – drone has six motors Oct – drone has eight motors
Notes:	Default value: Quad. The majority of our models today are four motor models.

**FIGURE 5-7** Data dictionary entry for data element.

and 5-8 illustrate common data dictionary entries for an entity, an attribute, and a relationship; notice the kinds of information the data dictionary captures about each element. Also recognize that some of the entries in these examples are incomplete, because often some implementation details are not decided until the physical data model is designed (see Chapter 10).

The information you see in the data dictionary is called **metadata**, which, quite simply, is data about data. Metadata is anything that describes an entity, attribute, or relationship, such as entity names, attribute descriptions, and relationship cardinality, and it is captured to help designers better understand the system that they are building and to help users better understand the system that they will use. Figure 5-9 lists typical metadata that are found in the data dictionary. Notice that the metadata can describe an ERD element (like entity name) and also information that is helpful to the project team (like the user contact, the analyst contact, and special notes).

Metadata are stored in the data dictionary so that they can be shared and accessed by developers and users throughout the SDLC. The data dictionary allows you to record the standard pieces of information about your ERD elements in one place, and it makes that information accessible to many parts of a project. For example, the data elements in a data model also appear on the process models as elements of data stores and data flows, and on the user interface as fields on an input screen. When you make a change in the data dictionary, the change ripples to the relevant parts of the project that are affected.

When metadata are complete, clear, and shareable, the information can be used to integrate the different pieces of the analysis phase and ultimately lead to a much better design. It becomes much more detailed as the project evolves through the SDLC.

**Entry Description**

Name:	<input type="text" value="Places"/>								
Entry Type:	<input type="button" value="Relationship"/>								
Description:	<input type="text" value="Customer places zero or more Custom Drone Orders; a Custom Drone Order is placed by one and only one Customer"/>								
Attached Entities:	<table border="0"> <tr> <td>Customer</td> <td>Min: 0 Max: Many</td> </tr> <tr> <td>Places</td> <td></td> </tr> <tr> <td>Custom Drone Order</td> <td>Min: 1 Max: 1</td> </tr> <tr> <td>Is Placed By</td> <td></td> </tr> </table>	Customer	Min: 0 Max: Many	Places		Custom Drone Order	Min: 1 Max: 1	Is Placed By	
Customer	Min: 0 Max: Many								
Places									
Custom Drone Order	Min: 1 Max: 1								
Is Placed By									
Notes:	<input type="text"/>								

**FIGURE 5-8** Data dictionary entry for relationship.

## Creating an Entity Relationship Diagram

Drawing an ERD is an iterative process of trial and revision. It usually takes considerable practice. ERDs can become quite complex—in fact, there are systems that have ERDs containing hundreds or thousands of entities.

In some situations, a data model based on the current as-is system may exist, providing an excellent starting point for the new system's data model. If that is the case, our task is to verify the accuracy of that data model and modify it as needed to meet the requirements of the new system. Chances are good that some changes will be needed. Having an as-is data model greatly simplifies the development of the to-be system data model.

If we do not have an as-is system data model, the basic steps in building an ERD are these: (1) Identify the entities, (2) add the appropriate attributes to each entity, and then (3) draw relationships among entities to show how they are associated with one another. First, we will describe the three steps in creating ERDs, using the data model example from Figure 5-1. We will then discuss several advanced data modeling concepts. Finally, we will present an ERD for DrōnTeq's Client Services System.

## Building Entity Relationship Diagrams

### Step 1: Identify the Entities

As we explained, the most common way to start an ERD is to first identify the entities for the data model. The entities represent the major categories of information that you need to store in your

ERD Element	Kinds of Metadata	Example
Entity	Name	Item
	Definition	Represents any item carried in inventory in the supermarket
	Special notes	Includes produce, bakery, and deli items
	User contact	Nancy Keller (x6755) heads up the item coding department
	Analyst contact	John Michaels is the analyst assigned to this entity
Attribute	Name	Item_UPC
	Definition	The standard Universal Product Code for the item based on Global Trade Item Numbers developed by GS1
	Alias	Item Bar Code
	Sample values	036000291452; 034000126453
	Acceptable values	Any 12-digit set of numerals
	Format	12 digit, numerals only
	Type	Stored as alphanumeric values
	Special notes	Values with the first digit of 2 are assigned locally, representing items packed in the store, such as meat, bakery, produce, or deli items. See Nancy Keller for more information.
Relationship	Verb phrase	Included in
	Parent entity	Item
	Child entity	Sold item
	Definition	An item is included in zero or more sold items. A sold item includes one and only one item.
	Cardinality	1:N
	Modality	Null
	Special notes	

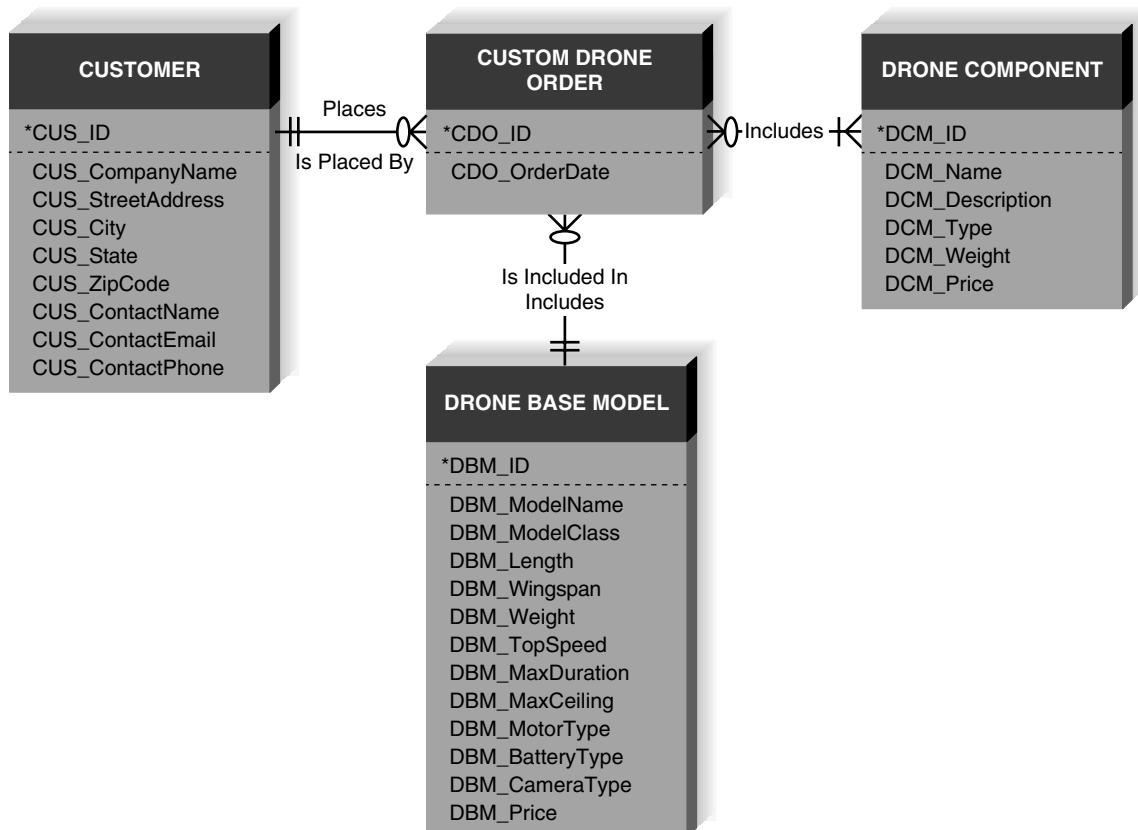
**FIGURE 5-9** Types of metadata captured by the data dictionary.

system. If you have use cases available, look at the major inputs to the use case, the major outputs, and the information used for the use case steps. If the process model (e.g., DFDs) has been prepared, the data stores on the DFDs, the external entities, and the data flows indicate the kinds of information that are captured and flow through the system. If you are doing data modeling before creating use cases or process models, then look at existing files, forms, reports, and other documents currently in use to discover the major categories of data. These categories are likely to be entities in your new data model.

In the Custom Drone Sales System, the Custom Drone Order plays a key role, and so is included as a data entity. In addition, the Drone Base Model and Drone Components will need to be described with data, and so will also be included as data entities. Finally, we will need to capture information about the Customers, since these individuals are the key actors in the system. These entities are depicted in Figure 5-10. Note that we do not show the Ordered Drone Component entity. As mentioned previously, this entity came into existence to resolve a many-to-many relationship between the Custom Drone Order and Drone Components. It is not necessary to worry about this situation at this early stage in data model development; it will be dealt with later.

### Step 2: Add Attributes and Assign Identifiers

The information that describes each entity becomes its attributes. Our task is to determine all specific pieces of data that must be captured and stored in our system to meet all the processing and reporting needs; no more and no less!



**FIGURE 5-10** Preliminary sales system ERD.

### YOUR TURN 5-2

### Evaluate Your Case Tool

Examine the CASE tool that you will be using for your project or find a CASE tool on the Web that you are interested in learning about. What kind of metadata does its data dictionary

capture? Does the CASE tool integrate data model information with other parts of a project? How?

On a real project, there are several places you can go to figure out what attributes belong in your entity. For one, you can check in the CASE software—often, an analyst will describe a process model data flow in detail when he or she enters the data flow into the CASE repository. For example, an analyst may create an entry for the new drone component data flow, listing six data elements that describe the new drone component. The elements of the data flow should be added to the ERD as attributes in your entity. A second approach is to check the requirements definition. Often, there is a section within functional requirements called data requirements. This section describes the data needs for the system that were identified while requirements were gathered. A final approach to identifying attributes is to use requirements elicitation techniques. The most effective techniques would be interviews (e.g., asking people who create and use forms and reports about their data needs) or document analysis (e.g., examining existing forms, reports, or input screens).

Once the attributes are identified, one or more of them will become the entity's identifier. The identifier must be an attribute(s) that is able to uniquely identify each instance of the entity. Look at Figure 5-10 and notice the identifiers that were selected for each entity.

### Step 3: Identify Relationships

The last step in creating ERDs is to determine how the entities are related to each other. Lines are drawn between entities that have relationships, each relationship is labeled, and cardinality and modality are assigned. The easiest approach is to begin with one entity and determine all the entities with which it shares relationships. In our example in Figure 5-10, we can see that Customer places Custom Drone Orders, and a drone component(s) is included in a Custom Drone Order.

When you find a relationship to include on the model, you need to determine its cardinality and modality. For cardinality, ask how many instances of each entity participate in the relationship. For example, it makes sense that a specific Custom Drone Order includes one Drone Base Model, and a specific Drone Base Model may be included on many Custom Drone Orders. Therefore, we place a crow's foot next to the Custom Drone Order entity and a single bar closest to the Drone Base Model entity. This suggests that there is a 1:N relationship in which the Drone Base Model is the parent entity (the "1") and the Custom Drone Order is the child entity (the "many").

Next, we examine the relationship's modality. Can a Drone Base Model instance exist without an associated Custom Drone Order instance? In our example, the answer is "yes," so the modality is "null" or not required. A zero is placed next to the crow's foot near the Custom Drone Order entity. Now, can a Custom Drone Order instance exist without an associated Drone Base Model entity instance? This answer is "no," so the modality is "not null" or required, and we place a single bar next to the Drone Base Model entity.

Again, remember that data modeling is an iterative process. Often, the assumptions and decisions you make change as you learn more about the business requirements and as changes are made to the use cases and process models. But you must start somewhere—so do the best you can with the three steps we just described and keep iterating until you have a model that works. Later in this chapter, we will show you a few ways to validate the ERDs that you draw.

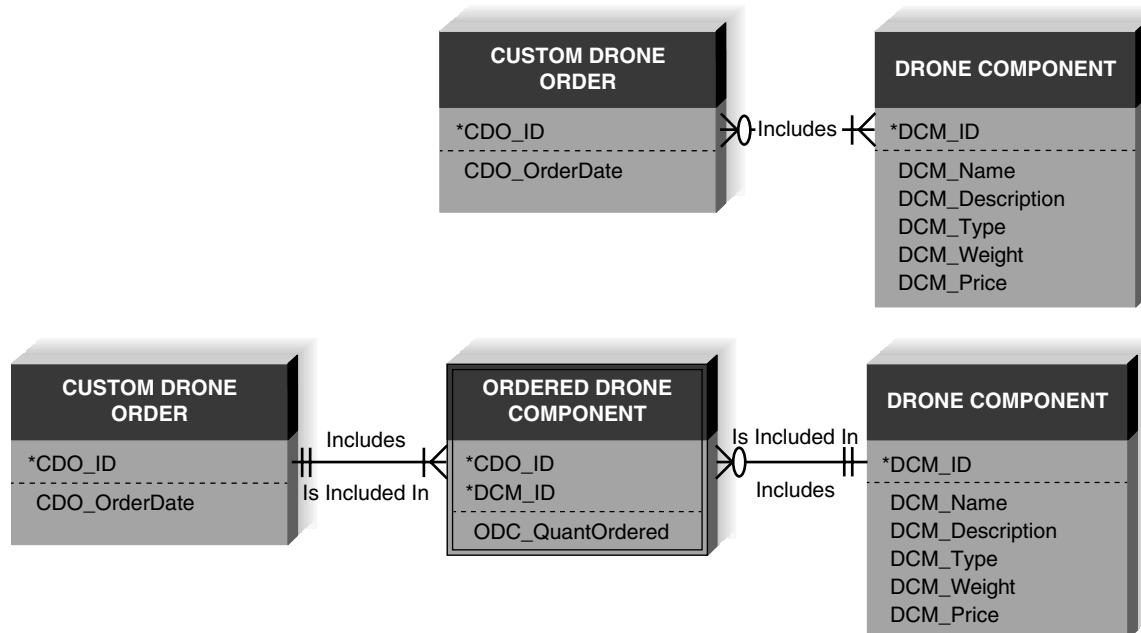
## Advanced Syntax

Now that we have created a data model according to the basic syntax that was presented earlier, we can move to several advanced concepts. We will explain three special types of entities and show how they can be used in our DrōnTeq Sales system.

### Intersection Entity

An important special kind of entity is the **intersection entity**. It exists to capture some information about the relationship between two other entities. Typically, intersection entities are added to a data model to store information about two entities sharing an **M:N relationship**. These entities are also called *associative entities*. Think back to the M:N relationship between Custom Drone Order and Drone Component shown in Figure 5-5. In that figure, one instance of a Custom Drone Order could include many Drone Components, and an instance of a Drone Component could be included in many Custom Drone Orders. A difficulty arises if we want to capture the quantity of a Drone Component that was requested on a specific Custom Drone Order. We cannot include the quantity ordered as an attribute in the Drone Component entity, because the Drone Component is included on many Custom Drone Orders and the quantity ordered may be different on each order. We also cannot include the quantity ordered as an attribute in the Custom Drone Order entity, because there are many Drone Components included in the Custom Drone Order. Therefore, we need another entity that enables us to associate a specific Drone Component on a specific Custom Drone Order with a specific quantity of the component ordered.

The process of adding an intersection entity is called “resolving an M:N relationship” because it eliminates the M:N relationship and its associated problems from the data model. There are three steps involved in adding an intersection entity. Step 1: Remove the M:N relationship line and insert a new entity in between the two existing ones. Step 2: Add two 1:N relationships to the model. The two original entities should serve as the parent entities for each 1:N, and the new intersection entity becomes the child entity in both relationships. Step 3: Name the intersection entity. Intersection entities are often named by combining the names of the two entities that created it in some way, such as Ordered Drone Component, making its meaning clear. Alternatively, the entity can be given another appropriate name. Figure 5-11 shows the M:N Custom Drone Order–Drone Component relationship and how it was resolved with the use of an intersection entity.



**FIGURE 5-11** Resolving an M:N relationship.

### YOUR TURN 5-3

### Understanding the Elements of an ERD

A wealthy businessman owns many paintings that he loans to museums all over the world. He is interested in setting up a system that records what he loans to whom so that he does not lose track of his investments. He would like to keep information about the paintings that he owns as well as the artists who painted them. He also wants to track the various museums that reserve his art, along with the actual reservations. Obviously, artists are associated with paintings, paintings are associated with reservations, and reservations are associated with museums.

#### Questions

1. Draw the four entities that belong on this data model.
2. Provide some basic attributes for each entity, and select an identifier, if possible.
3. Draw the appropriate relationships between the entities and label them.
4. What is the cardinality for each relationship? Depict this on your drawing.
5. What is the modality for each relationship? Depict this on your drawing.
6. List two business rules that are communicated by your ERD.

### Independent Entity

An **independent entity** is an entity that can exist without the help of another entity, such as Customer, Custom Drone Order, Drone Base Model, and Drone Component. These entities all have identifiers that were created from their own attributes. Attributes from other entities were not needed to uniquely identify instances of these entities. Independent entities are drawn as rectangles with a single border line.

When a relationship includes an independent child entity, it is called a **non-identifying relationship**. This name is derived from the fact that parent entity attributes are not needed as part of the child entity's identifier. In our example, the relationship between Customer and Custom Drone Order is an example of a non-identifying relationship.

### Dependent Entity

There are situations when a child entity does require attributes from the parent entity to uniquely identify an instance. In these cases, the child entity is called a **dependent entity**, and its identifier consists of at least one attribute from the parent entity.

A good example of a dependent entity is the Ordered Drone Component entity shown in Figure 5-1. An Ordered Drone Component is included in a specific Custom Drone order and includes a specific Drone Component. We include the CDO\_ID and the DCM\_ID to fully identify each Ordered Drone Component. Ordered Drone Component is considered a dependent entity and is shown as a rectangle with a double border line.

When relationships have a dependent child entity, they are called **identifying relationships**. This name is derived from the fact that parent entity attributes are needed as part of the child entity's identifier.

Are intersection entities dependent or independent? Actually, it depends. Sometimes an intersection entity has a logical identifier that can uniquely identify its instances. For example, an intersection entity between a student and a course (a student may take many courses and a course is taken by many students) may be called a transcript. If transcripts have unique transcript numbers, then the entity would be considered independent. In contrast, as noted previously, the Ordered Drone Component intersection entity in Figure 5-11 requires the identifiers from both Custom Drone Order and Drone Component for an instance to be uniquely identified. Thus, Ordered Drone Component is a dependent entity.

## Applying the Concepts at DrōnTeq

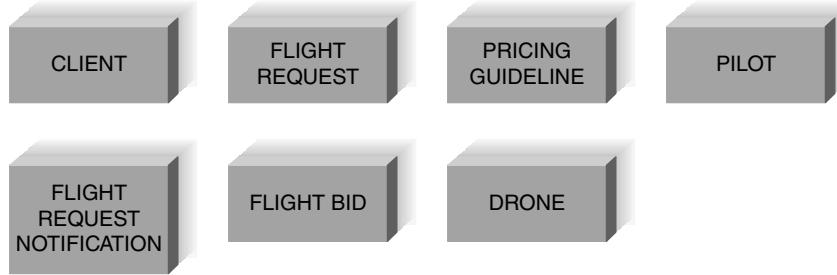
Let us go through one more example of creating a data model by using the context of DrōnTeq. First, review the use cases that were presented in Figure 4-11 and DFDs shown in Figures 4-27 through 4-31.

### Identify the Entities

When you examine the DrōnTeq DFDs shown in 4-27 through 4-31, you see that there are five data stores: flight requests, pricing guidelines, flight request notifications, flight bids, and pilots. Each of these unique types of data likely will be represented by entities on a data model.

As a next step, you should examine the external entities and ask yourself, “Will the system need to capture information about any of these entities?” The Client external entity fits this criterion, and so we will add it to our list of data entities in the data model.

Finding the final entity in our data model is more subtle. We know that a pilot will be bidding on flights that require the capabilities of the drone the pilot owns. The pilot may own more than one drone, however. Consequently, it makes sense to create a separate entity that



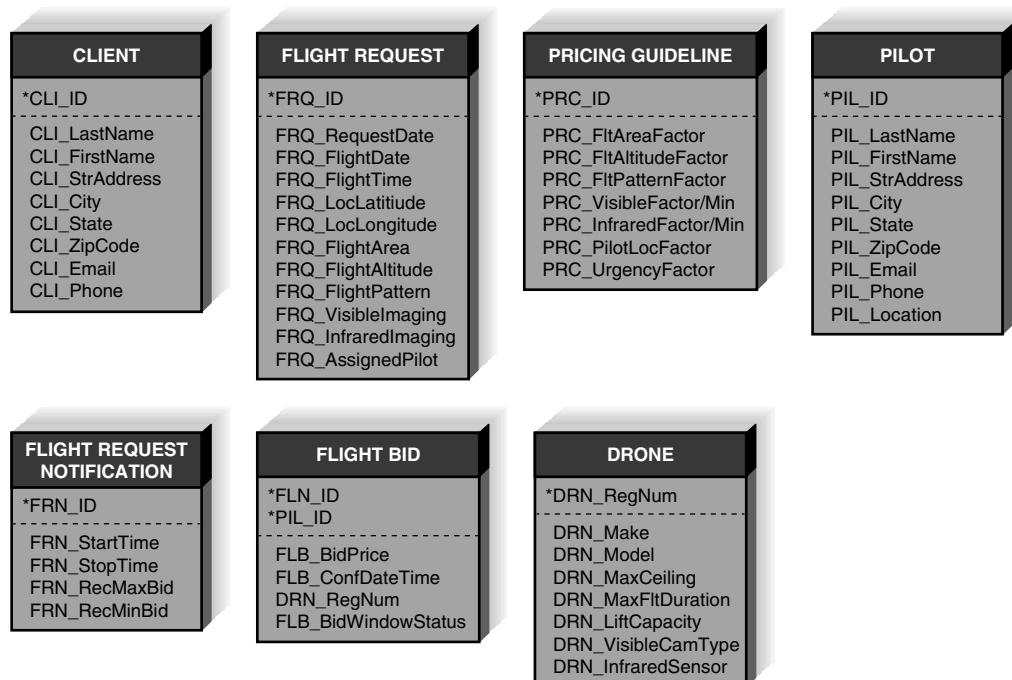
**FIGURE 5-12**  
Entities for DrōnTeq  
Assign Flight Request  
Subsystem ERD.

describes the drone(s) owned by the pilots. See Figure 5-12 for the entities that form the start of our data model.

### Identify the Attributes

The next step is to select which attributes should be used to describe each entity. You may have identified a handful of attributes as you read the DrōnTeq use cases and examined the DFDs. For example, a Flight Request has a request date, flight date and time, location, flight area, flight pattern, flight altitude, and specific imaging requirements. Some attributes of the Client and Pilot entities are name and contact information, including address, phone number, and e-mail address.

Figure 5-13 shows the data model entities with data attributes listed. The two entities Flight Request and Flight Request Notification might seem similar at first glance, but they are used to capture different types of information about the client's drone flight needs. A Flight Request compiles all the pertinent facts about the drone flight the client needs. In the Flight Request entity, we see facts that capture when the request was made, when the client wants the flight to occur, where the flight should take place, the area to cover, the desired altitude and flight pattern,



**FIGURE 5-13**  
Attributes and Identifiers for DrōnTeq  
Assign Flight Request Subsystem ERD.

and the type of imaging needed (visible, infrared). After the bidding process is complete, the ID of the pilot who is assigned the flight is added to the Flight Request. On the other hand, the Flight Request Notification contains suggested pricing guidelines based on the characteristics of the flight request, and specifies the flight bidding window start and stop date/time. The Pricing Guideline entity contains flight characteristic pricing factors that will be used in a pricing algorithm to generate suggested flight bid minimum and maximum values.

Pilots are described with basic contact information along with the pilot's location. The Drone entity is used to describe the features and characteristics of the drones that are owned by the DrōnTeq partner pilots. It is important to know whether a drone owned by a pilot has the capabilities needed to perform the flight. Finally, the Flight Bid entity captures the details of a pilot's bid in response to a specific Flight Request Notification. We need to know the specific flight request notification involved, the pilot submitting the bid, the exact date/time the pilot confirmed the flight bid submission, the bid price, and the ID of the drone the pilot will use for the flight. We also include an attribute that indicates whether the bid was received within the bidding window time frame.

To determine the entity identifiers, we consider the attribute or attributes that will uniquely identify each entity. Out of all our entities, only one has a naturally-occurring unique attribute – the Drone entity. Since the drones owned by DrōnTeq's partner pilots are used commercially, they must be registered with the Federal Aviation Administration (FAA), therefore, each drone has a unique FAA registration number that can serve as an entity identifier. New ID attributes will be created for the Client, Flight Request, Flight Request Notification, Pricing Guideline, and Pilot entities. The Flight Bid entity is uniquely identified by attributes provided by its parent entities, Flight Request Notification and Pilot.

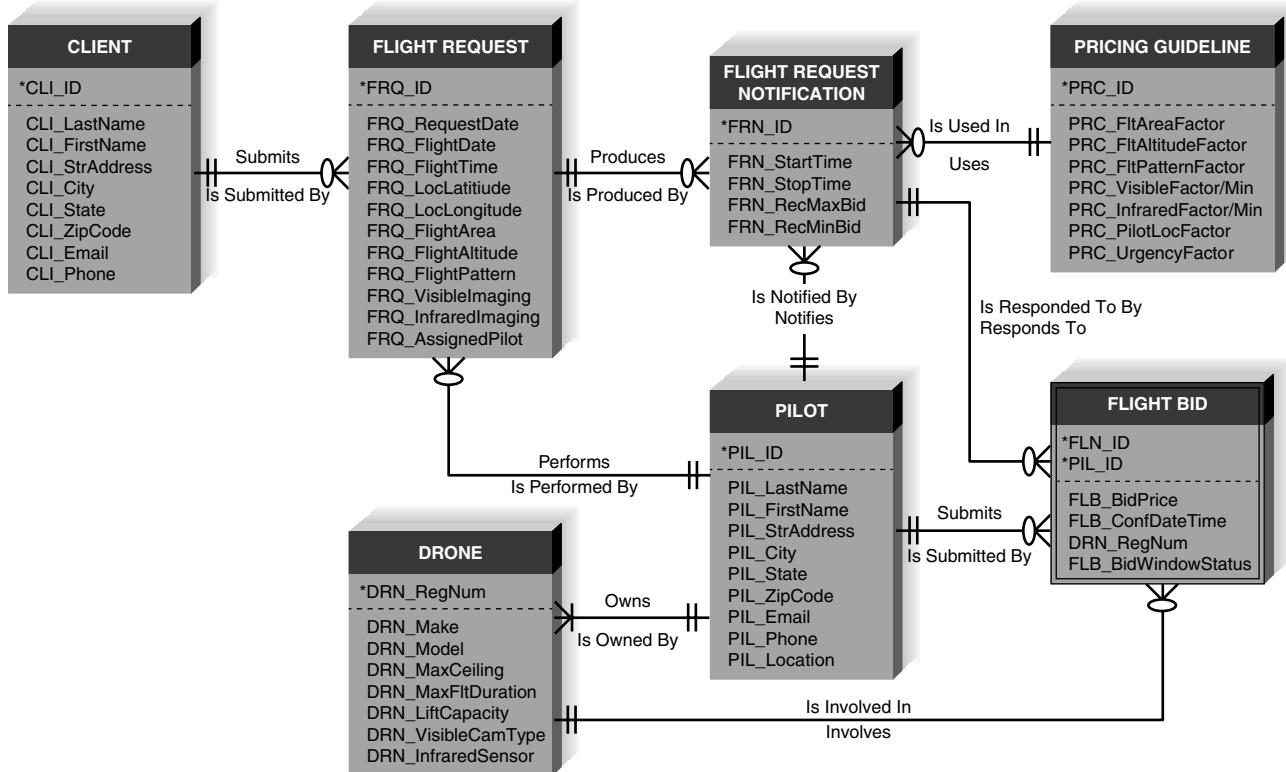
The Client, Flight Request, Flight Request Notification, Pricing Guideline, Drone, and Pilot entities are independent entities; attributes from other entities are not needed to uniquely identify instances. The identifier for the Flight Bid entity, however, does rely on attributes from its parent entities. Therefore, it is considered a dependent entity.

### Identify the Relationships

The last step in creating ERDs is to determine how the entities are related to each other. Lines are drawn between entities that have relationships, and each relationship is labeled and assigned a cardinality and modality.

Figure 5-14 depicts the relationships that exist between the entities in this data model. To illustrate the meaning of these relationships, a Client entity instance may submit many Flight Request entity instances, while a Flight Request entity instance is submitted by one Client entity instance. A Client entity instance does not require a related Flight Request entity instance, but a Flight Request entity instance does require a related Client instance. This relationship makes sense for DrōnTeq, since it wants to allow clients to create an account without being obligated to submit a request for a flight at the same time. However, when a flight request is created it must be associated with an existing client.

Similarly, a Flight Request entity instance produces many Flight Request Notification entity instances, while a Flight Request Notification entity instance is produced by one Flight Request entity instance. A Flight Request entity instance does not require a related Flight Request Notification entity instance, but a Flight Request Notification entity instance does require a related Flight Request instance. When a Flight Request entity instance is created by a client, the new system will search for pilots who are in reasonable proximity to the flight location and will create many Flight Request Notification entity instances to notify those pilots; however, the Flight Request Notification is not required for the related Flight Request entity instance to exist. A Flight Request Notification entity instance does require a related Flight Request entity instance.



**FIGURE 5-14** Relationships for Assign Flight Request Subsystem ERD.

The data model also shows that a Flight Request Notification entity instance notifies one Pilot entity instance, and that related Pilot instance must exist. A Pilot entity instance may be notified by many Flight Request Notification entity instances, and a Pilot entity instance does not require that a related Flight Request Notification entity instance exist. The business model that DrōnTeq is using expects that pilots will enter the partnership program and will establish accounts before ever receiving notices of potential flights to perform, so these business rules seem appropriate.

DrōnTeq wishes to provide some general price ranges to its partner pilots as a part of a flight request notification. The pricing rules are contained in the Pricing Guideline entity. An instance of the Pricing Guideline entity many be related to many Flight Request Notification entity instances, but the relationship may be null. A Flight Request Notification entity instance will be related to one Pricing Guideline entity instance and the relationship is required.

After receiving a flight notification, the pilot may want to submit a bid to try to get assigned to perform the requested drone flight. Since this is a new venture for DrōnTeq, it was decided not to limit a pilot to just one bid submission. Therefore, the data model shows that a Pilot entity instance can submit many Flight Bid entity instances in response to a Flight Bid Notification. A Pilot entity instance is not required to have submitted a Flight Bid entity instance to exist. A Flight Bid entity instance must be related to one and only one Pilot entity instance.

DrōnTeq anticipates that there could be multiple flight bid responses when a flight notification is sent out to the pilot partners. Therefore, an instance of a Flight Request Notification may be responded to by many Flight Bid entity instances, but a Flight Bid entity instance is not required

for the Flight Request Notification entity instance to exist. A Flight Bid entity instance must be related to one and only one Flight Request Notification entity instance.

There are three relationships in the data model that we have not described in words. By now you should be developing some proficiency in the interpretation of relationships between entities and how that meaning conveys DrōnTeq's business rules. See Your Turn 5-6 and complete the descriptions of these relationships on your own.

## Validating an Entity Relationship Diagram

As you probably guessed from the previous section, creating ERDs is pretty tough. It takes a lot of experience to draw ERDs correctly, and there are not many black-and-white rules to help guide you. Luckily, there are some general design guidelines that you can keep in mind as you build ERDs, and once the ERDs are drawn, you can use a technique called **normalization** to validate that your models are well formed. Another technique is to check your ERD against your process models to make sure that both models balance each other.

## Design Guidelines

Design guidelines are not rules that must be followed; rather, they are “best practices” that often lead to better quality diagrams. For example, labels and naming conventions are important for creating clear ERDs. Names should not be ambiguous (e.g., name, number); instead, they should clearly communicate what the model component represents. These names should be consistent across the model and reflect the terminology used by the business. If DrōnTeq refers to people

### CONCEPTS IN ACTION 5-A

### The User’s Role in Data Modeling

I have two very different stories regarding data models. First, when I worked with First American Corporation, the head of Marketing kept a data model for the marketing systems hanging on a wall in her office. I thought this was a little unusual for a high-level executive, but she explained to me that data was critical for most of the initiatives that she puts in place. Before she can approve a marketing campaign or new strategy, she likes to confirm that the data exists in the systems and that it is accessible to her analysts. She has become very good at understanding ERDs over the years because they had been such an important communications tool for her to use with her own people and with IT.

On a very different note, here is a story I received from a friend of mine who heads up an IT department:

“We were working on a business critical, time dependent development effort, and VERY senior management decided that the way to ensure success was to have the various teams do technical design walkthroughs to senior management on a weekly basis. My team was responsible for the data architecture and database design. How could senior management, none of whom probably had ever designed an Oracle architecture, evaluate the soundness of our work?

So, I had my staff prepare the following for the one (and only) design walkthrough our group was asked to do. First, we merged several existing data models and then duplicated each one . . . that is, every entity and relationship printed twice (imitating, if asked, the redundant architecture). Then we intricately color coded the model and printed the model out on a plotter and printed one copy of every inch of model documentation we had. On the day of the review, I simply wheeled in the documentation and stretched the plotted model across the executive boardroom table. ‘Any questions,’ I asked? ‘Very impressive,’ they replied. That was it! My designs were never questioned again.” *Barbara Wixom*

#### Questions

1. From these two stories, what do you think is the user’s role in data modeling?
2. When is it appropriate to involve users in the ERD creation process?
3. How can users help analysts create better ERDs?

**YOUR TURN 5-4****Campus Housing System**

Consider the accompanying system, which was described in Chapter 4. Use the use cases and process models that you created in Chapter 4 to help you answer the questions that follow.

The Campus Housing Service helps students find apartments. Owners of apartments fill in information forms about the rental units they have available (e.g., location, number of bedrooms, monthly rent). Students who register with the service can search the rental information to find apartments that meet their needs (e.g., a two-bedroom apartment for \$800 or less per month within 1/2 mile of campus). They then contact

the apartment owners directly to see the apartment and, possibly, rent it. Apartment owners call the service to delete their listing when they have rented their apartment(s).

*Questions*

1. What entities would you include on a data model?
2. What attributes would you list for each entity? Select an identifier for each entity, if possible.
3. What relationships exist between the entities that you identified? Label the relationships appropriately and denote the cardinality and modality of each relationship.

who request drone flights as **clients**, the data model should include an entity called Client, not Customer or Stakeholder.

There are no rules covering the layout of ERD components. They can be placed anywhere you like on the page, although most systems analysts try to put the entities together that are related to each other. If the model becomes too complex or busy (some companies have hundreds of entities on a data model), the model can be broken down into **subject areas**. Each subject area would contain related entities and relationships, and the analyst can work with one group of entities at a time to make the modeling process less confusing.

In general, data modeling can be quite tricky, mainly because the data model is heavily based on interpretation; therefore, when business rules change, the relationships or other data model components will have to be altered. **Assumptions** are an important part of data modeling. It is important that we verify all assumptions about business rules so that our data model is correct.

Therefore, when you model data, do not panic or become overwhelmed by details. Rather, add components to the diagram slowly, knowing that they will be changed and rearranged many times. Make assumptions along the way and then confirm these assumptions with the business users. Work iteratively and constantly challenge the data model with business rules and exceptions to see whether the diagram is communicating the business system appropriately. Figure 5-15 summarizes the guidelines presented in this chapter to help you evaluate your data model.

**YOUR TURN 5-5****Independent Entities**

Locate the independent entities on Figure 5-14. How do you know which of the entities are independent? Locate the non-identifying relationships. How did you find them? Can you

create a rule that describes the association between independent entities and non-identifying relationships?

**YOUR TURN 5-6****Dependent Entities**

Locate the dependent entities on Figure 5-14. Locate the identifying relationships. How did you find them? Can you create a

rule that describes the association between dependent entities and identifying relationships?

**YOUR TURN 5-7** || Intersection Entities

Describe the following relationships shown in Figure 5-14 in words.

- Pilot  $\leftarrow \rightarrow$  Drone
- Pilot  $\leftarrow \rightarrow$  Flight Request
- Drone  $\leftarrow \rightarrow$  Flight Bid

Explain the meaning of the relationship and the cardinality and modality symbols. Be sure to include both directions of the relationship in your explanation. Then provide an interpretation of the relationship in terms of DrönTeq's business rules. You may need to make some assumptions about the way DrönTeq expects to operate. If so, state those assumptions clearly.

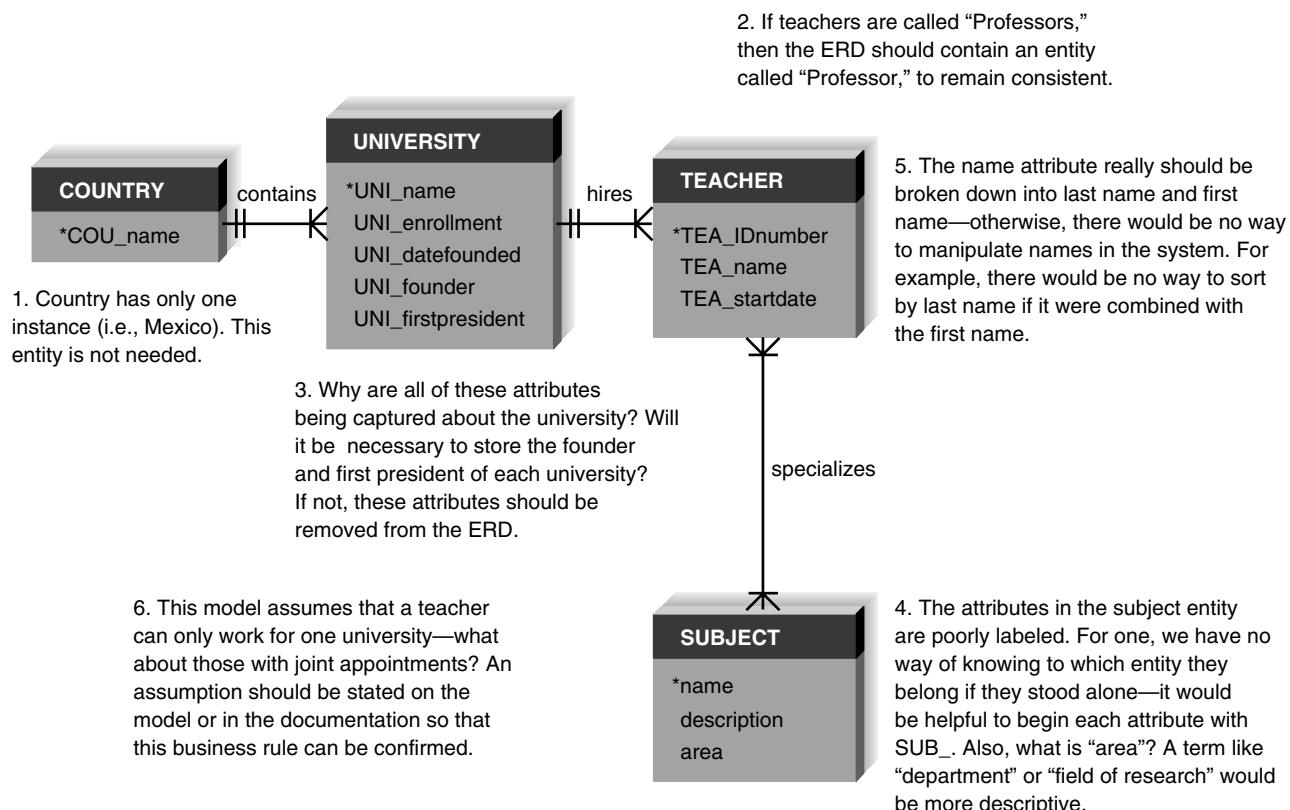


FIGURE 5-15 Data modeling guidelines summary.

**CONCEPTS IN ACTION 5-B** || Implementing an Enterprise Information Management System

A large direct health and insurance medical provider needed to enable enterprise-wide information management and to support the effective use of data for critical cross-functional decision making. The company faced numerous information challenges: the company data resided in multiple locations, the data were developed for department-specific use, there was limited enterprise access, data definitions were created by individual departments and were not standardized, and data were being managed by multiple departments within the company. An enterprise information management (EIM) system can help

resolve issues related to data redundancy, inconsistency, and unnecessary expenditure.

Adapted from: “Large Health and Medical Insurance Provider Implements Enterprise Information Management System,” [www.deloitte.com](http://www.deloitte.com), Health Care Providers Case Studies.

*Questions*

1. What solution would you propose for this company?
2. Discuss the role that data modeling would play in a project to solve this problem.

## Normalization

Once you have created your ERD, there is a technique called normalization that can help analysts validate the models that they have drawn. It is a process whereby a series of rules are applied to a logical data model or a file to determine how well formed it is. Normalization rules help analysts identify entities that are not represented correctly in a logical data model, or entities that can be broken out from a file. The result of the normalization process is that the data attributes are arranged to form stable, yet flexible, relations for the data model. In Appendix 5A, we describe three normalization rules that are applied regularly in practice.

## Balancing Entity Relationship Diagrams with Data Flow Diagrams

All the analysis activities of the systems analyst are interrelated. For example, the requirements analysis techniques are used to determine how to draw both the process models and data models, and the CASE repository is used to collect information that is stored and updated throughout the entire analysis phase. Now we will see how the process models and data models are interrelated.

Although the process model focuses on the processes of the business system, it contains two data components—the data flow (which is composed of data elements) and the data store. The purposes of these are to illustrate what data are used and created by the processes and where those data are kept. These components of the DFD need to **balance** with the ERD. In other words, the DFD data components need to correspond with the ERD's data stores (i.e., entities) and the data elements that comprise the data flows (i.e., attributes) depicted on the data model.

Many CASE tools offer the feature of identifying problems with balance between DFDs and ERDs; however, it is a good idea to understand how to identify problems on your own. This involves examining the data model you have created and comparing it with the process models that have been created for the system. Check your data model and see whether there are any entities you have created that do not appear as data stores on your process models. If there are, you should add them to your process models to reflect your decision to store information about that entity in your system.

Similarly, the bits of information that are contained in the data flows (these are usually defined in the CASE entry for the data flow) should match up to the attributes found in entities in the data models. For example, the New Flight Request data flow that goes from the *Client* external entity to the *Submit Flight Request* process should match the attributes in the *Flight Request* entity on the data model. We must verify that all the data items included in the data stores and data flows in the process model have been included somewhere as an entity attribute in the data model. We want to ensure that the data model fully incorporates all the data identified in the process model. If it does not, then the data model is incomplete. In addition, all the data elements in the data

### YOUR TURN 5-8

### Boat Charter Company

A charter company owns boats that are used for charter trips to islands. The company has created a computer system to track the boats it owns, including each boat's ID number, name, and seating capacity. The company also tracks information about the various islands, such as their names and population. Every time a boat is chartered, it is important to know the date that the trip is to take place and the number of people on the trip. The company also keeps information about each captain, such as Social Security number, name, birthdate, and contact

information for next of kin. Boats travel to only one island per visit.

#### Questions

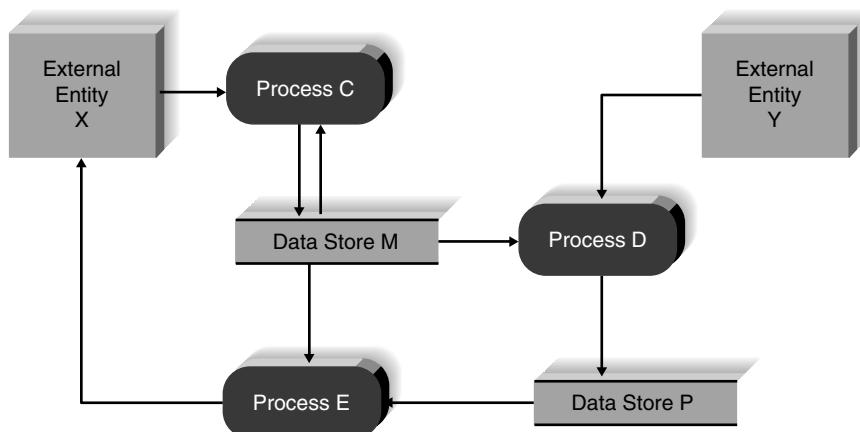
1. Create a data model. Include entities, attributes, identifiers, and relationships.
2. Which entities are dependent? Which are independent?
3. [Optional] Use the steps of normalization to put your data model in 3NF. Describe how you know that it is in 3NF.

model should appear as a part of a data store and data flow(s) in the process model. If some data elements have been omitted from the process model, then we need to investigate whether those data items are truly needed in the processing of the system. If they are needed, they must be added to the process model data stores and data flows; otherwise, they should be deleted from the data model as extraneous data items.

A useful tool to clearly depict the interrelationship between process and data models is the **create, read, update, delete (CRUD) matrix**. The CRUD matrix is a table that depicts how the system's processes use the data within the system. It is helpful to develop the CRUD matrix based on the logical process and data models and then revise it later in the design phase. The matrix also provides important information for program specifications because it shows exactly how data are created and used by the major processes in the system.

To create a CRUD matrix, draw a table listing all the system processes along the top, and all the data entities (and entity attributes) along the left-hand side of the table. Then, from the information presented in the process model, the analyst fills in each cell with a C, R, U, D, (or nothing) to describe the process's interaction with each data entity (and its attributes). Figure 5-16 shows a portion of a data flow diagram and the CRUD matrix that can be derived from it. As you can see, if a process reads information from a data store, but does not update it, there should be a data flow coming out of the data store only. When a process updates a data store in some way, there should be a data flow going from the process to the data store.

Thinking carefully about the content of the data flows in the process models, we can identify places where attributes may have been omitted from the data stores/entities. In addition, we can verify that every attribute is created, read, updated, and deleted somewhere in the process model. If it is not read by some process, then the attribute is probably not needed. If it is not created or updated, the attribute probably needs to be added to a data flow(s) in the process model.



	Process C	Process D	Process E
Data Entity M			
Attribute M-1	CRUD	R	R
Attribute M-2	CRUD		R
Attribute M-3	CRUD	R	
Attribute M-4	CRUD		R
Data Entity P			
Attribute P-1		C	R
Attribute P-2		C	
Attribute P-3		C	R

**FIGURE 5-16** Partial process model and CRUD matrix.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Define the meaning and purpose of the entity and relationship shown on an entity relationship diagram (ERD).
- Explain the meaning and purpose of attributes included in a data model.
- Explain what is meant by an entity's identifier.
- Explain the meaning of the cardinality and modality of a relationship.

- Explain the concept of metadata and how it is compiled in the project repository.
- Discuss the process used to create a data model.
- Describe how to ensure that the process model and data model are balanced through the use of the CRUD matrix.
- Discuss how the normalization process is performed and how it contributes to the quality of the data model (from chapter appendix).

## KEY TERMS

1:1 relationships	Create, read, update, delete (CRUD)	First normal form (1NF)	Non-identifying relationship	Second normal form (2NF)
1:N relationships	matrix	Identifier	Normalization	Subject area
Assumptions		Identifying relationships	Parent entity	Third normal form (3NF)
Attribute	Data dictionary	Independent entity	Partial dependency	Transitive dependency
Balance	Data model	Instances	Physical data model	
Business rules	Dependent	Intersection entity	Relationships	
Cardinality	Dependent entity	Logical data model	Repeating attributes	
Child entity	Derived attributes	Metadata	Repeating attribute groups	
Clients	Entity	M:N relationship		
Concatenated identifier	Entity relationship			
CRUD matrix	diagram (ERD)			

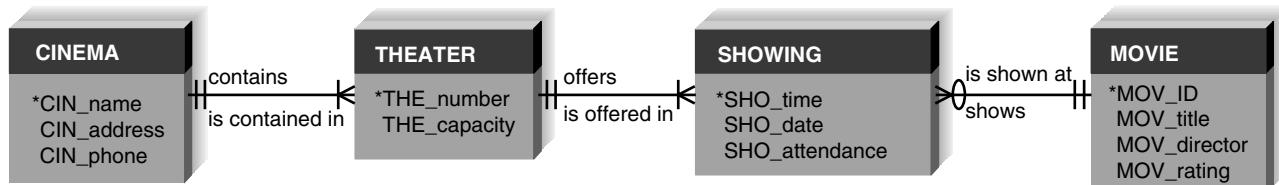
## QUESTIONS

1. Provide three different options that are available for selecting an identifier for a student entity. What are the pros and cons of each option?
2. What is the purpose of developing an identifier for an entity?
3. What type of high-level business rule can be stated by an ERD? Give two examples.
4. Define what is meant by an *entity* in a data model. How should an entity be named? What information about an entity should be stored in the CASE repository?
5. Define what is meant by an *attribute* in a data model. How should an attribute be named? What information about an attribute should be stored in the CASE repository?
6. Define what is meant by a *relationship* in a data model. How should a relationship be named? What information about a relationship should be stored in the CASE repository?
7. A team of developers is considering including “warehouse” as an entity in its data model. The company for whom they are developing the system has just one warehouse location. Should “warehouse” be included? Why or why not?
8. What is meant by a concatenated identifier?
9. Describe, in terms a businessperson could understand, what are meant by the cardinality and modality of a relationship between two entities.
10. What are metadata? Why are they important to system developers?
11. What is an independent entity? What is a dependent entity? How are the two types of entities differentiated on the data model?
12. Explain the distinction between identifying and non-identifying relationships.
13. What is the purpose of an intersection entity? How do you know whether one is needed in an ERD?
14. Describe the three-step process of creating an intersection entity.
15. Is an intersection entity dependent or independent? Explain your answer.
16. What is the purpose of normalization?
17. Describe the analysis that is applied to a data model in order to place it in first normal form (1NF).
18. Describe the analysis that is applied to a data model in order to place it in second normal form (2NF).
19. Describe the analysis that is applied to a data model in order to place it in third normal form (3NF).
20. Describe how the data model and process model should be balanced against each other.
21. What is a CRUD matrix? How does it relate to process models and data models?

**EXERCISES**

- A. Draw data models for the following entities:
- Movie (title, producer, length, director, genre)
  - Ticket (price, adult or child, showtime, movie)
  - Patron (name, adult or child, age)
- B. Draw a data model for the following entities, considering the entities as representing a system for a patient billing system and including only the attributes that would be appropriate for this context:

- Patient (age, name, hobbies, blood type, occupation, insurance carrier, address, phone)
- Insurance carrier (name, number of patients on plan, address, contact name, phone)
- Doctor (specialty, provider identification number, golf handicap, age, phone, name)



- C. Draw the relationships that follow. Would the relationships be identifying or non-identifying? Why?
- A patient must be assigned to only one doctor, and a doctor can have many patients.
  - An employee has one phone extension, and a unique phone extension is assigned to an employee.
  - A movie theater shows many different movies, and the same movie can be shown at different movie theaters around town.
- D. Draw an entity relationship diagram (ERD) for the following situations:
- Whenever new patients are seen for the first time, they complete a patient information form that asks their name, address, phone number, and insurance carrier, all of which are stored in the patient information file. Patients can be signed up with only one carrier, but they must be signed up to be seen by the doctor. Each time a patient visits the doctor, an insurance claim is sent to the carrier for payment. The claim must contain information about the visit, such as the date, purpose, and cost. It would be possible for a patient to submit two claims on the same day.
  - The state of Georgia is interested in designing a database that will track its researchers. Information of interest includes researcher name, title, position, university name, location, enrollment, and research interests. Each researcher is associated with only one institution, and each researcher has several research interests.
  - A department store has a bridal registry. This registry keeps information about the customer (usually the bride), the products that the store carries, and the products for which each customer registers. Customers typically register

for a large number of products, and many customers register for the same products.

4. Jim Smith's dealership sells Fords, Hondas, and Toyotas. The dealership keeps information about each car manufacturer with whom it deals so that employees can get in touch with manufacturers easily. The dealership also keeps information about the models of cars that it carries from each manufacturer. It keeps such information as list price, the price the dealership paid to obtain the model, and the model name and series (e.g., Honda Civic LX). The dealership also keeps information about all sales that it has made. (For instance, employees will record the buyer's name, the car the buyer bought, and the amount the buyer paid for the car.) To allow employees to contact the buyers in the future, contact information is also kept (e.g., address, phone number, e-mail).

- E. Examine the data models that you created for Exercise D. How would the respective models change (if at all) based on these corresponding new assumptions?

- Two patients have the same first and last names.
- Researchers can be associated with more than one institution.
- The store would like to keep track of purchased items.
- Many buyers have purchased multiple cars from Jim over time because he is such a good dealer.

- F. Visit a website that allows customers to order a product over the Web (e.g., Amazon.com). Create a data model that the site needs to support its business process. Include entities to show what types of information the site needs. Include attributes to represent the type of information the site uses and creates. Finally, draw relationships, making assumptions about how the entities are related.

- G. Create metadata entries for the following data model components and, if possible, input the entries into a computer-aided software engineering (CASE) tool of your choosing:
- Entity—product
  - Attribute—product number
  - Attribute—product type
  - Relationship—company makes many products, and any one product is made by only one company.
- H. Describe the assumptions that are implied from the data model shown at the top of this page.
- I. Create a data model for one of the processes in the end-of-chapter Exercises for Chapter 4. Explain how you would balance the data model and process model.
- J. Apply the steps of normalization to validate the models you drew in Exercise D.
- K. You have been given a file that contains fields relating to CD information. Using the steps of normalization, create a logical

data model that represents this file in third normal form. The fields include the following:

- Musical group name
- Musicians in group
- Date group was formed
- Group's agent
- CD title 1
- CD title 2
- CD title 3
- CD 1 length
- CD 2 length
- CD 3 length

The assumptions are as follows:

- Musicians in group contain a list of the members of the people in the musical group.
- Musical groups can have more than one CD, so both group name and CD title are needed to uniquely identify a particular CD.

## MINICASES

1. West Star Marinas is a chain of 12 marinas that offer lakeside service to boaters; service and repair of boats, motors, and marine equipment; and sales of boats, motors, and other marine accessories. The systems development project team at West Star Marinas has been hard at work on a project that eventually will link all the marina's facilities into one unified, networked system.

The project team has developed a logical process model of the current system. This model has been carefully checked for syntax errors. Last week, the team invited a number of system users to role-play the various data flow diagrams, and the diagrams were refined to the users' satisfaction. Right now, the project manager feels confident that the as-is system has been adequately represented in the process model.

The director of operations for West Star is the sponsor of this project. He sat in on the role-playing of the process model and was very pleased by the thorough job the team had done in developing the model. He made it clear to you, the project manager, that he was anxious to see your team begin work on the process model for the to-be system. He was a little skeptical that it was necessary for your team to spend any time modeling the current system in the first place, but grudgingly admitted that the team really seemed to understand the business after going through that work.

The methodology that you are following, however, specifies that the team should now turn its attention to developing the logical data model for the as-is system. When you stated this to the project sponsor, he seemed confused and a little irritated. "You are going to spend even more time looking at the current system? I thought you were done with that! Why is this necessary? I want to see some progress on the way things will work in the future!"

2. What is your response to the director of operations?
- a. Why do we perform data modeling?
  - b. Is there any benefit to developing a data model of the current system at all?
  - c. How does the process model help us develop the data model?

The system development team at the Wilcon Company is working on developing a new customer order entry system. In the process of designing the new system, the team has identified the following data entity attributes:

### Inventory Order

Order Number (identifier)

Order Date

Customer Name

Street Address

City

State

Zip

Customer Type

Initials

District Number

Region Number

1 to 22 occurrences of:

Item Name

Quantity Ordered

Item Unit

Quantity Shipped

Item Out

Quantity Received

- a. State the rule that is applied to place an entity in first normal form. Revise this data model so that it is in first normal form.
- b. State the rule that is applied to place an entity into second normal form. Revise the data model (if necessary) to place it in second normal form.
- c. State the rule that is applied to place an entity into third normal form. Revise the data model to place it in third normal form.
- d. What other guidelines and rules can you follow to validate that your data model is in good form?

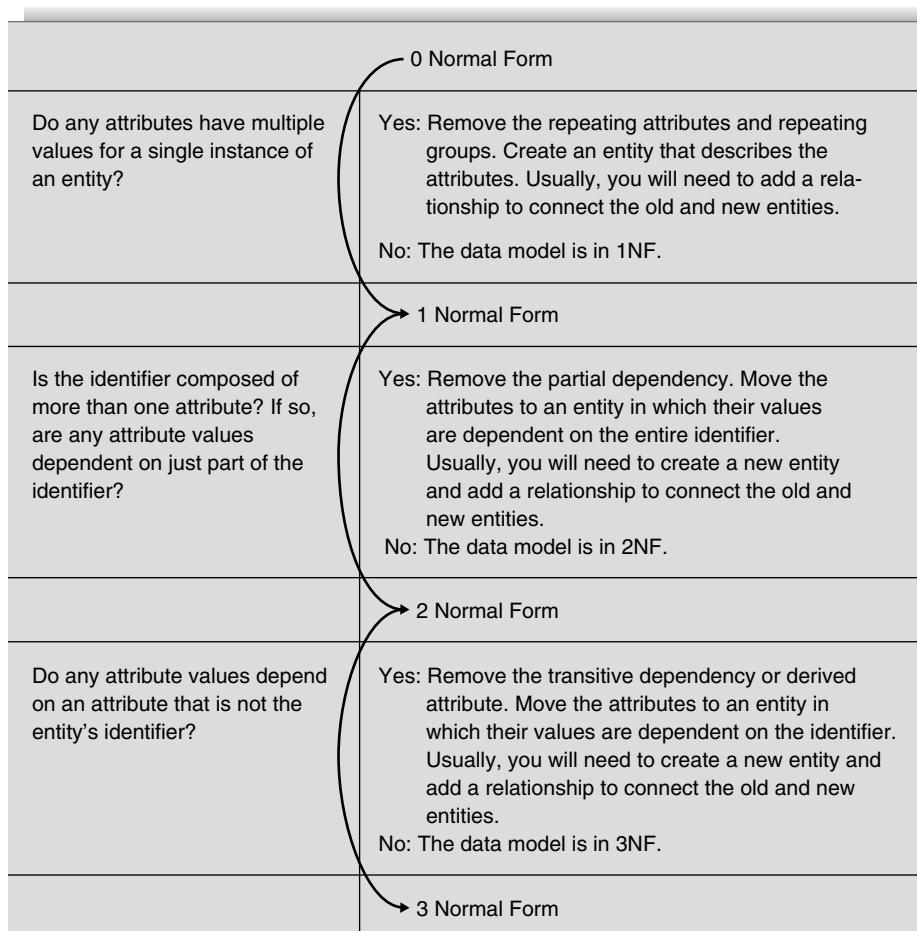
## APPENDIX 5A: NORMALIZING THE DATA MODEL

In this Appendix, we describe the rules of normalization that help analysts improve the quality of the data model. These rules help identify entities that are not represented correctly in the logical data model and entities that can be broken out from a file. The result of the normalization process is that the data attributes are arranged to form stable yet flexible relations for the data model. The normalization process is an important step in preparing the data model for actual implementation in an data base management system.

Typically, three rules of normalization are applied regularly in practice (Figure 5A-1). We describe these rules and illustrate them with an example here.

### First Normal Form

A logical data model is in **first normal form (1NF)** if it does not contain attributes that have repeating values for a single instance of an entity. Often, this problem is called **repeating attributes**, or **repeating attribute groups**. Every attribute



**FIGURE 5A-1**  
Normalization steps.

in an entity should have only one value per instance for the model to “pass” 1NF.

To illustrate the process of normalization, we will use a scenario in which a project team member has been tasked with developing a normalized data model for a simple human resource management (HRM) system under development. The existing system in this scenario is a legacy system with very little documentation. The team member was able to find the layout for the Employee file that is used by the existing HRM system. She decides to put the data elements from the file layout into a third normal form data model to make the information easier to understand. She hopes this will give her a good foundation for the new HRM system’s data model. See Figure 5A-2 for the existing system’s file layout.

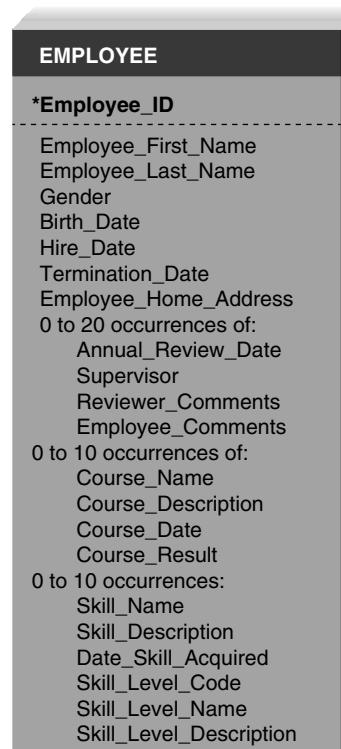
If you examine the file carefully, you should notice that there are three places in which groups of attributes repeat. Repeating attribute groups violate the 1NF rule and are removed into separate entities. The repeated group of attributes describing performance reviews are removed by creating a new entity called Performance Review and placing all the performance review attributes into it. Similar steps are taken for the group of attributes describing Job Skills and Training Courses.

The second 1NF violation type is typically not as readily noticed. If a single attribute instance can contain several values, we have a 1NF issue. A careful look at the attributes

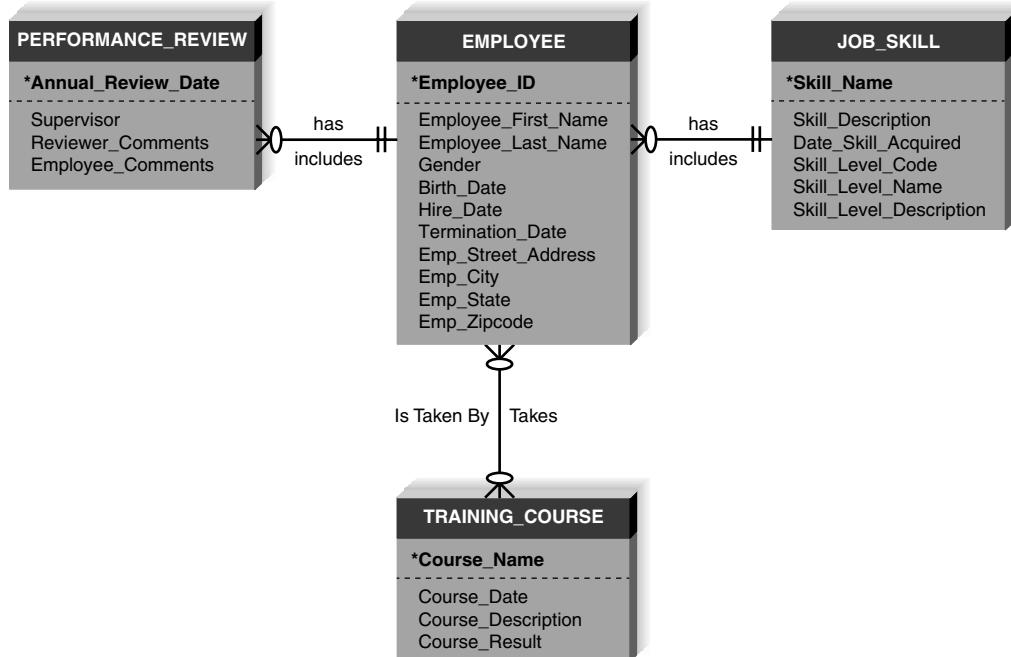
does not reveal this problem in this data. If you see an attribute name that is plural, you may have a clue that several different values may be captured for each instance of the entity and that attribute is a repeating attribute. When this occurs, create a new entity that contains the attribute information. You may need to create an identifier attribute in the new entity. See Figure 5A-3a for the current data model in 1NF.

One additional change was made in the Employee entity at this time. The attribute Emp\_Home\_Address is an example of a *composite* attribute because it represents several different attributes. We have expanded that attribute to include street address, city, state, and zip code as separate attributes.

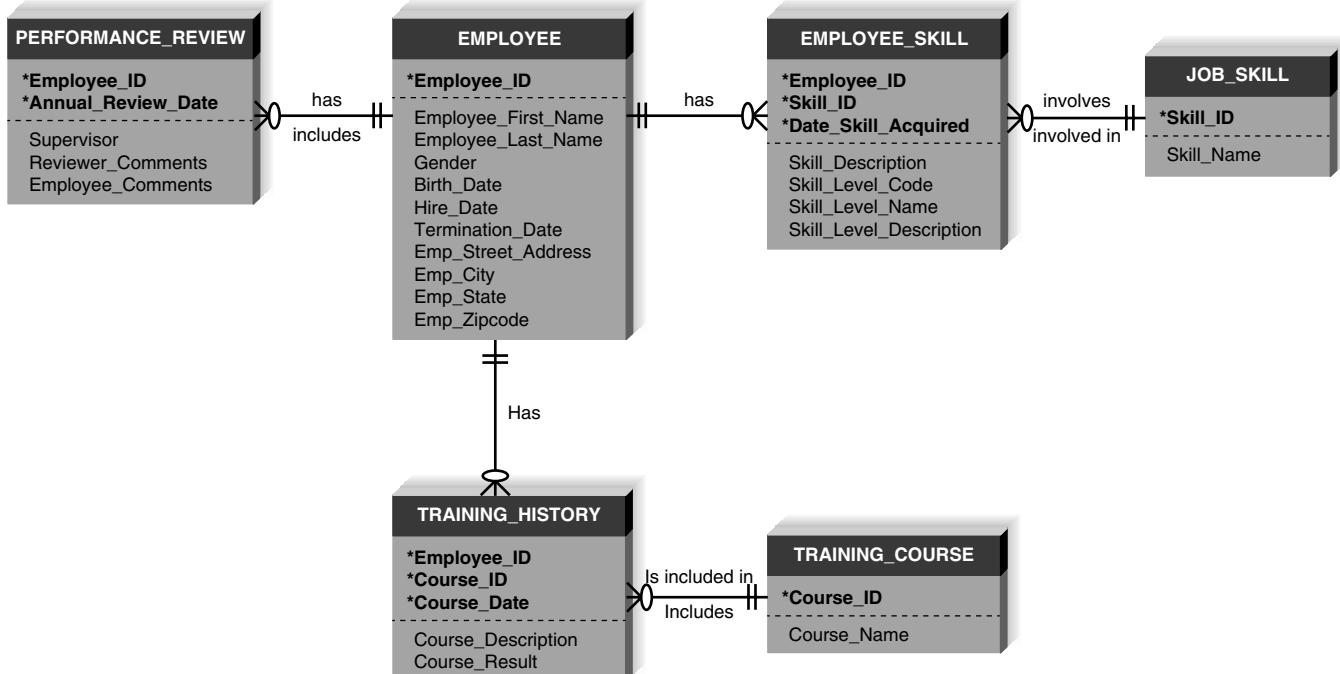
Two M:N relationships are shown in Figure 5A-3a: between the Employee and Job Skill entities and between the Employee and Training Course entities. Since we normally resolve M:N relationships as the ERD develops, we have done so now in Figure 5A-3b. Note that a new intersection entity, Employee Skill, was inserted between the Employee and Job Skill entities to associate an instance of Employee with specific instance of Job Skills. Also, the intersection entity Training History was inserted between the Employee and Training Course entities to associate a specific Employee with a specific instance of Training Course. The attribute Date Skill Acquired was moved to Employee Skill because the employee can achieve various Job Skills on different



**FIGURE 5A-2** Initial existing HRM system file layout.



**FIGURE 5A-3a**  
First normal form.



**FIGURE 5A-3b** First normal form with M:N relationships resolved.

dates; therefore, this attribute describes a date a specific job skill was acquired by a specific employee. Similarly, since a Training Course can be offered on many different dates, the Course Date attribute was moved to the Training History entity to describe the specific course offering date in which the employee participated.

We have defined more complete identifier attributes in Figure 5A-3b. In the Performance Review entity, Employee ID was added as an identifier attribute, along with the Annual Review Date, so that each Performance Review entity instance is uniquely associated with a specific employee's review on a specific date. In the Job Skill and Training Course entities, an ID attribute was created for the identifier attribute rather than the Name attribute. Finally, in the two intersection entities (Employee Skill and Training History), the identifiers from the parent entities were added along with the date the skill was acquired / course occurred, respectively.

### Second Normal Form

**Second normal form (2NF)** requires that the data model is in 1NF and that the data model leads to entities containing attributes that are **dependent** on the whole identifier. This means that the value of all attributes that serve as identifier can determine the value for all of the other attributes for an instance in an entity. Sometimes, non-identifier attributes

are dependent on only part of the identifier (i.e., **partial dependency**), and these attributes belong in another entity.

To search for partial dependencies, look at every entity with a concatenated identifier. For all the non-identifier attributes, ask yourself if the value of that attribute depends on knowing the entire identifier or just part of the identifier. As we look at Figure 5A-3b, there are two partial dependencies that exist. First, in the Employee Skill entity, the non-identifier attribute, Skill Description, depends just on the Skill ID portion of the identifier, not on the whole identifier. The second partial dependency is found in the Training History entity. Here, the non-identifier attribute, Course Description, depends only on the Course ID piece of the identifier, not the entire identifier. In each case, the non-identifier attribute needs to be removed into the related attribute describing Job Skills/Training Course, respectively. Figure 5A-4 shows the ERD in 2NF following these changes.

### Third Normal Form

**Third normal form (3NF)** occurs when a model is in both 1NF and 2NF and when, in the resulting entities, none of the attributes is dependent on a non-identifier attribute (i.e., **transitive dependency**). A violation of 3NF can be found in the Employee Skill entity in Figure 5A-4.

The 3NF violation in the Employee Skill entity is seen by examining the non-identifier attributes. The Skill Level

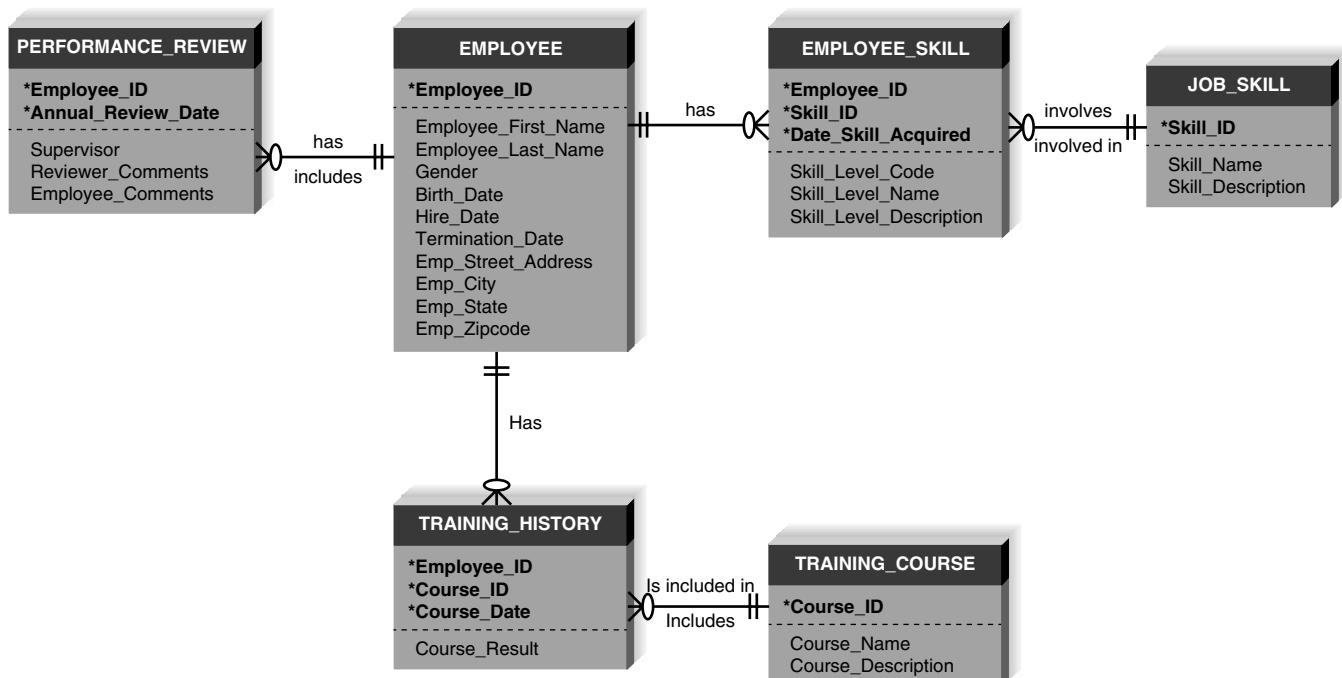
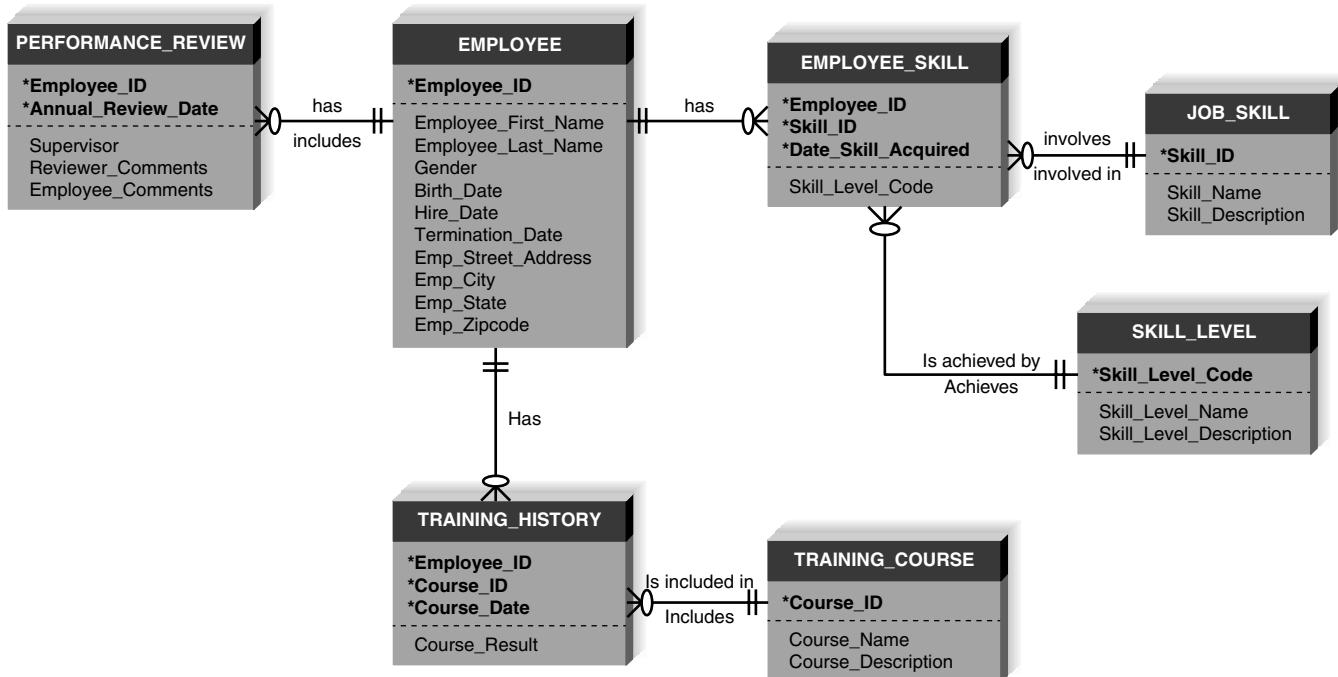


FIGURE 5A-4 Second normal form.

Name and Skill Level Description depend on the non-identifier attribute Skill Level Code, not on the entity identifier. The correct way to resolve this transitive dependency is to create a separate entity for Skill Level. This change is shown in Figure 5A-5.

Third normal form also addresses issues of *derived*, or calculated, *attributes*. By definition, **derived attributes**

can be calculated from other attributes and do not need to be stored in the data model. As an example, a person's age would not be stored as an attribute if birthdate were stored, because, by knowing the birthdate and current date, we can always calculate the age. There are no derived attributes shown in the ERD in Figure 5A-5, so we have achieved a 3NF data model.



**FIGURE 5A-5** Third Normal Form.

### YOUR TURN 5A-1 ||| Normalizing a Student Activity File

Pretend that you have been asked to build a system that tracks student involvement in activities around campus. You have been given a file with information that needs to be imported into the system, and the file contains the following fields:

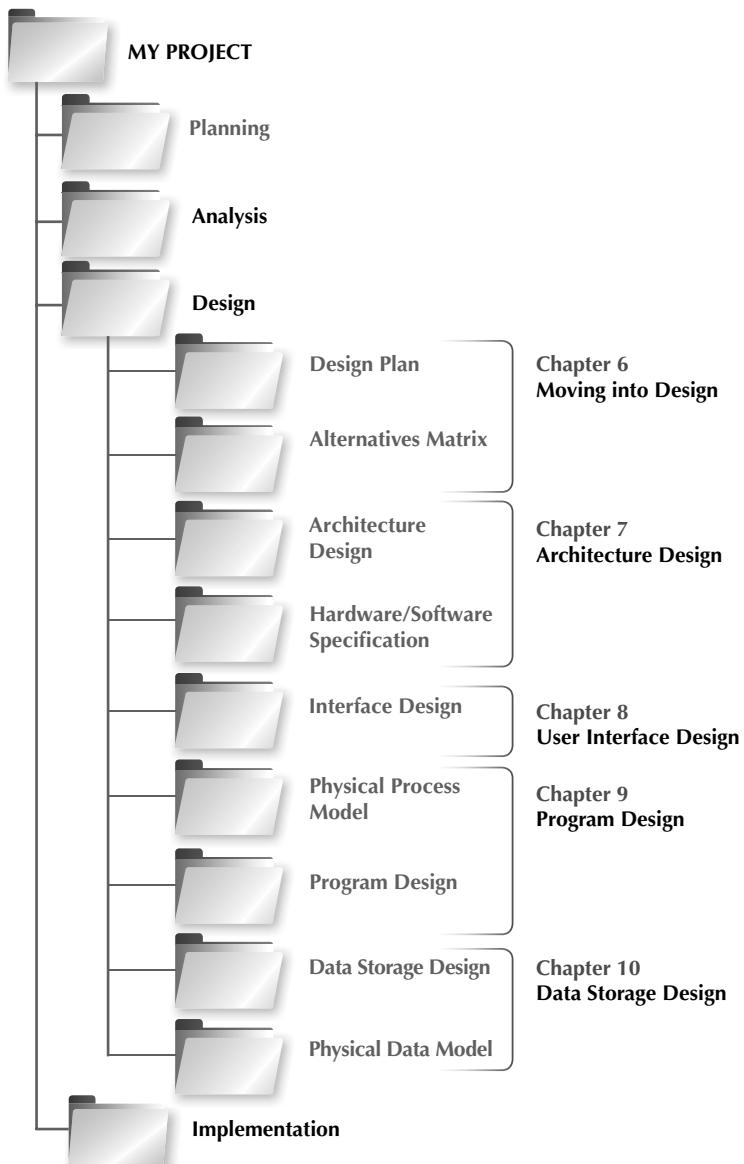
- Student Social Security number (identifier)
- Activity 1 code (identifier)
- Activity 1 description
- Activity 1 start date
- Activity 1 years with activity
- Activity 2 code
- Activity 2 description
- Activity 2 start date

- Activity 3 code
- Activity 3 description
- Activity 3 start date
- Activity 3 years with activity
- Student last name
- Student first name
- Student birthdate
- Student age
- Student advisor name
- Student advisor phone

Normalize the file. Show how the logical data model would change as you move from 1NF to 2NF to 3NF.

# DESIGN PHASE

PART 3



The Design Phase determines how the system will be implemented and provides detailed plans for all system components.

A final review of the design specifications and revised feasibility analysis is made before proceeding to the implementation phase.

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# Moving into Design

# 6

## DESIGN

### TASK CHECKLIST

- Select Design Strategy.
- Design Architecture.
- Select Hardware and Software.
- Develop Use Scenarios.
- Design Interface Structure.
- Develop Interface Standards.
- Design Interface Prototype.
- Evaluate User Interface.
- Design User Interface.
- Develop Physical Data Flow Diagrams.
- Develop Program Structure Charts.
- Develop Program Specifications.
- Select Data Storage Format.
- Develop Physical Entity Relationship Diagrams.
- Denormalize Entity Relationship Diagram.
- Performance Tune Data Storage.
- Size Data Storage.

The design phase of the SDLC uses the requirements that were gathered during analysis to create a blueprint for the future system. A successful design builds on what was learned in earlier phases and leads to a smooth implementation by creating a clear, accurate plan of what needs to be done. This chapter describes the initial transition from analysis to design and presents three ways to accomplish the design for the new system.

### OBJECTIVES

- Explain the initial transition from analysis to design.
- Create a system specification.
- Describe three ways to acquire a system: custom, packaged, and outsourced alternatives.
- Create an alternative matrix.

## Introduction

The design phase decides *how* the new system will operate. Many activities will be involved as the development team develops the system requirements. This chapter provides an outline of those design phase activities, which culminates in the creation of the system specification. We also describe three alternative strategies for acquiring the system that are available to the development team.

## Transition from Requirements to Design

The purpose of the analysis phase is to figure out what the business needs. The purpose of the **design phase** is to decide how to build it. System design is the determination of the overall system architecture—consisting of a set of physical processing components, hardware, software, people, and the communication among them—that will satisfy the system's essential requirements.<sup>1</sup>

During the initial part of design, the project team converts the business requirements for the system into **system requirements** that describe the technical details for building the system. Unlike business requirements, which are listed in the requirements definition and communicated through use cases and *logical* process and data models, system requirements are communicated through a collection of design documents and *physical* process and data models. Together, the design documents and physical models make up the blueprint for the new system.

We should note here that our focus is on the design of the technical system blueprint that will satisfy the system's requirements. An important element of the final, complete information system, however, will be redesigned workflows and procedures that users will follow when using the new system. Business analysts often turn their attention to the design of these components at this stage of the project, while systems analysts focus on more technical design elements. Ultimately, the redesigned business processes and procedures will be communicated in user documentation and training materials, which we discuss in Chapter 11.

The design phase has several activities that lead to the system blueprint (Figure 6-1). An important initial part of the design phase is the examination of several system acquisition strategies to

Activities in the Design Phase	Deliverables	Chapter
✓ Determine preferred system acquisition strategy (make, buy, or outsource).	– Alternative matrix	6
✓ Design the architecture for the system.	– Architecture design	7
✓ Make hardware and software selections.	– Hardware and software specification	
✓ Design system navigation, inputs, and outputs.	– Interface design	8
✓ Convert logical process model to physical process model.	– Physical process model	9
✓ Update CASE repository with additional system details.	– Updated CASE repository	
✓ Design the programs that will perform the system processes.	– Program design specifications	
✓ Convert logical data model to physical data model.	– Physical data model	10
✓ Update CASE repository with additional system details.	– Updated CASE repository	
✓ Revise CRUD matrix.	– CRUD matrix	
✓ Design the way in which data will be stored.	– Data storage design	
✓ Compile final system specification.	– System specification: all of the above deliverables combined and presented to approval committee	6

FIGURE 6-1 Activities of the design phase.

<sup>1</sup> Ken Shumate and Marilyn Keller, *Software Specification and Design*, New York: John Wiley & Sons, 1992.

decide which will be used to meet the requirements of the system. Systems can be built from scratch, purchased, and customized, or outsourced to others, and the project team needs to investigate the viability of each alternative. The decision to make, to buy, or to outsource influences the design tasks that are performed throughout the rest of the phase.

The project team carefully considers the nonfunctional business requirements that were identified during analysis. The nonfunctional business requirements influence the system requirements that drive the design of the system's architecture. Major considerations of the "how" of a system are operational, performance, security, cultural, and political in nature. For example, the project team needs to plan for the new system's performance: how fast the system will operate, what its capacity should be, and its availability and reliability. The team needs to create a secure system by specifying access restrictions and by identifying the need for encryption, authentication, and virus control. The nonfunctional requirements are converted into system requirements that are described in the **architecture design** document (Chapter 7).

At the same time, architecture decisions are made regarding the hardware and software that will be purchased to support the new system (Chapter 7). These decisions are documented in the **hardware and software specification**, which is a document that describes what hardware and software are needed to support the new application. The actual acquisition of hardware and software is sometimes the responsibility of the purchasing department or the area in the organization that handles capital procurement; however, the project team uses the hardware and software specification to communicate the hardware and software needs to the appropriate people.

The user's interactions with the system also must be designed. The system inputs and outputs will be designed along with a plan or roadmap of the way the system's features will be navigated. Chapter 8 describes these activities in detail, along with techniques, such as storyboarding and prototyping, that help the project team design a system that meets the needs of its users and is satisfying to use. Design decisions made regarding the interface are communicated through the design document called the **interface design**.

The processes described in the logical process model provide the foundation for the system's functionality. Chapter 9 describes how these logical DFDs are converted into physical DFDs that document physical design decisions about how the system will be built. CASE repository entries are updated to reflect specific technology decisions as they are made. Program specifications are prepared to provide the final design details and ensure that programmers have sufficient information to build the right system efficiently. The program design document contains all the information about the new system's programs.

The data component of the system, described in the logical data model, also must be designed prior to implementation. Chapter 10 discusses the development of the physical data model, updates to the CASE repository, and describes how the CRUD matrix should be updated to verify the consistency between the process and data models. Design decisions regarding data storage are written up in the data storage design document.

Although a textbook such as this must present information sequentially, the many activities of the design phase are highly interrelated. As with the steps in the analysis phase, analysts often go back and forth between them. For example, prototyping in the interface design step often uncovers additional information that is needed in the system, leading to a revision of the physical DFDs or ERDs. Alternatively, a system that is being designed for an organization with centralized systems may require substantial hardware and software investments if the project team decides to change to a system in which all the processing is distributed.

At the end of the design phase, the project team creates the final deliverable for the phase called the **system specification**. This document contains all of the design documents just described: physical process models, physical data model, architecture design, hardware and software specification, interface design, data storage design, and program design. Collectively, the system

- Recommended System Acquisition Strategy
- System Acquisition Weighted Alternative Matrix
- Architecture Design
- Hardware and Software Specification
- Interface Design
- Physical Process Model
- Program Design Specifications
- Physical Data Model
- Data Storage Design
- Updated CRUD Matrix
- Updated CASE Repository Entries

**FIGURE 6-2** System specification outline.

specification conveys exactly what system the project team will implement during the implementation phase of the SDLC. See Figure 6-2 for an outline of the system specification content.

## System Acquisition Strategies

In our chapters devoted to the analysis phase of the SDLC, we have carefully avoided committing ourselves to a specific way of obtaining the new system. We have stressed that the team should focus on determining the system's logical requirements during the analysis phase and postpone the issue of *how* the system should be acquired until the design phase.



### PRACTICAL TIP 6-1

### Avoiding Classic Design Mistakes

In Chapters 2 and 3, we discussed several classic mistakes and how to avoid them. Here, we summarize four classic mistakes in the design phase and discuss how to avoid them:

#### 1. Reducing design time:

If time is short, there is a temptation to reduce the time spent in such “unproductive” activities as design so that the team can jump into “productive” programming. This results in missing important details that have to be investigated later at a much higher time cost (usually, at least 10 times longer).

**Solution:** If time pressure is intense, use rapid application development (RAD) techniques and timeboxing to eliminate functionality or move it into future versions.

#### 2. Feature creep:

Even if you are successful at avoiding scope creep, about 25% of system requirements will still change. Changes—big and small—can significantly increase time and cost.

**Solution:** Ensure that all changes are vital and that the users are aware of the impact on cost and time. Try to move proposed changes into future versions.

#### 3. Silver bullet syndrome:

Analysts sometimes believe the marketing claims that some design tools solve all problems and magically reduce time and costs. No one tool or technique can eliminate overall time or costs by more than 25% (although some can reduce individual steps by this much).

**Solution:** If a design tool has claims that appear too good to be true, just say no.

#### 4. Switching tools in midproject:

Sometimes, analysts switch to what appears to be a better tool during design in the hopes of saving time or costs. Usually, any benefits are outweighed by the need to learn the new tool. This also applies to even “minor” upgrades to current tools.

**Solution:** Do not switch or upgrade unless there is a compelling need for specific features in the new tool, and then explicitly increase the schedule to include learning time.

Until now, we have implicitly assumed that the system will be designed, developed, and implemented by the project team. This is not an entirely realistic assumption. In many projects, the team may recognize that some parts or even all the new system's software will be acquired from some outside provider. Some organizations have established acquisition policies strongly favoring purchased software. We explain in this chapter that there are many good reasons supporting this decision. Does this mean that all the work described in Chapters 3 through 5 can be skipped? Our position on this issue is that the work performed in the analysis phase is still essential to the project's success, especially the tools and techniques that are used to determine, define, and clarify the business and user requirements. It is essential to know what we need before seeking a product that provides the best fit. Otherwise, we run the risk of letting a software vendor tell us what we need, and we obtain software that does not fulfill our real business and user requirements.

There are, however, three primary ways to approach the creation of a new system: (1) develop a custom application in-house; (2) buy a packaged system and (possibly) customize it; and (3) rely on an external vendor, developer, or service provider to build or provide the system. Each of these choices has its strengths and weaknesses. These are summarized in Figure 6-3. In addition, each option is more appropriate in different situations. There may be obvious characteristics of the project that suggest the preferred acquisition strategy. The following sections describe each acquisition choice in turn, and then we present criteria you can use to select one of the three approaches for your project.

Pros	Cons
Custom Development	
Get <b>exactly</b> what we want New system built consistently with existing technology and standards Build and retain technical skills and functional knowledge in-house Allows team flexibility and creativity Unique solutions created for strategic advantage	Requires significant time and effort May add to existing backlogs May require skills we do not have Often costs more Often takes more calendar time Risk of project failure
Packages (purchased or obtained from ASP or SaaS)	
No need to "reinvent the wheel" for common business needs Tested, proven product Cost savings Time savings Utilize vendors' expertise Some customization may be possible	Rarely a perfect fit Organizational processes must adapt to software Reliance on vendor for maintenance and future enhancements Will not develop in-house functional and technical skills Unique needs may go unmet May require system integration
Outsourced Development	
Hire expertise we do not have May save time and money Lower risk	No opportunity to build in-house expertise Reliance on vendor Future options limited Security—potential loss of confidential info Performance based on contract terms

**FIGURE 6-3** Summary of software acquisition options pros and cons.

**CONCEPTS IN ACTION 6-A****Out of the Box . . . ?**

A consultant I know led a very large project revising the financial systems of a major global financial services company. The company had a successful, well-defined program of software standards in place. Therefore, initially, the project team attempted to employ software from one of the major ERP

software vendors in the project. After experiencing dismal (and unacceptable) processing speed during tests of the ERP software, the CIO and team concluded, “Out of the Box is out of the question.” *Roberta Roth*

## Custom Development

Many project teams assume that **custom development**, or building a new system from scratch, is the best way to create a system, because teams have complete control over the way the system looks and functions. Let us consider the drone sales process at DrönTeq. The company wanted a Web-based sales capability that enabled customers to select and customize the drone for purchase. This sales process was standardized, as there are many types of products that are ordered in this way (e.g., ordering a computer from Dell). A unique feature of the drone sales process, however, was the need to link the ordering process to a shop management process that would evaluate the customer’s selected drone configuration to ensure proper flight characteristics. The need for integration and the unique evaluation performed was a complex, highly specialized situation, and suggests that custom development would be necessary for this aspect of the system. Alternatively, DrönTeq might have a technical environment in which all information systems are built from standard technology and interface designs so that they are consistent and easier to update and support. In both cases, it could be highly effective to create a new system from scratch that meets these highly specialized requirements.

In some situations, the challenges being addressed with the new system are so significant and demanding that serious systems engineering is required to solve them. In these cases, the developers really cannot find a packaged solution that can meet the project requirements, and a custom development project is the only real viable choice (Concepts in Action 6-A).

Custom development also allows developers to be flexible and creative in the way they solve business problems. In the new Client Services business unit, DrönTeq may envision the Web interface used by clients requesting flights to be an important strategic enabler. The company may want to use the information from the system to better understand its clients who request drone flight services over the Web. It may also want to use technology such as data-mining software and geographic information systems to better understand the use of its data analysis products relative to client location. A custom application would be easier to change to include components that take advantage of current technologies that can support such strategic efforts.

Building a system in-house also builds technical skills and functional knowledge within the company. As developers work with business users, their understanding of the business grows, and they become better able to align information systems with strategies and needs. These same developers climb the technology learning curve so that future projects applying similar technology become much easier.

Custom application development, however, requires a dedicated effort that includes long hours and hard work. Many companies have a development staff that is already overcommitted. Facing huge backlogs of systems requests, the staff just does not have time for another project. Also, a variety of skills—technical, interpersonal, functional, project management, modeling—all must be in place for the project to move ahead smoothly. IS professionals, especially highly skilled individuals, are quite difficult to hire and retain.

The risks associated with building a system from the ground up can be quite high, and there is no guarantee that the project will succeed. Developers could be pulled away to work on other

**CONCEPTS IN ACTION 6-B****Bucking Conventional Wisdom with Custom Development**

Bonhams 1793 Ltd. is a London-based auctioneering house, ranked number three globally behind Christie's International PLC and Sotheby's. After embarking on a series of acquisitions in 2000, the firm recognized the need to standardize its IT system. The requirements that Bonhams 1793 faced included ERP functions, CRM, and auction catalog production, among others. Rather than follow the lead of its larger competitors and acquire a software package from SAP AG or Siebel Systems Inc., Bonhams 1793 instead developed a system from scratch. By carefully planning the system architecture, selecting powerful and integrated development tools, employing open source

software when possible, and empowering its in-house developers, Bonhams 1793 developed a custom system rapidly and at lower cost than it could have by using a packaged solution. Bonhams 1793 avoided purchasing an expensive package and then spending a significant amount to tailor and implement it. The result is a successful custom system that provides exactly the functions that Bonhams 1793 sought.

*Source: Anthes, Gary, "Best in Class 2007, Bonhams 1793," Computerworld, August 14, 2007.*

projects, technical obstacles could cause unexpected delays, and the business users could become impatient with a lengthening timeline.

## Packaged Software

Many business needs are not unique, and because it makes little sense to reinvent the wheel, many organizations buy **packaged software** that has already been written, rather than developing their own custom solution. In fact, there are thousands of commercially available software programs that have already been written to serve a multitude of purposes. Think about your own need for a word processor—did you ever consider writing your own word processing software? That would be very silly, considering the number of good software packages available for a relatively inexpensive cost.

Similarly, most companies have needs, such as payroll or accounts receivable, that can be met quite well by packaged software. It can be much more efficient to buy programs that have already been created, tested, and proven, and a packaged system can be bought and installed quickly compared with a custom system. Plus, packaged systems incorporate the expertise and experience of the vendor who created the software.

Let's think about the needs that DrōnTeq will have in its Client Services system. One requirement is to have a simple, fast, and flexible capability to deliver information to prospective clients and pilots about the flight request line of business. There are many software packages designed to build content-rich websites that are highly functional and easy to maintain. Another small, but essential element in this overall system is the capability of uploading large quantities of flight data after a pilot's drone has completed its flight. These data files must be uploaded to the DrōnTeq server and then, in many cases, routed to various DrōnTeq proprietary data analysis routines. Fast and secure file upload management software should be readily available as packaged software. DrōnTeq should consider these types of options as it considers alternative ways to obtain the requirements of the Client Services information system.

Packaged software can range from small single-function tools, such as a client-side file upload manager, to huge all-encompassing systems, such as **enterprise resource planning (ERP)** applications that are installed to automate an entire business. Implementing ERP systems is a popular practice in which large organizations spend millions of dollars installing packages by such companies as SAP, Oracle, and Infor and then change their businesses accordingly. Installing ERP software is much more difficult than installing small application packages, because benefits can be harder to realize and problems are much more serious.

One challenge is that companies utilizing packaged systems must accept the functionality that is provided by the system, and rarely is there a perfect fit. If the packaged system is large in scope, its implementation could mean a substantial change in the way the company does business. Letting technology drive the business can be a dangerous way to go.

Most packaged applications allow for some customization or for the manipulation of system parameters to change the way certain features work. For example, the package might have a way to accept information about your company or the company logo that would then appear on input screens. An accounting software package could offer a choice of various ways to handle cash flow or inventory control so that it could support the accounting practices in different organizations. If the amount of customization is not enough and the software package has a few features that do not quite work the way the company needs them to work, the project team can create a **workaround**. A workaround is a custom-built add-on program that interfaces with the packaged application to handle special needs. It can be a nice way to create needed functionality that does not exist in the software package. However, workarounds should be a last resort, for several reasons. First, workarounds are not supported by the vendor who supplied the packaged software, so when upgrades are made to the main system, they may make the workaround ineffective. Also, if problems arise, vendors tend to blame the workaround as the culprit and refuse to provide support.

Although choosing a packaged software system is simpler than going with custom development, it also can benefit from following a formal methodology, just as if you were building a custom application. The search for a software package should be based on the detailed requirements identified during analysis.

**Systems integration** refers to the process of building new systems by combining packaged software, existing legacy systems, and new software written to integrate these. Many consulting firms specialize in systems integration, so it is not uncommon for companies to select the packaged software option and then outsource the integration of a variety of packages to a consulting firm. (Outsourcing is discussed in the following section.)

The key challenge in systems integration is finding ways to integrate the data produced by the different packages and legacy systems. Integration often hinges on taking data produced by one package or system and reformatting it for use in another package or system. The project team starts by examining the data produced by and needed by the different packages and systems and identifying the transformations that must occur to move the data from one to the other. In many cases, this involves fooling the different packages or systems into thinking that the data were produced by an existing program module that the package or system expects to produce the data, rather than by the new package or system that is being integrated.

For example, DrōnTeq has already dealt with an integration challenge in its Sales system. As we mentioned previously, the Sales system used a standard ordering with customization options process and did use a software package for this purpose. The custom drone order data created by this package was then accessed by a custom-developed process allowing the shop manager to perform the needed checks on the custom drone prior to final order approval. By integrating the two systems, DrōnTeq got the benefits of a cost-effective, proven ordering system and devoted its custom-development efforts to the unique needs of the drone configuration evaluation process.

## Outsourcing

The acquisition choice that requires the least in-house resources is **outsourcing**, which means hiring an external vendor, developer, or service provider to create or supply the system. Outsourcing has become quite popular in recent years, with both US and non-US (offshore) service providers available.

**CONCEPTS IN ACTION 6-C****Finding Just the Right Blend**

Welch Foods, Inc., recognized that the new ERP system being implemented did not have the same reporting capabilities as the systems that were being replaced. Key transportation operations and cost data was going to be lost. Welch's turned to a SaaS business intelligence solution to ensure continued access to old and new data. The SaaS solution was ideal because the company could not realistically manage another project or add an additional burden on its employees at the time, especially in

light of the ERP implementation. The SaaS solution provided a variety of business intelligence reporting capabilities to Welch's, enabling cost savings and overall transportation operational efficiencies.

*Source: Christina Torode, "SaaS BI helps boost Welch's efficiency, data retention," SearchCIO.com, January 13, 2010.*

The term outsourcing has come to include a variety of ways to obtain IT services and products. Outsourcing firms called **application service providers (ASPs)** supply software applications and/or software-related services over wide area networks or the Internet. In this approach to obtaining software, the ASP hosts and manages a software application, and owns, operates, and maintains the servers that run the application. The ASP also employs the people needed to maintain the application.

Organizations wishing to use a software application contract with the ASP, who makes it available to the customer via a wide area network or the Internet, either installed on client computers or through a browser. The customer is billed by the ASP for the application either on a per-use basis or on a monthly or annual fee basis.

**Software as a Service (SaaS)** is a popular term that is essentially an extension of the ASP model. This term is commonly used to describe situations in which SaaS vendors develop and manage their own software rather than managing and hosting a third-party independent software vendor's software (the more traditional ASP model). Software vendor Salesforce.com was an early provider of a SaaS version of its customer relationship management (CRM) software and helped to popularize this approach to providing software solutions that are Web-based and require only a browser to use.

There is an array of ASPs. Some deliver high-end business applications that can serve the entire enterprise. Some are focused more on serving a small- to medium-sized business clientele. Some ASPs specialize in specific business needs (such as CRM), while some specialize in specific industries (e.g., healthcare).

Obtaining access to a software package through an application service provider has many advantages. There is a low cost of entry and, in most cases, an extremely short setup time. The pay-as-you-go model is often significantly less expensive for all but the most frequent users of the service. Investments in IT staff can be reduced, and investments in specialized IT infrastructure often can be avoided.

Outsourcing firms are also available that will develop a custom system on behalf of the customer. There can be great benefit to having others develop your system. They may be more experienced in the technology or have more resources, such as experienced programmers. Many companies embark on outsourcing deals to reduce costs, whereas others see it as an opportunity to add value to the business. For example, DrōnTeq may decide to use an outsourcing partner to develop some of the more generic aspects of the new Client Services system. It could then use its in-house developers to concentrate their development efforts on the more unique, strategic aspects of the system.

For whatever reason, outsourcing can be a good alternative for a new system; however, it does not come without costs. If you decide to leave the creation of a new system in the hands of someone else, you could compromise confidential information or lose control over future

development. In-house professionals are not gaining new skills that could be learned from the project; instead, the expertise is transferred to the outside organization. Ultimately, important skills can walk right out the door at the end of the contract.

Most risks can be addressed if you decide to outsource, but two are particularly important. First, assess the requirements for the project thoroughly—you should never outsource what you do not understand. If you have conducted rigorous planning and analysis, then you should be well aware of your needs. Second, carefully choose a vendor, developer, or service with a proven track record with the type of system and technology that your system needs.

There are three primary types of contracts that can be drawn to control the outsourcing deal. A **time and arrangements deal** is very flexible because you agree to pay for whatever time and expenses are needed to get the job done. Of course, this agreement could result in a large bill that exceeds initial estimates. This arrangement works best when you and the outsourcer are unclear about what it is going to take to finish the job.

You will pay not more than expected with a **fixed-price contract** because if the outsourcer exceeds the agreed-on price, he or she will have to absorb the costs. Outsourcers are careful about clearly defining requirements up front, and there is little flexibility for change.

The type of contract gaining in popularity is the **value-added contract**, whereby the outsourcer reaps some percentage of the completed system's benefits. You have very little risk in this case but expect to share the wealth once the system is in place.

Creating fair contracts is an art because you need to carefully balance flexibility with clearly defined terms. Needs often change over time, so you do not want the contract to be so specific and rigid that alterations cannot be made. Think about how quickly technology like the World Wide Web changes. It is difficult to foresee how a project may evolve over a long period. Short-term contracts leave room for reassessment if needs change or if relationships are not working out the way both parties expected. In all cases, the relationship with the outsourcer should be viewed as a partnership in which both parties benefit and communicate openly.

#### CONCEPTS IN ACTION 6-D

#### Building a Custom System—With Some Help

I worked with a large financial institution in the southeast that suffered serious financial losses several years ago. A new chief executive officer was brought in to change the strategy of the organization to being more customer focused. The new direction was quite innovative, and it was determined that custom systems, including a data warehouse, would have to be built to support the new strategic efforts. The problem was that the company did not have the in-house skills for these kinds of custom projects.

The company now has one of the most successful data warehouse implementations because of its willingness to use outside skills and its focus on project management. To supplement skills within the company, eight sets of external consultants, including hardware vendors, system integrators, and business strategists, were hired to take part and transfer critical skills to internal employees. An in-house project manager coordinated the data warehouse implementation full time, and her primary goals were to clearly set expectations, define

responsibilities, and communicate the interdependencies that existed among the team members.

This company showed that successful custom development can be achieved even when the company may not start off with the right skills in-house. However, this kind of project is not easy to pull off—it takes a talented project manager to keep the project moving along and to transition the skills to the right people over time. *Barbara Wixom*

#### Questions

1. What are the risks in building a custom system without having the right technical skills available within the organization?
2. Why did the company select a project manager from within the organization?
3. Would it have been better to hire an external professional project manager to coordinate the project? Why or why not?

- Keep the lines of communication open between you and your outsourcer.
- Define and stabilize requirements before signing a contract.
- View the outsourcing relationship as a partnership.
- Select the vendor, developer, or service provider carefully.
- Assign a person to manage the relationship.
- Do not outsource what you do not understand.
- Emphasize flexible requirements, long-term relationships, and short-term contracts.

**FIGURE 6-4**  
Outsourcing guidelines.

Managing the outsourcing relationship is a full-time job. Thus, someone needs to be assigned full time to manage the outsourcer, and the level of that person should be appropriate for the size of the job. (A multimillion-dollar outsourcing engagement should be handled by a high-level executive.) Throughout the relationship, progress should be tracked and measured against predetermined goals. If you do embark on an outsourcing design strategy, be sure to get more information. Many books have been written that provide much more detailed information on the topic.<sup>2</sup>

Figure 6-4 summarizes some guidelines for outsourcing.

## Influences on the Acquisition Strategy

There are valid reasons for choosing any of the acquisition strategies just discussed. Figure 6-5 summarizes the project characteristics that influence the choice of acquisition strategy.

### Business Need

If the business need for the system is common and technical solutions already exist in the marketplace that can fulfill the system requirements, it is usually appropriate to select a packaged software solution. Packaged systems are good alternatives for common business needs. The widespread availability and usefulness of packaged software has caused many larger companies to develop a recommended list of packaged solutions for use throughout the organization. By limiting the selection of software packages from the list of standard options, the organization is



	<b>When to Use Custom Development</b>	<b>When to Use a Packaged System</b>	<b>When to Use Outsourcing</b>
Business need	The business need is unique.	The business need is common.	The business need is not core to the business.
In-house experience	In-house functional and technical experience exists.	In-house functional experience exists.	In-house functional or technical experience does not exist.
Project skills	There is a desire to build in-house skills.	The skills are not strategic.	The decision to outsource is a strategic decision.
Project management	The project has a highly skilled project manager and a proven methodology.	The project has a project manager who can coordinate vendor's efforts.	The project has a highly skilled project manager at the level of the organization that matches the scope of the outsourcing deal.
Time frame	The time frame is flexible.	The time frame is short.	The time frame is short or flexible.

**FIGURE 6-5** Selecting a system acquisition strategy.

<sup>2</sup> For more information on outsourcing, we recommend M. Lacity and J. Rottman, *Offshore Outsourcing of IT Work: Client and Supplier Perspectives*, Palgrave Macmillan, 2008.

**CONCEPTS IN ACTION 6-E****Electronic Data System's Value-Added Contract**

Value-added contracts can be quite rare—and very dramatic. They exist when a vendor is paid a percentage of revenue generated by the new system, which reduces the up-front fee, sometimes to zero. The landmark deal of this type was signed several years ago by the City of Chicago and EDS (a large consulting and systems integration firm), which agreed to reengineer the process by which the city collects the fines on 3.6 million parking tickets per year. At the time, because of clogged courts and administrative problems, the city collected on only about 25% of all tickets issued. It had a \$60 million backlog of uncollected tickets.

Dallas-based EDS invested an estimated \$25 million in consulting and new systems in exchange for the right to up to 26% of the uncollected fines, a base processing fee for new

tickets, and software rights. To date, EDS has taken in well over \$50 million on the deal, analysts say. The deal has come under some fire from various quarters as an example of an organization giving away too much in a risk/reward-sharing deal. City officials, however, counter that the city has pulled in about \$45 million in previously uncollected fines and has improved its collection rate to 65% with little up-front investment.

*Question*

1. Do you think the city of Chicago got a good deal from this arrangement? Why or why not?

*Source:* "Outsourcing? Go out on a Limb Together," *Datamation*, February 1, 1999, 41(2): 58–61, by JeffMoad.

able to ensure consistency across the organizational units, streamline decision making, and ultimately reduce costs.

Packaged software is not suitable for every situation, however. A custom solution should be explored when the business need is unique, when there are especially difficult or demanding requirements that cannot be addressed successfully with a package, or when the organization is unable to change enough to adapt to the way of doing business that is embodied in a software package.

Outsourcing can be used to assist a company with custom development projects and to acquire software packages. The specialization and expertise of an outsourcing firm can be very valuable. Because outsourcing brings an outside third party into the development process, it is usually used in situations where the business need is not a critical element of company strategy. If the business need is central to the company strategy, then it is usually better for the company to retain exclusive control over the project if possible.

Many organizations have experimented with using offshore outsourcing as a way of "exporting" IT-related work to countries that have lower labor costs. Good quality IT skills are available in many countries, but companies considering this option in order to save money need to carefully manage the risks of this way of obtaining IT services.<sup>3</sup>

## In-House Experience

If in-house experience exists for all the functional and technical needs of the system, it will be easier to build a custom application than if these skills do not exist. A packaged system may be a better alternative for companies that do not have the technical skills to build the desired system. For example, a project team that does not have Web commerce technology skills may want to acquire a Web commerce package that can be installed without many changes. Outsourcing is a good way to bring in outside experience that is missing in-house so that skilled people oversee building the system.

<sup>3</sup> Weier, Mary Hayes, "The Second Decade of Offshore Outsourcing: Where We're Headed," *Information-Week*, November 3, 2007.

## Project Skills

The skills that are applied during projects are either technical (e.g., Java, Structured Query Language [SQL]) or functional (e.g., electronic commerce), and different design alternatives are more viable, depending on how important the skills are to the company's strategy. For example, if certain functional and technical expertise that relates to Internet sales applications and Web commerce application development is important to the organization because the company expects the Internet to play an important role in sales over time, then it makes sense for the company to develop Web commerce applications in-house, using company employees so that the skills can be developed and improved. On the other hand, some skills, such as network security, may be either beyond the technical expertise of employees or not of interest to the company's strategists—it is just an operational issue that needs to be handled. In this case, packaged systems or outsourcing should be considered so that internal employees can focus on other business-critical applications and skills.

## Project Management

Custom applications require excellent project management and a proven methodology. There are so many things that can push a project off track, such as funding obstacles, staffing holdups, and overly demanding business users. Therefore, the project team should choose to develop a custom application only if it is certain that the underlying coordination and control mechanisms will be in place. Packaged and outsourcing alternatives also must be managed; however, they are more shielded from internal obstacles because the external parties have their own objectives and priorities (e.g., it may be easier for an outside contractor to say no to a user than for a person within the company to do so). The latter alternatives typically have their own methodologies, which can benefit companies that do not have an appropriate methodology to use.

## Time Frame

When time is a factor, the project team should probably start looking for a system that is already built and tested. In this way, the company will have a good idea of how long the package will take to put in place and what the result will contain. Of course, this assumes that the package can be installed as-is and does not need many workarounds to integrate it into the existing business processes and technical environment. The time frame for custom applications is hard to pin down, especially when you consider how many projects end up missing important deadlines. If you must choose the custom development alternative and the time frame is truly short, consider using techniques like timeboxing to manage this problem. The time to produce a system through outsourcing really depends on the system and the outsourcer's resources. If a service provider has services in place that can be used to support the company's needs, then a business need could be met quickly. Otherwise, an outsourcing solution could take as long as a custom development initiative.

## Selecting an Acquisition Strategy

Once the project team has a good understanding of how well each acquisition strategy fits with the project's needs, it must begin to understand exactly how to implement these strategies. For example, what tools and technology would be used if a custom alternative were selected? What vendors make packaged systems that address the project needs? What service providers would be able to build this system if the application were outsourced? This information can be obtained by talking to people working in the IS Department and getting recommendations from business

**YOUR TURN 6-1** || Select a Design Strategy

Suppose that your university were interested in creating a new course registration system that could support Web-based registration.

*Question*

1. What should the university consider when determining whether to invest in a custom, packaged, or outsourced system solution?

users by contacting other companies with similar needs and investigating the types of systems that they have put in place. Vendors and consultants are usually willing to provide information about various tools and solutions in the form of brochures, product demonstrations, and information seminars.

Project teams employ several approaches to gather additional information that is needed. One helpful tool is the **request for proposal (RFP)**, a document that solicits a formal proposal from a potential vendor, developer, or service provider. RFPs describe in detail the system or service that is needed, and vendors respond by describing in detail how they could supply those needs.

Although there is no standard way of writing an RFP, it should include certain key facts that the vendor requires, such as a detailed description of needs, any special technical needs or circumstances, evaluation criteria, procedures to follow, and timetable. In a large project, the RFP can be hundreds of pages long, since it is essential that all required project details are included.

The RFP is not just a way to gather information. Rather, it results in a vendor proposal that is a binding offer to accomplish the tasks described in the RFP. The vendor proposal includes a schedule and a price for which the work is to be performed. Once the winning vendor proposal is chosen, a contract for the work is created.

For smaller projects with smaller budgets, the **request for information (RFI)** may be sufficient. An RFI is a shorter, less detailed request that is sent to potential vendors to obtain general information about their products and services. Sometimes, the RFI is used to determine which vendors have the capability to perform a service. It is often then followed up with an RFP to the qualified vendors.

When a list of equipment is so complete that the vendor need only provide a price, without any analysis or description of what is needed, the **request for quote (RFQ)** may be used. For example, if 20 long-range RFID tag readers are needed from the manufacturer on a certain date at a certain location, the RFQ can be used. If an item is described, but a specific manufacturer's product is not named, then extensive testing will be required to verify fulfillment of the specifications.

After evaluating the acquisition strategy options and seeking additional information, the design team will likely have several viable choices to use to obtain the system. For example, the project team may find three vendors who make packaged systems that could meet the project's needs; or the team may be debating over whether to develop a system by using Visual Basic as a development tool and the database management system from Sybase; or the team may think it worthwhile to outsource the development effort to a consulting firm like Accenture or American Management Systems. Each alternative will have pros and cons associated with it that must be considered, and only one solution can be selected in the end.

## Alternative Matrix

An **alternative matrix** can be used to organize the pros and cons of the design alternatives so that the best solution will be chosen in the end (Figure 6-6). This matrix is created by the same steps as the feasibility analysis, which was presented in Chapter 1. The only difference is that the

Evaluation Criteria	Relative Importance (Weight)	Alternative 1: Custom Application Using VB.NET	Score (1–5)*	Weighted Score	Alternative 2: Custom Application Using Java	Score (1–5)*	Weighted Score	Alternative 3: Packaged Software Product ABC	Score (1–5)*	Weighted Score
Technical Issues:										
Criterion 1	20		5	100		3	60		3	60
Criterion 2	10		3	30		3	30		5	50
Criterion 3	10		2	20		1	10		3	30
Economic Issues:										
Criterion 4	25	Supporting	3	75	Supporting	3	75	Supporting	5	125
Criterion 5	10	Information	3	30	Information	1	10	Information	5	50
Organizational Issues										
Criterion 6	10		5	50		5	50		3	30
Criterion 7	10		3	30		3	30		1	10
Criterion 8	5		3	15		1	5		1	5
TOTAL	100			350			270			360

\* This denotes how well the alternative meets the criteria. 1 = poor fit; 5 = perfect fit.

**FIGURE 6-6** Sample alternative matrix using weights.

alternative matrix combines several feasibility analyses into one matrix so that the alternatives can be easily compared. The alternative matrix is a grid that contains the technical, economical, and organizational feasibilities for each system candidate, pros and cons associated with adopting each solution, and other information that is helpful when making comparisons. Sometimes, weights are provided for different parts of the matrix to show when some criteria are more important to the final decision.

To create the alternative matrix, draw a grid with the alternatives across the top and different criteria (e.g., feasibilities, pros, cons, and other miscellaneous criteria) along the side. Next, fill in the grid with detailed descriptions about each alternative. This becomes a useful document for discussion because it clearly presents the alternatives being reviewed and comparable characteristics for each one.

Sometimes, weights and scores are added to the alternative matrix to create a **weighted alternative matrix** that communicates the project's most important criteria and the alternatives that best address them. A scorecard is built by adding a column labeled "weight" that includes a number depicting how much each criterion matters to the final decision. Typically, analysts take 100 points and spread them out across the criteria appropriately. If five criteria were used and all mattered equally, each criterion would receive a weight of 20. However, if cost were the most important criterion for choosing an alternative, it may receive 60 points, and the other four criteria may get only 10 points each.

Then, the analysts add to the matrix a column called "Score" that communicates how well each alternative meets the criteria. Usually, number ranges like 1–5 or 1–10 are used to rate the appropriateness of the alternatives by the criteria. So, for the cost criterion, the least expensive alternative may receive a 5 on a 1–5 scale, whereas a costly alternative would receive a 1. Weighted scores are computed with each criterion's weight multiplied by the score it was given for each alternative. Then, the weighted scores are totaled for each alternative. The highest weighted score achieves the best match for our criteria. When numbers are used in the alternative matrix, project teams can make decisions quantitatively and on the basis of hard numbers.

**YOUR TURN 6-2****Weighted Alternative Matrix**

Pretend that you have been assigned the task of selecting a CASE tool for your class to use for a semester project. Using the Web or other reference resources, select three CASE tools (e.g., Visible Analyst Workbench, Oracle Designer). Create

a weighted alternative matrix that can be used to compare the three software products in the way in which a selection decision can be made. Have a classmate select the “right” tools, according to the information in your matrix.

It should be pointed out, however, that the score assigned to the criteria for each alternative is nothing more than a subjective assignment. Consequently, it is entirely possible for an analyst to skew the analysis according to his or her own biases. In other words, the weighted alternative matrix can be made to support whichever alternative you prefer and yet retains the appearance of an objective, rational analysis. To avoid the problem of a biased analysis, each analyst on the team could develop ratings independently; then, the ratings could be compared and discrepancies resolved in an open team discussion.

The final step, of course, is to decide which solution to design and implement. The approval committee should make the decision after the issues involved with the different alternatives are well understood. Remember that the line between the analysis and design is quite fuzzy. Sometimes alternatives are described and selected at the end of analysis, and sometimes this is done at the beginning of design. The bottom line is that at some point before moving into the heart of the design phase, the project team and the approval committee must understand all of the feasible ways in which the system can be created, and they must select the way that makes the most sense for the organization. The acquisition strategy selection that is made will then drive many of the remaining activities in the design phase.

## Applying the Concepts at DrōnTeq

Jiang Tsiao, senior systems analyst, and project manager for DrōnTeq’s Client Services system, had three different approaches that he could take with the new system: he could develop the entire system, using development resources from DrōnTeq; he could buy a packaged software program (or a set of different packages and integrate them); or he could hire a consulting firm or service provider to create the system. Immediately, Jiang ruled out the third option. Building these Internet-based applications was becoming increasingly important to the DrōnTeq business strategy. By outsourcing these Internet applications, DrōnTeq would not develop Internet application development skills and business skills within the organization.

Instead, Jiang decided that this system would be developed primarily using custom development with the company’s standard Web development tools. In this way, the company would be developing critical technical and business skills in-house, and the project team would be able to have a high level of flexibility and control over the final product. Jiang believed that the strategic importance of the new Client Services business unit and the critical role the information system he was overseeing justified the time and expense of a custom developed system. There were some components, however, that he felt could be obtained through purchased software products that would be integrated into the overall system.

As mentioned previously, there was at least one part of the project that might be handled by packaged software: the website that would be used to provide information to potential flight service clients and to prospective drone pilots. Jiang realized that a multitude of programs have been written and are available (at low prices) to handle development of content-rich, informational websites. These programs, called website builders, usually allow users to build websites quickly,

are generally easy to use, and provide an array of templates and optional add-in components. Jiang believed that the project team should at least consider some of these packaged alternatives so that less time would be spent handling basic Web tasks and more time could be devoted to the unique, strategic elements of the client services system.

To help better understand some of the website builder programs that were available in the market and how their adoption could benefit the project, Jiang asked Maria, another team member, to research some options and narrow the list of candidates down to three. Maria found numerous options, but many were eliminated as not robust enough to meet DrōnTeq's standards. Maria consulted with Rahul, the team's infrastructure analyst, to help her create the evaluation criteria for this software tool. She then recruited Dawn, another team member, to work with her to review and assign scores to the final three candidate products.

Maria created a weighted alternative matrix that compared three different website builder programs against one another (Figure 6-7). She and Dawn determined the relative importance of the evaluation criteria to the project, and then assigned their scores and calculated each product's weighted average score. Although all three alternatives had positive points, Maria could see that alternative 3 (WB-3) was the best alternative for handling this project. WB-3 is based on PHP, a Web scripting language, and incorporates MySQL, an open-source relational database; both are included in DrōnTeq's standard Web development environment. While the cost of WB-3 was higher than the other products and it is difficult to learn initially, the high scores on all the technical evaluation criteria were persuasive. Maria made a note to investigate acquiring WB-3 as the Web development platform to build the informational component of the Client Services system.

Evaluation Criteria	Relative Importance (Weight)	Alt 1: WB-1		Score (1–5)*	Wtd Score	Alt 2: WB-2		Score (1–5)*	Wtd Score	Alt 3: WB-3		Score (1–5)*	Wtd Score
<b>Technical Issues:</b>													
Integration with existing infrastructure	15	Very little capability	2	30	Provided, but appears awkward	3	45	Strong, appears seamless	5	75			
Database capabilities	15	None	1	15	Limited	2	30	Excellent; compatible with company standards	5	75			
Access to underlying code	10	Not possible	1	10	Limited	3	30	Easy	5	50			
Video support	15	Yes; adequate	3	45	Yes; adequate	3	45	Yes; excellent	5	75			
<b>Economic Issues:</b>													
Cost	20	\$15/month	5	100	\$25/month	4	80	\$90/month	1	20			
<b>Organizational Issues:</b>													
Market adoption	5	Strong—widely used	4	20	Moderate—newer product	3	15	Strong—market leader	5	25			
Ease of learning	10	High	5	50	Somewhat complex	3	30	High learning curve	1	10			
Ease of use	10	Inflexible	2	20	Somewhat flexible	4	40	Very flexible; easy to modify	5	50			
<b>TOTAL</b>	<b>100</b>			<b>290</b>				<b>315</b>				<b>380</b>	

\* The score denotes how well the alternative meets the criteria; 1 = poor fit; 5 = perfect fit.

**FIGURE 6-7** Alternative matrix for website builder program.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Identify and describe the steps associated with the design phase of the project.
- Explain the meaning and purpose of the components of the system specification.
- Explain the pros and cons of obtaining the new system through a custom development project.
- Explain the pros and cons of obtaining the new system through a purchasing a software package.

- Explain the pros and cons of obtaining the new system through an outsourcing firm.
- Explain how the characteristics of the project influence the selection of the acquisition strategy.
- Explain the use of RFPs, RFIs, and RFQs as ways of gathering information from vendors.
- Discuss the use of an alternatives matrix to systematically evaluate and compare alternatives.

## KEY TERMS

Alternative matrix	Enterprise resource planning (ERP)	Request for information (RFI)	Software as a Service (SaaS)	Time and arrangements deal
Application service provider (ASP)	Fixed-price contract	Request for proposal (RFP)	System requirement	Value-added contract
Custom development	Outsourcing	Request for quote (RFQ)	Systems integration	Weighted alternative matrix
Design phase	Packaged software		System specification	Workaround

## QUESTIONS

1. Summarize the distinctions between the analysis phase and the design phase of the SDLC.
2. Describe the primary activities of the design phase of the SDLC.
3. List and describe the contents of the system specification.
4. Describe the three primary strategies that are available to obtain a new system.
5. What circumstances favor the custom design strategy?
6. What circumstances favor the use of packaged software?
7. What circumstances favor using outsourcing to obtain the new system?
8. What are some problems associated with using packaged software? How can these problems be minimized?
9. What is meant by customizing a software package?
10. What is meant by creating a workaround for a software package? What are the disadvantages of workarounds (if any)?
11. What is involved with systems integration? When is it necessary?
12. Describe the role of application service providers (ASPs) in obtaining new systems. What are their advantages and disadvantages?
13. Distinguish between a traditional ASP and a provider of software as a service. What are the pros and cons of each solution approach?
14. Explain the distinctions between time and arrangements, fixed-price, and value-added outsourcing contracts. What are the pros and cons of each?
15. What is the purpose of a request for proposal (RFP)? How does it differ from the RFI?
16. What information is typically conveyed in an RFP?
17. What is the purpose of the weighted alternative matrix? Describe its typical content.
18. Should the analysis phase be eliminated or reduced when we intend to use a software package instead of custom development or outsourcing?

## EXERCISES

- A. Assume that you are developing a new system for a local real estate agency. The agency wants to keep a database of its own property listings and wants to have access to the citywide

multiple listings service used by all real estate agents. Which design strategy would you recommend for the construction of this system? Why?

- B. Assume that you are developing a new system for a multistate chain of gaming stores. Each store will run a standardized set of gaming store processes (cataloging game inventory, customer registration, game rentals, game returns, overdue fees, etc.). In addition, each store's system will be networked to the corporate offices for sales and expense reporting. Which design strategy would you recommend for the construction of this system? Why?
- C. Assume that you are part of a development team that is working on a new warehouse management system. You have the task of investigating software packages that are available through ASPs. Using the World Wide Web, identify at least two potential sources of such software. What are the pros and cons of this approach to obtaining a software package?
- D. Assume that you are leading a project that will implement a new course registration system for your university. You are thinking about using either a packaged course registration application or outsourcing the job to an external consultant. Create a request for proposal (RFP) to which interested vendors and consultants could respond.
- E. Assume that you and your friends are starting a small business painting houses in the summertime. You need to buy a software package that handles the financial transactions of the business. Create an alternative matrix that compares three packaged systems (e.g., Quicken, Microsoft Money, QuickBooks). Which alternative appears to be the best choice?

## MINICASES

1. Susan, president of MOTO, Inc., a human resources management firm, is reflecting on the client management software system her organization purchased 4 years ago. At that time, the firm had just gone through a major growth spurt, and the mixture of automated and manual procedures that had been used to manage client accounts became unwieldy. Susan and Nancy, her IS department head, researched and selected the package that is currently used. Susan had heard about the software at a professional conference she attended, and at least initially, it worked fairly well for the firm. Some of their procedures had to change to fit the package, but they expected that and were prepared for it.

Since that time, MOTO, Inc., has continued to grow, not only through an expansion of the client base, but through the acquisition of several smaller employment-related businesses. MOTO, Inc., is a much different business than it was 4 years ago. Along with expanding to offer more diversified human resource management services, the firm's support staff has also expanded. Susan and Nancy are particularly proud of the IS department they have built up over the years. Using strong ties with a local university, an attractive compensation package, and a good working environment, the IS department is well staffed with competent, innovative people, plus a steady stream of college interns keeps the department fresh and lively. One of the IS teams pioneered the use of the Internet to offer MOTO's services to a whole new market segment, an experiment that has proven highly successful.

It seems clear that a major change is needed in the client management software, and Susan has already begun to plan financially to undertake such a project. This software is a

central part of MOTO's operations, and Susan wants to be sure that a quality system is obtained this time. She knows that the vendor of their current system has made some revisions and additions to its product line. There are also several other software vendors who offer products that may be suitable. Some of these vendors did not exist when the purchase was made 4 years ago. Susan is also considering Nancy's suggestion that the IS department develop a custom software application.

- a. Outline the issues that Susan should consider which would support the development of a custom software application in-house.
  - b. Outline the issues that Susan should consider which would support the purchase of a software package.
  - c. Within the context of a systems development project, when should the decision of "make-versus-buy" be made? How should Susan proceed? Explain your answer.
2. In the DrönTeq scenario in this chapter, the project team evaluated several fictitious website builder packages for use in the new Client Service system. Assume that you have been asked to help some friends select such a package to help them quickly and easily create a website to provide information and promote their new small business involving pet sitter and dog walking services. Assume that your friends have no existing website, have limited Web design skills, and not a lot of money, but need to get a professional-looking Web presence developed soon. Create a reasonable set of selection criteria, assign reasonable weights, then research and compare three actual Web builder packages and make a recommendation to your friends.

# 7

# Architecture Design

## DESIGN

TASK CHECKLIST	
	<input checked="" type="checkbox"/> Select Design Strategy. <input type="checkbox"/> Design Architecture. <input type="checkbox"/> Select Hardware and Software. <input type="checkbox"/> Develop Use Scenarios. <input type="checkbox"/> Design Interface Structure. <input type="checkbox"/> Develop Interface Standards. <input type="checkbox"/> Design Interface Prototype. <input type="checkbox"/> Evaluate User Interface. <input type="checkbox"/> Design User Interface. <input type="checkbox"/> Develop Physical Data Flow Diagrams. <input type="checkbox"/> Develop Program Structure Charts. <input type="checkbox"/> Develop Program Specifications. <input type="checkbox"/> Select Data Storage Format. <input type="checkbox"/> Develop Physical Entity Relationship Diagram. <input type="checkbox"/> Denormalize Entity Relationship Diagram. <input type="checkbox"/> Performance Tune Data Storage. <input type="checkbox"/> Size Data Storage.

An important component of the design phase is the architecture design, which describes the system's hardware, software, and network environment. The architecture design flows primarily from the nonfunctional requirements, such as operational, performance, security, cultural, and political requirements. The deliverables from architecture design include the architecture design and the hardware and software specification.

### OBJECTIVES

- Describe the fundamental components of an information system.
- Describe client–server, server-based, and mobile application architectures.
- Describe how cloud computing can be incorporated as a system architecture component.
- Explain how operational, performance, security, cultural, and political requirements affect the architecture design.
- Create a hardware and software specification.

## Introduction

Today, most information systems are spread across two or more computers. A Web-based system, for example, can run in the browser on your desktop computer, but will interact with the Web server (and possibly other computers) over the Internet. A system that operates completely inside a company's network may have a Visual Basic program installed on your computer but interact with a database server elsewhere on the company network. An important step of the design phase is the creation of the **architecture design**, the plan for how the information system components will be distributed across multiple computers and what hardware, operating system software, and application software will be used on each computer (e.g., Windows or Linux operating system software).

Designing the system architecture can be quite difficult; therefore, many organizations use the skills of experienced, expert system architects (consultants or employees) who specialize in the task.<sup>1</sup> These specialists ensure that the new system is developed as a unified, coherent software system that satisfies the user and functional requirements and conforms to the organization's architectural standards and goals. It is important to remember that it takes lots of experience to perform this role well.

It is not feasible to discuss all aspects of the systems architect's role in one chapter; therefore, we limit our focus to several fundamental architectural concepts that are important for the systems analyst to understand. First, we explain how the designers think about application architectures and describe the client–server architecture, the most common architecture used today. We also discuss several trends in system architecture: cloud computing and mobile applications. Then we examine how the very general nonfunctional requirements from the analysis phase are refined into more specific requirements, and the implications that they have for architecture design. Finally, we consider how the requirements and architecture design can be used to develop the hardware and software specifications, defining the specific hardware and other software (e.g., database system) needed to support the information system being developed.

## Elements of an Architecture Design

The objective of architecture design is to determine how the software components of the information system will be assigned to the hardware devices of the system. In this section, we first discuss the major functions of the software to understand how the software can be divided into different parts. Then we briefly discuss the major types of hardware onto which the software can be placed. Although there are numerous ways in which the software components can be placed on the hardware components, the most common architecture is the client–server architecture, so we focus on it here.

## Architectural Components

The major **architectural components** of any system are the software and the hardware. The major software components of the system being developed must be identified and then allocated to the various hardware components on which the system will operate. Each of these components can be combined in a variety of different ways.

All software systems can be divided into four basic **functions**. The first is **data storage**. Most information systems require data to be stored and retrieved, whether a small file, such as a list of customers who have been granted a special status, or a large database that stores an organization's human resources records. These are the data entities documented in ERDs. The second function

<sup>1</sup>For more information on architecture design, see the Zachman Institute at [www.zifa.com](http://www.zifa.com).

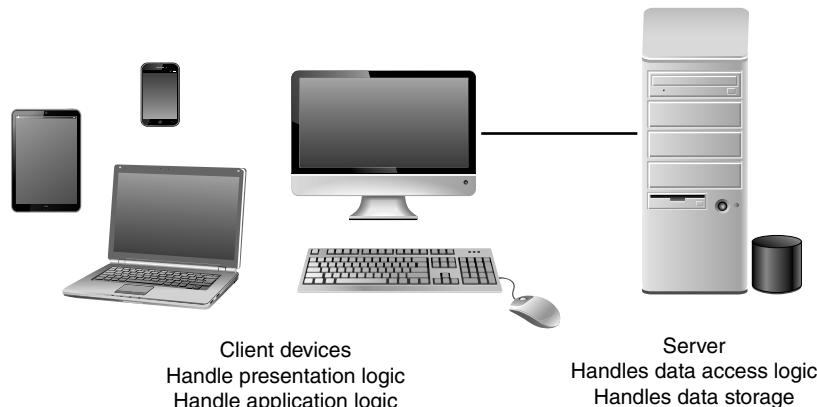
is the **data access logic**: the processing required to access data, often meaning database queries in Structured Query Language (SQL). The third function is the **application logic**: the logic documented in the DFDs, use cases, and functional requirements. The fourth function is the **presentation logic**: the display of information to the user and the acceptance of the user's commands (the user interface). These four functions (data storage, data access logic, application logic, and presentation logic) are the basic building blocks of any information system.

The three primary hardware components of a system are **client computers**, **servers**, and the **network** that connects them. Client computers are the input–output devices employed by the user and include desktop or laptop computers, handheld devices, smartphones, tablet devices, special-purpose terminals, and so on. Servers typically are larger multi-user computers used to store software and data that can be accessed by anyone who has permission. The network that connects the computers can vary in speed from slow cell phones or modem connections that must be dialed, to medium-speed always-on frame relay networks, to fast always-on broadband connections such as cable modem, DSL, or T1 circuits, to high-speed always-on Ethernet, T3, or ATM circuits.<sup>2</sup>

## Client–Server Architectures

Most organizations today are utilizing **client–server architectures**, which attempt to balance the processing between client devices and one or more server devices. In these architectures, the client is responsible for the presentation logic, whereas the server is responsible for the data access logic and data storage. The application logic may reside on the client, reside on the server, or be split between both (Figure 7-1). If the client shown in Figure 7-1 contained all or most of the application logic, it is called a **thick or fat client**. Currently, **thin clients**, containing just a small portion of the application logic, are popular because of lower overhead and easier maintenance. For example, many Web-based systems are designed with the Web browser performing presentation and only minimal application logic using such programming languages as JavaScript, while the server side has most of the application logic, all the data access logic, and all the data storage.

Client–server architectures have four important benefits. First and foremost, they are **scalable**. That means it is easy to increase or decrease the storage and processing capabilities of the servers. If one server becomes overloaded, you simply add another server so that many servers are used to perform the application logic, data access logic, or data storage. The cost to upgrade is gradual, and you can upgrade in small increments.



**FIGURE 7-1**  
Two-tiered client–server architecture.

<sup>2</sup>For more information on networks, see Jerry FitzGerald, Alan Dennis, and Alexandra Durcikova, *Business Data Communications and Networking*, 14th ed., Hoboken, NJ: John Wiley & Sons, 2021.

Second, client–server architectures can support many different types of clients and servers. It is possible to connect computers that use different operating systems so that you are not locked into one vendor. Users can choose which type of computer they prefer (e.g., combining both Windows computers and Apple Macintoshes on the same network). **Middleware** is a type of system software designed to translate between different vendors’ software. Middleware is installed on both the client computer and the server computer. The client software communicates with the middleware, which can reformat the message into a standard language that can be understood by the middleware, which assists the server software.

Third, for thin client–server architectures that use Internet standards, it is simple to clearly separate the presentation logic, the application logic, and the data access logic and design each to be somewhat independent. For example, the presentation logic can be designed in HTML or XML to specify how the page will appear on the screen (e.g., the colors, fonts, order of items, specific words used, command buttons, type of selection lists, and so on; see Chapter 8). Simple program statements are used to link parts of the interface to specific application logic modules that perform various functions. These HTML or XML files defining the interface can be changed without affecting the application logic. Likewise, it is possible to change the application logic without changing the presentation logic or the data, which are stored in databases and accessed by SQL commands.

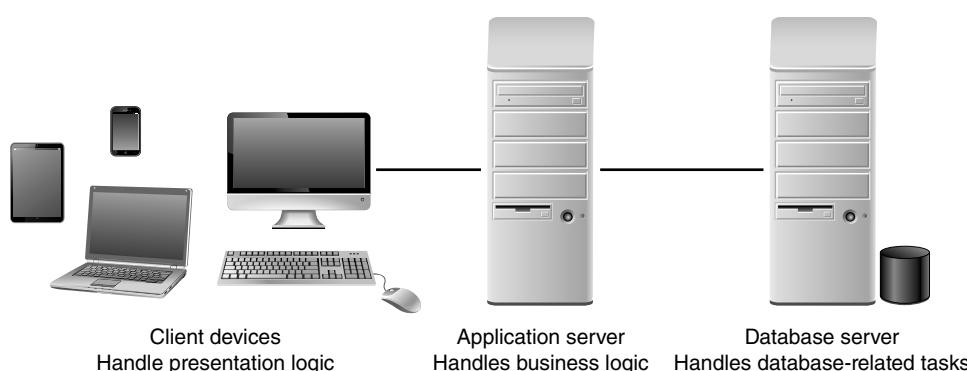
Finally, if a server fails in a client–server architecture, only the applications requiring that server will fail. The failed server can be swapped out and replaced and the applications can then be restored.

Client–server architectures also have some critical limitations, the most important of which is their complexity. All applications in client–server computing have two parts—the software on the client side and the software on the server side. Writing this software is more complicated than writing the traditional all-in-one software used in server-based architectures (discussed in a later section). Updating the overall system with a new version of the software is more complicated, too. With client–server architectures, you must update all clients and all servers, and you must ensure that the updates are applied on all devices.

## Client–Server Tiers

There are many ways in which the application logic can be partitioned between the client and the server. The arrangement in Figure 7-1 is a common configuration. In this case, the server is responsible for the data and the client is responsible for the application and presentation. This is called a **two-tiered architecture** because it uses only two sets of computers—clients and servers.

A **three-tiered architecture** uses three sets of computers, as shown in Figure 7-2. In this case, the software on the client computer is responsible for presentation logic, an application server(s)



**FIGURE 7-2**  
Three-tiered client–server architecture.

is responsible for the application logic, and a separate database server(s) is responsible for the data access logic and data storage. Typically, the user interface runs on a desktop PC or workstation and uses a standard **graphical user interface**. The application logic may consist of one or more separate modules running on a workstation or application server. Finally, a relational DBMS running on a database server contains the data access logic and data storage. The middle tier may be divided into tiers itself, resulting in an overall architecture called an “**n-tier architecture**.”

An n-tiered architecture distributes the work of the application (the middle tier) among multiple layers of more specialized server computers. This type of architecture is common in today’s Web-based e-commerce systems (Figure 7-3). The browser software on client computers makes HTTP requests to view pages from the Web server(s), and the Web server(s) enable the user to view merchandise for sale by responding with HTML documents. As the user shops, components on the application server(s) are called as needed to allow the user to put items in a shopping cart; determine item pricing and availability; compute purchase costs, sales tax, and shipping costs; authorize payments, etc. These elements of business logic, or detailed processing, are stored on the application server(s) and are accessible to any application. For example, the cash register application that needs item price look-ups could use the same price determination business logic that is used by the e-commerce website. The modular business logic can be used by multiple, independent applications that need that specific business logic. The database server(s) manage the data components of the system. Each of these four components is separate, which makes it easy to spread the different components on different servers and to partition the application logic on a Web-oriented server and a business-oriented server.

The primary advantage of an n-tiered client–server architecture compared with a two-tiered architecture (or a three-tiered with a two-tiered) is that it separates out the processing that occurs to better balance the load on the different servers; it is more scalable. In Figure 7-3, we have three separate server types, a configuration that provides more power than if we had used a two-tiered architecture with only one server. If we discover that the application server is too heavily loaded, we can simply replace it with a more powerful server or just put in several more application servers to share the load. Conversely, if we discover that the database server is underused, we could store data from another application on it.

There are two primary disadvantages to an n-tiered architecture compared with a two-tiered architecture (or a three-tiered with a two-tiered). First, the configuration puts a greater load on the network. If you compare Figures 7-1, 7-2, and 7-3, you will see that the n-tiered model requires more communication among the servers; it generates more network traffic, so you need a higher-capacity network. Second, it is much more difficult to program and test software in n-tiered architectures than in two-tiered architectures, because more devices must communicate properly to complete a user’s transaction.

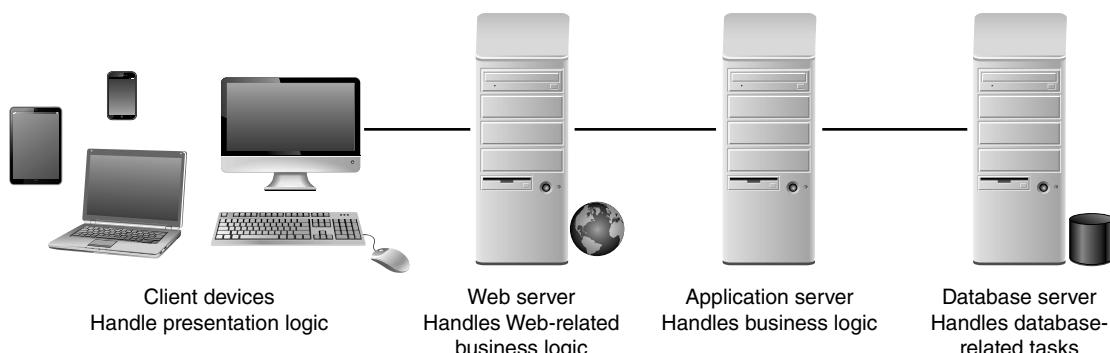


FIGURE 7-3 n-Tiered client–server architecture.

## Server-Based Architecture

In this section we discuss the **server-based architecture**, a less common, but still important architecture choice.

The very first computing architectures were *server-based*, with the server (usually, a central **mainframe** computer) performing all four application functions. The clients (in those days, “*dumb*” terminals) enabled users to send and receive messages to and from the server computer. The clients merely captured keystrokes and sent them to the server for processing, and accepted instructions from the server on what to display (Figure 7-4).

This remarkably simple architecture often works very well. Application software is developed and stored on the server, and all data are on the same computer. There is one point of control because all messages flow through the one central server. Software development and software administration are simplified because a single computer hosts the entire system (operating system and application software). Server-based system architectures are common today in situations where systems process very high transaction volumes and strong security is required.

The server-based architecture was the first architecture used in information systems but did not remain the only option as hardware and software evolved. The fundamental problem with early server-based systems was that the server processed all the work in the system. As the demands for more and more applications and the number of users grew, server computers became overloaded and unable to quickly process all the users’ demands. Response time became slower, and IS managers were required to spend increasingly more money to upgrade the server computer. In the early days, upgrading to a larger server computer (usually a mainframe) required a substantial financial commitment. Increased capacity came only in large, expensive chunks.

**Zero client**, or **ultrathin client**, is a server-based computing model that is often used today in a virtual desktop infrastructure (VDI). A typical zero client device is a small box that connects a keyboard, mouse, monitor, and Ethernet connection to a remote server. The server hosts everything: the client’s operating system and all software applications. The server can be accessed wirelessly or with cable.

Zero client computing has several benefits. Power usage can be significantly reduced compared to fat client configurations. This benefit is increasing in importance as more companies are investigating green computing. The devices used are much less expensive than PCs or even thin client devices. Since there is no software at the client device, there is no vulnerability to malware. The zero client computing model provides an efficient and secure way to deliver applications to end users. Administration is easy and multiple virtual PCs can be run on server class hardware in VDI environments, significantly reducing the number of physical PCs that must be acquired and maintained. In addition, the server-based zero-client model limits the nonbusiness use of the client computer (e.g., no Facebook; no Farmville, etc.).

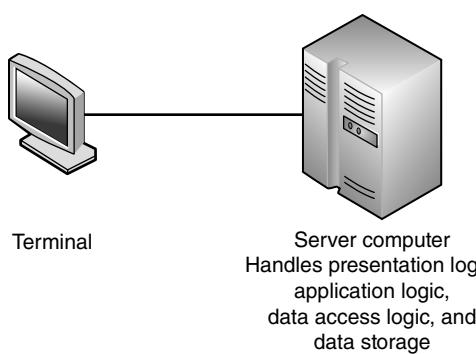


FIGURE 7-4 Server-based architecture.

## Mobile Application Architecture

In recent years, the variety and capability of mobile devices, such as tablet devices and smartphones, has led to a huge increase in demand for mobile consumer and business applications. Opportunities abound to connect and inform both customers and employees.

Similar to our previous discussion, the system architect must decide how much of the presentation logic, business logic, and data access logic will reside on the mobile device, and how much will reside on server devices. If the application requires local processing using the mobile device's resources, such as the camera or GPS, and is only occasionally connected to the server, it should be created as a **rich client**. With rich clients, the business and data access logic are included on the device along with the presentation logic. When the application can rely on the availability of server processing and will always be connected, a **thin Web-based client** can be developed. In this case, the business logic and data access logic will be located on the server side rather than the client side. If the application requires a rich user interface (UI), only limited access to local device resources, and must be portable to other platforms, design a **rich Internet application (RIA)** client. Rich Internet Applications are Web-based applications that function as traditional desktop applications; however, Web browsers are required for access. Unlike traditional applications, software installation on the mobile device is not required, but depending on the application, ActiveX, Java, Flash, or similar technologies must be installed on the client device.

Mobile applications also involve choices on how to develop the app. Unlike more traditional desktop or laptop clients having uniform capabilities, mobile devices offer a wide array of screen sizes, presentation formats, and device capabilities. In addition, the mobile device market is fragmented into the tablet and smartphone segments with an array of options in each segment. The devices themselves are rapidly evolving and the development environment choices are also very dynamic.

While discussion of the details of mobile application development is beyond the scope of this book, we describe the development technology choices for mobile applications:

- native applications,
- cross-platform frameworks, and
- mobile Web apps.

Native applications are written to run on a specific device with a specific operating system. Applications written in a device's native code (e.g., Objective C for Apple devices; Java for Android devices) provide the richest user experience and can take full advantage of the device's resources. Native applications must be re-built for each native operating system, however, and developers with skills in multiple languages are scarce. In addition, the apps must be updated as new device models and operating system versions are released.

Cross-platform frameworks exist that enable developers to create a mobile app in Web-based technologies like Javascript or HTML and use the framework to adapt the application for multiple devices. Usually the app must be "tweaked" for each device on which it will be deployed. Mobile applications developed with this approach will not provide the same rich user experience as the native apps, so it is best to use this approach with informational applications that do not require heavy use of device functions.

Mobile Web apps are platform independent and can be deployed on any device equipped with the Web browser. Mobile Web apps are built with Web technology such as HTML5. These applications cannot use the hardware and software on the device, require an Internet connection to work, and will provide the most generic user experience.

## Advances in Architecture Configurations

Advances in hardware, software, and networking have given rise to several new architecture options. A detailed discussion of all these options is beyond the scope of this book. Two advances that are currently getting a lot of attention, **virtualization** and **cloud computing**, will be described here briefly.

### Virtualization

This term, in the computing domain, refers to the creation of a virtual device or resource, such as a server or storage device. You may be familiar with this concept if you have partitioned your computer's hard drive into more than one separate hard drive. While you only have one physical hard drive in your system, you treat each partitioned, "virtual" drive as if it is a distinct physical hard drive. Today, this term has become a common buzz word, as we hear about server virtualization, storage virtualization, network virtualization, and other variations of virtualization.

**Server virtualization** involves partitioning a physical server into smaller virtual servers. Software is used to divide the physical server into multiple virtual environments, called virtual or private servers. This capability overcomes the primary limitation of the older style server-based architectures that were based on single, large, expensive, monolithic computers. Today, a physical server device can be used to provide many virtual servers that are independent of each other but co-reside on the same physical server. Each virtual server runs an operating system and can be rebooted independently of the other virtual servers. Less hardware is required to provide a set of virtual servers as compared to equivalent physical servers, so costs are reduced. This arrangement can also optimize the utilization of the physical server, saving on operational costs.

According to Spiceworks research,<sup>3</sup> server virtualization is ubiquitous, used by 92% of businesses. Among emerging virtualization technologies, the most common is storage virtualization (also called software-defined storage) with a 40% adoption rate, followed by application virtualization at 39% and virtual desktop infrastructure (VDI) technology at 32%. Spiceworks research indicates more than half of businesses plan to use storage virtualization and application virtualization by 2021.

**Storage virtualization** involves combining multiple network storage devices into what appears to be a single storage unit. A **storage area network (SAN)** uses storage virtualization to create a high-speed subnetwork of shared storage devices. In this environment, tasks such as backup, archiving, and recovery are easier and faster.

### Cloud Computing

It is no longer necessary for organizations to own, manage, and administer their own computing infrastructure. We are in the midst of the rise of **cloud computing**, wherein everything, from computing power to computing infrastructure, applications, business processes to personal collaboration—can be delivered as a service wherever and whenever needed. The "cloud" in cloud computing can be defined as the set of hardware, networks, storage, services, and interfaces that combine to deliver aspects of computing as a service. Cloud services include the delivery of software, infrastructure, and storage over the Internet (either as separate components or a complete platform) based on user demand.

Cloud computing can be implemented in three ways: private cloud, public cloud, and hybrid clouds. With public clouds, services are provided "as a service" over the Internet with little or no control over the underlying technology infrastructure. Private clouds offer activities and functions "as a service," but are deployed over a company intranet or hosted data center. Hybrid clouds combine the power of both public and private clouds. In this scenario, activities and tasks are allocated to private or public clouds as required.

<sup>3</sup>The 2020 State of Virtualization Technology, <https://www.spiceworks.com/marketing/reports/state-of-virtualization/>, accessed March 2021.

Currently, cloud computing is becoming widespread. Proponents of cloud computing point to several advantages of the cloud computing model. First, when utilizing the cloud, the resources allocated can be increased or decreased based upon demand. This capability, termed **elasticity**, makes the cloud scalable—the cloud can scale up for periods of peak demand and scale down for times of less demand. Applications in the cloud can scale up as users are added and when the application's requirements change. Second, cloud customers can obtain cloud resources in a straightforward fashion. Arrangements are made with the cloud service provider for a certain amount of computing, storage, software, process, or other resources. After using these resources, they can be released if no longer required. Third, cloud services typically have standardized **application program interfaces (APIs)**. This means that the services have standardized the way that programs or data sources communicate with each other. This capability lets the customer more easily create linkages between cloud services. Finally, the cloud computing model enables customers to be billed for resources as they are used. Usage of the cloud is measured, and customers pay only for resources used—much like your use of electricity in your apartment. This feature makes cloud computing extremely attractive from a financial perspective.

Cloud computing suppliers utilize virtualization as a key enabling technology. For cloud computing customers, however, the point is to outsource IT technology, applications, and skills with a pay per usage model. The concept of cloud computing has captured the attention and imagination of organizations of all sizes. Through the cloud computing model, the power of virtualization is converted into measurable business value.

Although the benefits of the cloud computing model are many (scalability, cost reduction, device independence, performance, and more), it is still in its infancy and companies are still learning how best to utilize it. Recently, Amazon, one of the prominent suppliers of cloud computing, experienced a catastrophic failure that affected hundreds of organizations that use Amazon's cloud services to run their businesses.<sup>4</sup> Therefore, organizations should be prepared to carefully structure their cloud computing arrangements and include redundancy in their applications so that the negative consequences of a catastrophic failure are minimized.

## Comparing Architecture Options

Most systems are built to use the existing infrastructure in the organization, so often the current infrastructure restricts the choice of architecture. For example, if the new system will be built for a mainframe-centric organization, server-based architecture may be the best option. Other factors like corporate standards, existing licensing agreements, and product/vendor relationships also can mandate the project team's architecture choice. Many organizations now have a variety of infrastructures in use, however, or are actively looking for pilot projects to test new architectures and infrastructures, enabling the project team to select an architecture based on other important factors.

Each of the architectures just discussed has its strengths and weaknesses. Client–server architectures are strongly favored based on the cost of infrastructure (the hardware, software, and networks that will support the application system). The client–server architecture is highly scalable because servers can be added to (or removed from) the infrastructure when processing needs change. The GUI development tools used to create applications for client–server architectures can be intuitive and easy to use. The development of applications for these architectures can be fast and painless. Keep in mind, however, that client–server architectures do involve the added complexity of several layers of hardware (e.g., database servers, Web servers, client workstations) that must communicate effectively with each other. Project teams often underestimate the difficulty associated with creating secure, efficient client–server applications.

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<sup>4</sup><http://www.cnn.com/2011/TECH/web/04/22/amazon.cloud.mashable/index.html?hpt=Sbin>, accessed 6/12/2011.

## Creating an Architecture Design

The architecture design specifies the overall architecture and the placement of software and hardware that will be used. Architecture design is an extraordinarily complex process that is often left to experienced architecture designers and consultants, but we will give a sense of the process here.

Each of the computing architectures discussed earlier has its strengths and weaknesses. Most organizations are moving to client–server architectures for cost and scalability reasons, so, if there is no reason other than cost, client–server is generally used today.

Creating an architecture design begins with the nonfunctional requirements. The first step is to refine the nonfunctional requirements into more detailed requirements that are then employed to help select the architecture to be used and the software components to be placed on each device. In a client–server architecture, one also must decide whether to use a two-tier, three-tier, or n-tier architecture. Then the nonfunctional requirements and the architecture design are used to develop the hardware and software specification.

There are four primary types of nonfunctional requirements that can be important in designing the architecture: operational requirements, performance requirements, security requirements, and cultural and political requirements. We describe each in turn and then explain how they may affect the architecture design.

## Operational Requirements

Operational requirements specify the operating environment(s) in which the system must perform and how those may change over time. This usually refers to operating systems, system software, and information systems with which the system must interact, but will on occasion also include the physical environment if the environment is important to the application (e.g., in a noisy factory floor where no audible alerts can be heard). Figure 7-5 summarizes four key operational requirement areas and provides some examples of each.

### Technical Environment Requirements

**Technical environment requirements** specify the type of hardware and software on which the system will work. These requirements usually focus on the operating system software (e.g., Windows, Linux), database system software (e.g., Oracle), and other system software (e.g., Internet Explorer). Occasionally, there may be specific hardware requirements that impose important limitations on the system, such as the need to operate on a smartphone with a tiny display.

### System Integration Requirements

**System integration requirements** are those that require the system to operate with other information systems, either inside or outside the company. These typically specify interfaces through which data will be exchanged with other systems.

### Portability Requirements

Information systems never remain constant. Business needs and operating technologies change, so the information systems that support them and run on them must change, too. **Portability requirements** define how the technical operating environments may evolve over time and how the system must respond (e.g., the system may currently run on Windows 7, but in the future may have to run on Windows 10 and Linux). Portability requirements also refer to potential changes in business requirements that will drive technical-environment changes. For example, many organizations today are working to ensure their applications are optimized for tablet or smartphone devices in response to user demand.

Type of Requirement	Definition	Examples
<b>Technical Environment Requirements</b>	Special hardware, software, and network requirements imposed by business requirements	<ul style="list-style-type: none"> <li>The system will work over the Web environment with any browser.</li> <li>All office locations will have an always-on network connection to enable real-time database updates.</li> <li>A version of the system will be provided for customers connecting over the Internet via a small-screen smartphone.</li> </ul>
<b>System Integration Requirements</b>	The extent to which the system will operate with other systems	<ul style="list-style-type: none"> <li>The system must be able to import and export Excel spreadsheets.</li> <li>The system will read and write to the main inventory database in the inventory system.</li> </ul>
<b>Portability Requirements</b>	The extent to which the system will need to operate in other environments	<ul style="list-style-type: none"> <li>The system must be able to work with different operating systems (i.e., Linux, Windows 10).</li> <li>The system may need to operate with mobile devices such as an iPad.</li> </ul>
<b>Maintainability Requirements</b>	Expected business changes to which the system should be able to adapt	<ul style="list-style-type: none"> <li>The system will be able to support more than one manufacturing plant upon 3 months advance notice.</li> <li>New versions of the system will be released every 2 months.</li> </ul>

FIGURE 7-5 Operational requirements.

### Maintainability Requirements

**Maintainability requirements** specify the business requirement changes that can be anticipated. Not all changes are predictable, but some are. For example, suppose that a small company has only one manufacturing plant, but is anticipating the construction of a second plant in the next 5 years. All information systems must be written to make it easy to track each plant separately, whether for personnel, budgeting, or inventory management. The maintainability requirement attempts to anticipate future requirements so that the systems designed today will be easy to maintain if and when those future requirements appear. Maintainability requirements may also define the update cycle for the system, such as the frequency with which new versions will be released.

### Performance Requirements

**Performance requirements** focus on performance issues such as response time, capacity, and reliability. As analysts define the performance requirements for the system, the testability of those requirements is a key issue. Each requirement must be measurable so that a benchmark comparison can be made. Only in that way can the achievement of a performance requirement be verified. In fact, many systems analysts write a test specification containing a well-defined test for each requirement, while they create the requirements. Such attention to testability prevents the creation of a poor performance requirement, such as “The system must have a response time fast enough to allow staff to effectively accomplish their work.” Figure 7-6 summarizes three key performance requirement areas and provides some examples.

#### Speed Requirements

**Speed requirements** are exactly what they say: how fast the system must operate. First and foremost, this is the **response time** of the system: How long does it take the system to respond to a

Type of Requirement	Definition	Examples
<b>Speed Requirements</b>	The time within which the system must perform its functions	<ul style="list-style-type: none"> <li>• Response time must be 4 seconds or less for any transaction over the network.</li> <li>• The inventory database must be updated in real time.</li> <li>• Orders will be transmitted to the factory floor every 3 minutes.</li> </ul>
<b>Capacity Requirements</b>	The total and peak number of users and the volume of data expected	<ul style="list-style-type: none"> <li>• There will be a maximum of 2000 simultaneous users at peak use times.</li> <li>• A typical transaction will require the transmission of 300 K of data.</li> <li>• The system will store data on approximately 50,000 customers for a total of about 2 GB of data.</li> </ul>
<b>Availability and Reliability Requirements</b>	The extent to which the system will be available to the users and the permissible failure rate due to errors	<ul style="list-style-type: none"> <li>• The system should be available 24/7, with the exception of scheduled maintenance.</li> <li>• Scheduled maintenance shall not exceed one 6-hour period each month.</li> <li>• The system will have 99% uptime performance.</li> </ul>

**FIGURE 7-6** Performance requirements.

user request? While everyone would prefer low response times with the system responding immediately to each user request, this is not practical. We could design such a system, but it would be expensive. Most users understand that certain parts of a system will respond quickly, while others are slower. Those actions that are performed locally on the user's computer must be almost immediate (e.g., typing, dragging, and dropping), while others that require communicating across a network can have higher response times (e.g., a Web request). In general, response times less than 7 seconds are considered acceptable when they require communication over a network.

The second aspect of speed requirements is how long it takes transactions in one part of the system to be reflected in other parts. For example, how soon after an order is placed will the items it contains be shown as no longer available for sale to someone else? If the inventory is not updated immediately, then someone else could place an order for the same item, only to find out later that it is out of stock. Or how soon after an order is placed is it sent to the warehouse to be picked from inventory and shipped? In this case, some time delay might have little impact.

### Capacity Requirements

**Capacity requirements** attempt to predict how many users the system will have to support, both in total and simultaneously. Capacity requirements are important in understanding the size of the databases, the processing power needed, and so on. The most important requirement is usually the peak number of simultaneous users, because this has a direct impact on the processing power of the computer(s) needed to support the system.

It is often easier to predict the number of users for internal systems designed to support an organization's own employees than it is to predict the number of users for customer-facing systems, especially those on the Web. How does weather.com estimate the peak number of users who will simultaneously seek weather information? This is as much an art as a science, so the team often provides a range of estimates, with wider ranges used to signal a less accurate estimate.

**CONCEPTS IN ACTION 7-A****When Performance Counts**

A global financial services company's new financial system (a multi-hundred million dollar program) posed a major challenge in terms of processing performance. Tests of an ERP package resulted in dismal and unacceptable processing performance (Concepts in Action 6-A). The project team determined that custom development was required for a system capable of providing acceptable performance, given the huge transaction volume associated with this system. "Modern" programming languages involve so much resource overhead in the systems developed with them that they were

incapable of adequate processing speed. Ultimately, the project team settled on implementation with COBOL and assembly language, with the bulk of the processing being done on IBM z-series mainframe computers. These languages enabled the developers to work much closer to the machine, and they were able to develop systems capable of processing the huge transaction volume very rapidly. Transaction throughput rates for the package were in the range of 50,000 per hour. Throughput for the custom solution came out in the range of 2 million per minute. *Roberta Roth*

### Availability and Reliability Requirements

**Availability and reliability requirements** focus on the extent to which users can assume that the system will be available for them to use. While some systems are intended to be used just during the 40-hour work week, other systems are designed to be used by people around the world. For such systems, project team members need to consider how the application can be operated, supported, and maintained **24/7** (i.e., 24 hours a day, 7 days a week). This 24/7 requirement means that users may need help or may have questions at any time and a support desk available 8 hours a day will not be sufficient. It is also important to consider what reliability is needed in the system. A system that requires high reliability (e.g., a medical device or an e-commerce order processing system during the Christmas shopping season) needs far greater planning and testing than one that does not have such high reliability needs (e.g., personnel system, Web catalog).

It is more difficult to predict the peaks and valleys in system usage with a global audience. Typically, applications are backed up on weekends or late evenings when users are no longer accessing the system. Such maintenance activities will have to be rethought with global initiatives. The development of Web interfaces has escalated the need for 24/7 support; by default, the Web can be accessed by anyone at any time. For example, the developers of a Web application for US outdoor gear and clothing retailer Orvis were surprised when the first order after going live came from Japan.

### Security Requirements

Security is the ability to protect the information system from disruption and data loss, whether caused by an intentional act (e.g., a hacker or a terrorist attack) or a random event (e.g., disk failure, tornado).<sup>5</sup> Security is primarily the responsibility of the operations group—the staff responsible for installing and operating security **controls** such as firewalls, intrusion detection systems, and routine backup and recovery operations. Nonetheless, developers of new systems must ensure that the system's **security requirements** produce reasonable precautions to prevent problems; system developers are responsible for ensuring security within the information systems themselves.

<sup>5</sup>For more information, see Mark Stamp, *Information Security: Principles and Practice*, 2nd Edition, Hoboken, NJ: John Wiley & Sons, 2011.

**CONCEPTS IN ACTION 7-B****The Importance of Capacity Planning**

At the end of 1997, Oxford Health Plans posted a \$120 million loss to its books. The company's unexpected growth was its undoing because the system, which was originally planned to support the company's 217,000 members, had to meet the needs of a membership that exceeded 1.5 million.

System users found that processing a new-member sign-up took 15 minutes instead of the proposed 6 seconds. Also, the computer problems left Oxford unable to send out bills to many of its customer accounts and rendered it unable to track payments to hundreds of doctors and hospitals. In less than a year, uncollected payments from customers tripled to

more than \$400 million, and the payments owed to caregivers amounted to more than \$650 million. Mistakes in infrastructure planning can cost far more than the cost of hardware, software, and network equipment alone.

*Source:* "Management: How New Technology was Oxford's Nemesis," *The Wall Street Journal*, December 11, 1997, P. A.1, by Ron Winslow and George Anders.

*Question*

1. If you had overseen the Oxford project, what things would you have considered when planning the system capacity?

System developers must know the security standards that are applicable to their organizations. Some industries are subject to various restrictions imposed by law. For example, the Sarbanes–Oxley Act is well known for the responsibilities it places on publicly traded companies to protect their financial systems from fraud and abuse. The Health Insurance Portability and Accountability Act (HIPAA) applies to health-care providers, health insurers, and health information data processors, while the financial industry must conform to the requirements of the Graham–Leach–Bliley (GLB) Act. There are also voluntary security standards that companies may choose to benchmark against, such as the standards adopted by the International Standards Organization (ISO). ISO 17799 is a generally accepted standard for information security, and organizations can become ISO 17799 compliant by engaging an accredited outside auditor to examine their security practices and operations. Retailers will focus on complying with the Payment Card Industry Data Security Standards (PCI DSS), which were established by the major credit card companies to ensure the privacy of stored customer information.

Security is an ever-increasing problem in today's Internet-enabled world. Historically, the greatest security threat has come from inside the organization itself. Ever since the early 1980s when the FBI first began keeping computer crime statistics and security firms began conducting surveys of computer crime, organizational employees have perpetrated most computer crimes.

External threats became a more significant problem in the early 2000s. Today, surveys show that internal security threats are a bigger problem than external threats. Many organizations are struggling with liability concerns following the theft of confidential records, making hundreds or thousands of employees and customers vulnerable to identity theft.

Developing security requirements usually starts with some assessment of the value of the system and its data. This helps pinpoint extremely important systems so that the operations staff are aware of the risks. Security within systems usually focuses on specifying who can access what data, identifying the need for encryption and authentication, and ensuring that the application prevents the spread of viruses (Figure 7-7).

Adding security requirements to the system obviously adds cost. How much should be spent to ensure security in a system? A good rule of thumb is to estimate the amount of the expected loss and then estimate the probability of that loss occurring. Multiplying these values provides an estimate of how much to spend on security measures. So, a \$100,000,000 expected loss with a 10% probability means that  $\$100 \text{ million} \times 10\%$ , or up to \$10 million, should be spent on security.

Type of Requirement	Definition	Examples
<b>System Value Estimates</b>	Estimated business value of the system and its data	<ul style="list-style-type: none"> <li>The system is not mission critical, but a system outage is estimated to cost \$150,000 per hour in lost revenue.</li> <li>A complete loss of all system data is estimated to cost \$20 million.</li> </ul>
<b>Access Control Requirements</b>	Limitations on who can access what data	<ul style="list-style-type: none"> <li>Only department managers will be able to change inventory items within their own department.</li> <li>Customer Service personnel will be able to read and create items in the customer file, but cannot change or delete items.</li> </ul>
<b>Encryption and Authentication Requirements</b>	Defines what data will be encrypted where and whether authentication will be needed for user access	<ul style="list-style-type: none"> <li>Data will be encrypted from the user's computer to the website to provide secure ordering.</li> <li>Users logging in from outside the office will be required to authenticate.</li> </ul>
<b>Virus Control Requirements</b>	Controls the spread of viruses	<ul style="list-style-type: none"> <li>All uploaded files will be checked for viruses before being saved in the system.</li> </ul>

**FIGURE 7-7** Security requirements.

### System Value

The most important computer asset in any organization is not the equipment; it is the organization's data. For example, suppose that someone destroyed a mainframe computer worth \$10 million. The mainframe could be replaced simply by buying a new one. It would be expensive, but the problem would be solved in a few weeks. Now suppose that someone destroyed all the student records at your university so that no one knew what courses anyone had taken or their grades. The cost of this destruction would far exceed the cost of replacing a \$10 million computer. The lawsuits alone would easily exceed \$10 million, and the cost of staff to find and reenter paper records would be enormous and certainly would take more than a few weeks.

In some cases, the information system itself has value that far exceeds the cost of the equipment as well. For example, for an Internet bank that has no brick-and-mortar branches, the website is a **mission critical system**. If the website crashes, the bank cannot conduct business with its customers. A mission critical application is an information system that is literally critical to the survival of the organization. It is an application that cannot be permitted to fail, and if it does fail, the operations staff drops everything else to fix it. Mission critical applications are usually clearly identified so that their importance is not overlooked.

Even temporary disruptions in service can have significant costs. The cost of disruptions to a company's primary website or to the LANs and backbones that support telephone sales operations often measures in millions of dollars. Amazon.com, for example, had average in 2017 revenues of more than \$6.9 million per hour, so if its website were unavailable for an hour or two, it would cost them millions of dollars in lost revenue if customers took their business elsewhere. Companies that do less e-business or telephone sales have lower costs, but recent surveys suggest that losses of \$100,000 to \$200,000 per hour are not uncommon for major customer-facing information systems.

### Access Control Requirements

Some of the data stored in the system need to be kept confidential; some data need special controls on who can change or delete them. Personnel records, for example, should be readable only by the personnel department and the employee's supervisor; changes should be permitted to be

made only by the personnel department. **Access control requirements** state who can access what data and what type of access is permitted—whether the individual can create, read, update, and/or delete the data. The requirements reduce the chance that an authorized user of the system can perform unauthorized actions.

## Encryption and Authentication Requirements

One of the best ways to prevent unauthorized access to data is **encryption**, which is a means of disguising information by the use of mathematical algorithms (or formulas). Encryption can be used to protect data stored in databases or data that are in transit over a network from a database to a computer. There are two fundamentally different types of encryption: symmetric and asymmetric. A **symmetric encryption algorithm** [such as Data Encryption Standard (DES) or Advanced Encryption Standard (AES)] is one in which the key used to encrypt a message is the same as the one used to decrypt it. With symmetric encryption, it is essential to protect the key, and a separate key must be used for each person or organization with whom the system shares information (or else everyone can read all the data).

In an **asymmetric encryption algorithm** (such as **public key encryption**), the key used to encrypt data (called the **public key**) is different from the one used to decrypt it (called the **private key**). Even if everyone knows the public key, once the data are encrypted, they cannot be decrypted without the private key. Public key encryption greatly reduces the key management problem. Each user has a public key that is used to encrypt incoming messages. These public keys are widely publicized (e.g., listed in a telephone book-style directory)—that is why they are called “public” keys. The private key, in contrast, is kept secret (that is why it is called a “private” key).

Public key encryption also permits **authentication** (or digital signatures). When one user sends a message to another, it is difficult to legally prove who sent the message. Legal proof is important in many communications, such as bank transfers and buy/sell orders in currency and stock trading, which normally require legal signatures. Public key encryption algorithms are **invertible**, meaning that text encrypted with either key can be decrypted by the other. Normally,

### CONCEPTS IN ACTION 7-C Securing the Environment

Quinnipiac University is a four-year university in Hamden, Connecticut, with about 7400 students. The IT staff has to support academic functions—but, since the university has residence halls, the IT staff has to be an “Internet service provider” (ISP) for students as well. The IT staff can shape much of the academic usage of the Internet, but students living in residence halls can cause havoc. Students (and faculty) inadvertently open the campus to all kind of attacks from viruses, malware, worms, spybots, and other intruders, as they access various websites. A particularly trying time is after the semester break in late January when students return to campus and plug in their laptops that have been corrupted with other viruses from home networks. These viruses try to infect the entire campus.

Quinnipiac University installed an intrusion prevention system (IPS) by Tipping Point Technology in August 2006. Daily, this IPS detects and drops thousands of destructive messages and packets. But the real proof was in late January 2007 when students returned to campus from semester break. In the

previous year, the viruses and spyware virtually took the campus network down for 3 days. But in January 2007, there were no outages and the network remained strong and functioning at full speed. Brian Kelly, Information Security Officer at Quinnipiac University, said, “Without the IPS solution, this campus would have struggled under this barrage of malicious packets and may have shut down. With the IPS system, we were able to function at full speed without any problems.”

#### Questions

1. What is the value of the network on a college campus? Consider students, faculty, and staff perspectives in your answer.
2. What might be some of the tangible and intangible costs of having the Internet down for 3 days on a busy college campus?
3. What benefits would an instruction prevention system offer to the end users on campus (e.g., faculty, staff, and students)?

**CONCEPTS IN ACTION 7-D****Power Outage Costs a Million Dollars**

Lithonia Lighting, located just outside of Atlanta, Georgia, is the world's largest manufacturer of light fixtures, with more than \$1 billion in annual sales. One afternoon, the power transformer at its corporate headquarters exploded, leaving the entire office complex, including the corporate data center, without power. The data center's backup power system immediately took over and kept critical parts of the data center operational. However, it was insufficient to power all systems, so the system supporting sales for all of Lithonia Lighting's North American agents, dealers, and distributors had to be turned off.

The transformer was quickly replaced, and power was restored. However, the 3-hour shutdown of the sales system cost \$1 million in potential sales lost. Unfortunately, it is not uncommon for the cost of a disruption to be hundreds or thousands of times the cost of the failed components.

*Question*

1. What would you recommend to avoid similar losses in the future?

we encrypt with the public key and decrypt with the private key. However, it is possible to do the inverse: encrypt with the private key and decrypt with the public key. Since the private key is secret, only the real user could use it to encrypt a message. Thus, a digital signature or authentication sequence is used as a legal signature on many financial transactions. This signature is usually the name of the signing party plus other unique information from the message (e.g., date, time, or dollar amount). This signature and the other information are encrypted by the sender using the private key. The receiver uses the sender's public key to decrypt the signature block and compares the result with the name and other key contents in the rest of the message to ensure a match.

The only problem with this approach lies in ensuring that the person or organization who sent the document with the correct private key is the person or organization they claim to be. Anyone can post a public key on the Internet, so there is no way of knowing for sure who they are. For example, it would be possible for persons other than "Organization A" in this example to claim to be Organization A when in fact they are an imposter.

This is where the Internet's public key infrastructure (PKI) becomes important.<sup>6</sup> The PKI is a set of hardware, software, organizations, and policies designed to make public key encryption work on the Internet. PKI begins with a **certificate authority (CA)**, which is a trusted organization that can vouch for the authenticity of the person or organization using authentication (e.g., VeriSign). A person wanting to use a CA registers with the CA and must provide some proof of identity. There are several levels of certification, ranging from a simple confirmation from valid e-mail address to a complete police-style background check with an in-person interview. The CA issues a digital certificate that is the requestor's public key encrypted, using the CA's private key as proof of identify. This certificate is then attached to the user's e-mail or Web transactions, in addition to the authentication information. The receiver then verifies the certificate by decrypting it with the CA's public key—and must also contact the CA to ensure that the user's certificate has not been revoked by the CA.

The **encryption and authentication requirements** state what encryption and authentication requirements are needed for what data. For example, will sensitive data such as customer credit card numbers be stored in the database in encrypted form, or will encryption be used to take orders over the Internet from the company's website? Will users be required to use a digital certificate in addition to a standard password?

A promising new security technology is **blockchain**. Blockchain is used to secure the transactions taking place between users in the same network. Its primary goal is to certify transactions between parties. With blockchain, a public register stores transactions between two users belonging to the same network in a secure, permanent, and verifiable way. Data describing the transactions are saved inside cryptographic blocks that are connected as a chain of data blocks.

<sup>6</sup>For more on the PKI, [http://csrc.nist.gov/groups/ST/crypto\\_apps\\_infra/pki/index.html](http://csrc.nist.gov/groups/ST/crypto_apps_infra/pki/index.html).

Blockchain is highly secure, quickly becoming an important technology in the financial industry, with potential value in many other industries.

### Virus Control Requirements

The single most common security problem comes from **viruses**. Recent studies have shown that over 50% of organizations suffer a virus infection each year. Viruses cause unwanted events—some harmless (such as nuisance messages), some serious (such as the destruction of data). Any time a system permits data to be imported or uploaded from a user's computer, there is the potential for a virus infection. Many systems require that all information systems permitting the import or upload of user files check those files for viruses before they are stored in the system.

## Cultural and Political Requirements

**Cultural and political requirements** are specific to the countries in which the system will be used. In today's global business environment, organizations are expanding their systems to reach users around the world. Although this can make great business sense, its impact on application development should not be underestimated. Yet another important part of the design of the system's architecture is understanding the global cultural and political requirements for the system (Figure 7-8).

### Multilingual Requirements

The first and most obvious difference between applications used in one region and those designed for global use is language. Global applications often have **multilingual requirements**, which means that they must support users who speak different languages and write with non-English letters (e.g., those with accents, Cyrillic, Japanese). Even systems used exclusively in the United States, for example, may be used in regions with high populations of non-English-speaking immigrants. One of the most challenging aspects in designing multilingual systems is getting a good translation of the original-language messages into a new language. Words often have similar meanings but can convey subtly different ideas when they are translated, so it is important to use translators skilled in translating technical words.

Type of Requirement	Definition	Examples
<b>Multilingual Requirements</b>	The language in which the system will need to operate	<ul style="list-style-type: none"> <li>The system will operate in English, French, and Spanish.</li> </ul>
<b>Customization Requirements</b>	Specification of what aspects of the system can be changed by local users	<ul style="list-style-type: none"> <li>Country managers will be able to define new fields in the product database to capture country-specific information.</li> <li>Country managers will be able to change the format of the telephone-number field in the customer database.</li> </ul>
<b>Making Unstated Norms Explicit</b>	Explicitly stating assumptions that differ from country to country	<ul style="list-style-type: none"> <li>All date fields will be explicitly identified as using the month-day-year format.</li> <li>All weight fields will be explicitly identified as being stated in kilograms.</li> </ul>
<b>Legal Requirements</b>	The laws and regulations that impose requirements on the system	<ul style="list-style-type: none"> <li>Personal information about customers cannot be transferred out of European Union countries into the United States.</li> <li>It is against US federal law to divulge information on who rented what videotape, so access to a customer's rental history is permitted only to regional managers.</li> </ul>

FIGURE 7-8 Cultural and political requirements.

**CONCEPTS IN ACTION 7-E****Developing Multilingual Systems**

I've had the opportunity to develop two multilingual systems. The first was a special-purpose decision support system to help schedule orders in paper mills called BCW-Trim. The system was installed by several dozen paper mills in Canada and the United States, and it was designed to work in either English or French. All messages were stored in separate files (one set English, one set French), with the program written to use variables initialized either to the English or French text. The appropriate language files were included when the system was compiled to produce either the French or English version.

The second program was a groupware system called GroupSystems, for which I designed several modules. The system has been translated into dozens of different languages, including French, Spanish, Portuguese, German, Finnish, and Croatian.

This system enables the user to switch between languages at will by storing messages in simple text files. This design is far more flexible because each individual installation can revise the messages at will. Without this approach, it is unlikely that there would have been sufficient demand to warrant the development of versions to support less commonly used languages (e.g., Croatian). *Alan Dennis*

*Questions*

1. How would you decide how much to support users who speak languages other than English?
2. Would you create multilingual capabilities for any application that would be available to non-English-speaking people? Think about websites that exist today.

The other challenge often is screen space. In general, English-language content usually takes 20–30% fewer letters than the French or Spanish counterparts. Designing global systems requires allocating more screen space to content than might be used in the English-language version.

Some systems are designed to handle multiple languages on the fly so that users in different countries can use different languages concurrently; that is, the same system supports several different languages simultaneously (a **concurrent multilingual system**). Other systems contain separate parts that are written in each language and must be reinstalled before a specific language can be used; that is, each language is provided by a different version of the system so that any one installation will use only one language (i.e., a **discrete multilingual system**). Either approach can be effective, but this functionality must be designed into the system well in advance of implementation.

### Customization Requirements

For global applications, the project team will need to give some thought to **customization requirements**: how much of the application will be controlled by a central group and how much of the application will be managed locally? For example, some companies allow subsidiaries in some countries to customize the application by omitting or adding certain features. This decision has trade-offs between flexibility and control because customization often makes it more difficult for the project team to create and maintain the application. It also means that training can differ between different parts of the organization, and customization can create problems when staff move from one location to another.

### Unstated Norms

Many countries have **unstated norms** that are not shared internationally. It is important for the application designer to make these assumptions explicit, because they can lead to confusion otherwise. In the United States, the unstated norm for entering a date is the date format MM/DD/YYYY; however, in Canada and most European countries, the unstated norm is DD/MM/YYYY. When you are designing global systems, it is critical to recognize these unstated norms and make them explicit so that users in different countries do not become confused. Currency is the other item sometimes overlooked in system design; global application systems must specify the currency in which information is being entered and reported.

## Legal Requirements

**Legal requirements** are imposed by laws and government regulations. System developers sometimes forget to think about legal regulations, but unfortunately, ignorance of the law is no defense. For example, in 1997, a French court convicted the Georgia Institute of Technology of violating French language law. Georgia Tech operated a small campus in France that offered summer programs for American students. The information on the campus Web server was primarily in English because classes are conducted in English, which violated the law requiring French to be the predominant language on all Internet servers in France. By formally considering legal regulations, analysts can ensure that they are less likely to be overlooked.

## Designing the Architecture

In many cases, the technical environment requirements as driven by the business requirements may simply define the application architecture. In this case, the choice is simple: business requirements dominate other considerations. For example, the business requirements may specify that the system needs to work over the Web, using the customer's Web browser. In this case, the application architecture must be thin client–server. Such business requirements most likely occur in systems designed to support external customers. Internal systems may also impose business requirements, but usually they are not as restrictive.

In the event that the technical environment requirements do not require the choice of a specific architecture, then the other nonfunctional requirements become important. Even in cases when the business requirements drive the architecture, it is still important to work through and refine the remaining nonfunctional requirements, because they are important in later stages of the design and implementation phases. Figure 7-9 summarizes the relationship between requirements and recommended architectures.

## Operational Requirements

System integration requirements may lead to one architecture over another, depending upon the architecture and design of the system(s) with which the system needs to integrate. For example, if the system must integrate with a desktop system (e.g., Excel), then this may suggest a thin or thick client–server architecture, while if it must integrate with a server-based system, then a server-based architecture may be indicated. Systems that have extensive portability requirements tend to be best suited for a thin client–server architecture because it is simpler to write for Web-based standards (e.g., HTML, XML) that extend the reach of the system to other platforms than to write and rewrite extensive presentation logic for different platforms in the server-based or thick client–server architectures. Systems with extensive maintainability requirements may not be well suited to thick client–server architectures because of the need to reinstall software on the desktops.

## Performance Requirements

Information systems that have high performance requirements are best suited to client–server architectures. Client–server architectures are more scalable, which means that they respond better to changing capacity needs and thus enable the organization to better tune the hardware to the speed requirements of the system. Client–server architectures that have multiple servers in each tier should be more reliable and have greater availability, because if any one server crashes, requests are simply passed to other servers and users may not even notice (although the response time may be worse). In practice, however, reliability and availability depend greatly on the hardware and operating system, and Windows-based computers tend to have lower reliability and availability than Linux or mainframe computers.

Requirements	Server-Based	Thin Client-Server	Thick Client-Server
<b>Operational Requirements</b>			
System Integration Requirements	✓	✓	✓
Portability Requirements		✓	
Maintainability Requirements	✓	✓	
<b>Performance Requirements</b>			
Speed Requirements		✓	✓
Capacity Requirements		✓	✓
Availability/Reliability Requirements	✓	✓	✓
<b>Security Requirements</b>			
High System Value	✓	✓	
Access Control Requirements	✓		
Encryption/Authentication Requirements		✓	✓
Virus Control Requirements	✓		
<b>Cultural/Political Requirements</b>			
Multilingual Requirements		✓	
Customization Requirements		✓	
Making Unstated Norms Explicit		✓	
Legal Requirements	✓	✓	✓

**FIGURE 7-9**  
Nonfunctional requirements and their implications for architecture design.

## Security Requirements

Server-based architectures tend to be more secure because all software is in one location and because mainframe operating systems are more secure than **microcomputer** operating systems. For this reason, high-value systems are more likely to be found on mainframe computers, even if the mainframe is used as a server in a client–server architecture. In today’s Internet-dominated world, authentication and encryption tools for Internet-based client–server architectures are more advanced than those for mainframe-based server-based architectures. Viruses are potential problems in all architectures because they spread easily on desktop computers. The server-based zero client computing model eliminates software on the client device, however, thereby providing an environment that is protected from malware.

## Cultural and Political Requirements

As the cultural and political requirements become more important, the ability to separate the presentation logic from the application logic and the data becomes important. Such separation makes it easier to develop the presentation logic in different languages while keeping the application logic and data the same. It also makes it easier to customize the presentation logic for different

users and to change it to better meet cultural norms. To the extent that the presentation logic provides access to the application and data, it also makes it easier to implement different versions that enable or disable different features required by laws and regulations in different countries. This separation is the easiest in thin client–server architectures, so systems with many cultural and political requirements often use thin client–server architectures. As with system integration requirements, the impact of legal requirements depends upon the specific nature of the requirements.

## Hardware and Software Specification

The design phase is also the time to begin selecting and acquiring the hardware and software that will be needed for the future system. In many cases, the new system will simply run on the existing equipment in the organization. Other times, however, new hardware and software (usually, for servers) must be purchased. The **hardware and software specification** is a document that describes what hardware and software are needed to support the application. There are several steps involved in creating the document. Figure 7-10 shows a sample hardware and software specification.

First, you will need to define the software that will run on each component. This usually starts with the operating system (e.g., Windows, Linux) and includes any special purpose software on the client and servers (e.g., Oracle database). Here, you should consider any additional costs such as technical training, maintenance, extended warranties, and licensing agreements (e.g., a site license for a software package). Again, the needs that you list are influenced by decisions that are made in the other design phase activities.

Next, you must create a list of the hardware needed to support the future system. In general, the list can include such things as database servers, network servers, peripheral devices (e.g., printers, scanners), backup devices, storage components, and any other hardware component needed to support an application. At this time, you also should note the quantity of each item that will be needed.

Finally, you need to describe, in as much detail as possible, the minimum requirements for each piece of hardware. Many organizations have standard lists of approved hardware and software that must be used, so, in many cases, this step simply involves selecting items from the lists. Other times, however, the team is operating in new territory and is not constrained by the need to select from an approved list. In these cases, the project team must convey such requirements as the amount of processing capacity, the amount of storage space, and any special features that should be included.

This step will become easier for you with experience; however, there are some hints that can help you describe hardware needs (Figure 7-11). For example, consider the hardware standards within the organization or those recommended by vendors. Talk with experienced system

	<b>Standard Client</b>	<b>Standard Web Server</b>	<b>Standard Application Server</b>	<b>Standard Database Server</b>
<b>Operating System</b>	• Windows 10 Pro	• Linux	• Linux	• Linux
<b>Special Software</b>	• Real Audio • Adobe Acrobat Reader	• Apache	• Java	• Oracle
<b>Hardware</b>	• 1 TB disk drive • Intel®-Core™ i5-8400 six core processor • 22-inch LED Monitor	• 8 TB disk drive • Xeon E5-4600 v4	• 8 TB disk drive • Xeon E5-4600 v4	• 32 TB disk drive • RAID • Xeon 28 core processor
<b>Network</b>	• Always-on Broadband, preferred	• Dual 100 Mbps Ethernet	• Dual 100 Mbps Ethernet	• Dual 100 Mbps Ethernet

**FIGURE 7-10** Sample hardware and software specification.

**FIGURE 7-11**  
Factors in hardware  
and software selection.

1. **Functions and Features** What specific functions and features are needed (e.g., size of monitor, software features)?
2. **Performance** How fast do the hardware and software operate (e.g., processor, number of database writes per second)?
3. **Legacy Databases and Systems** How well do the hardware and software interact with legacy systems (e.g., can it write to this database)?
4. **Hardware and OS Strategy** What are the future migration plans (e.g., the goal is to have all of one vendor's equipment)?
5. **Cost of Ownership** What are the costs beyond purchase (e.g., incremental license costs, annual maintenance, training costs, salary costs)?
6. **Political Preferences** People are creatures of habit and are resistant to change, so changes should be minimized.
7. **Vendor Performance** Some vendors have reputations or prospects that are different from those of a specific hardware or software system that they currently sell.

developers or other companies with similar systems. Finally, think about the factors that affect hardware performance, such as the response-time expectations of the users, data volumes, software memory requirements, the number of users accessing the system, the number of external connections, and growth projections.

After preparing the hardware and software specification, the project team works with the purchasing department to acquire the hardware and software. The project team prepares an RFP based on legal and organizational policies provided by the purchasing department, which then issues the RFP. The project team then selects the most desirable vendor for the hardware and software based on the proposals received, perhaps using a weighted alternative matrix. On a large project, this evaluation may take months and involves extensive testing and benchmarking of the projects offered by the vendors. The purchasing department is actively involved in the vendor selection, again ensuring that organizational policies are followed. Finally, the purchasing department negotiates final terms with the vendor, issues a contract, and accepts delivery of the items, subject to approval of the project team.

#### **YOUR TURN 7-1** || University Course Registration System

Think about the course registration system in your university. First, develop a set of nonfunctional requirements as if the system were to be developed today. Consider the operational

requirements, performance requirements, security requirements, and cultural and political requirements. Then create an architecture design to satisfy these requirements.

#### **YOUR TURN 7-2** || Global e-Learning System

Many multinational organizations provide global Web-based e-learning courses to their employees. First, develop a set of nonfunctional requirements for such a system. Consider the

operational requirements, performance requirements, security requirements, and cultural and political requirements. Then create an architecture design to satisfy these requirements.

# Applying the Concepts at DrōnTeq

## Creating an Architecture Design

Jiang Tsaio, senior systems analyst and project manager for DrōnTeq's Client Services system, realized that the hardware, software, and networks that would support the new application would need to be integrated into the current infrastructure at DrōnTeq. He began using the high-level nonfunctional requirements developed in the analysis phase (see Figure 3-14 in Chapter 3) and conducted interviews with Carmella Herrera and her management team in the Client Services department. Jiang also met with the DrōnTeq system architecture group. From them, he learned many more details about the technical environment for this system. Based on these discussions, Jiang refined the nonfunctional requirements as shown in Figure 7-12. The system will employ a

### 1. Operational Requirements

- |                       |  |
|-----------------------|--|
| Technical Environment | 1.1 The system will work over the Web with any browser<br>1.2 Nonregistered customers using mobile devices will access the system using the mobile device browser<br>1.3 Registered clients and pilots using mobile devices will access a rich Internet application from the mobile device browser   |
| System Integration    | 1.4 The informational portion of the system will read content from the drone database in the Sales system. No write access is allowed.<br>1.5 The portion of the system for registered clients and pilots will read and write to the client, pilot, flight request, and flight bid datastores<br>1.6 Data from completed drone flights must be uploaded from anywhere into the DrōnTeq Amazon S3 cloud storage<br>1.7 Clients can download completed drone video from the DrōnTeq Amazon S3 cloud storage<br>1.8 Clients can download completed data analyses from the DrōnTeq Amazon S3 cloud storage |
| Portability           | 1.9 iOS and Android devices are supported  |
| Maintainability       | 1.10 The system will need to remain current with evolving Web standards, especially those pertaining to Web video formats.   |

### 2. Performance Requirements

- |              |   |
|--------------|---|
| Speed        | 2.1 Response times must be less than 7 seconds<br>2.2 Upload and download speeds must be maintained above the industry norm                           |
| Capacity     | 2.3 There will be a maximum of 100 simultaneous users at peak use times<br>2.4 The system will support streaming video to up to 50 simultaneous users |
| Availability | 2.5 The system should be available 24/7   |
| Reliability  | 2.6 The system shall have 99% uptime performance  |

### 3. Security Requirements

- |                               |   |
|-------------------------------|---|
| System Value                  | 3.1 The system has high strategic value and is essential to the functioning of the new Client Services business unit  |
| Access Control/Authentication | 3.2 Registered clients and pilots will access their accounts with username and password   |
| Encryption                    | 3.3 Client payment information must be transmitted securely<br>3.4 Drone data uploads and completed drone videos and data analyses must be transmitted securely |
| Virus Control                 | 3.5 All standard virus controls are mandated  |

### 4. Cultural and Political Requirements

- |                |   |
|----------------|---|
| Multilingual   | 4.1 No special multilingual requirements are expected                     |
| Customization  | 4.2 Pilots will be provided customization options for the pilot dashboard |
| Unstated Norms | 4.3 No special unstated norms are expected                                |
| Legal          | 4.4 No special legal requirements are expected                            |

FIGURE 7-12 Selected nonfunctional requirements for DrōnTeq.

Web-based architecture with a thin client–server architecture. It will also utilize Amazon S3 cloud storage. These aspects will make the development of this system an exciting challenge for Jiang and his team.

DrōnTeq’s formal system architecture group is responsible for managing its architecture and its hardware and software infrastructure. This group determined that the Client Services system would be its first initiative to employ cloud storage. The large volume of data associated with the drone flight data collection, the need for pilots to upload that data and clients to download that data rapidly and seamlessly, and the need to perform an array of proprietary data analyses on the drone flight data make the cloud an important component of this new system environment. Therefore, Jiang set up a meeting with the project team and the architecture group. During the meeting, the team learned more about the planned architecture, and two team members were selected to get in-depth training on Amazon’s S3 cloud service.

The team plans to build the system using a multi-tier, thin client–server architecture. Everyone believed that it was hard to know at this point exactly how much traffic the system would experience, but the large data file sizes and the need for specialized data analyses suggest the need for several specialized tiers: Web server tier, application tier, database tier, video server tier, and data analysis tier. The client–server architecture will allow DrōnTeq to easily scale up the system as needed as the Client Services unit grows. Nonregistered customers would use their personal computers or mobile devices running a Web browser as the client. The mobile app would be developed as a thin Web-based mobile client. Registered clients and pilots using mobile devices will access their accounts using a browser-based rich Internet application. A database server would store the system’s operational databases, whereas an application server would include the programs associated with clients’ flight requests and pilot’s flight bids. The data analysis and video server tier will be hosted in the cloud.

Given that the Web interface could reach a geographically dispersed group, the project team realized that it needed to plan for 24/7 system support. Jiang met with the DrōnTeq systems operations group and discussed how they might be able to support the system outside of standard working hours.

## Hardware and Software Specification

The architecture group and the Jiang’s project team decided that the architecture group would determine the specific new components needed for the system. They developed a hardware and software specification for these components, prepared an RFP, and worked with the purchasing department to acquire the hardware and software.

### YOUR TURN 7-3

#### University Course Registration System

Develop a hardware and software specification for the university course registration system described in “Your Turn 7-1.”

### YOUR TURN 7-4

#### Global e-Learning System

Develop a hardware and software specification for the global e-learning system described in “Your Turn 7-2.”

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Identify and describe the four basic functions of a software system.
- Describe the basic premise of the client–server architecture.
- Explain the difference between thick clients and thin clients.
- Discuss the “tiered” approach to client–server architectures.
- Explain the architectural options for mobile applications.

- Discuss several ways to create mobile applications and the pros and cons of each.
- Explain the use of nonfunctional requirements in the creation of the architecture design.
- Describe the purpose and typical content of the hardware and software specification.

## KEY TERMS

24/7	Controls	Microcomputer	Storage area network (SAN)
Access control requirements	Cultural and political requirements	Middleware	Storage virtualization
Application logic	Customization requirements	Mission critical system	Symmetric encryption
Application program interfaces (API)	Data access logic	Multilingual requirements	algorithm
Architectural components	Data storage	Network	System integration
Architecture design	Discrete multilingual system	n-tier architecture	requirements
Asymmetric encryption algorithm	Elasticity	Performance requirements	System Value
Authentication	Encryption	Portability requirements	Technical environment
Availability and reliability requirements	Encryption and authentication requirements	Presentation logic	requirements
Blockchain	Fat client	Private key	Terminal
Capacity requirements	Functions	Public key	Thick client
Certificate authority (CA)	Graphical user interface (GUI)	Public key encryption	Thin client
Client computers	Hardware and software specification	Response time	Thin Web-based client
Client–server architectures	Invertible	Rich client	Three-tiered architecture
Cloud computing	Legal requirements	Rich Internet application (RIA)	Two-tiered architecture
Cloud computing	Mainframe	Scalable	Ultra thin client
Concurrent multilingual system	Maintainability requirements	Security requirements	Unstated norms
		Servers	Virtualization
		Server-based architecture	Virus
		Server virtualization	Virus Control Requirements
		Speed requirements	Zero client

## QUESTIONS

1. List and describe the four primary functional components of a software application.
2. List and describe the three primary hardware components of a system.
3. Explain the client–server architecture.
4. Explain the server-based architecture.
5. Explain the mobile application architecture.
6. Distinguish between the two-tier, three-tier, and n-tier client–server architectures.
7. Compare and contrast the server-based and client–server architectures.
8. What is meant by the term *scalable*? What is its importance in architecture selection?
9. Explain the term virtualization.
10. Describe cloud computing and how it is impacting architecture choices.
11. Describe the types of operational requirements and how they may influence architecture design.
12. Describe the types of performance requirements and how they may influence architecture design.
13. Describe the types of security requirements and how they may influence architecture design.
14. What is meant by system value? Explain how various systems can have a different value to the organization.
15. Explain the difference between a symmetric encryption algorithm and an asymmetric encryption algorithm.

16. What is meant by authentication? What is its role in securing transactions?
17. Describe the usefulness of the Internet's public key infrastructure (PKI).
18. Describe the types of cultural and political requirements and how they may influence architecture design.
19. Explain the difference between concurrent multilingual systems and discrete multilingual systems.
20. Why is it useful to define the nonfunctional requirements in more detail even if the technical environment requirements dictate a specific architecture?
21. What is the purpose of the hardware and software specification?
22. What do you think are three common mistakes that novice analysts make in developing the architecture design and hardware/software specification?
23. Are some nonfunctional requirements more important than others in influencing the architecture design and hardware/software specification?
24. What do you think are the most important security issues for a system?

## EXERCISES

- A. Using the Web (or past issues of computer industry magazines, such as Computerworld), locate a system that runs in a server-based environment. On the basis of your reading, why do you think the company chose that computing environment?
- B. Using the Web (or past issues of computer industry magazines, such as Computerworld), locate a system that runs in a client-server environment. On the basis of your reading, why do you think the company chose that computing environment?
- C. Using the Web, investigate the term, virtual desktop infrastructure (VDI). Write a short memo explaining the concept to your boss.
- D. You have been selected to find the best client-server computing architecture for a Web-based order entry system that is being developed for L.L. Bean. Write a short memo that describes to the project manager your reason for selecting an n-tiered architecture over a two-tiered architecture. In the memo, give some idea of the different components of the architecture that you would include.
- E. Think about the system that your university currently uses for career services and pretend that you oversee developing a mobile app for students to use to access the system. Describe how you would decide on the architecture and development approach for the new app using the criteria presented in this chapter. What information will you need to find out before you can make an educated comparison of the alternatives?
- F. Locate a consumer products company on the Web and read its company description (so that you get a good understanding of the geographic locations of the company). Pretend that the company is about to create a new application to support retail sales over the Web. Create an architecture design that depicts the locations that would include components that support this application.
- G. Pretend that your mother is a real estate agent and that she has decided to automate her daily tasks by using a laptop computer. Consider her potential hardware and software needs and create a hardware and software specification that describes them. The specification should be developed to help your mother buy her hardware and software on her own.
- H. Pretend that the admissions office in your university has a Web-based application so that students can apply for admission online. Recently, there has been a push to admit more international students into the university. What do you recommend that the application include to ensure that it supports this global requirement?

## MINICASES

1. The system development project team at Birdie Masters golf schools has been working on defining the architecture design for a new system. The major focus of the project is a networked school location operations system allowing each school location to easily record and retrieve all school location transaction data. Another system element is the use of the Internet to enable current and prospective students to view

class offerings at any of the Birdie Masters' locations, schedule lessons and enroll in classes at any Birdie Masters' location and maintain a student progress profile—a confidential analysis of the student's golf skill development.

The project team has been considering the globalization issues that should be factored into the architecture design. The school's plan for expansion into the golf-crazed Japanese

market is moving ahead. The first Japanese school location is tentatively planned to open about 6 months after the target completion date for the system project. Therefore, it is important that issues related to the international location be addressed now during design.

Prepare a set of nonfunctional requirements, including operational requirements, performance requirements, security requirements, and cultural and political requirements. Much information is incomplete but do your best.

2. Jerry is the project manager for a team developing a retail store management system for a chain of sporting goods stores. Company headquarters is in Las Vegas, and the chain has 27 locations throughout Nevada, Utah, and Arizona. Several cities have multiple stores. Stores will be linked to one of three regional servers, and the regional servers will be linked to corporate headquarters in Las Vegas. The regional servers also link to each other. Each retail store will be outfitted with similar configurations of two PC-based point-of-sale terminals networked to a local file server. Jerry has been given the

task of developing the architecture design and hardware and software specification for a network model that will document the geographic structure of this system. He has not faced a system of this scope before and is a little unsure of how to begin. What advice would you give?

3. Java Masters is an employment exchange agency that has offices in Northern California. Java Masters operates as a broker that links its client companies with independent software experts (commonly called contractors) with advanced Java and Web-development skills for short-term contracts. They are developing a Web-based system that will enable client companies to list job needs and search the database of independent contractors. The independent contractors also can post résumés and availabilities and search the database of available jobs. Both contractors and companies pay fees to join the service. Some contractors and companies prefer to remain anonymous until they meet face-to-face. Develop the nonfunctional requirements and architecture design for the system.

# 8

# User Interface Design

## DESIGN

### TASK CHECKLIST

- Select Design Strategy.
- Design Architecture.
- Select Hardware and Software.
- Develop Use Scenarios.
- Design Interface Structure.
- Develop Interface Standards.
- Design Interface Prototype.
- Evaluate User Interface.
- Design User Interface.
- Develop Physical Data Flow Diagrams.
- Develop Program Structure Charts.
- Develop Program Specifications.
- Select Data Storage Format.
- Develop Physical Entity Relationship Diagram.
- Denormalize Entity Relationship Diagram.
- Performance Tune Data Storage.
- Size Data Storage.

A user interface is the part of the system with which the users interact. It includes the screen displays that provide navigation through the system, the screens and forms that capture data, and the reports that the system produces. This chapter introduces the basic principles and processes of interface design and discusses how to design the interface to achieve a highly usable interface.

### OBJECTIVES

- Explain the concept of usability regarding the user interface.
- Describe several fundamental user interface design principles.
- Explain the process of user interface design.
- Explain ways to understand the perspectives of the users of the user interface.
- Describe ways to define the structure of the user interface.
- Explain the standards that should be established for the user interface.
- Describe various ways to prototype the user interface.

- Discuss ways to evaluate and test the user interface.
- Discuss special concerns associated with touch-screen-enabled user interfaces.
- Be able to design a highly usable user interface.

## Introduction

Interface design is the process of defining how the system interacts with the external entities (e.g., customers, suppliers, and other systems). In this chapter, we focus on the design of **user interfaces**—the way in which the users interact with the system. It is also important to remember that there may be **system interfaces** that exchange information with other systems. System interfaces are typically designed as part of a systems integration effort. They are defined in general terms on the physical data flow diagrams (DFDs) and in the nonfunctional (operational) requirements and are designed in detail during program design (see Chapter 9) and data storage design (see Chapter 10).

The user interface includes three fundamental parts. The first is the **navigation mechanism**, the way in which the user gives instructions to the system and tells it what to do (e.g., **buttons**, **menus**). The second is the **input mechanism**, the way in which the system captures information (e.g., **forms** for adding new customers). The third is the **output mechanism**, the way in which the system provides information to the user (e.g., **reports**). Each of these is conceptually different, but are closely related. User interface screens typically always contain some navigation mechanisms, and most contain input and/or output mechanisms. Therefore, navigation design, input design, and output design are tightly coupled.

Evolving technology has enabled us to move from plain, text-based user interfaces to **graphical user interfaces**<sup>1</sup> with windows, menus, icons, and a mouse, to small screen touch-based mobile device applications. The study of **human-computer interaction** (HCI) focuses on improving the interactions between users and computers by making computers more usable and receptive to the user's needs. Mobile, ubiquitous, and social computing applications have broadened our concerns to that of the overall **user experience (UX)**—where users' feelings, motivations, and values are considered as well as efficiency, effectiveness, and satisfaction. A complete discussion of UX design is beyond the scope of this textbook; however, we will include extensive discussion of one of the key elements of the UX—usability.

This chapter first introduces the concept of usability. Guidelines and best practices are discussed for both traditional screen designs and mobile device screen designs. Second, an overview of the user interface design process is described. It then provides an overview of the navigation, input, and output components that are used in interface design.

## The Usability Concept

As a systems analyst, you are concerned with many elements of an information system, including the data that is captured and stored and the processing that must be performed. The users of the system, however, only perceive the reality of the system through the user interface. Users are generally unaware of the elegance and efficiency of the system's underpinnings; users simply want applications that meet their needs and are easy to use. In short, users want an interface that is high on usability so that needed tasks are performed quickly and effectively.

<sup>1</sup>Many people attribute the origin of GUI interfaces to Apple or Microsoft. Some people know that Microsoft copied from Apple, which in turn "borrowed" the whole idea from a system developed at the Xerox Palo Alto Research Center (PARC) in the 1970s. Very few know that the Xerox system was based on one developed by Doug Englebart that was first demonstrated at the Western Computer Conference in 1968. Around the same time, Doug also invented the mouse, desktop videoconferencing, groupware, and a host of other things we now take for granted. Doug is a legend in the computer science community and has won too many awards to count, but is relatively unknown by the general public.

The term **usability** encompasses two related concepts: systems that are easy to use and easy to learn. When a system's user interface is very usable, users will be more likely to use the system, an important consideration when using the system is optional. A usable interface will reduce user effort, enabling the user to focus attention on the task at hand, not on making the system work. In addition, usability increases the speed of task completion and reduces errors. Clearly, usability is an essential aspect of a quality information system but developing a user interface that ranks high on usability is neither a simple nor a trivial process. In the next section, we describe several principles and guidelines that can contribute to the creation of a highly usable user interface.

## Principles for User Interface Design

In many ways, user interface design is an art. The goal is to make the interface pleasing to the eye and simple to use, while minimizing the effort users expend to accomplish their work. The system is never an end in itself; it is merely a means to accomplish the business of the organization.

We have found that the greatest problem facing experienced designers is using space effectively. Simply put, there is more information to present than room to present it. Analysts must balance the need for simplicity and pleasant appearance against the need to present the information across multiple pages or screens, which decreases simplicity. In this section, we discuss some fundamental interface design principles, which are common for navigation design, input design, and output design<sup>2</sup> (Figure 8-1). We conclude this section with some special considerations when designing for touch screen applications.

### Layout

The first principle of user interface design deals with the **layout** of the **screen**, form, or report. Layout refers to organizing areas of the screen or document for different purposes and using



Principle	Description
Layout	The interface should be a series of areas on the screen that are used consistently for different purposes—for example, a top area for commands and navigation, a middle area for information to be input or output, and a bottom area for status information.
Content awareness	Users should always be aware of where they are in the system and what information is being displayed.
Aesthetics	Interfaces should be functional and inviting to users through careful use of white space, colors, and fonts. There is often a trade-off between including enough white space to make the interface look pleasing and losing so much space that important information does not fit on the screen.
Usage level	Although ease of use and ease of learning often lead to similar design decisions, there is sometimes a trade-off between the two. Infrequent users of software will prefer ease of learning, whereas frequent users will prefer ease of use.
Consistency	Consistency in interface design enables users to predict what will happen before they perform a function. It is one of the most important elements in ease of learning, ease of use, and aesthetics.
Minimize user effort	The interface should be simple to use. Most designers plan on having no more than three mouse clicks from the starting menu until users perform work.

**FIGURE 8-1**  
Principles of user interface design.

<sup>2</sup>Good books on the design of interfaces include Jeff Johnson, *Designing with the Mind in Mind*, 2nd Ed., Waltham, MA: Elsevier, Inc., 2014; Jenifer Tidwell, *Designing Interfaces*, 2nd Ed., O'Reilly Media, 2011; Alan Cooper, Robert Reimann, and David Cronin, *About Face: The Essentials of Interaction Design*, 4th Ed., New York: Wiley, 2014.

those areas consistently throughout the user interface. Most software designed for personal computers follows the standard Windows or Macintosh approach for screen layout. This approach divides the screen into three main areas: the top area provides the user with ways to navigate through the system; the middle (and largest) area is for display of the user's work; and the bottom area contains status information about what the user is doing.

In many cases (particularly on the Web), multiple layout areas are used. Figure 8-2 shows a model screen layout for an informational website. Note that site navigation is provided in three separate areas. As the user navigates to each part of the site, the overall page layout is the same.

This use of multiple layout areas also applies to inputs and outputs. Data areas on reports and forms are often subdivided into subareas, each of which is used for different types of information. These areas are almost always rectangular in shape, although sometimes space constraints will require odd shapes. Nonetheless, the margins on the edges of the screen should be consistent. Each of the areas within the report or form is designed to hold different information. For example, on an order form (or order summary report), one part may be used for customer information (e.g., name, address), one part for information about the order in general (e.g., date, payment information, shipping instructions), and one part for the order details (e.g., how many units of which items at what price each). Each area is self-contained so that information in one area does not run into another.

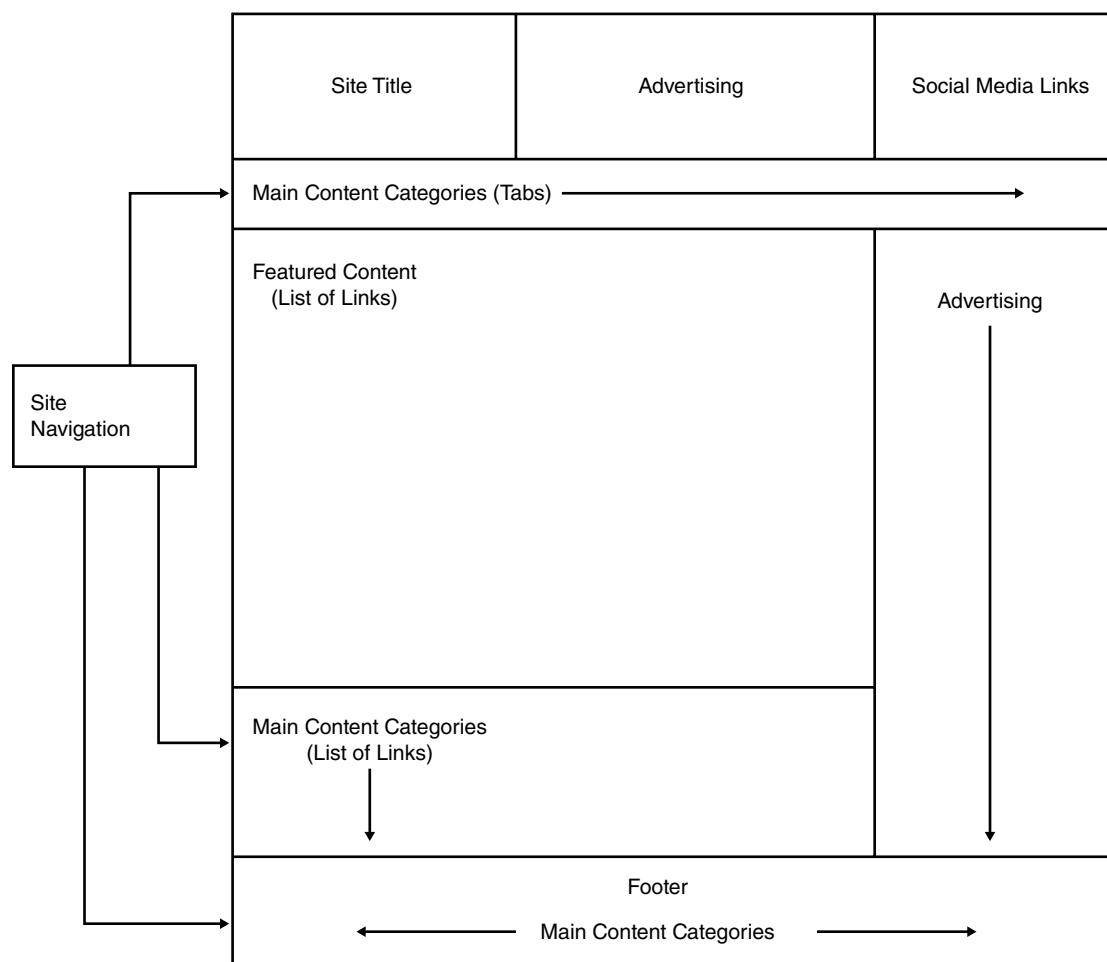
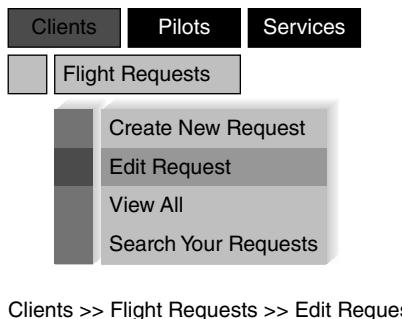


FIGURE 8-2 Model Web page layout.



**FIGURE 8-3** Content awareness with menu selection highlights and breadcrumbs.

The areas and information within areas should have a natural intuitive flow to minimize users' movement from one area to the next. People in Western nations (e.g., Europe, North America) tend to read top to bottom, left to right, so that related information should be placed so that it is used in this order (e.g., address lines, followed by city, state/province, and then zip code/postal code). Sometimes, the sequence is in chronological order, or from the general to the specific, or from most frequently to least frequently used. In any event, before the areas are placed on a form or report, the analyst should have a clear understanding of what arrangement makes the most sense for how the form or report will be used. The flow between sections should also be consistent, whether horizontal or vertical (Figure 8-3). Ideally, the areas will remain consistent in size, shape, and placement for the forms used to enter information (whether on paper or on a screen) and the reports used to present it.

## Content Awareness

**Content awareness** refers to the ability of an interface to make the user aware of the information it contains with the least amount of effort by the user. All parts of the interface, whether navigation, input, or output, should provide as much content awareness as possible, but it is particularly important for forms or reports that are used quickly or irregularly (e.g., a website).

Content awareness applies to the interface in general. All interfaces should have titles (e.g., on the screen frame). Menus should show where the user is and, if possible, where the user came from to get there. For example, in Figure 8-3, we show how the Main Menu and submenu for the Flight Request system is reinforced with **breadcrumbs**, a listing of the page hierarchy.

Content awareness also applies to the area within forms and reports. All areas should be clear and well defined (with titles if space permits) to reduce the chances that users become confused about the information in any area. Then users can quickly locate the part of the form or report that is likely to contain the information they need. Ideally, the areas are separated by **white space** so that clutter is minimized.

Content awareness also applies to the fields within each area. **Fields** are the individual elements of data that are input or output. The **field labels** that identify the fields on the interface should be short and specific—objectives that often conflict. The words that you place on the interface are the user’s primary source of information, so select your words carefully and use terminology that is familiar to the user. There should be no uncertainty about the format of information within fields, whether for entry or display. For example, a date of 10/5/23 means different things, depending on whether you are in the United States (October 5, 2023) or in Canada (May 10, 2023). Any fields for which there is the possibility of uncertainty or multiple interpretations should provide explicit explanations (such as labeling US\$ versus HK\$ to distinguish United States dollars from Hong Kong dollars if there is any chance for confusion).

Content awareness also applies to the information that a form or report contains. In general, all forms and reports should contain the date prepared so that the age of the information is obvious.

Likewise, all printed forms and software should provide version numbers so that users, analysts, and programmers can identify outdated materials.

## Aesthetics

**Aesthetics** refers to designing interfaces that are pleasing to the eye. Interfaces do not have to be works of art, but they do need to be functional and inviting to use. In most cases, “less is more,” meaning that a simple, minimalist design is the best.

Space usually is at a premium on forms and reports, and often there is the temptation to squeeze as much information as possible onto a page or a screen. Unfortunately, this can make a form or report so unpleasant that users do not want to complete it. In general, all forms and reports need at least a minimum amount of white space that is intentionally left blank.

Look at Figure 8-4. What is your first reaction? This is the most unpleasant form at the University of Georgia, according to staff members. Its **density** is too high; it has too much information packed into too small a space with too little white space. Although it may be efficient in saving paper by being one page instead of two, it is not effective for many users.

In general, novice or infrequent users of an interface, whether on a screen or on paper, prefer interfaces with low density, often one with a density of less than 50% (i.e., less than 50% of the interface occupied by information). More experienced users prefer higher densities, sometimes approaching 90% occupied, because they know where information is located and high densities reduce the amount of physical movement through the interface. We suspect that the form in Figure 8-4 was designed for the experienced staff in the personnel office, who use it daily, rather than for the clerical staff in academic departments, who have less personnel experience and use the form only a few times a year.

The design of text is equally important. In general, there should be one font for the entire form or report and no more than two sizes of that font on the form or report. A larger font size may be used for titles, section headings, etc., and a smaller font for the report or form content. If the form or report is printed, the smaller font should be at least 8 points in size. A minimum of 10 points is preferred if the users are older people. For forms or reports displayed on the screen, consider a minimum of a 12-point font size if the display monitor is set for a high screen resolution. Italics and underlining should be avoided because they make text harder to read.

Serif fonts (i.e., those having letters with serifs, or “tails,” such as Times Roman or the font you are reading right now) are the most readable for printed reports, particularly for small letters. Sans serif fonts (i.e., those without serifs, such as Tahoma or Arial or the ones used for the chapter objectives in this book) are the most readable for computer screens and are often used for headings in printed reports. Never use all capital letters, except possibly for titles—all-caps text “shouts” and is harder to read.

Color and patterns should be used carefully and sparingly and only when they serve a purpose. (About 10% of men are color blind, so the improper use of color can impair their ability to read information.) A quick trip around the Web will demonstrate the problems caused by indiscriminate use of colors and patterns. Remember, the goal is pleasant readability, not art; colors and patterns should be used to strengthen the message, not overwhelm it. Color is best used to separate and categorize items, such as showing the difference between headings and regular text, or to highlight important information. Therefore, use colors with high contrast (e.g., black text on a white background or white text on a dark blue background).

## Usage Level

An information system may be used frequently by some people and infrequently by others. The user interface should be designed for both types of users. **Usage level** refers to designing the user

EMPLOYEE PERSONNEL REPORT												PAY TYPE																							
DOCUMENT NO.	PAGE	DATE	FY	DEPARTMENT PHONE	COLLEGE OR DIVISION							EMPLOYMENT HISTORY																							
DEPARTMENT/PROJECT				PRI DEPT	HIGH DEGREE	INSTITUTION			YEAR			(C) CURRENT <input type="checkbox"/> (P) PREVIOUS DATE _____																							
SOC. SEC. NUM.	LAST NAME			FIRST NAME/INITIAL		MIDDLE INITIAL/NAME			SUF		<input type="checkbox"/> (1) REGULAR <input type="checkbox"/> (3) TEMPORARY <input type="checkbox"/> (2) STUDENT <input type="checkbox"/> (4) NR-ALIEN <input type="checkbox"/> (E) EXEMPT <input type="checkbox"/> (N) NON-EXEMPT <input type="checkbox"/> (T) TIPPED <input type="checkbox"/> (M) MALE <input type="checkbox"/> (S) SINGLE <input type="checkbox"/> (Y) FACULTY-RANK <input type="checkbox"/> (F) FEMALE <input type="checkbox"/> (M) MARRIED <input type="checkbox"/> (N) NON-FACULTY <input type="checkbox"/> (1) WHITE <input type="checkbox"/> (3) ORIENTAL/ASIAN <input type="checkbox"/> (5) HISPANIC <input type="checkbox"/> (2) BLACK <input type="checkbox"/> (4) AMERICAN INDIAN <input type="checkbox"/> (6) MULTIRACIAL <input type="checkbox"/> (9) _____																								
STREET OR ROUTE NO. (LINE 1)				NON-WORK PHONE		BIRTH DATE	SPOUSE'S NAME		CHAIR			% TIME _____ ACTION YR _____																							
STREET OR ROUTE NO. (LINE 2)				UNIVERSITY PHONE		CITIZEN OF		VISA	COUNTY																										
CITY	STATE	ZIP + 4		UNIVERSITY BUILDING NAME			BLDG.NO/FLOOR/ROOM																												
FOR PAYROLL DEPT USE ONLY												COOP. EXT. EMPLOYEES ONLY	PAYROLL PAYMENT DISTRIBUTION																						
FED EXM	STATE EXM	OASDI		RETIRE	GDCP		COUNTY MONEY (PER PAY PERIOD)					SALAR	<input type="checkbox"/> (1) SEND TO DEPT (DIST CODE)																						
		HI		EIC								COUNTY MONEY	<input type="checkbox"/> (2) DIRECT DEPOSITS(SEND PR105 TO PAYROLL <input type="checkbox"/> (3) PICK UP AT PAYROLL WINDOW																						
												TOTAL																							
TRX	HOME DEPT	SHORT TITLE	POSN NO.	APPT. MO	DA	BEGIN YR	APPT. MO	DA	END YR	JOBCLASS HR	CODE	POSITION TITLE				POS %	TIME C N	FULL ANNUAL SALARY	S C	SUPPLEMENT AMOUNT															
PAYROLL AUTHORIZATION												FISCAL YEAR				MO	DA	YR	HR	MO	DA	YR	HR	MO	DA	YR	HR	MO	DA	YR	HR				
TRX	HOME DEPT	SHORT TITLE	POSN NO.	ACCOUNT				EFT	BUDGET			FROM					MO	DA	YR	HR	MO	DA	YR	HR	MO	DA	YR	HR							
												THRU																							
												AMOUNT																							
												PER PAY																							
												PERIOD																							
												OR																							
												HOURLY RATE																							
TOTALS																																			
<input type="checkbox"/> (A) NEW EMPLOYEE <input type="checkbox"/> (B) LATERAL TRANSFER <input type="checkbox"/> (C) PROMOTION <input type="checkbox"/> (K) CHANGE TITLE FROM _____ TO _____ <input type="checkbox"/> (D) REPLACEMENT POSN-NAME OF LAST INCUMBENT _____ <input type="checkbox"/> (L) CHANGE NAME FROM _____ TO _____ <input type="checkbox"/> (E) APPOINTMENT TO NEW POSITION <input type="checkbox"/> (M) CHANGE SSN FROM _____ TO _____ <input type="checkbox"/> (F) CHANGE % TIME EMPLOYED FROM _____ TO _____ <input type="checkbox"/> (N) LEAVE W/O PAY FROM _____ TO _____ <input type="checkbox"/> (G) CONTINUATION WITHIN EXISTING BUDGET POSITION <input type="checkbox"/> (O) CHG COUNTY \$ FROM _____ TO _____ <input type="checkbox"/> (H) REVISE DISTRIBUTION OF SALARY <input type="checkbox"/> (P) TERMINATION-REASON _____ <input type="checkbox"/> (I) TRANSFER FROM DEPT _____ TO _____ <input type="checkbox"/> (Q) OTHER (SPECIFY) _____ <input type="checkbox"/> (J) CHANGE PAY TYPE FROM _____ TO _____																																			
REMARKS																																			

**FIGURE 8-4** Form example.

interface to accommodate both users who use the system heavily and routinely and users who use the system only occasionally. Infrequent users are usually most concerned with **ease of learning**—how quickly and easily they can learn to use the system. Frequent users are typically more concerned with **ease of use**—how quickly and easily they can complete a task with the system once they have learned how to use it. Often, these two objectives are complementary and lead to similar design decisions, but sometimes, there are trade-offs. Therefore, it is important to consider the expected usage level of the system and design the user interface to accommodate your users.

Some systems are used regularly as an integral part of a job and have mostly frequent users (e.g., a customer support application used by customer support representatives). Although interfaces should try to balance ease of use and ease of learning, these types of systems should put more emphasis on ease of use. Users should be able to access the commonly employed functions quickly, with few keystrokes or a small number of menu selections.

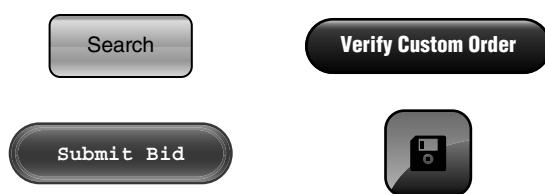
In many other systems (e.g., decision support systems [DSS]), most people will remain occasional users for the lifetime of the system. In these cases, greater emphasis may be placed on ease of learning rather than on ease of use. Infrequent users appreciate menus that show all available system functions because these promote ease of learning.

The balance between quick access to commonly used and well-known functions and guidance through new and less-well-known functions is challenging to the interface designer, and this balance often requires elegant solutions. Microsoft introduced a significant departure from its traditional menu-oriented user interface when it introduced the ribbon in Office 2007. This interface provides icons that represent common tasks organized within similar groupings under the ribbon's main tabs. Infrequent users can quickly access a brief help message about an icon by a mouse hover, thus assisting their ease of learning. Frequent users can use that mouse hover to learn about less frequently used parts of the system (ease of learning) but can also learn and apply shortcuts to the commonly used commands (e.g., Cntl + C for copying text), thereby increasing their ease of use.

## Consistency

**Consistency** in design is probably the single most important factor in making a system simple to use, because it enables users to predict what will happen. When interfaces are consistent, users can interact with one part of the system and then know how to interact with the rest—aside, of course, from elements unique to those parts. Consistency usually refers to the interface within one computer system, so that all parts of the same system work in the same way. Ideally, however, the system also should be consistent with other computer systems in the organization and with whatever commercial software is used (e.g., Windows). For example, many users are familiar with the Web, so the use of Web-like interfaces can reduce the amount of learning required by the user. In this way, the user can reuse Web knowledge, thus significantly reducing the learning curve for a new system.

Look at the buttons that are included in Figure 8-5. These buttons all came from the same application. Clearly, there is a lot of inconsistency shown here which is likely to cause uncertainty



**FIGURE 8-5**  
Inconsistent symbols  
and terminology.

and confusion. Consistency occurs at many different levels. Consistency in the navigation controls conveys how actions in the system should be performed. Consistency in terminology is also important. For example, using the same icon and/or command to perform a search clearly communicates how searches are made throughout the system. This also refers to using the same words for elements on forms and reports (e.g., not “customer” in one place and “client” in another).

We also believe that consistency in report and form design is important, although one study suggests that being too consistent can cause problems.<sup>3</sup> When reports and forms are similar except for minor changes in titles, users sometimes have difficulty perceiving the differences. Designers should make the reports and forms similar, but give them some distinctive elements (e.g., color, size of titles) that help users distinguish them.

## Minimize User Effort

Finally, interfaces should be designed to minimize the amount of effort needed to accomplish tasks. This means using the fewest possible mouse clicks or keystrokes to move from one part of the system to another. Most interface designers follow the **three-clicks rule**: users should be able to go from the start or main menu of a system to the information or action they want in no more than three mouse clicks or three keystrokes.

## Special Issues of Touch Screen Interface Design

The keyboard and mouse have ruled the user interaction domain for decades, but recent advances in multitouch technology have changed the game. The iPhone and iPad paved the way for touch screen interfaces on all sorts of devices. The natural and simple interaction enabled by touch screens is appealing but does add several important new considerations to user interface design. In general, applications involving significant data entry are not ideal for the touch screen environment. The optimal use of touch screens is to retrieve and display information rather than enter new data.

When using a finger to interact with the application, the finger obscures some of the content on the screen. Because of this fact, navigation elements should be placed at the bottom of the screen with the results/display area at the top. In addition, labels that describe a screen element should be along the top of the element rather than the bottom so that the finger does not hide the label from the user. Remember that both right-handed and left-handed people will use the application. You should either create vertically symmetrical navigation or include an option to flip your layout. Finally, a bright background color or pattern is preferred to hide glare and reduce the annoyance of fingerprints on the screen.

Another consideration is selecting and sizing the screen elements correctly. Whenever possible, use graphical objects that can be manipulated rather than entering text (e.g., use a listbox to scroll a set of values). A mouse pointer has a precision of 1–2 pixels, while the typical finger covers 8–10 mm. It is important that the interactive screen elements are large enough for “fat fingers” and have adequate spacing between elements to increase the user’s accuracy. This is also important because of the difficulty some users have in coordinating their eyes and fingers when using the touch screen.

With touch screens, hand gestures are used to directly interact with the interactive elements on the screen. It is no longer possible to provide information to the user through hovering and

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<sup>3</sup> John Satzinger and Lorne Olfman, “User Interface Consistency Across End-User Application: The Effects of Mental Models,” *Journal of Management Information Systems*, Spring 1998, 14(4): 167–193.

Gesture	Meaning/Function
<b>Navigational Gestures: Help users to move through a product easily. Supplement other explicit input methods, like buttons and navigational components</b>	
Tap	Users can navigate to destinations by touching elements
Scroll and pan	Users can slide surfaces vertically, horizontally, or omnidirectionally to move continuously through content
Drag	Users can slide surfaces to bring them into and out of view
Swipe	Users can move surfaces horizontally to navigate between peers, like tabs
Pinch	Users can scale surfaces to navigate between screens
<b>Action Gestures: Perform actions or provide shortcuts for completing actions</b>	
Tap or Long press	Users can interact with elements and access additional functionality
Swipe	Users can slide elements to complete actions upon passing a threshold
<b>Transform Gestures: Transform an element's size, position, and rotation with gestures</b>	
Double tap or Pinch	Users can zoom into and out of content
Compound gestures	Users can fluidly transition between various gestures
Pick up and move	Users can reorder content with a long press and drag
Source: <a href="https://material.io/design/interaction/gestures.html#types-of-gestures">material.io/design/interaction/gestures.html#types-of-gestures</a>	

**FIGURE 8-6**  
Common set of gestures supported by Android devices.

**tool tips.** It is therefore important to use standardized gesture interactions to enhance the user's ease of learning and ease of use. You should carefully consider which gestures are incorporated into the device where your application will be deployed and design appropriately as there may be differences between Windows, Apple, Android, and Blackberry devices. Figure 8-6 summarizes some of the more common Android touch screen hand gestures.

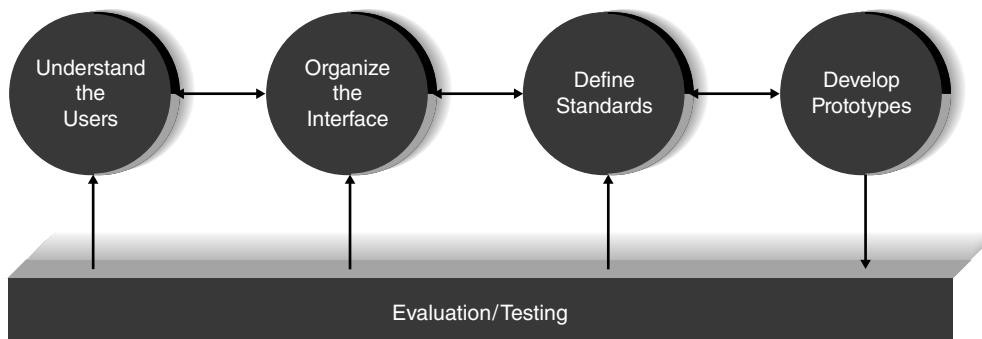
## User Interface Design Process

User interface design<sup>4</sup> is a five-component process that is iterative—analysts often move back and forth between components rather than proceed sequentially (Figure 8-7). An important starting point is to ensure that we understand the users of the system, particularly if the users are external to the organization. The analysts examine the DFDs and use cases developed in the analysis phase (see Chapter 4) to clarify the user audience. Identified user groups can be represented with **personas**. The most common usage patterns of the system are depicted with *use scenarios* so that the interface can enable users to perform these scenarios quickly and smoothly. Second, the analysts organize the interface using a variety of tools, such as the

### YOUR TURN 8-1 || Web Page Critique

Visit the Web home page for your university and navigate through several of its Web pages. Evaluate the extent to which they meet the six design principles.

<sup>4</sup>One of the best books on user interface design is Schneiderman, Plaisant, Cohen, Jacobs, and Elmquist, *Designing the User Interface: Strategies for Effective Human–Computer Interaction*, 6th ed., Boston, MA: Pearson Education, 2018.



**FIGURE 8-7**  
Interface design process.

**interface structure diagram (ISD)** and **site map**. Third, the analysts design **interface standards**, which are the basic design elements on which interfaces in the system are based. Fourth, the analysts create an **interface design prototype** for each of the individual interfaces in the system, such as navigation controls, input screens, output screens, forms (including preprinted paper forms), and reports. Prototypes can take a variety of forms, including **storyboards**, **wireframe diagrams**, **wireflow diagrams**, and more realistic models. Finally, the individual interfaces are subjected to **interface evaluation/testing** to determine whether they are satisfactory and how they can be improved.

In practice, most analysts interact closely with the users during the interface design process, so that users have many chances to see the interface as it evolves. The best advice is “test early; test often” when it comes to the user interface. For example, if the interface structure or standards need improvement, it is better to identify changes before most of the screens that use the standards have been designed. Interface evaluations almost always identify improvements, so the elements of the interface design are adjusted until no new improvements are identified.

## Understand the Users

In the days when the primary user audience for an information system was a group of relatively homogeneous employees from an organizational unit, it was easy to understand their behaviors, objectives, and expectations from the new system. Today, with many websites and mobile applications targeting an array of external user audiences, it is helpful to develop a good understanding of the distinct groups of people in that audience. Personas can be used to create descriptions of a fictional person who aggregates the common characteristics of a particular user group. By defining this person in terms of interests, typical behaviors, goals and objectives, and expectations, the analyst can plan for a user interface that will be satisfying for that user group. Although there is no set format for a persona, the simplest ones contain a fictitious name, the basic key descriptive feature, descriptive dimensions such as knowledge, tasks, interests, and characteristics, and objectives and motivations.

In the DrōnTeq Sales System, a website is used to provide detailed information about the commercial drone models offered for sale. Some site visitors want to learn about the models and options for DrōnTeq’s products. Other site visitors want to learn generally about the uses and functions of commercial drones. Figure 8-8 shows several simple personas that convey these different approaches and intentions for DrōnTeq’s drone sales-oriented website. As you read these descriptions, you will begin to understand two distinctive user groups who will want to use the DrōnTeq website in quite different ways. The site design will need to accommodate both user groups.

<b>Martin: wants to learn details about DrōnTeq's products</b>	
"I'm focused on finding the best commercial drone for my business needs."	
Knowledge:	Understands commercial drones and has specific uses and capabilities in mind for the drone purchase.
Tasks:	Arrives a site to select and configure custom drones. Wants to be able to easily identify drone models and options to meet his intended purposes. Wants to save and compare several configurations in terms of capabilities and prices.
Interests:	Has a business interest in commercial drones. Wants to find the best tool to use to fulfill business needs. Cost/benefit analysis is important.
Characteristics:	Deliberate; thoughtful; expects to be able to develop and compare alternative configurations easily and seamlessly.
<b>Jesse: wants to learn about the uses of commercial drones</b>	
"I'm intrigued by the possibilities of commercial drones and want to learn more."	
Knowledge:	Extremely limited specific knowledge of commercial drone uses and capabilities. Most likely knowledgeable about hobby-level drones. Wants to explore through examples, case studies, video clips, and owner descriptions of commercial drone applications.
Tasks:	Arrives at site and looks for video clips of drones performing commercial operations: photography, agricultural surveys, pipeline inspections, security surveillance, etc. Within each usage category, wants to discover more details through product descriptions, examples, and owner comments.
Interests:	Has a general interest in commercial drone applications and prefers to see an array of ideas and examples.
Characteristics:	Curious, open-minded; creative, exploratory. Wants to get excited by the possibilities offered by commercial-level drones.

**FIGURE 8-8** DrōnTeq Sales System personas.

A **use scenario** is an outline of the steps that the users perform to accomplish some part of their work. A use scenario is one commonly used path through a use case. Recall that use cases and DFDs (Chapter 4) may include multiple ways in which the response to the event can be completed. The DFD was designed to model all possible uses of the system—that is, its complete functionality or all possible paths through the use case. But use scenarios are just one path through the use case. In the sample use scenarios shown in Figure 8-9, we have described

Use Scenario: Focused Visitor	Use Scenario: Exploratory Visitor
<p>User wants to easily develop alternative drone configurations and compare price and performance of the alternatives</p> <ol style="list-style-type: none"> <li>1. User selects a drone base model</li> <li>2. User looks at lists of available options for that model</li> <li>3. User selects options and wants to learn price and capabilities of that configuration</li> <li>4. User saves, modifies, or discards that configuration and repeats with other options or other drones</li> <li>5. User has one or more configurations to save and consider for purchase.</li> <li>6. User may want to contact a sales representative with questions.</li> </ol>	<p>User wants to learn about applications of commercial drones through video clips and written material</p> <ol style="list-style-type: none"> <li>1. User views video clips of drones being used in commercial applications</li> <li>2. User selects an application area and views more clips in that area</li> <li>3. User reads site marketing material</li> <li>4. User reads owner descriptions and comments</li> <li>5. User repeats steps 2-4 for other commercial application areas.</li> <li>6. User views list of drone models</li> <li>7. User selects a model and reads site marketing material for that drone.</li> </ol>

**FIGURE 8-9** Two use scenarios for the DrōnTeq sales website.

**YOUR TURN 8-2** || Personas and Use Scenario Development for the Web

Visit the website for your university and navigate through several of its Web pages. Identify and describe two personas that represent the characteristics of the users of the site. Then, develop a use scenario that describes the most common site usage by each of your personas.

**YOUR TURN 8-3** || Personas and Use Scenario Development for an Automated Teller Machine

Pretend that you have been charged with the task of redesigning the interface for the ATM at your local bank. Develop two personas and two use scenarios for it.

the use scenarios for the two previously described personas. You can see by reading these use scenarios that these two users will approach the website quite differently. If you think about the tasks listed in the use scenarios corresponding to different processes on the DFD, you can visualize how the use scenarios describe different paths through the DFD. Some designers like to include DFD process numbers on each step of the use scenario to further document the usage pattern.

The key point in using use scenarios for interface design is not to document all possible use scenarios within a use case, because then you end up just repeating the DFD in a different form. The goal is to describe the handful of most commonly occurring use scenarios so that the interface can be designed to enable the most common uses to be performed simply and easily.

## Organize the Interface

The **interface structure design** defines the basic components of the interface and how they work together to provide functionality to users. An *interface structure diagram* (ISD) is used to show how all the screens, forms, and reports used by the system are related and how the user moves from one to another. Most systems have several ISDs, one for each major part of the system.

One way to draw an ISD is to draw each interface element (e.g., screen, form, report) as a box and give it a unique number (at the top) and a unique name (in the middle). The numbers usually follow a tree-type structure, although this is not always done. Unlike with DFDs, the numbers do not mean that all the screens belong to “parents” higher in the tree; instead, they usually imply relationships between a menu and a submenu. The lines denote the ability to navigate from one menu to another.

Figure 8-10 shows an example ISD for the partial DrōnTeq Shop Management system depicted in Figures 4-27 through 4-31. This portion of the Shop Management system involves determining the necessary parts needed for a shop work order, creating requests for those parts, recording receipt of parts when received in the shop, verifying receipt of all needed parts, and finalizing the work order as ready to be worked on. Each box on this diagram corresponds to the interface that will enable the user to perform the stated task(s). The numbers on the lower portion of the boxes link to processes on the system’s DFDs. Each interface is linked to other interfaces by lines that show how users can transition from one interface to the next. In most cases, the interfaces form a hierarchy, or a tree.

The basic structure of the interface follows the basic structure of the business process itself as defined in the process model. The analyst starts with the DFD and develops the fundamental

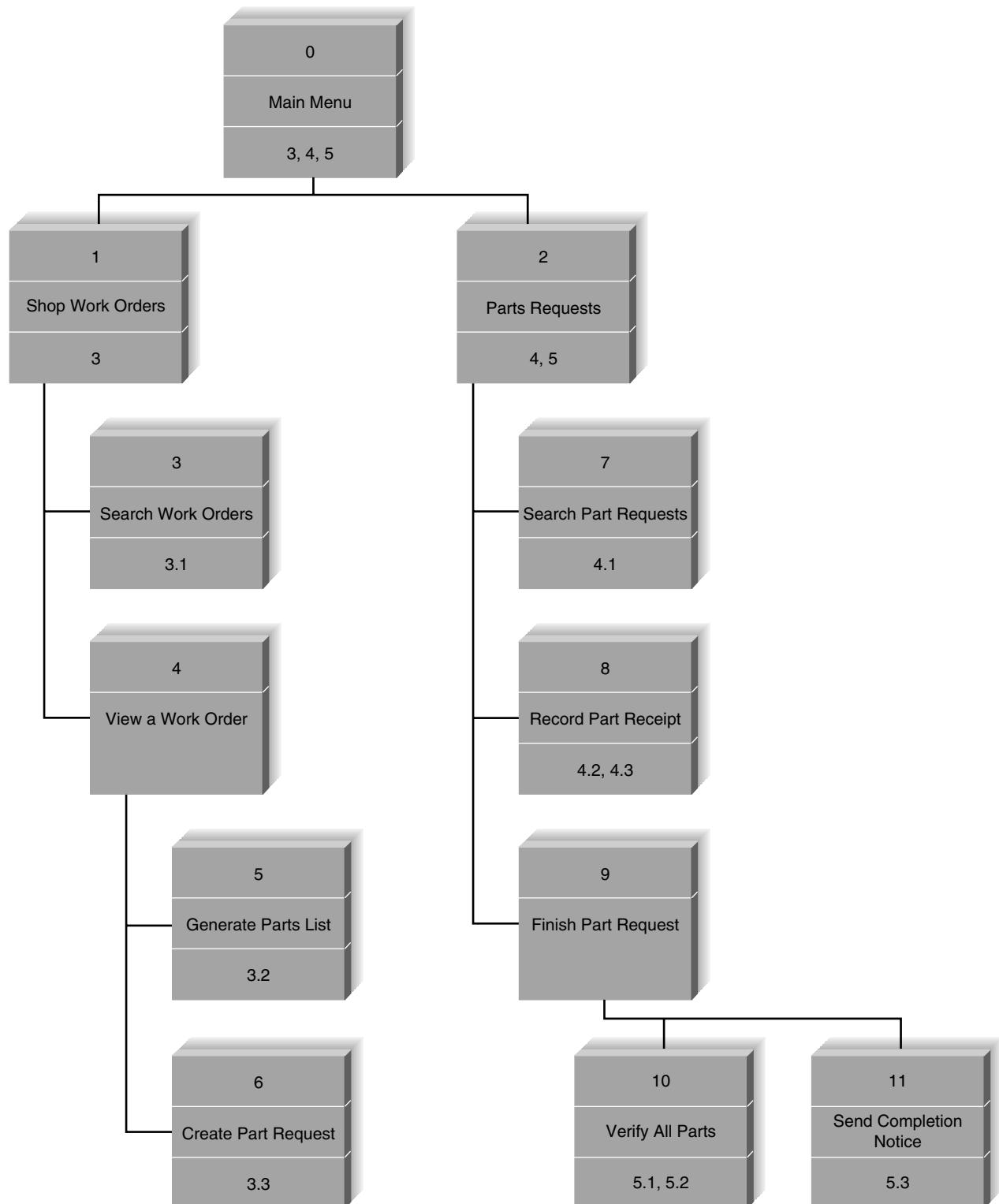


FIGURE 8-10 Shop management interface structure diagram.

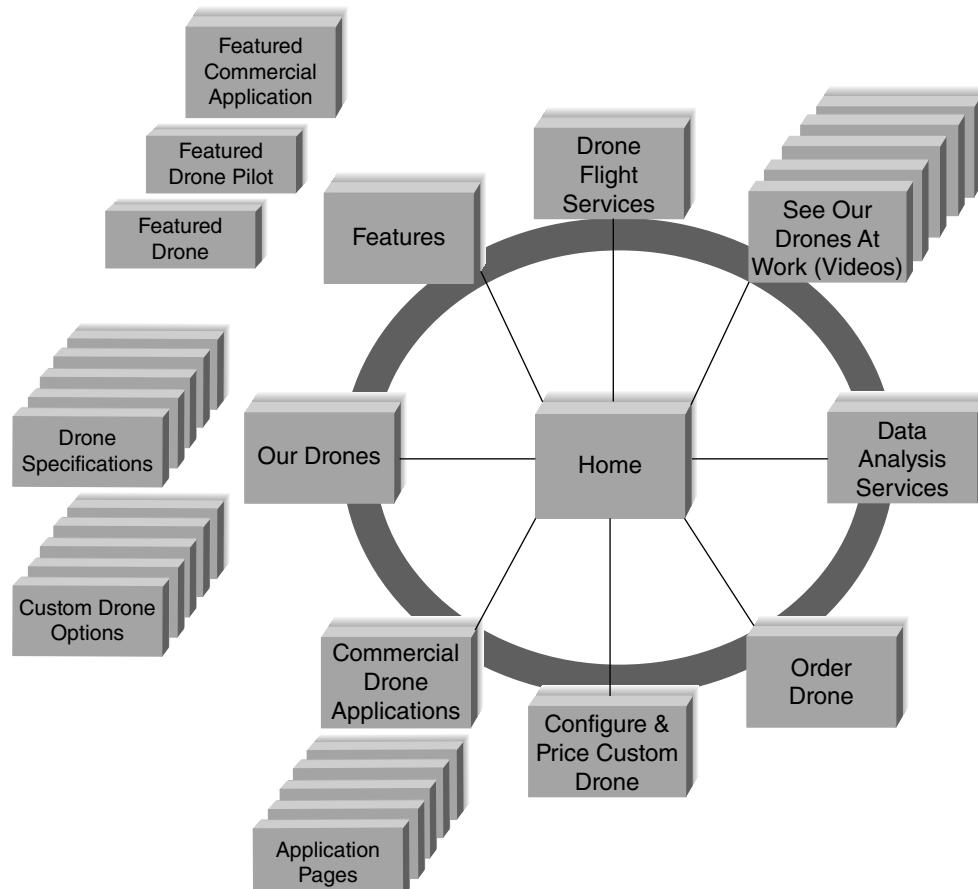
flow of control of the system as it moves from process to process. There are usually several major parts to an information system, each of them distinct, in the same way that there are several high-level processes in a DFD. In general—but not always—there is one ISD for each process on the level 0 DFD.

The analyst then examines the use scenarios to see how well the ISD supports them. Quite often, the use scenarios identify paths through the ISD that are more complicated than they should be. The analyst then reworks the ISD to simplify the ability of the interface to support the use scenarios, sometimes by making major changes to the menu structure, sometimes by adding shortcuts.

When developing a website, a *site map* can be a useful tool to organize the content. A site map helps analysts clarify how all the information on the site fits together and helps establish the hierarchy of information on the site. There is no standard format for a site map: some are drawn as a hierarchy while others look more like a network of nodes.

Figure 8-11 shows a preliminary site map for the new DrōnTeq Drone Flight Services website. The ring that surrounds the site's home page indicates the categories that are the primary structural elements of the site. These elements will always be available as the primary site navigational links.

As websites get more complex, the site map is a useful tool that conveys where the different content elements can be found. The project team should study and critique the site map carefully, imagining users coming to the site and using the structure to accomplish their goals. Imagining



**FIGURE 8-11**  
DrōnTeq site map.

the various personas using the site will help clarify if the site is usable for those personas or needs restructuring to enhance their experience.

## Define Standards

The interface standards are the basic design elements that are common across the individual screens, forms, and reports within the system. There may be several sets of interface standards for different parts of the system (e.g., one for Web screens, one for paper reports, one for input forms). The standards serve as the touchstone ensuring that the interfaces are consistent across the system.

### Interface Metaphor

The fundamental **interface metaphor(s)** is a concept from the real world that is used as a model for the information system. The metaphor helps the user to understand the system and enables the user to predict what features the interface might provide, even without actually using the system. Sometimes systems have one metaphor, whereas in other cases there are several metaphors in different parts of the system.

In some cases, the metaphor is so obvious that it requires no thought. Most e-commerce sites use the retail shopping cart as the metaphor. In other cases, the metaphor is explicit for the situation, such as money management software using a checkbook/check register metaphor, or an appointment system using a calendar metaphor. A metaphor may be hard to identify, however. In general, it is better not to force-fit a metaphor, because an ill-fitting metaphor will confuse users by promoting incorrect assumptions.

### Interface Objects and Actions

The major **interface objects** are the fundamental building blocks of the system, such as the entities and data stores. The **interface actions** are common commands that will be employed by the users. It is important to use terminology that fits the users' expectations consistently throughout the system. In many cases, the object names are straightforward, such as calling the shopping cart the "shopping cart." In other cases, it is not so simple. For example, DrōnTeq might consider calling drone users "customers," "buyers," or "users," but it chooses to use the term "pilot," a more aviation-sounding term. The object names should be easily understood and should help promote the interface metaphor. Similarly, the actions give names to essential tasks in the navigation design, such as "buy" versus "purchase," "exit" versus "quit," or "find" versus "search." In general, in cases of disagreements between the users and the analysts over names, whether for objects or actions, the users should win. A more understandable name always beats a more precise or more accurate name.

### Interface Icons

The interface objects and actions and their status (e.g., deleted, error), may be represented by **interface icons**. Icons are small pictures that will appear on command buttons as well as in forms and reports to highlight important information. Icon design is particularly challenging because it means developing a tiny simple picture that must convey an often-complex meaning. The simplest and best approach is to adopt icons developed by others (e.g., a pencil indicates "edit;" a trashcan indicates "delete"). Because users have seen them in other software, the meaning will be easily understood.

### Interface Templates

The **interface template** defines the general appearance of all interface components in the information system (screens, forms, and reports). The template design specifies the basic layout

of the screens (e.g., where the navigation area(s), status area, and form/report area(s) are placed), the color scheme(s) that will be applied, and the font styles and sizes to be used. It defines whether windows will replace one another on the screen or will cascade on top of each other. The template defines a standard placement and order for common interface actions (e.g., “File, Edit, View” rather than “File, View, Edit”). In short, the template draws together all the other major interface design elements: metaphors, objects, actions, and icons. Templates help ensure user interface consistency throughout the system.

## Interface Design Prototyping

An interface design prototype is a mock-up or a simulation of a computer screen, form, or report. A prototype is prepared for each interface in the system to show the users how the system will perform and the programmers what to develop. There are many different tools used to create prototypes, ranging from simple paper sketches to models that closely represent the final interface. Reviewing all the techniques is beyond our scope, so we focus on a few of the more common options.

### Defining the Look

A wireframe diagram is used to convey the basic content and behavior of the screens in the system (typically **Web pages**). The goal of these diagrams is to enable the developers to focus on the screen’s functionality, not on how it looks. With a wireframe diagram, we can address what types of information will be on the page and the relative priorities of that information. However, one of the challenges with wireframe diagrams is their inability to show the interactivity that is possible on the Web page (such as carousels or expanding panels). An example of a wireframe diagram for the DrōnTeq home page is shown in Figure 8-12.

### Defining the Flow

At its simplest, an interface design prototype is a paper-based *storyboard*. The storyboard shows hand-drawn pictures of what the screens will look like and how they will flow from one screen to another, in the same way that a storyboard for a cartoon shows how the action will flow from one scene to the next (Figure 8-13). Storyboards are the simplest technique because all they require is paper (often on a flip chart) and a pen—and someone with some artistic ability.

When wireframe diagrams have been developed for the screens, some analysts prefer to create wireflow diagrams—a kind of merger of the storyboard and the wireframe diagram. With this combination, you can envision the use of the screens, perhaps in a series, to accomplish an

### YOUR TURN 8-4

#### Interface Structure Design

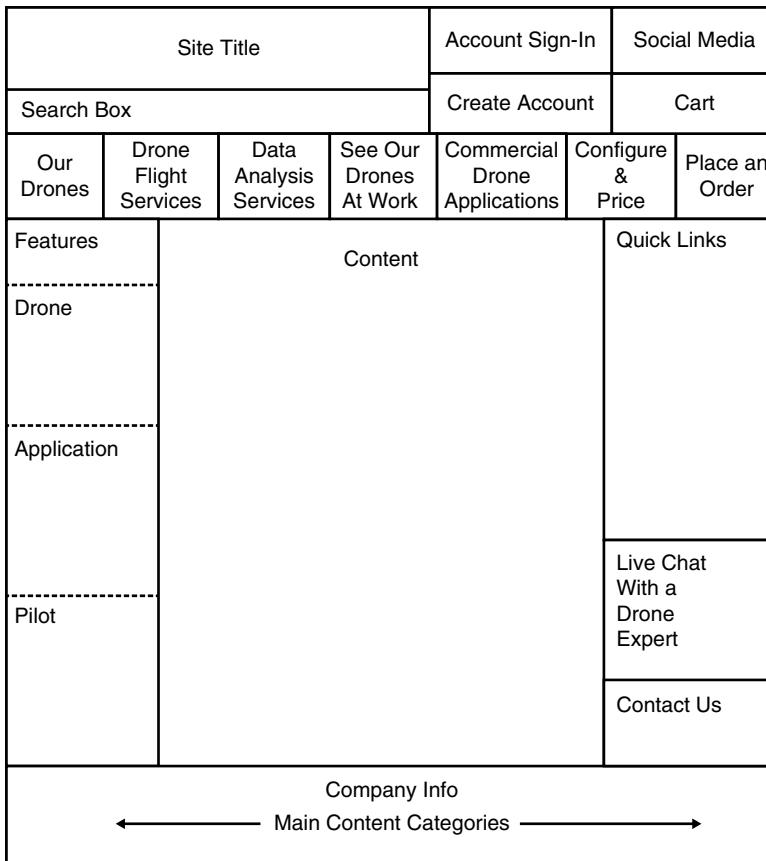
Pretend that you have been charged with the task of redesigning the interface for the ATM at your local bank. Design an ISD that shows how a user would navigate among the screens.

### YOUR TURN 8-5

#### Interface Standards Development

Pretend that you have been charged with the task of redesigning the interface for the ATM at your local bank. Develop an

interface standard that includes metaphors, objects, actions, icons, and a template.



**FIGURE 8-12**  
DrōnTeq wire-frame diagram.

overall task. Another idea is to envision a specific persona interacting with the wireflow diagram and imagining that persona's reaction to the experience.

One of the most common types of interface design prototypes used today is the **HTML prototype**. As the name suggests, an HTML prototype is built with the use of Web pages created in hypertext mark-up language (HTML). The designer uses HTML to create a series of Web pages that show the fundamental parts of the system. The users can interact with the pages by clicking on buttons and entering pretend data into forms (but because there is no system behind the pages, the data are never processed). The pages are linked together so that, as the user clicks on buttons, the requested part of the system appears. HTML prototypes are superior to storyboards in that they enable users to interact with the system and gain a better sense of how to navigate among the different screens. However, HTML has limitations—the screens shown in HTML will never appear exactly like the real screens in the system (unless, of course, the real system will be a Web system built with HTML).

Finally, a **language prototype** is an interface design prototype built in the actual language or by the actual tool that will be used to build the system. Language prototypes are designed in the same way as HTML prototypes. (They enable the user to move from screen to screen, but they perform no real processing.) For example, in Visual Basic, it is easy to create and view screens without attaching program code to the screens. See Figure 8-14 for a sample Visual Basic language prototype. Language prototypes take longer to develop than do storyboards or HTML prototypes, but they have the distinct advantage of showing exactly what the screens will look like. The user does not have to guess the shape or position of the elements on the screen.

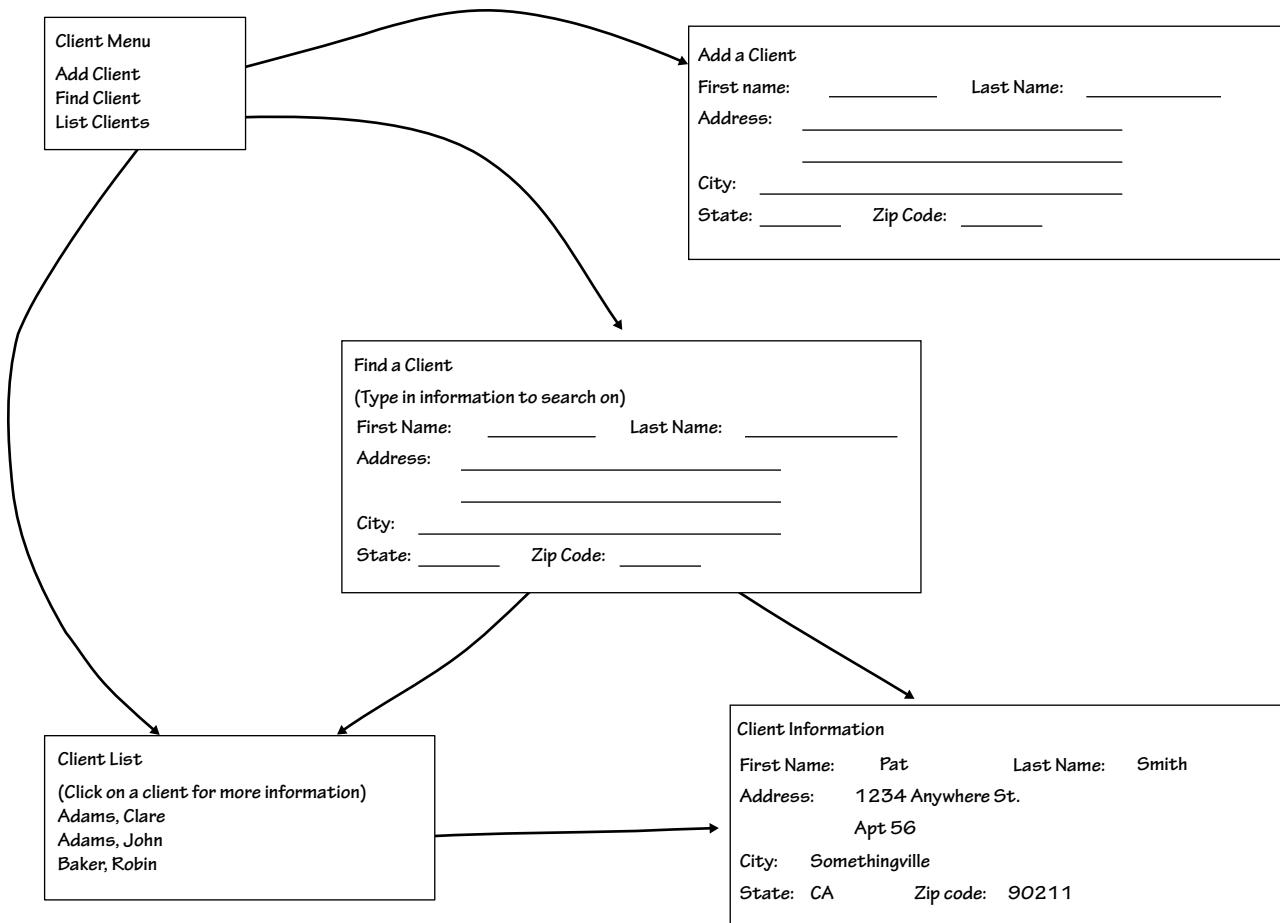


FIGURE 8-13 An example storyboard.

Projects often use a combination of different interface design prototyping techniques for different parts of the system. Storyboarding is the fastest and least expensive but provides the least amount of detail. Language prototyping is the slowest, most expensive, and most detailed approach. Wireframe diagrams, wireflow diagrams, and HTML prototyping fall between the two extremes. Therefore, storyboarding is used for parts of the system in which the interface is well understood and when more expensive prototypes are not needed. The other techniques should be used when it is necessary to understand the structure and behavior of the interface components more fully.

## Interface Evaluation/Testing

The objective of interface evaluation is to understand how to improve the interface design. Interface design is subjective; there are no formulas that guarantee a great user interface. Most interface designers intentionally or unintentionally design an interface that meets their personal preferences, which may or may not match the preferences of the users. The key message, therefore, is to have as many people as possible evaluate the interface—and the more users, the better. Most experts recommend involving at least 10 potential users in the evaluation process.

Many organizations save interface evaluation for the very last step in the SDLC before the system is installed. Ideally, however, interface evaluation should be performed while the system is being designed—before it is built—so that any major design problems can be identified and corrected before the time and cost of programming have been spent on a weak design. It is not uncommon for the system to undergo one or two major changes after the users see the first interface design prototype, because they identify problems that are overlooked by the project team.

As with interface design prototyping, interface evaluation can take many different forms, each with different costs and different levels of detail. Four common approaches are heuristic evaluation, **walk-through evaluation**, interactive evaluation, and formal usability testing. As with interface design prototyping, the different parts of a system can be evaluated by different techniques.

### Heuristic Evaluation

A **heuristic evaluation** examines the interface by comparing it to a set of heuristics, or principles, for interface design. The project team develops a checklist of interface design principles—from the list at the start of this chapter, for example, as well as the lists of principles in the navigation, input, and output design sections. At least three members of the project team then individually work through the interface design prototype, examining each interface to ensure that it satisfies each design principle on the formal checklist. After each member has gone through the prototype separately, they all meet as a team to discuss their evaluation and identify specific

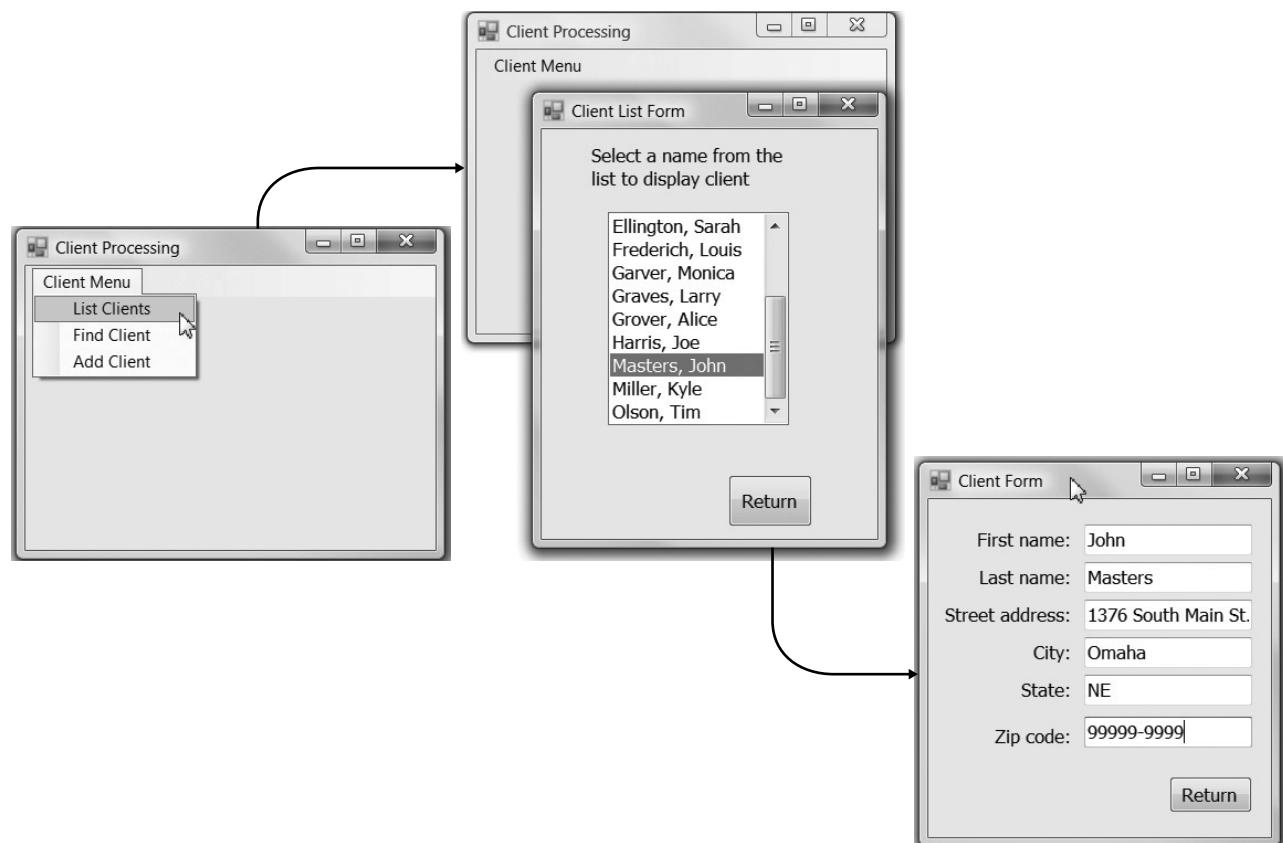


FIGURE 8-14 Sample language prototype—Part A.

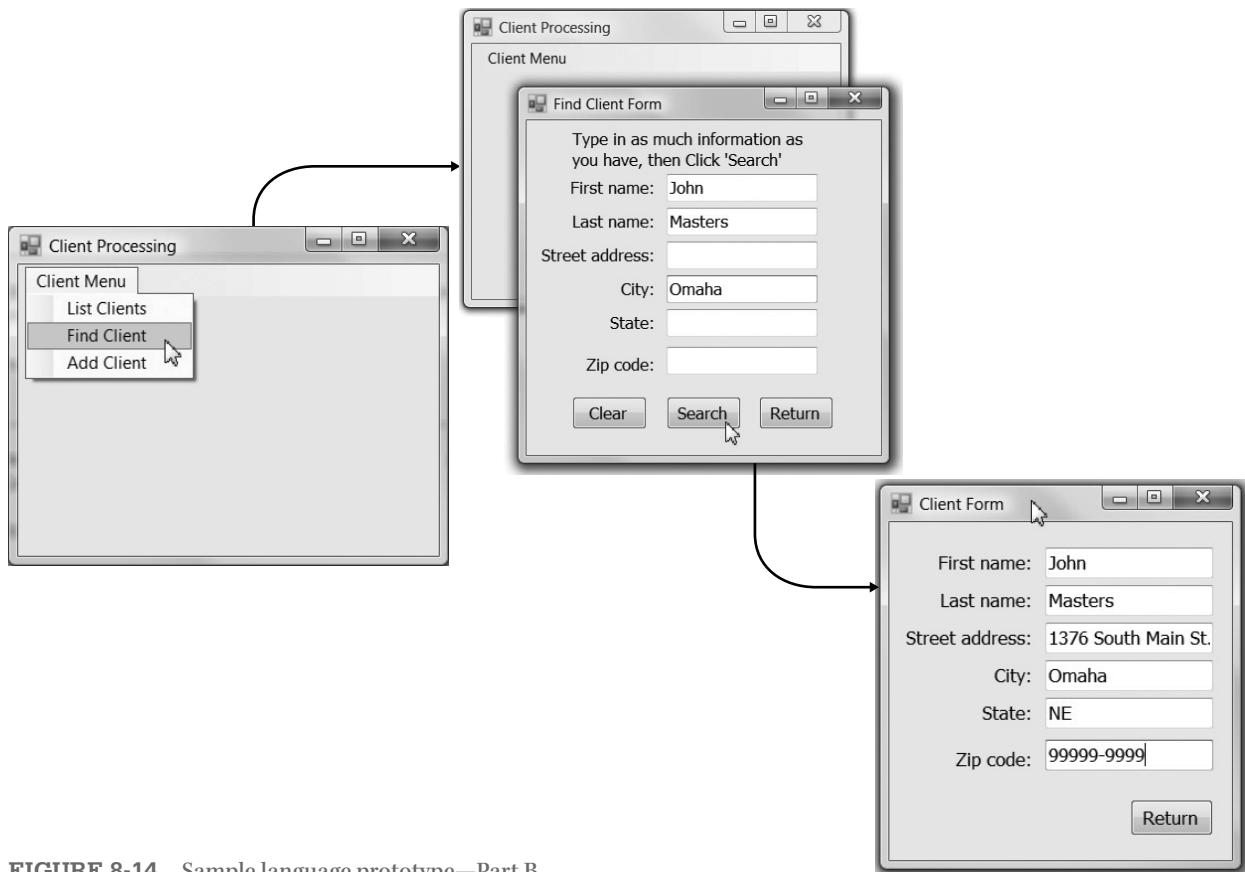


FIGURE 8-14 Sample language prototype—Part B.

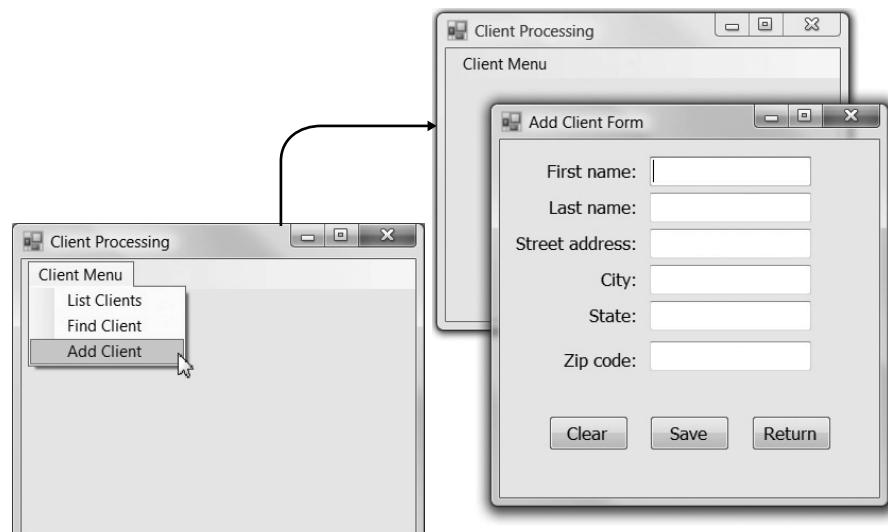


FIGURE 8-14  
Sample language  
prototype—Part C.

improvements that are required. Because this technique does not involve the users, it is considered the weakest type of evaluation.

### Walk-Through Evaluation

An interface design walk-through evaluation is a meeting conducted with the users who will ultimately have to operate the system. The project team presents the prototype to the users and walks them through the various parts of the interface. The project team shows the storyboard or demonstrates the HTML or language prototype and explains how the interface will be used. The users identify improvements to each of the interfaces that are presented.

### Interactive Evaluation

With an **interactive evaluation**, the users themselves work with the HTML or language prototype in one-on-one sessions with members of the project team. (An interactive evaluation cannot be used with a storyboard.) As the user works with the prototype (often by going through the use scenarios or just navigating at will through the system), he or she tells the project team members what he or she likes and does not like and what additional information or functionality is needed. As the user interacts with the prototype, team members record the situation when the user appears to be unsure of what to do, makes mistakes, or misinterprets the meaning of an interface component. If the pattern of uncertainty, mistakes, or misinterpretations recurs across several evaluation sessions with several users, it is a clear indication that those parts of the interface need improvement.

### Formal Usability Testing

Formal **usability testing** is commonly done with commercial software products and products developed by large organizations that will be widely used through the organization. As the name suggests, it is a very formal—almost scientific—process that can be used only with language prototypes (and systems that have been completely built and are awaiting installation or shipping).<sup>5</sup> As with interactive evaluation, usability testing is done in one-on-one sessions in which a user works directly with the software. However, it is typically done in a special lab equipped with

#### CONCEPTS IN ACTION 8-A

#### Interface Design Prototypes for a DSS Application

I was involved in the development of several DSS while working as a consultant. On one project, a future user was frustrated because he could not imagine what a DSS looked like and how one would be used. He was a key user, but the project team had a difficult time involving him in the project because of his frustration. The team used SQL Windows (one of the most popular development tools at the time) to create a language prototype that demonstrated the future systems appearance, proposed menu system, and screens (with fields, but no processing).

The team was amazed at the user's response to the prototype. He appreciated being given a context with which to visualize

the DSS, and he soon began to recommend improvements to the design and flow of the system, and to identify some important information that was overlooked during the analysis phase. Ultimately, the user became one of the strongest supporters of the system, and the project team felt sure that the prototype led to a much better product in the end.

*Barbara Wixom*

#### Questions

1. Why do you think the team chose to use a language prototype rather than a storyboard or HTML prototype?
2. What trade-offs were involved in the decision?

<sup>5</sup>A good source for usability testing is Jakob Nielsen and Robert Mack, eds. *Usability Inspection Methods*, New York: John Wiley & Sons, 1994. See also [www.useit.com/papers](http://www.useit.com/papers).

**YOUR TURN 8-6** || Prototyping and Evaluation

Pretend that you have been charged with the task of redesigning the interface for the ATM at your local bank. What type of prototyping and interface evaluation approach would you recommend?

video cameras and special software that records each keystroke and mouse operation so that they can be replayed to help in understanding exactly what the user did.

The user is given a specific set of tasks to accomplish (usually the use scenarios), and after some initial instructions the project team member(s) are not permitted to assist the user. The user must work with the software without help, which can be hard on the user if he or she becomes confused with the system. It is critical that users understand that the goal is to test the interface, not their abilities, and if they are unable to complete the task, the interface—not the user—has failed the test. Several performance measures are used, such as the time taken to complete the task, error rate, and user satisfaction.

Formal usability testing is quite expensive. Each one-user session (which typically lasts 1–2 hours) can take 1–2 days to analyze due to the volume of detail collected in the computer logs and videotapes. Most usability testing involves 5–10 users. Fewer than five users make the results depend too much on the specific individual users who participated, but more than 10 users are often too expensive to justify (unless you work for a large commercial software developer).

## Navigation Design

The navigation component of the interface enables the user to move throughout the system, perform actions, and receive feedback messages as needed. The goal of the navigation system is to make the system as simple as possible to use. A good navigation component is one that the user never really notices. It simply functions the way the user expects, and thus the user gives it little thought.

## Basic Principles

One of the hardest things about using a computer system is learning how to manipulate the navigation controls to make the system do what you want. Analysts usually must assume that users have not read the manual, have not attended training, and do not have external help readily at hand. All controls should be clear and understandable and placed in an intuitive location on the screen. Ideally, the controls should anticipate what the user will do and simplify his or her efforts. For example, after logging in to your bank's website, the first thing you would like to see is your list of accounts.

### Prevent Mistakes

The first principle of designing navigation controls is to prevent the user from making mistakes. A mistake costs time and creates frustration. Worse still, a series of mistakes can cause the user to discard the system. Mistakes can be reduced by labeling commands and actions appropriately and by limiting choices. Too many choices can confuse the user, particularly when they are similar and hard to describe in the short space available on the screen. When there are many similar choices on a menu, consider creating a second level of menu or a series of options for basic commands.

Never display a command that cannot be used. For example, many Windows applications gray-out commands that cannot be used; they are displayed on pull-down menus in a very light-colored font, but they cannot be selected. This shows that the options exist, but that they cannot be used in the current context. It also keeps all menu items in the same place.

When the user is about to perform a critical function that is difficult or impossible to undo (e.g., deleting a file), it is important to confirm the action with the user (and make sure the selection was not made by mistake). This is usually done by having the user respond to a confirmation message that explains what the user has requested and asks the user to confirm that this action is correct.

### Simplify Recovery from Mistakes

No matter what the system designer does, users will make mistakes. The system should make it as easy as possible to correct these errors. Ideally, the system will have an “Undo” button that makes mistakes easy to override; however, writing the software for such buttons can be complicated.

### Use Consistent Grammar Order

One of the most fundamental decisions is the **grammar order**. Most commands require the user to specify an object (e.g., file, record, word) and the action to be performed on that object (e.g., copy, delete). The interface can require the user to first choose the object and then the action (an **object-action order**) or first choose the action and then the object (an **action-object order**). Most Windows applications use an object-action grammar order (e.g., think about copying a block of text in your word processor).

The grammar order should be consistent throughout the system, both at the data element level and at the overall menu level. Experts debate about the advantages of one approach over the other, but because most users are familiar with the object-action order, most systems today are designed with that approach.

## Menu Tips

The most common type of navigation system today is the menu. A *menu* presents the user with a list of choices, each of which can be selected. Menus are easy to learn because the user sees an organized but limited set of choices. Clicking on an item with a pointing device or pressing **hot keys** that match the menu choice (e.g., Cntl + P) takes little effort.

Menus should be designed with care, because the submenus behind a main menu are hidden from users until they click on the menu item. It is better to make menus broad and shallow (i.e., with each menu containing many items and each item containing only one or two layers of menus) rather than narrow and deep (i.e., with each menu containing only a few items, but each item leading to three or more layers of menus). A broad and shallow menu presents the user with the most information initially, so that he or she can see many options, and requires only a few mouse clicks or keystrokes to perform an action. A narrow and deep menu makes users hunt and seek for items hidden behind menu items and requires many more clicks or keystrokes to perform an action.

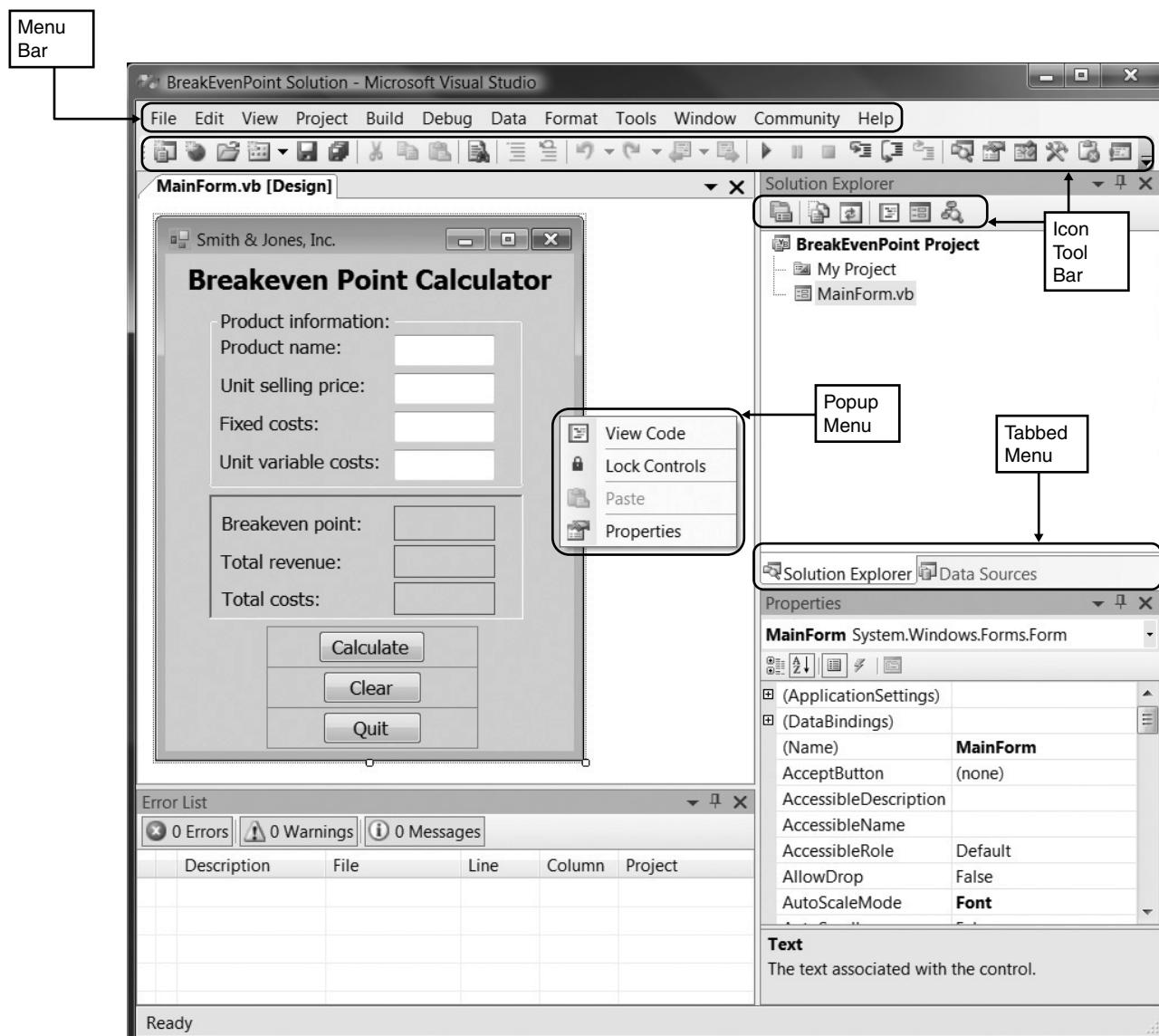
Research suggests that in an ideal world, any one menu should contain no more than eight items and it should take no more than two mouse clicks or keystrokes from any menu to perform an action (or three from the main menu that starts a system).<sup>6</sup> However, analysts sometimes must break this guideline in the design of complex systems. In this case, menu items are often grouped together and separated by a horizontal line (Figure 8-15).

<sup>6</sup>Kent L. Norman, *The Psychology of Menu Selection*. Norwood, NJ: Ablex Publishing, 1991.

**YOUR TURN 8-7** || Design a Navigation System

Design a navigation system for a form into which users must enter information about customers, products, and orders. For all three information categories, users will want to change, delete, find one specific record, and list all records.

Similar categories of items should put together within a menu option so that the user can intuitively guess what the menu option contains. Most designers recommend grouping menu items by interface objects (e.g., Customers, Purchase Orders, Inventory) rather than by interaction actions (e.g., New, Update, Format), so that all actions pertaining to one object are in one menu, all actions for another object are in a different menu, and so on. However, this is highly dependent on the specific application.



**FIGURE 8-15** Common types of menus—Part A.

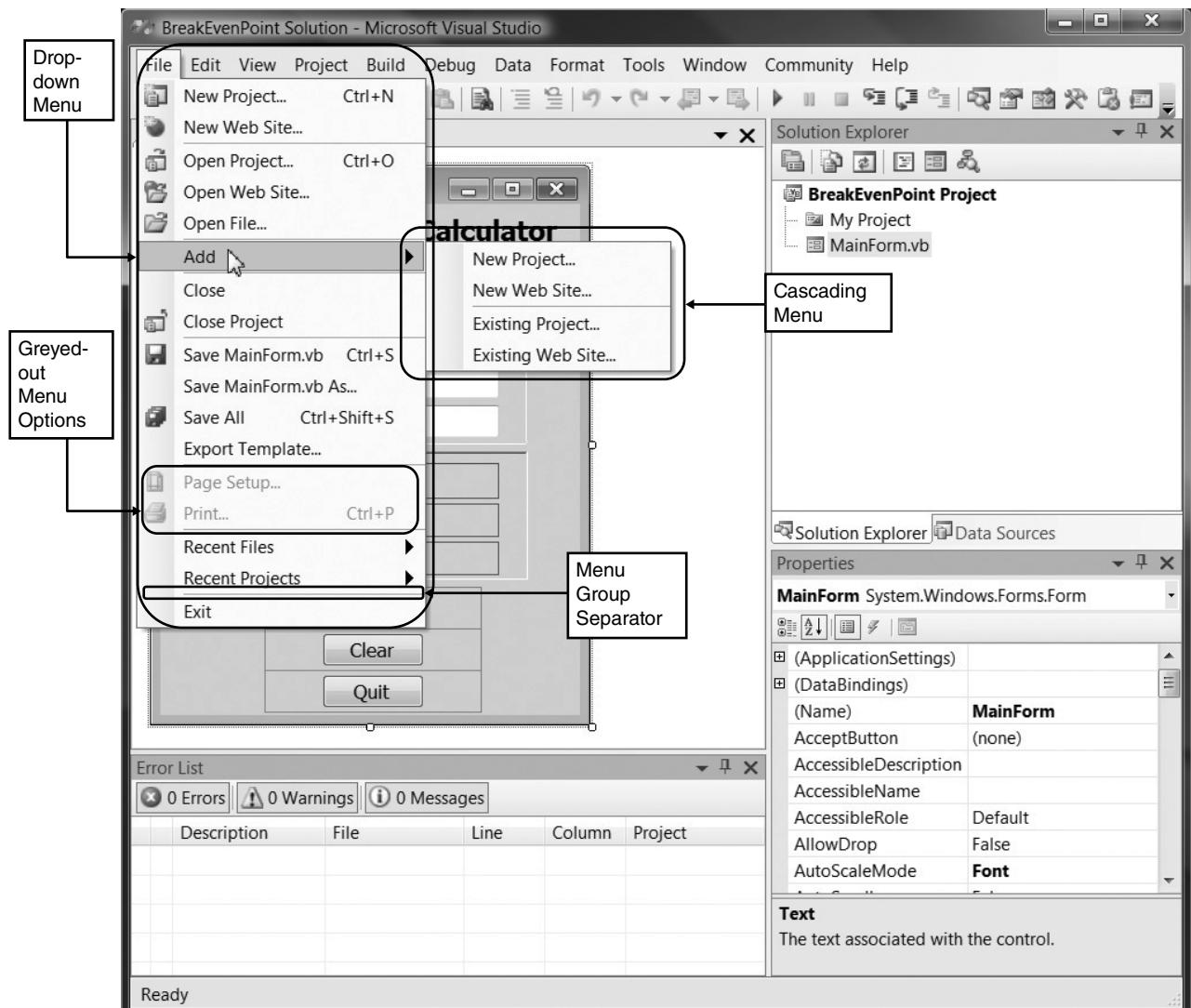


FIGURE 8-15 Common types of menus—Part B.

As Figure 8-15 shows, Microsoft Visual Studio groups menu items by interface objects (e.g., File, Project, Window) *and* by interface actions (e.g., Edit, View, Build) on the same menu. Some of the more common types of menus include **menu bars**, **drop-down menus**, **pop-up menus**, **tab menus**, **tool bars**, and **image maps**. (See Figures 8-15 and 8-16.)

As mentioned previously, Microsoft moved away from traditional menu-driven navigation when it introduced the ribbon in Office 2007. Further changes to navigation will continue as touchscreen-based applications become available. As always, our best practices will evolve as the technology we use in our systems evolves.

## Message Tips

Messages are the way in which the system responds to a user and informs him or her of the status of the interaction. There are many different types of messages, such as *error messages*,

Type of Menu	When to Use	Notes
<b>Menu Bar</b>  List of commands at the top of the screen. Always on screen.	Main menu for system	<ul style="list-style-type: none"> <li>• Use the same organization as the operating system and other packages (e.g., File, Edit, View).</li> <li>• Menu items are always one word, never two.</li> <li>• Menu items lead to other menus, rather than performing action.</li> <li>• Never allow users to select actions they cannot perform. (Instead, use grayed-out items).</li> </ul>
<b>Drop-down Menu</b>  Menu that drops down immediately below another menu. Disappears after one use.	Second-level menu, often from menu bar	<ul style="list-style-type: none"> <li>• Menu items are often multiple words.</li> <li>• Avoid abbreviations</li> <li>• Menu items perform action or lead to another cascading drop-down menu, pop-up menu, or tab menu.</li> </ul>
<b>Hyperlink Menu</b>  A set of items arranged as a menu, usually along one edge of the screen.	Main menu for Web-based system	<ul style="list-style-type: none"> <li>• Most users are familiar with hyperlink menus on the left edge of the screen, although they can be placed along any edge.</li> <li>• Menu items are usually only one or two words.</li> </ul>
<b>Embedded Hyperlinks</b>  A set of items embedded and underlined in text.	As a link to ancillary, optional information	<ul style="list-style-type: none"> <li>• Used sparingly to provide additional information, because they can complicate navigation.</li> <li>• Usually open a new window that is closed once the action is complete so that the user can return to the original use scenario.</li> </ul>
<b>Pop-up Menu</b>  Menu that pops up and floats over the screen. Disappears after one use	As a shortcut to commands for experienced users	<ul style="list-style-type: none"> <li>• Often (not always) invoked by a right click in Windows-based systems.</li> <li>• Menu choices vary depending on pointer position.</li> <li>• Often overlooked by novice users, so usually should duplicate functionality provided in other menus.</li> </ul>
<b>Tab Menu</b>  Multipage menu with one tab for each page that pops up and floats over the screen. Remains on screen until closed.	When user needs to change several settings or perform several related commands	<ul style="list-style-type: none"> <li>• Menu items should be short to fit on the tab label.</li> <li>• Avoid more than one row of tabs because clicking on a tab to open it can change the order of the tabs, and in virtually no other case does selecting from a menu rearrange the menu itself.</li> </ul>
<b>Tool Bar</b>  Menu of buttons (often with icons) that remains on the screen until closed.	As a shortcut to commands for experienced users	<ul style="list-style-type: none"> <li>• All buttons on the same tool bar should be the same size.</li> <li>• If the labels vary dramatically in size, then use two different sizes (small and large).</li> <li>• Buttons with icons should have a tool tip—an area that displays a text phrase explaining the button when the user pauses the pointer over it.</li> </ul>
<b>Image Map</b>  Graphical image in which certain areas are linked to actions or other menus.	Only when the graphical image adds meaning to the menu	<ul style="list-style-type: none"> <li>• Image should convey meaning to show which parts perform an action when clicked.</li> <li>• Tool tips can be helpful.</li> </ul>

**FIGURE 8-16** Types of menus.

**confirmation messages, acknowledgment messages, delay messages, and help messages** (Figure 8-17). In general, messages should be clear, concise, and complete, which are sometimes conflicting objectives. All messages should be grammatically correct and free of jargon and abbreviations (unless they are users' jargon and abbreviations). Avoid negatives, because they can be confusing (e.g., replace "Are you sure you do not want to continue?" with "Do you want

Type of Messages	When to Use	Notes
<b>Error message</b>  Informs the user that he or she has attempted to do something to which the system cannot respond.	When user does something that is not permitted or not possible	Always explain the reason and suggest corrective action.  Traditionally, error messages have been accompanied by a beep, but many applications now omit it or permit users to remove it.
<b>Confirmation message</b>  Asks the user to confirm that he or she really wants to perform the action selected.	When user selects a potentially dangerous choice, such as deleting a file	Always explain the cause and suggest possible action.  Often include several choices other than "OK" and "cancel."
<b>Acknowledgment message</b>  Informs the user that the system has accomplished what it was asked to do.	Seldom or never; users quickly become annoyed with all the unnecessary mouse clicks	Acknowledgment messages are typically included because novice users often like to be reassured that an action has taken place.  The best approach is to provide acknowledgment information without a separate message on which the user must click. For example, if the user is viewing items in a list and adds one, then the updated list on the screen showing the added item is sufficient acknowledgment.
<b>Delay message</b>  Informs the user that the computer system is working properly.	When an activity takes more than seven seconds	This message should permit the user to cancel the operation in case he or she does not want to wait for its completion.  The message should provide some indication of how long the delay may last.
<b>Help message</b>  Provides additional information about the system and its components.	In all systems	Help information is organized by table of contents and/or keyword search.  Context-sensitive help provides information that is dependent on what the user was doing when help was requested.  Help messages and online documentation are discussed in Chapter 11.

**FIGURE 8-17** Types of messages.

to quit?""). Likewise, avoid humor, because it wears off quickly after the same message appears dozens of times.

Messages should require the user to acknowledge them (e.g., by clicking), rather than being displayed for a few seconds and then disappearing. The exceptions are messages that inform the user of delays in processing, which should disappear once the delay has passed. In general, messages are text, but sometimes standard icons are used. For example, Windows 10 displays a revolving circle when the system is busy.

All messages should be carefully crafted, but **error messages** and help messages require particular care. Messages (and especially error messages) should always explain the problem in polite, succinct terms (e.g., what the user did incorrectly) and explain corrective action as clearly and as explicitly as possible so that the user knows exactly what needs to be done. In the case of complicated errors, the error message should display what the user entered, suggest probable causes for the error, and propose possible user responses. When in doubt, provide either more information than the user needs or the ability to get additional information. Error

messages should provide a message number. Message numbers are not intended for users, but their presence makes it simpler for those staffing help desks and customer support lines to identify problems and help users, because many messages use similar wording.

## Input Design

Input mechanisms facilitate the entry of data into the computer system, whether highly structured data, such as order information (e.g., item numbers, quantities, costs), or unstructured information (e.g., comments). Input design means designing the screens used to enter the information, as well as any forms on which users write or type information (e.g., timecards, expense claims).

## Basic Principles

The goal of input design is to capture accurate information for the system simply and easily. The fundamental principles for input design reflect the nature of the inputs (whether batch or online) and ways to simplify their collection.

### Use Online and Batch Processing Appropriately

There are two general approaches for entering inputs into a computer system: online processing and batch processing. With **online processing** (sometimes called **online transaction processing**), each input transaction is entered and processed at the time the event occurs. For example, when you make an airline reservation, the reservation system uses online processing to immediately record the transaction in the appropriate database(s). Online processing is needed when it is critical to have **real-time information** about the business process. For example, when you reserve that airline seat, the seat should not be sold to someone else, so that piece of information must be recorded immediately.

With **batch processing**, all the input transactions collected over some time period are gathered together and processed at one time in a batch. Some business processes naturally generate information in batches. For example, most hourly payroll processing uses batch processing because timecards are gathered together each pay period and processed as a batch. Batch processing also is used for transaction processing systems that do not require real-time information. For example, retail stores typically send sales information to district offices so that new replacement inventory can be ordered. This sales information could be sent in real time as it is captured in the store, so that the district offices are aware within a second or two that an item has been sold. If up-to-the-second real-time sales data is not needed, they will collect sales data throughout the day and transmit the data every evening in a batch to the district office. This batching simplifies the data communications process and often cuts communications costs. It does mean, however, that inventories are not accurate in real time, but rather are accurate only after the batch has been processed at the end of the day.

### Capture Data at the Source

Perhaps the most important principle of input design is to capture the data in an electronic format at the original source or as close to the original source as possible. Most transaction processing systems today employ **source data automation** by using special hardware devices to capture data. Stores commonly use **bar code readers** that automatically scan products and enter data directly into the computer system. No intermediate formats, such as paper forms, are used. Similar technologies include **optical character recognition**, which can read printed numbers and text (e.g., on checks); **magnetic stripe readers**, which can read information encoded on a stripe of magnetic material (e.g., credit cards); and **smart cards** that contain microprocessors, memory chips, and

batteries (much like credit card-size calculators). A recent development is the **radio frequency identification (RFID) tag**, combining a microprocessor chip with an antenna to broadcast its information to electronic readers. Information can be read from or written to the **RFID tag**. As well as reducing the time and cost of data entry, these systems reduce errors because they are far less likely to capture data incorrectly. Today, an array of portable and mobile devices allow data to be captured at the source even in remote settings (e.g., package courier deliveries, car rentals).

With the widespread use of the Web today, much data is captured directly from the customer. Consequently, the forms for capturing information on-screen should provide a logical flow and should allow the user to easily complete the forms and check their entries before submitting them. Since data entered by the user is prone to inaccuracies, validation checks (Figure 8-20) should be used whenever possible.

### Minimize Keystrokes

Another important principle is to minimize keystrokes. Keystrokes take time and are frequently incorrect. The system should never ask for information that can be obtained in another way

#### YOUR TURN 8-8

#### Career Services

Pretend that you are designing the new interface for a career services system at your university that accepts student résumés and presents them in a standard format to recruiters. Describe how you could incorporate the basic principles of input design

into your interface design. Remember to include the use of online versus batch data input, the capture of information, and plans to minimize keystrokes.

#### CONCEPTS IN ACTION 8-B

#### Public Safety Depends on a Good User Interface

Police officers in San Jose, California, experienced several problems with a new mobile dispatch system that included a Windows-based touch screen computer in every patrol car. Routine tasks were difficult to perform, and the essential call for assistance was considered needlessly complicated.

The new system, costing \$4.7 million, was an off-the-shelf system purchased from Intergraph Corp. It replaced a 14-year-old text-based system that was custom developed. Initially, the system was unstable, periodically crashing a day or two after installation and down for the next several days.

At the request of the San Jose police union, a user-interface design consulting firm was brought in to evaluate the new system. Many errors were discovered in the system, including inaccurate map information, screens cluttered with unnecessary information, difficult-to-read on-screen type, and difficult-to-perform basic tasks, such as license plate checks. In addition, the police officers themselves were not consulted about the design of the interface. Many users felt that the Windows desktop GUI with its complex hierarchical menu structure was not suitable for in-vehicle use. While driving, officers

found that the repeated taps on the screen required to complete tasks were very distracting, and one officer crashed his vehicle into a parked car because of the distraction of working with the system.

Further complicating the transition to the new system was the bare-bones training program. Just 3 hours of training were given on a desktop system, using track pads on the keyboards, not the 12-inch touch screen that would be found in the patrol cars.

After the rocky start, the software vendor worked closely with the city of San Jose to fix bugs and smooth out workflows. It seems clear, however, that the rollout could have been much easier if the officers and dispatchers had been involved in planning the system in the first place.

*Source:* “Wanted by the Police: A Good Interface,” *The New York Times*, November 11, 2004, by Katie Hafner.

#### Question

1. If you were involved in the acquisition of a new system for the police force in your community, what steps could you take to ensure the success of the project?

(e.g., by retrieving it from a database or by performing a calculation). Likewise, a system should not require a user to type information that can be selected from a list; selecting reduces errors and speeds entry. This is particularly important on small screen mobile devices, where typing can be slow and inaccurate.

In many cases, we can predict the most likely value for a field. These values should be used as the **default value** for the data so that the user can simply accept the value and not have to retype it time and time again. Examples of default values are the current date, the area code held by the majority of a company's customers, and a shipping address that is the same as the billing address. Changes to default values are made when necessary to reflect the actual data.

## Input Tips

When creating a form to enable the user to enter new data into the system, the analyst must create a form that is simple to use and ensures the most accurate data possible. Each data item that must be input is linked to a field, on the form into which its value is typed. As a rule, entry of new data using the keyboard should be kept to a minimum since mistakes are common when typing. Use selection input controls whenever possible, particularly if you are developing a small screen, touch-enabled application. Each field should have a field label, which is the text beside, above, or below the field, that tells the user what type of information belongs in the field. As you can see in Figure 8-18, there are a variety of options that can simplify and improve the accuracy of user input.

### Entering Text

When it is necessary to enter text from the keyboard, a **text box** control is used. In a non-touch-screen application, place the field label to the left of the text box; in a touch-screen application, place the label along the top of the text box. If the entry is a numeric value with a standard format, such as a phone number, apply an *input mask* to the text box.

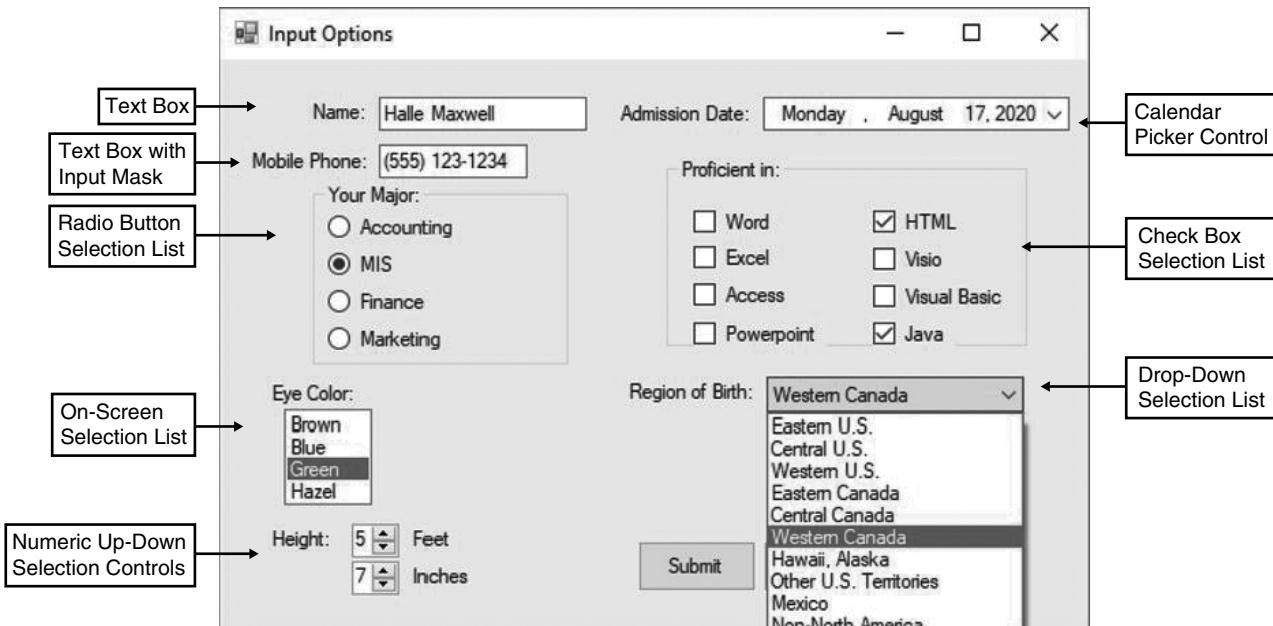


FIGURE 8-18 User input options.

## Making Selections

A variety of options are available that allow the user to manipulate the control to select the desired input value (Figure 8-19). Rather than entering a date with numbers, use a *calendar picker control* for date selection. *Numeric up-down selectors* can be used for selecting numeric values.

Selection lists come in several styles, each enabling the user to select a value or values from a predefined list. The items in the list should be arranged in some meaningful order, such as alphabetical for long lists, or in order of most frequently used. The default selection value should be chosen with care. A selection list can be initialized as “unselected” or, better still, start with the

Type of Selection Control	When to Use	Notes
<b>Check box selection list</b>  Presents a complete list of choices, each with a square box in front.	When several items can be selected from a list of items	Check boxes are not mutually exclusive.  Do not use negatives for box labels.  Check box labels should be placed in some logical order, such as that defined by the business process, or failing that, alphabetically or most commonly used first.  Use no more than 10 check boxes for any particular set of options. If you need more boxes, group them into subcategories.
<b>Radio button selection list</b>  Presents a complete list of mutually exclusive choices, each with a circle in front.	When only one item can be selected from a set of mutually exclusive items	Use no more than six radio buttons in any one list; if you need more, use a drop-down selection list.  If there are only two options, one check box is usually preferred to two radio buttons, unless the options are not clear.  Avoid placing radio buttons close to check boxes to prevent confusion between different selection lists.
<b>On-screen selection list</b>  Presents a list of choices in a box	Seldom or never—only if there is insufficient room for check boxes or radio buttons	This box can permit only one item to be selected (in which case it is an ugly version of radio buttons).  This box can also permit many items to be selected (in which case it is an ugly version of check boxes), but users often fail to realize that they can choose multiple items.  This box permits the list of items to be scrolled, thus reducing the amount of screen space needed.
<b>Drop-down selection list</b>  Displays selected item in one-line box that opens to reveal list of choices.	When there is insufficient room to display all choices	This box acts like radio buttons but is more compact.  This box hides choices from users until it is opened, which can decrease ease of use; conversely, because it shelters novice users from seldom-used choices, it can improve ease of use. This box simplifies design if the number of choices is unclear, because it takes only one line when closed.
<b>Combo box selection list</b>  A special type of drop-down list box that permits user to type as well as scroll the list.	Shortcut for experienced users	This box acts like a drop-down list but is faster for experienced users when the list of items is long.
<b>Up-down numeric control</b>  Scroll arrows move up or down through numeric range.	When entering a numeric value	Beginning and ending range values and increments can be defined.  Best for entering values with narrow value ranges, such as “Quantity Ordered.”

FIGURE 8-19 Types of selection controls.

**YOUR TURN 8-9****Career Services**

Consider a Web form that a student would use to input student information and résumé information into a career services application at your university. Sketch out how this form would

look and identify the fields that the form would include. What types of validity checks would you use to make sure that the correct information is entered into the system?

most often selected item already selected. If screen space is limited and only one item can be selected, then a **drop-down selection list** is the best choice, because not all list items need to be displayed on the screen. If the list is short, an **on-screen selection list** can be used. A **check box selection list** (for multiple selections) and **radio button selection list** (for single selections) always display all list items, thus requiring more screen space, but since they display all choices, they are often simpler for infrequent users.

## Input Validation

All data entered into the system must be validated in order to ensure accuracy. Input **validation** (also called **edit checks**) can take many forms. Ideally, to prevent invalid information from entering the system, computer systems should not accept data that fail any important validation check. However, this can be quite difficult, and invalid data often slip by the users providing the information. It is up to the system to identify invalid data and either make changes or notify someone who can resolve the information problem.

There are six different types of validation checks: **completeness check, format check, range check, check digit check, consistency check, and database check** (Figure 8-20). Every system should use at least one validation check on all entered data and, ideally, will perform all appropriate checks where possible.

## Output Design

Outputs are the reports that the system produces, whether on the screen, on paper, or in other media, such as the Web. Outputs are perhaps the most visible part of any system because a primary reason for using an information system is to access the information that it produces.

## Basic Principles

The goal of the output mechanism is to present information to users so that they can accurately understand it with the least effort. The fundamental principles for output design reflect how the outputs are used and ways to make it simpler for users to understand them.

### Understand Report Usage

The first principle in designing reports is to understand how they are used. Reports can be used for many different purposes. In some cases—but not very often—reports are read cover to cover because all information is needed. In most cases, reports are used to identify specific items or are used as references to find information, so the order in which items are sorted on the report or grouped within categories is critical. This is particularly important for the design of electronic or Web-based reports. Web reports that are intended to be read end to end should be presented in one long scrollable page, whereas reports that are primarily used to find specific information should



Type of Validation	When to Use	Notes
<b>Completeness check</b>  Ensures that all required data have been entered	When several fields must be entered before the form can be processed	If required information is missing, the form is returned unprocessed to the user.
<b>Format check</b>  Ensures that data are of the right type (e.g., numeric) and in the right format (e.g., month, day, year).	When fields are numeric or contain coded data	Ideally, numeric fields should not permit users to type text data, but if this is not possible, the entered data must be checked to ensure that it is numeric.  Some fields use special codes or formats (e.g., license plates with three letters and three numbers) that must be checked.
<b>Range check</b>  Ensures that numeric data are within correct minimum and maximum values.	With all numeric data, if possible	A range check permits only numbers between correct values.  Such a system can also be used to screen data for "reasonableness"—such as rejecting birthdates prior to 1890 because people do not live to be a great deal over 100 years old (most likely, 1990 was intended).
<b>Check digit check</b>  Check digits are added to numeric codes.	When numeric codes are used	Check digits are numbers added to a code as a way of enabling the system to quickly validate correctness. For example, US Social Security Numbers and Canadian Social Insurance Numbers assign only eight of the nine digits in the number. The ninth number—the check digit—is calculated by a mathematical formula from the first eight numbers.  When the identification number is typed into a computer system, the system uses the formula and compares the result with the check digit. If the numbers do not match, then an error has occurred.
<b>Consistency checks</b>  Ensure that combinations of data are valid.	When data are related	Data fields are often related. For example, someone's birth year should precede the year in which he or she was married.  Although it is impossible for the system to know which data are incorrect, it can report the error to the user for correction.
<b>Database checks</b>  Compare data against a database (or file) to ensure that they are correct.	When data are available to be checked	Data are compared against information in a database (or file) to ensure that they are correct. For example, before an identification number is accepted, the database is queried to ensure that the number is valid.  Because database checks are more "expensive" than the other types of checks (they require the system to do more work), most systems perform the other checks first and perform data base checks only after the data have passed the previous checks.

**FIGURE 8-20** Types of input validation.

be broken into multiple pages, each with a separate link. Page numbers and the date on which the report was prepared also are important for reference reports.

The frequency of the report may also play an important role in its design and distribution. **Real-time reports** provide data that are accurate to the second or minute at which they were produced (e.g., stock market quotes). **Batch reports** are those that report historical information that may be months, days, or hours old, and they often provide additional information beyond the reported information (e.g., totals, summaries, historical averages).

There are no inherent advantages to real-time reports over batch reports. The only advantages lie in the time value of the information. If the information in a report is time critical (e.g., stock prices, air traffic control information), then real-time reports have value. This is particularly important because real-time reports often are expensive to produce; unless they offer some clear business value, they may not be worth the extra cost.

## Manage Information Load

Most managers get too much information, not too little (i.e., the **information load** confronting the manager is too great). The goal of a well-designed report is to provide all the information

needed to support the task for which it was designed. This does not mean that the report should provide all the information available on the subject—just what the users decide they need to perform their jobs. In some cases, this may result in the production of several different reports on the same topics for the same users, because they are used in different ways. This is not bad design.

For users in Westernized countries, the most important information generally should be presented first, in the top left corner of the screen or paper report. Information should be provided in a format that is usable without modification. The user should not need to resort the report's information, highlight critical information to find it more easily amid a mass of data, or perform additional mathematical calculations.

### Minimize Bias

No analyst sets out to design a biased report. The problem with **bias** is that it can be very subtle; analysts can introduce it unintentionally. Bias can be introduced by the way in which lists of data are sorted, because entries that appear first in a list may receive more attention than those appearing later in the list. Data often are sorted in alphabetic order, making those entries starting with the letter A more prominent. Data can be sorted in chronological order (or reverse chronological order), placing more emphasis on older (or most recent) entries. Data may be sorted by numeric value, placing more emphasis on higher or lower values. For example, consider a monthly sales report by state. Should the report be listed in alphabetic order by state name, in descending order by the amount sold, or in some other order (e.g., geographic region)? There are no easy answers to this, except to say that the order of presentation should match the way in which the information is used.

Graphic displays and reports can present particularly challenging design issues.<sup>7</sup> The scale on the axes in graphs is particularly subject to bias. For most types of graphs, the scale should always begin at zero; otherwise, comparisons among values can be misleading. For example, in Figure 8-21, have sales increased by very much since 2017? The numbers in both charts are the same, but the visual images are quite different. A glance at Figure 8-21a would suggest only minor changes, whereas a glance at Figure 8-21b might suggest that there have been some significant increases. In fact, sales have increased by a total of 15% over 5 years, or 3% per year. Figure 8-21a presents the most accurate picture; Figure 8-21b is biased because the scale starts close to the lowest value in the graph and misleads the eye into inferring that there have been major changes (i.e., more than doubling from “two lines” in 2017 to “five lines” in 2022). Figure 8-21b is the default graph produced by Microsoft Excel, so be aware of how easy it is to unintentionally introduce bias in graphs.

### Types of Outputs

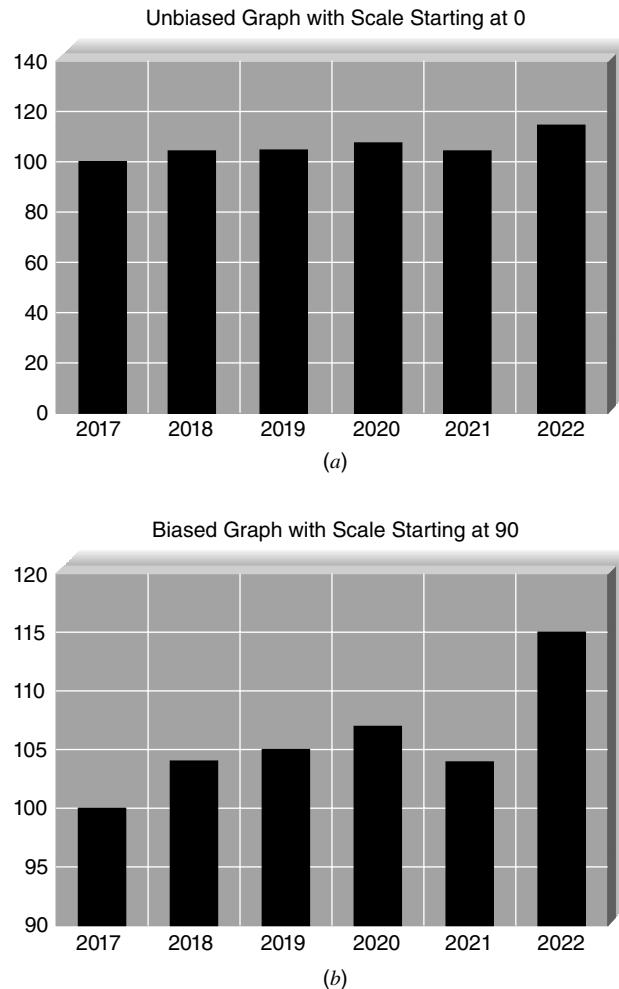
There are many different types of reports, such as **detail reports**, **summary reports**, **exception reports**, **turnaround documents**, and **graphs** (Figure 8-22). Classifying reports is challenging because many reports have characteristics of several different types. For example, some detail reports also produce summary totals, making them summary reports.

#### YOUR TURN 8-10

#### Finding Bias

Read through recent copies of a newspaper or popular press magazine such as *Time*, *Newsweek*, or *BusinessWeek* and find four graphs. How many are biased and how many are unbiased?

<sup>7</sup>Some of the best books on the design of charts and graphical displays are by Edward R. Tufte, *The Visual Display of Quantitative Information* (2001), *Envisioning Information* (1990), and *Visual Explanations* (1997), Cheshire, CT: Graphics Press. Another good book is by William Cleveland, *Visualizing Data*, Summit, NJ: Hobart Press, 1993.



**FIGURE 8-21** Bias in graphs: (a) unbiased graph with scale starting at 0; (b) biased graph with scale starting at 90.

### CONCEPTS IN ACTION 8-C

### Selecting the Wrong Students

I helped a university department develop a small decision support system to analyze and rank students who applied to a specialized program. Some of the information was numeric and could easily be processed directly by the system (e.g., grade point average, standardized test scores). Other information required the faculty to make subjective judgments among the students (e.g., extracurricular activities, work experience). The users entered their evaluations of the subjective information via several data analysis screens in which the students were listed in alphabetical order.

In order to make the system “easier to use,” the reports listing the results of the analysis were also presented in alphabetical order by student name, rather than in order from the highest

ranked student to the lowest ranked student. In a series of tests prior to installation, the users selected the wrong students to admit in 20% of the cases. They assumed, wrongly, that the students listed first were the highest ranked students and simply selected the first students on the list for admission. Neither the title on the report, nor the fact that all the students’ names were in alphabetical order made them realize that they had read the report incorrectly.

*Alan Dennis*

#### Question

1. What concerns could this problem raise about the rest of the system?

Type of Box	When to Use	Notes
<b>Detail report</b>  Lists detailed information about all the items requested.	When user needs full information about the items	This report is usually produced only in response to a query about items matching some criteria.  This report is usually read cover to cover to aid understanding of one or more items in depth.
<b>Summary report</b>  Lists summary information about all items.	When user needs brief information on many items	This report is usually produced only in response to a query about items matching some criteria, but it can be a complete database.  This report is usually read for the purpose of comparing several items with each other.
<b>Turnaround document</b>  Outputs that “turn around” and become inputs.	When a user (often a customer) needs to return an output to be processed	The order in which items are sorted is important.  Turnaround documents are a special type of report that are both outputs and inputs. For example, most bills sent to consumers (e.g., credit card bills) provide information about the total amount owed and contain a form that consumers fill in and return with payment.
<b>Graphs</b>  Charts used in addition to and instead of tables of numbers.	When users need to compare data among several items	Well-done graphs help users compare two or more items or understand how one has changed over time.  Graphs are poor at helping users recognize precise numeric values and should be replaced by or combined with tables when precision is important.  Bar charts tend to be better than tables of numbers or other types of charts when it comes to comparing values between items. (But avoid three-dimensional charts that make comparisons difficult.)  Line charts make it easier to compare values over time, whereas scatter charts make it easier to find clusters or unusual data.  Pie charts show proportions or the relative shares of a whole.

**FIGURE 8-22** Types of reports.**CONCEPTS IN ACTION 8-D** || Cutting Paper to Save Money

One of the Fortune 500 firms with which I have worked had an 18-story office building for its world headquarters. It devoted two full floors of this building to nothing more than storing “current” paper reports (a separate warehouse was maintained outside the city for “archived” reports such as tax documents). Imagine the annual cost of office space in the headquarters building tied up in these paper reports. Now imagine how a staff member would gain access to the reports, and you can quickly understand the driving force behind electronic reports,

even if most users end up printing them. Within 1 year of switching to electronic reports (for as many reports as practical) the paper report storage area was reduced to one small storage room. *Alan Dennis*

*Question*

1. What types of reports are most suited to electronic format? What types of reports are less suited to electronic reports?

**Media**

Many organizations today produce reports electronically, whereby reports are “printed,” but stored in electronic format on file servers or Web servers so that users can easily access them. Often, the reports are available in multiple predesigned formats, because the cost of producing and storing different formats is minimal. Electronic reports also can be produced on demand as needed, and they enable the user to search more easily for certain words. Furthermore, electronic

reports can provide a means to support ad hoc reports when users customize the contents of the report at the time the report is generated. Some users may still print the electronic report on their own printers. The reduced cost of electronic delivery over distance and improved user access to the reports usually offsets the cost of local printing.

## Applying the Concepts at DrōnTeq

For the DrōnTeq Flight Services system, there are three user interface components to consider. First, there will be a public website that is accessed from the Drone Flight Service link on the main DrōnTeq website (Figures 8-11 and 8-12). This website will provide detailed information about Flight Services that clients can request. It also describes how pilots can enroll in the DrōnTeq Pilot Partnership program. Second, there will be a website accessible only to registered Flight Services clients. Third, there will be a website accessible just to members of the Pilot Partnership program.

### Understand the Users

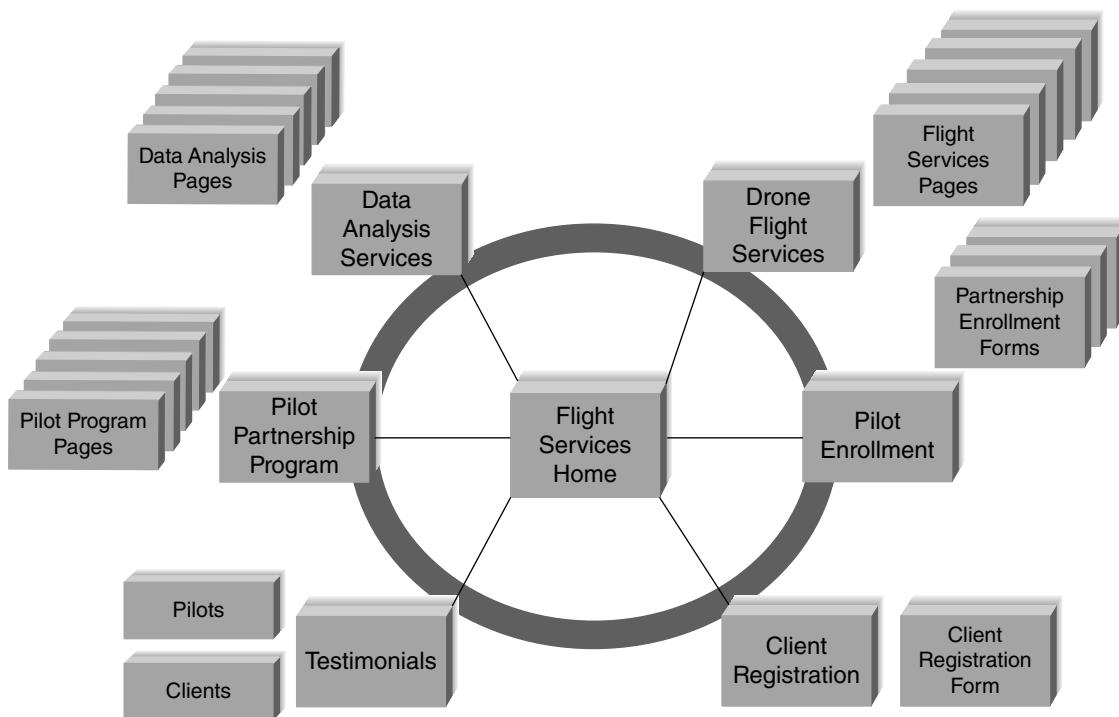
The first step in the interface design process was to develop an understanding of the users of the DrōnTeq Flight Services system. Jiang Tsiao and Carmella Herrera had several conversations about the two main user groups, clients and pilots, and how they would prefer to interact with the system. Mobility will be important for both user groups. Jiang and Carmella were unable to create distinct personas for the client users and the pilot users; however, the two user groups will have quite different needs and intentions for using the system. So, they developed several use scenarios for client users and several other use scenarios for pilot users. These use scenarios, shown in Figure 8-23, helped to clarify the most essential patterns of use for each user group.

Use Scenarios: Clients		
US-1: Create Flight Request	US-2: Check Flight Request Status	US-3: View Flight Results
1. User opens Flight Request form 2. User enters all necessary info on Flight Request form 3. User submits Flight Request form 4. User confirms submission 5. User receives submission confirmation message	1. User views list of all open Flight Requests 2. User selects one Flight Request from the list and requests status	1. User views list of completed flights 2. User selects the flight of interest 3. User specifies the result to view
Use Scenarios: Pilots		
US-1: View Open Flight Request Notifications	US-2: Place Flight Bid	US-3: Upload Flight Data
1. User requests list of all open FR Notifications 2. User selects one FRN 3. User views details of the selected FRN	1. User opens Flight Bid form 2. User selects the Flight Request Notification associated with the bid 3. Form is populated with relevant data from FRN 4. User enters flight bid data 5. User submits Flight Bid form 6. User confirms submission 7. User receives submission confirmation message	1. User requests list of all assigned Flight Requests 2. User selects the flight of interest 3. User confirms the Drone ID of the drone that made the flight 4. User initiates data upload from the drone.

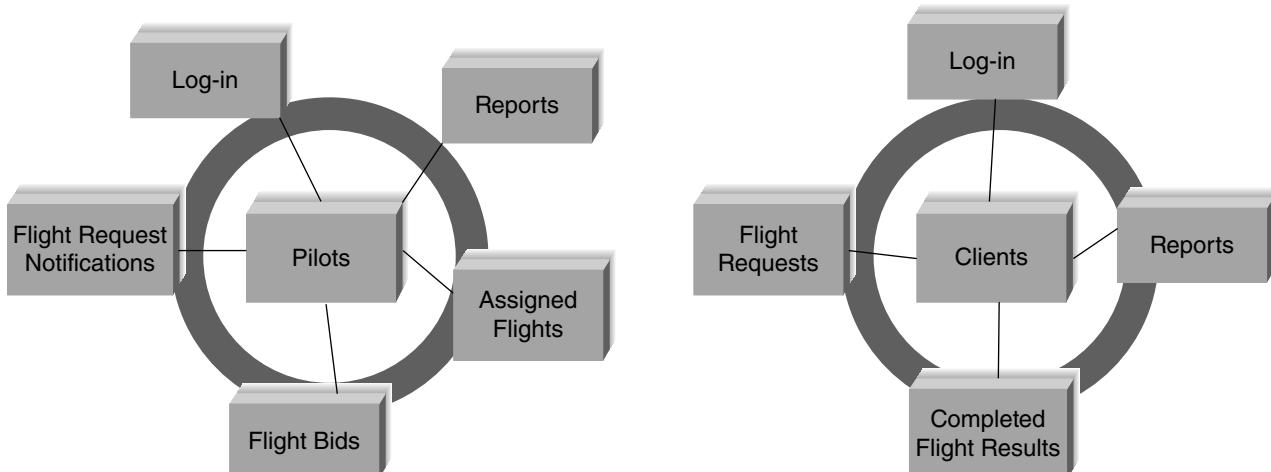
FIGURE 8-23 Client and pilot sample use scenarios.

## Organize the Interface

When visitors to the DrōnTeq main website want to learn more about DrōnTeq's Flight Services, they will click the "Drone Flight Services" link, taking them to the Flight Services public home page. Extensive information is provided on this page regarding the drone flight services and data analyses available to clients and regarding the Pilot Partnership program. Links are provided to allow clients to register and to enable pilots to enroll in the partnership program. Registered clients and enrolled pilots will be provided with links to private websites for their individual needs. Jiang developed the site maps shown in Figure 8-24 to document the structure of these websites.



**FIGURE 8-24A** Flight services home site map.



**FIGURE 8-24B** Pilot and client site maps.

To further clarify the elements of the client site and the pilot site, Jiang decided to develop interface structure diagrams for each site (Figure 8-25). Working with Carmella, he identified all the primary tasks the users would need to perform on each site. They then decided on an organizational structure for these tasks based on the key system objects. We have not shown all the processes for this system on DFDs, but the DFD process numbers have been inserted where possible.

As you review the two ISDs shown in Figure 8-25, you should be able to understand the navigation and functionality that will be provided to the users of these sites. The clients will be able to manage flight requests, access completed flight results, and view client-oriented reports. Pilots will be able to see flight request notifications, submit and manage flight bids, manage assigned flights, and view pilot-oriented reports. A new element in the pilot ISD is the direct line drawn from interface 5 (View New Flight Request Notification) to interface 7 (Submit Bid). Carmella believed that pilots would want to be able to submit a flight bid quickly after viewing a new flight request notification, so she asked for a shortcut to be added to move directly between interfaces.

Jiang then applied the use scenarios (Figure 8-23) to see how well the ISD supported those common uses of the system. He started with the client use scenarios and followed each one through the ISD, imagining what would appear on each screen and pretending to navigate through the system. He also evaluated the pilot use scenarios in a similar way. He found that the ISDs worked well, but he did make a note to clarify that clients can access the details of a flight request by either viewing all flight requests and then selecting one from the list, or by entering a specific flight request ID. A similar clarification will be needed for pilots and flight bids.

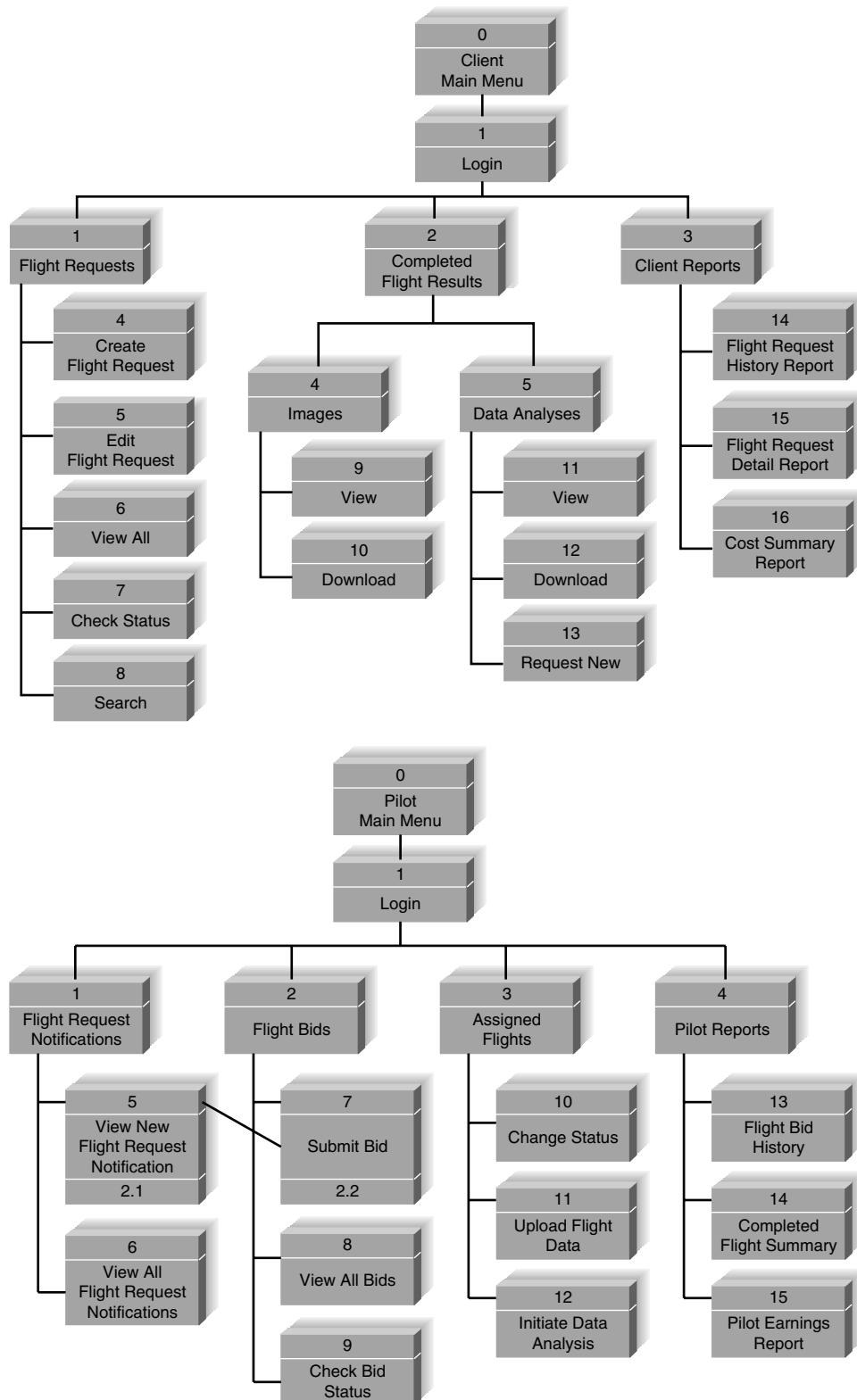
## Define Standards

Once the ISD was complete, Jiang moved on to develop the interface standards for the system. There was no specific interface metaphor to apply to any of the three websites. The Drone Flight Services public site is an informational type of site, while the client and pilot sites will be transactional in nature (entering data, viewing results and reports). The key interface objects and actions were straightforward, as was the use of the DrōnTeq logo icon (Figure 8-26).

## Interface Template Design

Jiang began the development of the template by creating the wireframe diagrams shown in Figure 8-27. Once he was comfortable with the basic organization of three sites, he began work on the interface template. For the interface templates, Jiang decided that the main Drone Flight Services page needed to be heavily based on graphical images and video clips to convey the power and utility of drone applications. He obtained permission from Carmella to contract out the design of this site to the Web design company that had designed the main DrōnTeq website.

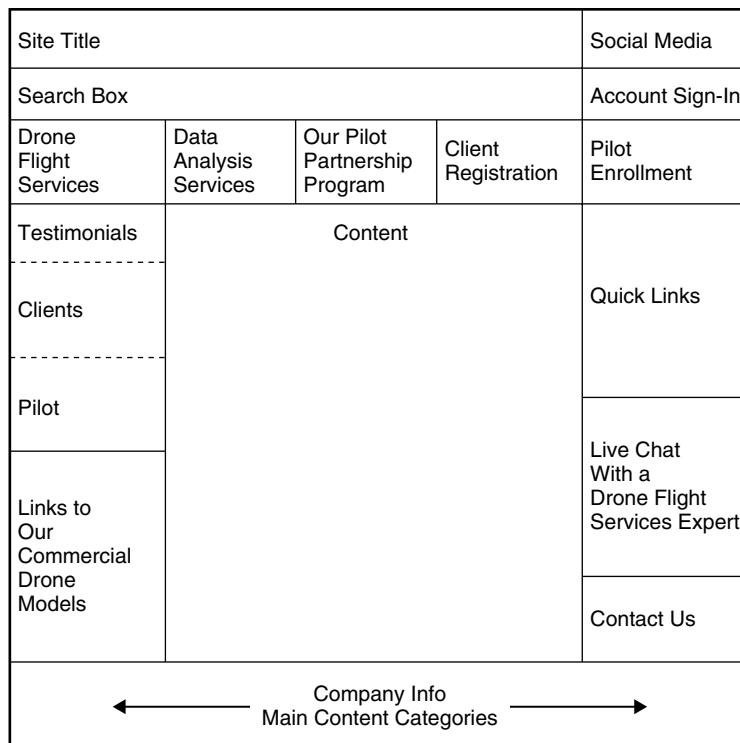
For the Client and Pilot websites (Figure 8-28), he settled on a simple, clean design that had the DrōnTeq logo in the upper left corner. The template featured the main navigation menu across the top in a format that should be suitable for mouse or touch-screen interaction. He created an area on the side for quick links and plans to consult with Carmella to ensure he has included the most useful links for each user. A button to chat with a Flight Services expert is included on each site to facilitate user support. This is particularly important since this is a new business and user support is essential to maintain client and pilot satisfaction. The center area of the screen is used for displaying forms and reports when the appropriate link is clicked.



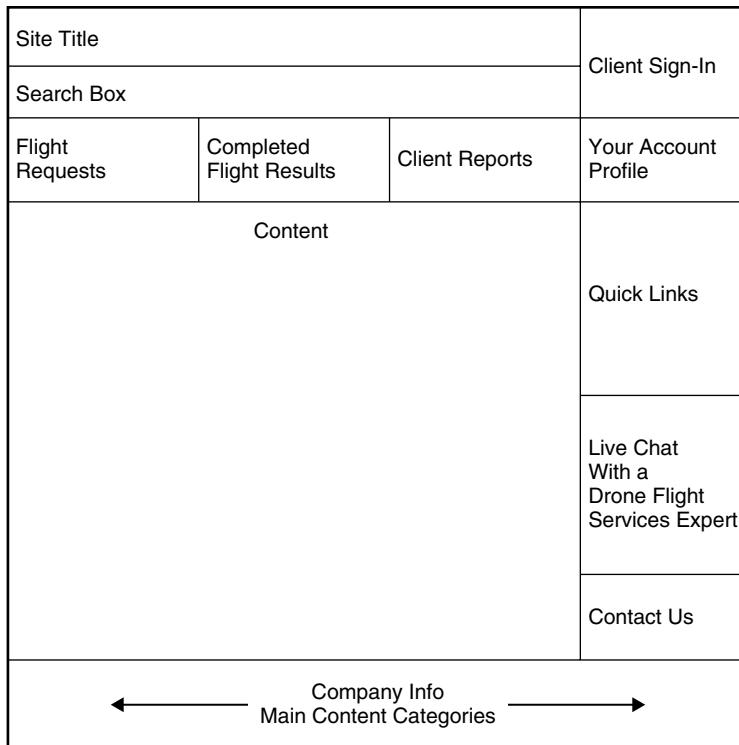
**FIGURE 8-25** Interface structure diagrams for client and pilot websites.

**Interface Metaphor: none****Interface Objects****Flight Request:** Client's request for a drone flight**Flight Request Notification:** Notice sent to selected pilots about a new client flight request**Flight Bid:** Pilot's bid on a specific client flight request**Assigned Flight:** A flight request that has been assigned to a specific pilot to perform the flight**Client:** Person or company registered with DrōnTeq and authorized to submit requests for drone flights**Pilot:** Qualified commercial drone pilot enrolled in the DrōnTeq Pilot Partnership program**Drone:** Commercial drone utilized in a drone flight**Drone Flight:** A specific flight performed in response to a client flight request**Visible Images:** Individual images or video clips made during a drone flight made by drone camera**Infrared Images:** Infrared sensor data acquired during a drone flight by a drone infrared sensor**Data Analysis:** A specific analysis of data produced by on-board drone sensors during a drone flight**Interface Actions****View:** See a list or a specific flight request or flight bid or assigned flights**Submit:** Enter new data into the system as a flight request or a flight bid**Upload:** Transfer drone sensor data to DrōnTeq's servers following completion of a drone flight**Download:** Transfer data to client's computer**Interface Icons****DrōnTeq** company logo will appear on all screens

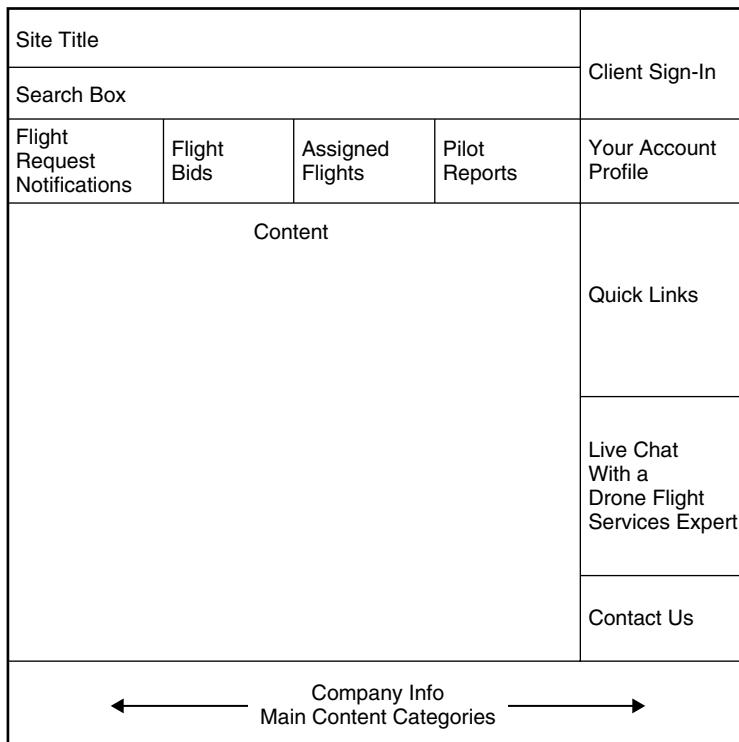
**FIGURE 8-26**  
DrōnTeq drone flight services interface standards.



**FIGURE 8-27A**  
Wireframe diagram for flight services website.

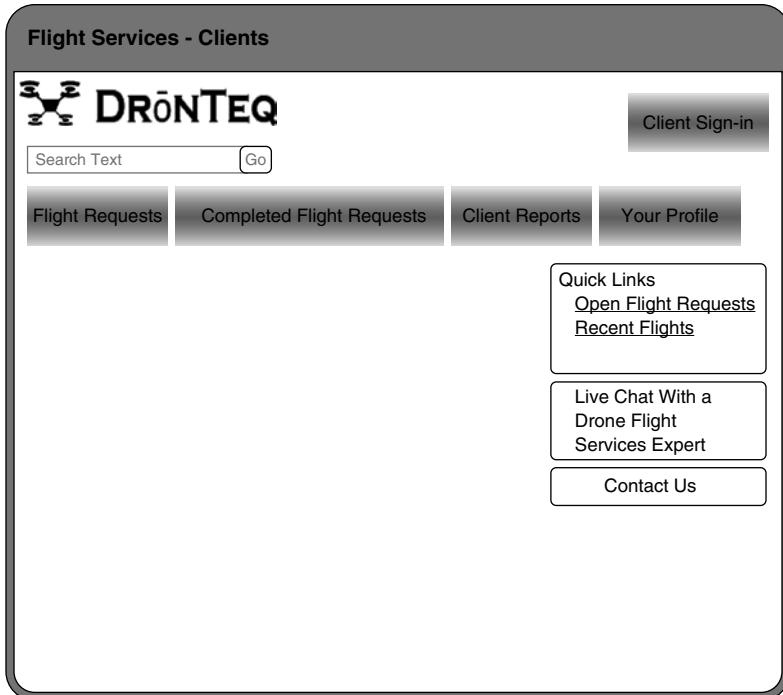


**FIGURE 8-27B**  
Wireframe diagram for  
client website.

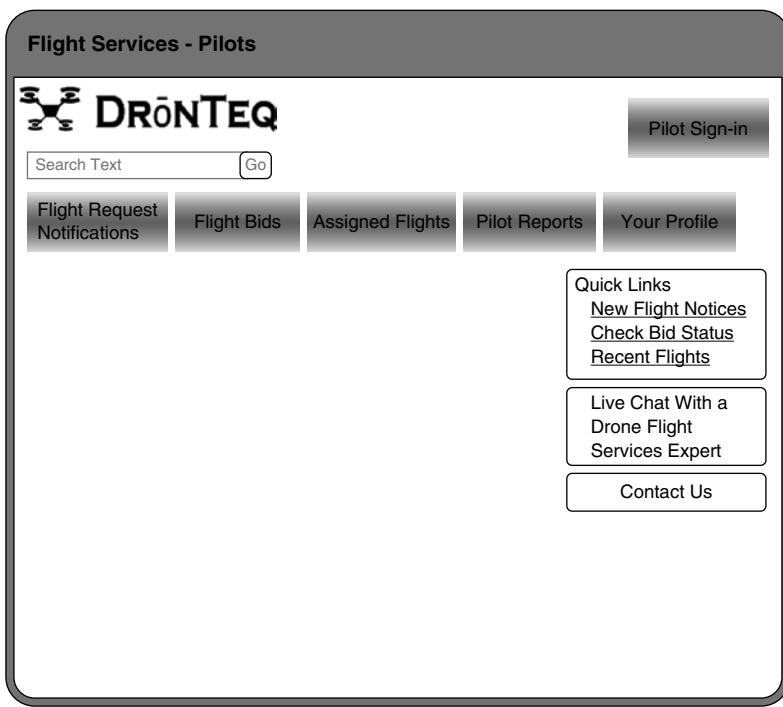


**FIGURE 8-27C**  
Wireframe diagram for  
pilot website.

**FIGURE 8-27** Wireframe diagrams for drone flight services websites.



**FIGURE 8-28A**  
Template diagram for client website.



**FIGURE 8-28B**  
Template diagram for pilot website.

**FIGURE 8-28** Design templates for flight services client and pilot sites.

At this point, Jiang decided to seek some quick feedback on the interface structure and standards before investing time in prototyping the interface designs. Therefore, he met with Carmella Herrera, the project sponsor, to discuss the emerging design. Making changes at this point would be much simpler than waiting until after doing the prototype. Carmella had a few suggestions; so, after the meeting, Jiang made the changes and moved into the design prototyping step.

## Develop Prototypes

Jiang decided to use Visio to create prototypes of the system. The Drone Flight Services system was new territory for DrōnTeq and a strategic investment in a new business model, so it was important to make sure that no key issues were overlooked. The prototypes would provide the most detailed information and could be developed rapidly. Once satisfied with the layout, Jiang planned to create HTML prototypes that could be used to test the interface interactively.

Jiang began designing the prototype and gradually worked his way through all the screens. The process was very iterative, and he made many changes to the screens as he worked. Once he had an initial prototype designed, he shared it with other members of the development team and solicited comments. He revised it according to the comments he received. Once the page designs were completed in Visio, Jiang assigned several team members to begin building the HTML prototype for final evaluation. Figure 8-29 presents an example screen from the prototype.

The screenshot shows a user interface for a flight request entry form. At the top, there is a header bar with the title "Flight Services - Clients". Below the header is a logo for "DRōNTEQ" featuring a stylized drone icon. To the right of the logo is a "Client Sign-in" button. The main content area contains several input fields and buttons. At the top of this section are five buttons: "Flight Requests", "Completed Flight Requests", "Client Reports", "Your Profile", "Create New" (which is highlighted in white), "Edit", "View All", "Check Status", and "Search". Below these buttons are two text input fields: "Flight Request Number: 22-00125" and "Flight Request Date: 04/25/2022". The form is divided into several sections: "Desired Flight Schedule:" with "Date:" and "Time:" inputs; "Desired Flight Location:" with "Latitude:" and "Longitude:" inputs; "Flight Pattern:" with options for "Circumference", "Parallel Passes by Length", and "Parallel Passes by Width"; "Flight Area Dimensions:" with a "W x L" input; "Imaging Types:" with checkboxes for "Visible Camera Frames", "Visible Camera Video", and "Infrared Sensor Stream"; and "Submit Request" and "Cancel Request" buttons at the bottom right. At the very bottom of the form are two links: "Live Chat With a Drone Flight Services Expert" and "Contact Us".

**FIGURE 8-29**  
Prototype of new flight  
request entry form.

## Interface Evaluation/Testing

The next step was interface evaluation. Jiang decided on a two-phase evaluation. The first evaluation was to be an interactive one conducted by Carmella Herrera and members of her management team. They worked hands-on with the prototype and identified several ways to improve it. Jiang modified the HTML prototype to reflect the changes suggested by the group and asked Carmella to review it again.

The second evaluation was again interactive, this time performed by a two focus groups of potential clients and prospective pilots. Once again, several minor changes were identified. Jiang again modified the HTML prototype and asked Carmella to review it once more. When she was satisfied, the interface design was complete.

### CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Identify and describe the five basic rules of user interface design.
- Describe the concept of usability with respect to a system's user interface. Why is this concept important to the interface designer?
- Explain three unique aspects of designing for a touch screen user interface.
- Discuss the five components of the user interface design process.
- Explain the unique issues associated with design of the system's navigation mechanism.
- Discuss ways to improve the quality of input data captured by the system.
- Explain the best ways to produce output from the system.

### KEY TERMS

Acknowledgment message	Error message	Interface standards	Site map
Action-object order	Exception report	Interface structure design	Smart card
Aesthetics	Field label	Interface structure diagram (ISD)	Source data automation
Bar code reader	Fields	Interface template	Storyboard
Batch processing	Form	Language prototype	Summary report
Batch reports	Format check	Layout	System interface
Bias	Grammar order	Magnetic stripe readers	Tab menu
Breadcrumbs	Graph	Menu	Text box
Button	Graphical user interface (GUI)	Menu bar	Three-clicks rule
Check box selection list	Help message	Navigation mechanism	Tool tip
Check digit check	Heuristic evaluation	Object-action order	Transaction processing
Completeness check	Hot keys	Online processing	Turnaround document
Confirmation message	HTML prototype	On-screen selection list	Usability
Consistency	Human-computer interaction (HCI)	Optical character recognition	Usability testing
Consistency check	Image map	Output mechanism	Usage level
Content awareness	Information load	Personas	Use scenario
Database check	Input mechanism	Pop-up menu	User experience (UX)
Default value	Interactive evaluation	Radio button selection list	User interface
Delay message	Interface action	Radio frequency identification (RFID) tag	Validation
Density	Interface design prototype	Range check	Walk-through evaluation
Detail report	Interface evaluation	Real-time information	Web pages
Drop-down menu	Interface icon	Real-time reports	White space
Drop-down selection list	Interface metaphor	Report	Wireflow diagram
Ease of learning	Interface object	Screen	Wireframe diagram
Ease of use			
Edit check			

**QUESTIONS**

1. Explain three important user interface design principles.
2. What are three fundamental parts of most user interfaces?
3. Why is content awareness important?
4. What is white space, and why is it important?
5. Under what circumstances should densities be low? High?
6. How can a system be designed to be used by both experienced and first-time users?
7. Why is consistency in design important? Why can too much consistency cause problems?
8. How can different parts of the interface be consistent?
9. Describe the basic process of user interface design.
10. What are personas and use scenarios, and why are they important?
11. What is a site map and an interface structure diagram (ISD), and why are they used?
12. Why are interface standards important?
13. Explain the purpose and contents of interface metaphors, interface objects, interface actions, interface icons, and interface templates.
14. Why do we prototype the user interface design?
15. Compare and contrast the three types of interface design prototypes.
16. Why is it important to perform an interface evaluation before the system is built?
17. Compare and contrast the four types of interface evaluation.
18. Under what conditions is heuristic evaluation justified?
19. What type of interface evaluation did you perform in the “Your Turn 8-1”?
20. Describe three basic principles of navigation design.
21. How can you prevent mistakes?
22. Explain the differences between object-action order and action-object order.
23. Describe four types of navigation controls.
24. Why are menus the most common navigation control?
25. Compare and contrast four types of menus.
26. Under what circumstances would you use a drop-down menu versus a tab menu?
27. Describe five types of messages.
28. What are the key factors in designing an error message?
29. What is context-sensitive help? Does your word processor have context-sensitive help?
30. Explain three principles in the design of inputs.
31. Compare and contrast batch processing and online processing. Describe one application that would use batch processing and one that would use online processing.
32. Why is capturing data at the source important?
33. Describe four devices that can be used for source data automation.
34. Describe five types of inputs.
35. Compare and contrast check boxes and radio buttons. When would you use one versus the other?
36. Compare and contrast on-screen selection list boxes and drop-down selection list boxes. When would you use one versus the other?
37. Why is input validation important?
38. Describe five types of input validation methods.
39. Explain three principles in the design of outputs.
40. Describe five types of outputs.
41. When would you use electronic reports rather than paper reports and vice versa?
42. What do you think are three common mistakes that novice analysts make in interface design?
43. How would you improve the form in Figure 8-4?
44. Discuss three issues unique to developing touch screen user interfaces.

**EXERCISES**

- A. Develop two personas and two use scenarios for a website that sells some retail products (e.g., books, music, clothes).
- B. Draw a site map and an ISD for a website that sells some retail products (e.g., books, music, clothes).
- C. Describe the primary components of the interface standards for a website that sells some retail products (metaphors, objects, actions, icons, and templates).
- D. Develop two use scenarios for the DFD in Exercise F in Chapter 4.
- E. Draw an ISD for the DFD in Exercise F in Chapter 4.
- F. Develop the interface standards (omitting the interface template) for the DFD in Exercise F in Chapter 4.
- G. Develop two use scenarios for the DFD in Exercise J in Chapter 4.
- H. Develop the interface standards (omitting the interface template) for the DFD in Exercise J in Chapter 4.
- I. Design an interface template for Exercise J in Chapter 4.

- J. Draw an ISD for the DFD in Exercise J in Chapter 4.
  - K. Design a storyboard for Exercise J in Chapter 4.
  - L. Develop an HTML prototype for Exercise E in this chapter.
  - M. Develop an HTML prototype for Exercise J in this chapter.
  - N. Develop the interface standards (omitting the interface template) for the DFD in Exercise L in Chapter 4.
  - O. Draw an ISD for the DFD in Exercise L in Chapter 4.
  - P. Design a storyboard for Exercise L in Chapter 4.
  - Q. Develop two use scenarios for the DFD in Exercise L in Chapter 4.
- 
- R. Ask ([www.ask.com](http://www.ask.com)) is an Internet search engine that uses natural language. Experiment with it and compare it with search engines that use key words.
  - S. Draw an ISD for “Your Turn 8-7,” using the opposite grammar order from your original design. (If you didn’t do the “Your Turn” exercise, draw two ISDs, one in each grammar order.) Which is “best”? Why?
  - T. Search the Internet for information on “Responsive Design.” Briefly summarize the meaning of this term and how it affects user interface design.

## MINICASES

1. Tots to Teens is a catalog retailer specializing in children’s clothing. A project has been underway to develop a new order-entry system for the company’s catalog clerks. The old system had a character-based user interface that corresponded to the system’s COBOL underpinnings. The new system will feature a graphical user interface more in keeping with up-to-date PC products in use today. The company hopes that this new user interface will help reduce the turnover they have experienced with their order-entry clerks. Many newly hired order entry staff found the old system quite difficult to learn and were overwhelmed by the numerous mysterious codes that had to be used to communicate with the system.

A user interface walk-through evaluation was scheduled for today to give the users a first look at the new system’s interface. The project team was careful to invite several key users from the order-entry department. Norma was included specifically because of her years of experience with the order-entry system. Norma was known to be an informal leader in the department; her opinion influenced many of her associates. Norma had let it be known that she was less than thrilled with the ideas she had heard for the new system. Due to her experience and good memory, Norma worked very effectively with the character-based system and was able to breeze through even the most convoluted transactions with ease. Norma had trouble suppressing a sneer when she heard talk of such things as “icons” and “buttons” in the new user interface.

Cindy was also invited to the walk-through because of her influence in the order-entry department. Cindy has been with the department for just 1 year, but she quickly became known because of her successful organization of a sick-child day-care service for the children of the department workers. Sick children are the number-one cause of absenteeism in the department, and

many of the workers could not afford to miss workdays. Never one to keep quiet when a situation needed improvement, Cindy has been a vocal supporter of the new system.

- a. Drawing upon the design principles presented in the text, describe the features of the user interface that will be most important to experienced users like Norma.
  - b. Drawing upon the design principles presented in the text, describe the features of the user interface that will be most important to novice users like Cindy.
2. The members of a systems development project team have gone out for lunch together, and as often happens, the conversation has turned to work. The team has been working on the development of the user interface design, and so far, work has been progressing smoothly. The team should be completing work on the interface prototypes early next week. A combination of storyboards and language prototypes has been used in this project. The storyboards depict the overall structure and flow of the system, but the team developed language prototypes of the actual screens because they felt that seeing the actual screens would be valuable for the users.

Chris (the youngest member of the project team): *I read an article last night about a really cool way to evaluate a user interface design. It’s called usability testing, and it’s done by all the major software vendors. I think we should use it to evaluate our interface design.*

Heather (system analyst): *I’ve heard of that, too, but isn’t it really expensive?*

Mark (project manager): *I’m afraid it is expensive, and I’m not sure we can justify the expense for this project.*

Chris: *But we really need to know that the interface works. I thought this usability testing technique would help us prove we have a good design.*

Amy (systems analyst): *It would, Chris, but there are other ways, too. I assumed we'd do a thorough walkthrough with our users and present the interface to them at a meeting. We can project each interface screen so that the users can see it and give us their reaction. This is probably the most efficient way to get the users' response to our work.*

Heather: *That's true, but I'd sure like to see the users sit down and work with the system. I've always learned a lot by watching what they do, seeing where they get confused, and hearing their comments and feedback.*

Ryan (systems analyst): *It seems to me that we've put so much work into this interface design that all we really need to do is review it ourselves. Let's just make a list of the design principles we're most concerned about and check it ourselves to make sure we've followed them consistently. If we have, we should be fine. We want to get moving on the implementation, you know.*

Mark: *These are all good ideas. It seems like we've all got a different view of how to evaluate the interface design. Let's try and sort out the technique that is best for our project.*

Develop a set of guidelines that can help a project team like the one discussed here select the most appropriate interface evaluation technique for their project.

3. The menu structure for Holiday Travel Vehicle's existing character-based system is shown here. Develop and prototype a new interface design for the system's functions, using a graphical user interface. Assume that the new system will need to include the same functions as those shown in the menus provided. Include any messages that will be produced as a user interacts with your interface (error, confirmation, status, etc.). Also, prepare a written summary that describes how your interface implements the principles of good interface design as presented in the textbook.

#### Holiday Travel Vehicles

##### Main Menu

1. Sales Invoice
2. Vehicle Inventory
3. Reports
4. Sales Staff

Type number of menu selection here:\_\_\_\_\_

#### Holiday Travel Vehicles

##### Sales Invoice Menu

1. Create Sales Invoice
2. Change Sales Invoice
3. Cancel Sales Invoice

Type number of menu selection here:\_\_\_\_\_

#### Holiday Travel Vehicles

##### Vehicle Inventory Menu

1. Create Vehicle Inventory Record
2. Change Vehicle Inventory Record
3. Delete Vehicle Inventory Record

Type number of menu selection here:\_\_\_\_\_

#### Holiday Travel Vehicles

##### Reports Menu

1. Commission Report
2. RV Sales by Make Report
3. Trailer Sales by Make Report
4. Dealer Options Report

Type number of menu selection here:\_\_\_\_\_

#### Holiday Travel Vehicles

##### Sales Staff Maintenance Menu

1. Add Salesperson Record
2. Change Salesperson Record
3. Delete Salesperson Record

Type number of menu selection here:\_\_\_\_\_

4. One aspect of the new system under development at Holiday Travel Vehicles will be the direct entry of the sales invoice into the computer system by the salesperson as the purchase transaction is being completed. In the current system, the salesperson fills out the paper form shown here.
5. Design and prototype an input screen that will permit the salesperson to enter all the necessary information for the sales invoice. The following information may be helpful in your design process: assume that Holiday Travel Vehicles sells recreational vehicles and trailers from four different manufacturers. Each manufacturer has a fixed number of names and models of RVs and trailers. For the purposes of your prototype, use this format:

Mfg-A	Name-1 Model-X	Mfg-C	Name-1 Model-X
Mfg-A	Name-1 Model-Y	Mfg-C	Name-1 Model-Y
Mfg-A	Name-1 Model-Z	Mfg-C	Name-1 Model-Z
Mfg-B	Name-1 Model-X	Mfg-C	Name-2 Model-X
Mfg-B	Name-1 Model-Y	Mfg-C	Name-3 Model-X
Mfg-B	Name-2 Model-X	Mfg-D	Name-1 Model-X
Mfg-B	Name-2 Model-Y	Mfg-D	Name-2 Model-X
Mfg-B	Name-2 Model-Z	Mfg-D	Name-2 Model-Y

Also, assume that there are 10 different dealer options which could be installed on a vehicle at the customer's request. The company currently has 10 salespeople on staff.

**Holiday Travel Vehicles**

Sales Invoice

Invoice # \_\_\_\_\_

Invoice Date \_\_\_\_\_

New RV/TRAILER

(circle one)

Name: \_\_\_\_\_

Model: \_\_\_\_\_

Serial #: \_\_\_\_\_ Year: \_\_\_\_\_

Manufacturer: \_\_\_\_\_

Trade-in RV/TRAILER

(circle one)

Name: \_\_\_\_\_

Model: \_\_\_\_\_

Year: \_\_\_\_\_

Manufacturer: \_\_\_\_\_

Options:

Code

Description

Price

---

---

---

---

Vehicle Base Cost: \_\_\_\_\_

Trade-In Allowance: \_\_\_\_\_

(Salesperson Name)

Total Options: \_\_\_\_\_

Tax: \_\_\_\_\_

License Fee: \_\_\_\_\_

Final Cost: \_\_\_\_\_

(Customer Signature)

# 9

# Program Design

DESIGN	
TASK CHECKLIST	
	<input checked="" type="checkbox"/> Select Design Strategy. <input checked="" type="checkbox"/> Design Architecture. <input checked="" type="checkbox"/> Select Hardware and Software. <input checked="" type="checkbox"/> Develop Use Scenarios. <input checked="" type="checkbox"/> Design Interface Structure. <input checked="" type="checkbox"/> Develop Interface Standards. <input checked="" type="checkbox"/> Design Interface Prototype. <input checked="" type="checkbox"/> Evaluate User Interface. <input checked="" type="checkbox"/> Design User Interface. <input type="checkbox"/> Develop Physical Data Flow Diagrams. <input type="checkbox"/> Develop Program Structure Charts. <input type="checkbox"/> Develop Program Specifications. <input type="checkbox"/> Select Data Storage Format. <input type="checkbox"/> Develop Physical Entity Relationship Diagram. <input type="checkbox"/> Denormalize Entity Relationship Diagram. <input type="checkbox"/> Performance Tune Data Storage. <input type="checkbox"/> Size Data Storage.

Another important activity of the design phase is designing the programs that will perform the system's application logic. Programs can be quite complex, so analysts must create instructions and guidelines for programmers which clearly describe what the program must do. This chapter describes the activities that are performed when the program design is developed. First, the process of revising logical data flow diagrams (DFDs) into physical DFDs is outlined. Then, two techniques typically used together for describing programs are presented. The structure chart depicts a program at a high level in graphic form. The program specification contains a set of written instructions in more detail. Together, these techniques communicate how the application logic for the system needs to be developed.

## OBJECTIVES

- Be able to revise logical DFDs into physical DFDs.
- Be able to create a structure chart.

- Be able to write a program specification.
- Be able to write instructions using pseudocode.
- Become familiar with event-driven programming.

## Introduction

The application logic for a system will be expressed in programs that are written during construction of the new system. Program design is the part of the design phase of the SDLC during which analysts determine what programs will be written, create instructions for the programmers about what the code should do, and identify how the pieces of code will fit together to form the system.

Some people may think that program design is becoming less important. Project teams increasingly rely on packaged software or libraries of preprogrammed code to build systems. Program design techniques are still very important, however, for two reasons. First, even the preexisting code needs to be understood, organized, and pieced together. Second, it is still common for the project team to have to write some (if not all) code and produce original programs that support the application logic of the system.

As analysts turn their attention to the programs that will need to be created for the new system, several things must be done. First, various implementation decisions will be made about the new system, such as what programming language(s) will be used. The data flow diagrams (DFDs) created during analysis are modified to show these implementation decisions, resulting in a set of *physical DFDs*. The analysts then determine how the processes of the system will be organized, using a **structure chart** to depict their decisions. Finally, detailed instructions called **program specifications** are developed so that during construction, the programmers know exactly what they should be creating. These activities are the subject of this chapter.

## Moving from Logical to Physical Process Models

During analysis, the systems analysts identified the processes and data flows that are needed to support the functional requirements of the new system. These processes and data flows are described on the logical DFDs for the to-be system. As we discussed in Chapter 4, the analysts avoid making implementation decisions during analysis, focusing first on the functional requirements of the system. The logical DFDs do not contain any indication of how the system will actually be implemented when the information system is built; they simply state what the new system will do. In this way, developers do not get distracted by technical details and avoid getting “tunnel vision” during the initial stages of system development. Business users better understand diagrams that show the “business view” of the system.

During design, **physical process models** are created to show implementation details and explain how the final system will work. These details can include references to actual technology, the format of information moving through processes, and the human interaction that is involved. In some cases, most often when packages are used, the use cases may need to be revised as well. These to-be models describe characteristics of the system that will be created, communicating the “systems view” of the new system.

## The Physical Data Flow Diagram

The **physical data flow diagram (DFD)** contains the same components as the logical DFD (e.g., data stores, data flows), and the same rules apply (e.g., balancing, decomposition). The basic

Step	Explanation
1. Add implementation references.	Using the existing logical DFD, add the way in which the data stores, data flows, and processes will be implemented to each component.
2. Draw a human-machine boundary.	Draw a line to separate the automated parts of the system from the manual parts.
3. Add system-related data stores, data flows, and processes.	Add system-related data stores, data flows, and processes to the model (components that have little to do with the business process).
4. Update the data elements in the data flows.	Update the data flows to include system-related data elements.
5. Update the metadata in the CASE repository.	Update the metadata in the CASE repository to include physical characteristics.

**FIGURE 9-1** Steps to create the physical data flow diagram.

difference between the two models is that a physical DFD contains additional details that describe how the system will be built. There are five steps to perform to make the transition to the physical DFD (Figure 9-1).

### Step 1: Add Implementation References

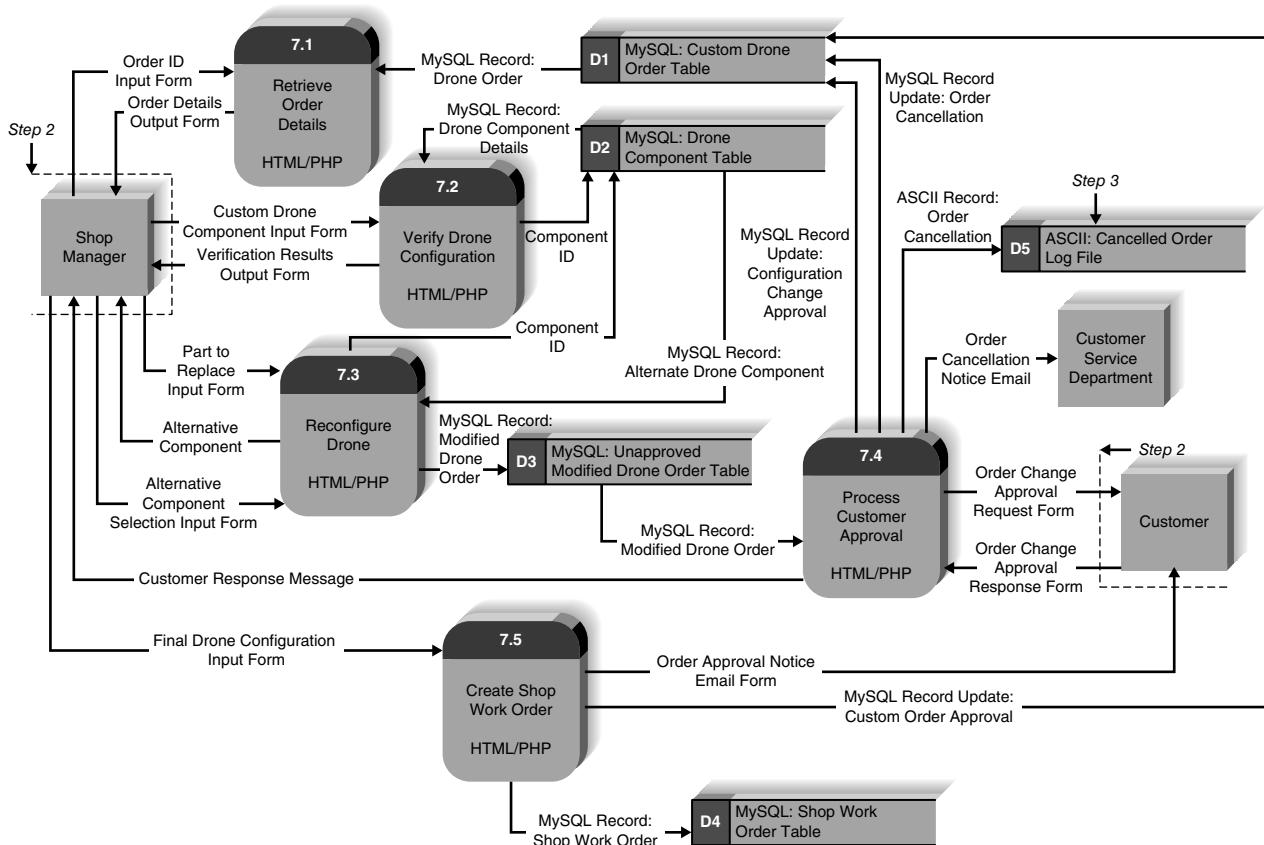
Begin with the existing logical DFDs and add references to the ways in which the data stores, data flows, and processes will be implemented. Data stores on physical DFDs will refer to files and/or database tables; processes, to programs or human actions; and data flows, to the physical media for the data, such as paper forms and reports, bar code scanning, input screens, or electronic reports. The names for the various components on the physical DFD should contain references to these implementation details. By definition, external entities on the DFD are outside of the scope of the system and therefore remain unchanged in the physical diagram.

Figure 9-2 shows the physical DFD that was drawn to depict the physical details for the original logical DFD from Figure 4-12. Notice the renaming of the Custom Drone Order data store to “MySQL: Custom Drone Order Table,” indicating the implementation of this data store as a MySQL database table. Similarly, the logical data flow Drone Order now includes notation that identifies it as a MySQL record from the Custom Drone Order table. Can you identify other changes that were made to the physical model to communicate how other components will be implemented?

### Step 2: Draw a Human-Machine Boundary

The second step is to add a **human-machine boundary**. Physical DFDs differentiate human and computer interaction by a human-machine boundary, a line drawn on the model to separate human action from automated processes. For example, all processes (i.e., processes 7.1–7.5) involve shop manager’s use of the system’s functionality. The physical model, therefore, contains a line separating the shop manager from the rest of the process to show exactly what is done by a person as opposed to a “machine” (Figure 9-2). Similarly, a line was drawn around the Customer entity to define another human-machine boundary.

Every part of every process in the system may not be automated, so it is up to the project team to determine where to draw a human-machine boundary and how large to draw it. The project team will need to weigh the following criteria when drawing the boundary: cost, efficiency, and integrity. First, a piece of the system should be automated only if the cost of computerizing it is less than doing it manually. Next, the system should be more efficient with the mode that is selected.



**FIGURE 9-2** Physical DFD for shop manager approval of custom drone order level 1 DFD.

For example, if the project team must decide whether to store a paper copy of a document or to save an electronic file of information in a central file server, the team likely will find the latter option to be more efficient in terms of improving the users' ability to access and update the information.

Finally, the team should consider the integrity of the information that is handled by the system. It may be cheaper for a clerk to record orders by phone and deliver the order forms to the distribution area; however, errors could be made when the clerk takes the order, and a form could be misplaced en route to distribution. Instead, the project team may be more comfortable with an automated process that accepts a customer's order from the customer directly, using a Web form that is then directly transmitted to the distribution system.

### Step 3: Add System-Related Data Stores, Data Flows, and Processes

In step 3, you will add to the DFD additional processes, stores, or flows that are specific to the implementation of the system and have little (or nothing) to do with the business process itself. These additions can be due to technical limitations or to the need for audits, controls, or exception handling. Technical limitations are rare, but may occur when technology cannot support the way in which the system is modeled logically.

Audits, controls, or exception handling refers to putting checks and balances in place in the system in case something goes wrong. For instance, on rare occasions, customers might call and cancel an order that they placed. Instead of just having the system get rid of the information about

that order, a process may be included for control purposes that records the deleted orders along with reasons for the cancellations. A new element on the DFD was added just for this purpose. An ASCII file containing canceled order information was added to maintain a history of canceled orders along with reasons for the cancellation.

#### **Step 4: Update the Data Elements in the Data Flows**

The fourth step is to update the elements in the data flows. The physical data flows may contain additional system-related data elements, for reasons similar to those described in the previous section. For example, most systems add system-related data elements to data flows that capture when changes were made to information (e.g., a last\_update data element) and who made the change (e.g., an updated\_by data element). Another physical data element is a system-generated number used to uniquely identify each record in a database. During step 4, the physical data elements are added to the metadata descriptions of the data flows in the CASE repository.

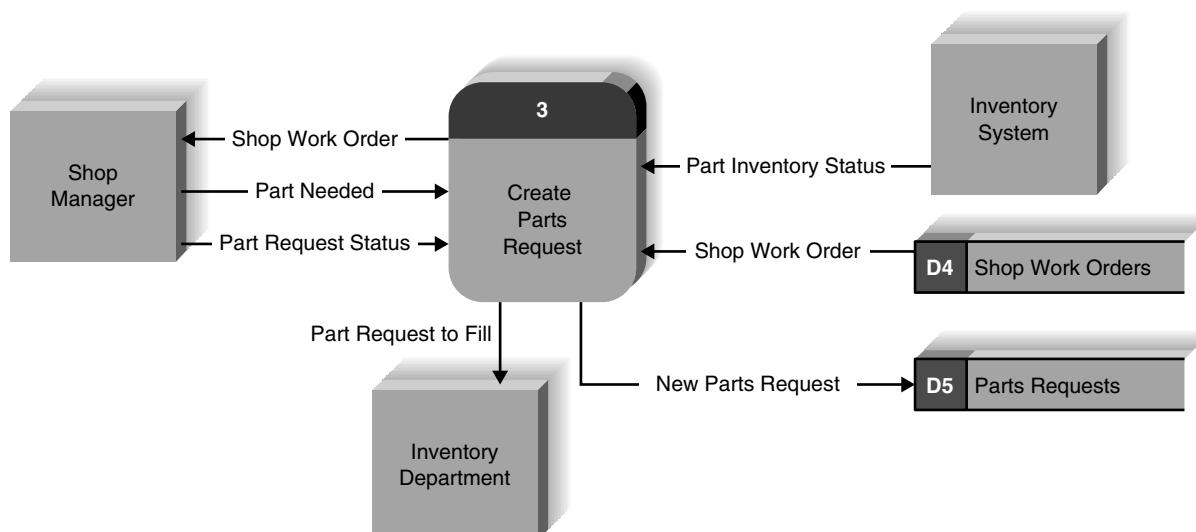
#### **Step 5: Update the Metadata in the Computer-Aided Software Engineering Repository**

Finally, the project team needs to make sure that the information about the DFD components in the CASE repository is updated with implementation-specific information. This information can include when batch processes will be run and how often, names of the actual tables or files that are represented by data flows, and the sizes and projected growth rates of the data stores.

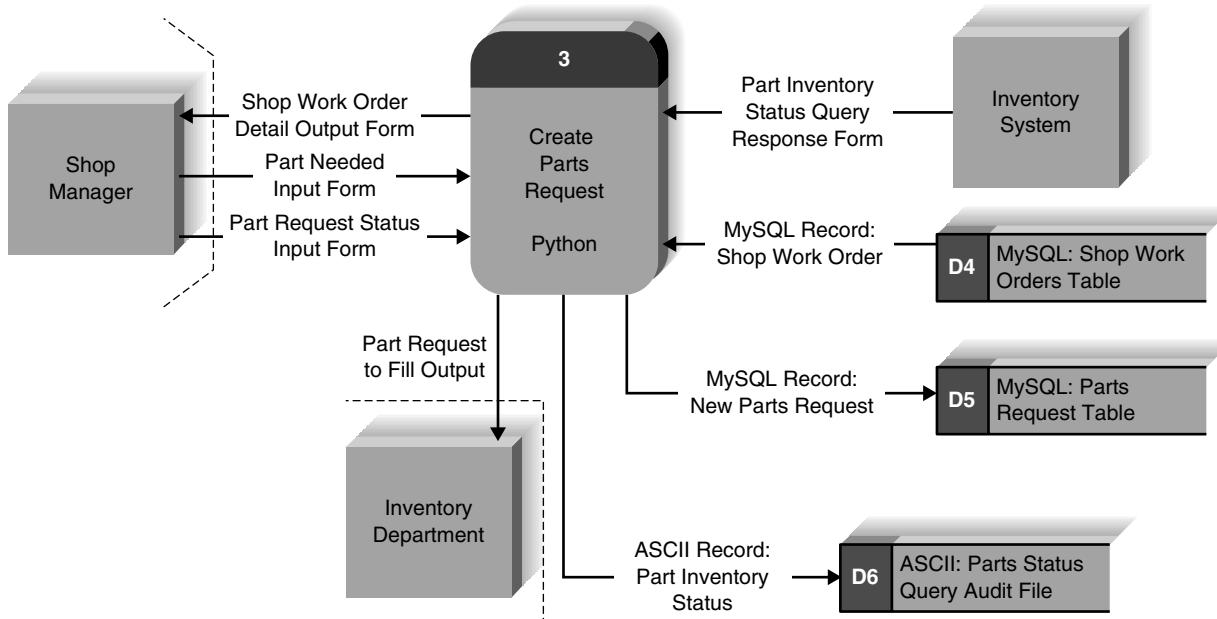
### **Applying the Concepts at DrōnTeq**

To better understand physical DFDs, we will now use an example based on the Create Parts Request process in DrōnTeq's Shop Management system. Figure 9-3 shows the logical DFD. We will perform each step to create the physical model, using the logical model as our starting point. Before we begin, see if you can identify how the data stores, data flows, and processes will need to change to reflect physical characteristics of the proposed system.

First, we need to identify how the data flows, data stores, and processes will be implemented and add the implementation references on the DFD. From the original business requirements,



**FIGURE 9-3** Logical model of DrōnTeq's shop management process 3: create parts request.



**FIGURE 9-4** Physical model for DrönTeq’s shop management process 3: create parts request.

we know that the shop manager uses the shop work order to prepare requests for parts from the Inventory Department. These parts are needed to complete the work on a custom drone order. During this process, the Inventory System is queried to determine the availability of needed parts. The completed parts requests are stored and transmitted to the Inventory Department to be fulfilled. On the physical DFD, each of the data flows is altered by renaming it appropriately, as shown in Figure 9-4.

As shown, the data stores (i.e., shop work orders and parts requests) are implemented as tables contained in a MySQL database; therefore, these data stores are renamed with this information. Also, the Create Parts Requests process will be written in Python, and this information is added to the process model.

A dotted line is drawn to represent the human–machine boundary and to communicate how much (and what parts) of the process is automated. System-related components are added to the model next. An ASCII file containing data about the part inventory availability queries will be created for audit trail purposes. Developers want to be sure this system-to-system interface works correctly. So, we add a data store to the diagram to reflect this decision. See Figure 9-4 for these changes.

Completion of the last two steps, 4 and 5, will not be apparent on the physical DFD. In step 4, we will add system-related data elements to the data flow entries in the CASE repository. Step 5 requires that we add implementation-specific information in the metadata in the CASE repository. This can include such information as the actual field types and sizes of the data elements that will be stored in the tables, or the expected response time for a report to be created for the marketing manager.

## Designing Programs

It can be tempting to jump right into the implementation phase by coding without much thought or planning, but this can lead to disastrous results, such as inefficient programs, code that does

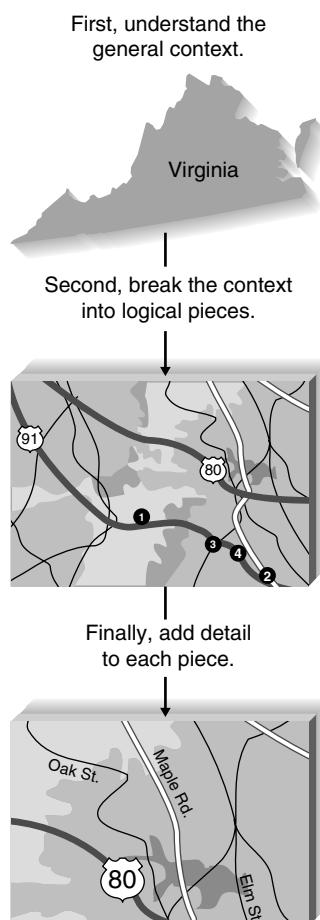
not work with other code, and a system that doesn't do what it's supposed to do. Instead, analysts should first take time in the design phase to create a maintainable system. In other words, analysts should create a design that is modular and flexible. To do this, analysts can design programs in a **top-down modular approach**, using a variety of program design techniques.

Think about giving someone directions to your house (Figure 9-5). Before getting to the details, such as naming streets and identifying landmarks, it is best to first orient the person to your general location (e.g., the state you live in, the part of town). As he or she becomes comfortable with where to go at a high level, you can become more detailed in your instructions. This top-down approach helps orient the other person and conveys the big picture of where you live, making the detailed directions much easier to understand.

Also, directions can be communicated in **modules**:

- First, drive from your house to the highway.
- Then, drive on the highway to the appropriate exit.
- Next, locate my neighborhood.
- Finally, drive to my house.

Each line, or module, can change without affecting the rest of the directions. For example, if one friend is traveling to your house from the north and another is traveling from the south, it is likely that the last two modules of directions (i.e., to the neighborhood and to the house) will



**FIGURE 9-5** Using a top-down modular approach.

**CONCEPTS IN ACTION 9-A****Winning by Design**

The rapid development face-off was a competition between rapid application development (RAD) teams from the leading consulting firms in the United States. The goal was to see which team could develop a specific system in the least amount of time. Most teams used a very short program design step and quickly began programming.

The Ernst & Young (E&Y) team members used a different approach. They spent much more time in the program design step to ensure that the system was well designed before they

moved into programming. At first, the E&Y team fell behind while its competitors jumped ahead. But E&Y ended up winning because the team spent much less time programming by following its well-designed blueprint.

**Question**

1. What are several reasons why planning ahead may have helped E&Y win?

not change even though the first two modules will differ for each friend. The modular approach makes the directions much easier to develop and change.

Good program design is similar to the top-down modular approach that we described. First, analysts create a high-level diagram that shows the various components of a program, how the components should be organized, and how the components interrelate. This diagram, known as the *structure chart*, illustrates the organization and interactions of the different pieces of code within the program to the analysts and programmers so that the program can be developed by many programmers working independently. The diagram can be used when the project team plans to write code from scratch or when existing pieces of code will be assembled to build the system. The physical process models just described provide a good starting point for understanding what this structure chart needs to include.

Once the overall program is defined at a high level, with a structure chart, program specifications are written to describe exactly what needs to be included in each program module. The specifications include basic module information (e.g., a name, calculations that need to be performed, and the target programming language), special instructions for the programmer, and pseudocode. Pseudocode is a technique similar to structured English that is used to communicate what needs to be written, using programming structures and a generic language that is not program language specific. Program specifications leave the implementation details to the programmers, but they communicate the basic logic and programming structures to help reduce logical and syntactical errors during the implementation phase. Some RAD approaches deemphasize program specifications.

You will notice that the design techniques that are described here are based on information and techniques from earlier phases of the SDLC. For example, the components of the structure chart typically mirror the processes found on the DFDs, and the process descriptions suggest the ways in which structure chart components should interrelate. Data models are used to explain the data that pass throughout the diagram. Also, analysts use the techniques and information to develop the program specifications, especially when writing pseudocode. Often during design, the analysts detect problems or inconsistencies with the analysis deliverables, and they must fine-tune or clarify previous work as they move forward.

In recent years, programmers have increasingly moved away from procedural programming languages and have migrated to event-driven programming. Programming languages that accommodate event-driven programming are popular due to the fact that they combine features of procedural, event-driven, and object-oriented programming. Applications written in Visual Basic, for example, are “naturally” modularized because code procedures are written to prescribe the

processing to perform when an event (e.g., a mouse click on a button object) occurs. These event procedures can be further decomposed to gain the advantages of modular design: code that is easier to understand, is reusable, has less redundancy, and is easier to maintain.

Therefore, the value of the modular design approaches we describe here has not truly diminished. The point is that planning before doing almost always improves the ultimate outcome when it comes to programming, and analysts should never begin writing code without having a complete understanding of what the code must do. Unfortunately, our experiences suggest that many project teams are much too quick at jumping into writing the program code without first organizing and defining the basic program modules and how they interact.

At the end of program design, the project team compiles the **program design** document, which includes all of the structure charts and program specifications that will be used to implement the system. The program design is used by programmers to write code. We first describe the structure chart, a helpful tool that illustrates the overall organization of a program. Then we present the program specification, which contains detailed information about each module of code. Much of the information here is based on a classic book written by Meiler Page-Jones,<sup>1</sup> which we highly recommend that you read if you are interested in additional information on modular program design.

## Structure Chart

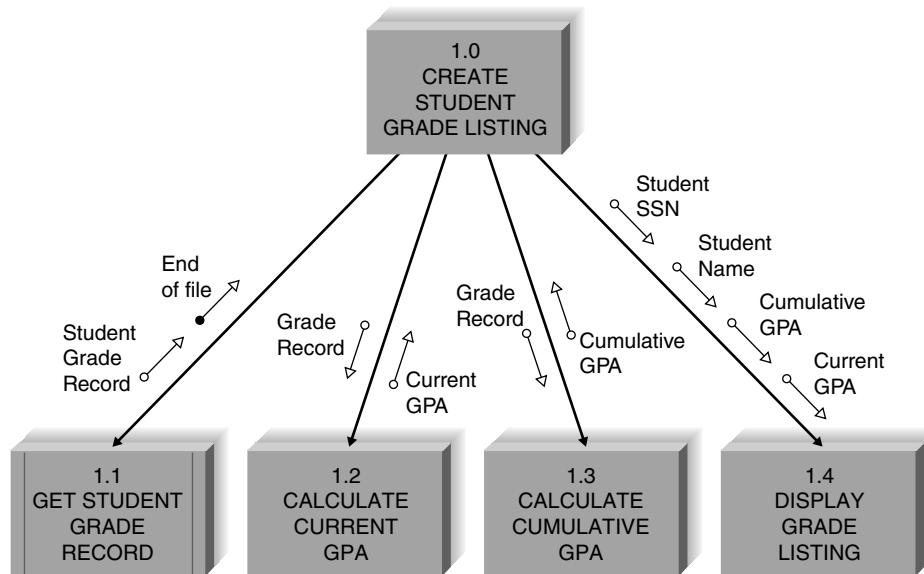
The *structure chart* is an important technique that helps the analyst design the program for the new system. The structure chart shows all the components of code that must be included in a program at a high level, arranged in a hierarchical format that implies **sequence** (in what order components are invoked), **selection** (under what condition a module is invoked), and **iteration** (how often a component is repeated). The components are usually read from top to bottom, left to right, and they are numbered by a hierarchical numbering scheme in which lower levels have an additional level of numbering (e.g., the third level of modules would be numbered 1.1.1, 1.1.2, 1.1.3, . . .).

Structure charts historically have been used to create transaction-based mainframe applications, which have many lines of code that must be carefully monitored. They help analysts create programs that are easy to understand and maintain, because the use of self-contained modules keeps changes from rippling throughout the programs. We believe that structure charts can be helpful in the building of many types of systems because they emphasize structure and reusability, characteristics of any good application.

Suppose that an academic system needs an application that will display a listing of students along with their grade point averages (GPAs), both for the current semester and overall. First, the program must retrieve the student grade records; then it must calculate the current and cumulative GPAs; finally, the grade list can be displayed. The structure chart shown in Figure 9-6 communicates the basic components of this program and shows the interrelatedness of the modules. For example, by looking at this structure chart, a programmer can tell that there are four main code modules involved in creating a student grade listing: getting the student grade records, calculating current GPA, calculating cumulative GPA, and displaying the listing. Also, there are various pieces of information that are either required by each module or created by it (e.g., the grade record, the cumulative GPA). The sections that follow use this example to describe each component of the structure chart.

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<sup>1</sup>Meiler Page-Jones, *The Practical Guide to Structured Systems Design*, New York: Yourdon Press, 1980.



**FIGURE 9-6** Structure chart example (GPA = grade point average).

## Syntax

### Module

A structure chart is composed of *modules* (lines of program code that perform a single function) that work together to form a program (Figure 9-7). The modules are depicted by a rectangle and connected by lines, which represent the passing of control. A **control module** is a higher-level component that contains the logic for performing other modules, and the components that it calls and controls are considered **subordinate modules**. For example, in Figure 9-6, module 1.0 is the control module that directs modules 1.1 through 1.4 as its subordinates.

At times, modules are standardized and used in many places throughout the system. These **library modules** have vertical lines on both sides of the rectangle to communicate that they will appear several times on the structure chart (Figure 9-7). The library module in Figure 9-6 is module 1.1, get student grade record, and this module is a generic module that will be depicted several times in other parts of the diagram. Library modules are highly encouraged because their reusability can save programmers from rewriting the same piece of code over and over again.

The lines that connect the modules communicate the passing of control. In Figure 9-6, the control is linear, whereby all of the modules are performed in order from top to bottom, left to right. There are two symbols that describe special types of control that can appear on the structure chart. The curved arrow, or **loop**, indicates that the execution of some or all subordinate modules is repeated, and a **conditional line** (depicted by a diamond) denotes that execution of one or more of the subordinate modules occurs in some cases but not in others (Figure 9-7).

Look at the structure chart in Figure 9-8 and see how the loops and conditional line affect the meaning of the diagram. First, the loop through the lines to modules 1.1, 1.2, and 1.3 means that, before the next two modules are invoked, the first three modules will be repeated until their functionality is completed (i.e., all of the student grades will be read and the two GPAs will be calculated before moving to the display modules). Second, the lines connected by the conditional line convey that both the dean's list report and grade listing are not displayed each time this program is run, but instead are performed based on some condition. Therefore, there are times when one or both of the display modules may not be invoked.

Structure Chart Element	Purpose	Symbol
<b>Every module:</b> <ul style="list-style-type: none"> <li>• Has a number.</li> <li>• Has a name.</li> <li>• Is a control module if it calls other modules below it.</li> <li>• Is a subordinate module if it is controlled by a module at a higher level.</li> </ul>	Denotes a logical piece of the program	
<b>Every library module</b> has: <ul style="list-style-type: none"> <li>• A number.</li> <li>• A name.</li> <li>• Multiple instances within a diagram.</li> </ul>	Denotes a logical piece of the program that is repeated within the structure chart	
<b>A loop:</b> <ul style="list-style-type: none"> <li>• Is drawn with a curved arrow.</li> <li>• Is placed around lines of one or more modules that are repeated.</li> </ul>	Communicates that a module(s) is repeated	
<b>A conditional line:</b> <ul style="list-style-type: none"> <li>• Is drawn with a diamond.</li> <li>• includes modules that are invoked on the basis of some condition.</li> </ul>	Communicates that subordinate modules are invoked by the control module based on some condition	
<b>A data couple:</b> <ul style="list-style-type: none"> <li>• Contains an arrow.</li> <li>• Contains an empty circle.</li> <li>• Names the type of data that are being passed.</li> <li>• Can be passed up or down.</li> <li>• Has a direction that is denoted by the arrow.</li> </ul>	Communicates that data are being passed from one module to another	
<b>A control couple:</b> <ul style="list-style-type: none"> <li>• Contains an arrow.</li> <li>• Contains a filled-in circle.</li> <li>• Names the message or flag that is being passed.</li> <li>• Should be passed up, not down.</li> <li>• Has a direction that is denoted by the arrow.</li> </ul>	Communicates that a message or a system flag is being passed from one module to another	
<b>An off-page connector:</b> <ul style="list-style-type: none"> <li>• Is denoted by the hexagon.</li> <li>• Has a title.</li> <li>• Is used when the diagram is too large to fit everything on the same page.</li> </ul>	Identifies when parts of the diagram are continued on another page of the structure chart	
<b>An on-page connector:</b> <ul style="list-style-type: none"> <li>• Is denoted by the circle.</li> <li>• Has a title.</li> <li>• Is used when the diagram is too large to fit everything in the same spot on a page.</li> </ul>	Identifies when parts of the diagram are continued somewhere else on the same page of the structure chart	

**FIGURE 9-7**  
Structure  
chart elements.

Another new symbol found on the structure chart in Figure 9-8 is the **connector** (Figure 9-7). Structure charts can become quite unwieldy, especially when they depict a large or complex program. A circle is used to connect parts of the structure chart when there are space constraints and a diagram needs to be continued on another part of the page (i.e., an **on-page connector**), and a hexagon is used to continue the diagram on another page entirely (i.e., an **off-page connector**). In Figure 9-8, notice that modules 1.4 and 1.5 are depicted on another page of the diagram.

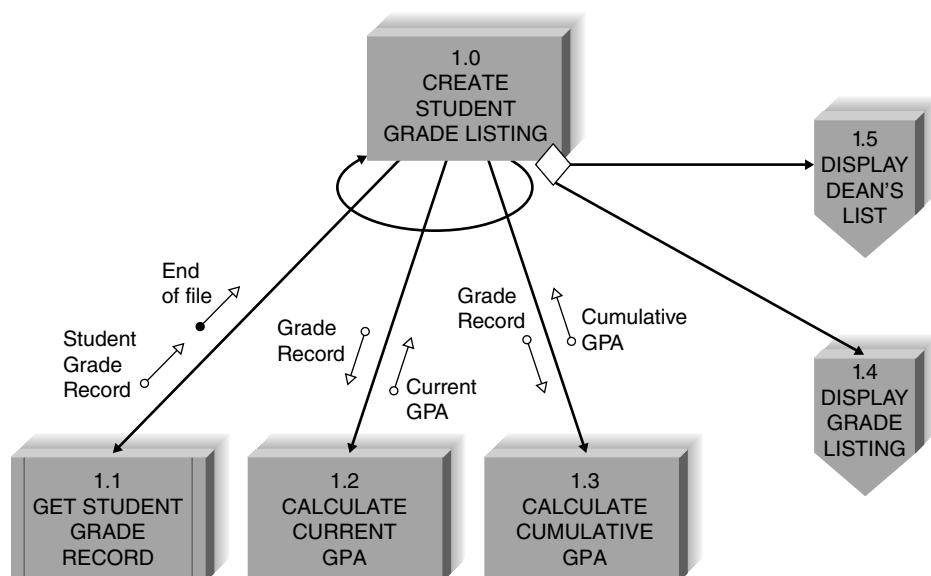
## Couples

**Couples**, shown by arrows, are drawn on the structure chart to show that information is passed between modules, with the arrowhead indicating which way the information is being sent (Figure 9-7). **Data couples**, shown by arrows with empty circles, are used to represent the passing of pieces of data or data structures to other modules. For example, in Figure 10-8, a student grade record must be sent to module 1.2 for the GPA to be calculated, so a data couple is used to show the grade data structure being passed along.

**Control couples**, drawn with the use of arrows with filled-in circles, are used to pass parameters or system-related messages back and forth among modules. If some type of parameter needs to be passed (e.g., the customer is a new customer; the end of a file has been reached), a control couple (also called a *flag*) would be used. In Figure 9-8, module 1.1 sends an end-of-file parameter when the program reaches the end of the student grade file.

In general, control flags should be passed from subordinates to control modules, but not the other way around. Control flags are passed so that the control modules can make decisions about how the program will operate (e.g., when module 1.1 passes the end-of-file control flag to module 1.0, module 1.0 determines it should no longer call module 1.1). Passing a control flag from higher to lower modules suggests that a lower-level module has control over the higher-level module.

The presence of couples signals that modules on the structure chart depend on each other in some way. A general rule is to be very conservative when applying couples to your diagram. In



**FIGURE 9-8**  
Revised structure chart example.

a later section, we will discuss style guidelines for using couples to help you determine “good” from “bad” coupling situations.

## Building the Structure Chart

Now that you understand the individual components of the structure chart, the next step is to learn how to put them together to form an effective design for the new system. Many times, process models are used as the starting point for structure charts. There are three basic kinds of processes on a process model: afferent, central, and efferent. **Afferent processes** are processes that provide inputs into the system, **central processes** perform critical functions in the operation of the system, and **efferent processes** deal with system outputs. Identify these three kinds of processes in Figure 9-9.

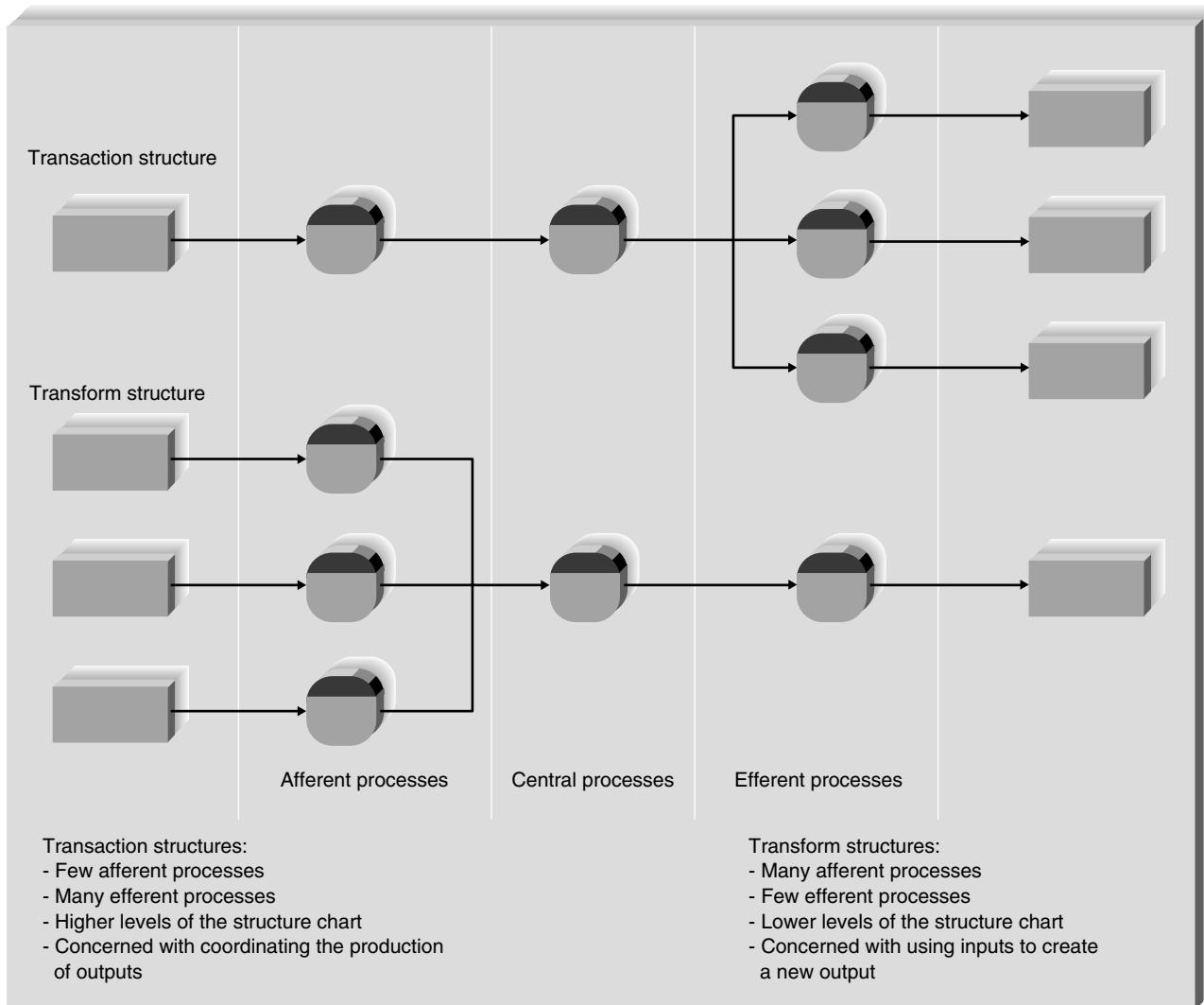


FIGURE 9-9 Transform and transaction structures.

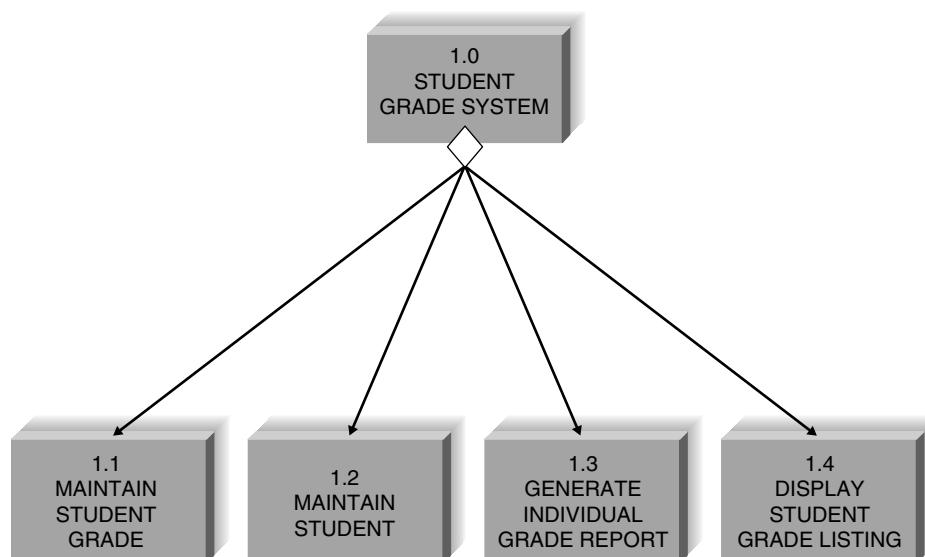
Each process of a DFD tends to represent one module on the structure chart, and if leveled DFDs are used, then each DFD level tends to correspond to a different level of the structure chart hierarchy (e.g., the process on the context-level DFD would correspond to the top module on the structure chart).

The difficulty comes when determining how the components on the structure chart should be organized. As we mentioned earlier, the structure chart communicates sequence, selection, and iteration, but none of these concepts is depicted explicitly in the process models. It is up to the analyst to make assumptions from the DFDs and read the process model descriptions to really understand how the structure chart should be drawn.

### Transaction Structure

Luckily, there are two basic arrangements, or structures, for combining structure chart modules. The first arrangement is used when each module performs one of a group of individual transactions. This **transaction structure** contains a control module that calls subordinate modules, each of which handles a particular transaction. Pretend that Figure 9-10 illustrates the highest level of a student grade system. Module 1 is the control module that accepts a user's selection for what activity needs to be performed (e.g., maintain grade), and depending on the choice, one of the subordinate modules (1.1 through 1.4) is invoked. Transaction structures often occur where the actual system contains menus or submenus, and they are usually found higher up in the levels of a structure chart.

If the project team has used leveled DFDs to illustrate the processes for the system, the high levels of the DFD usually represent activities that belong in a transaction structure. In the current example, student grade system could correspond to the single process on the context-level DFD, and the four modules (1.1 through 1.4) would be the four processes on the level 0 diagram. If a leveled DFD approach is not used, then it may be a bit more difficult to differentiate a control module from its subordinates by using the process model. One hint is to look for points on the DFD in which a single data flow enters a process that produces multiple data flows as output—this usually indicates a transaction structure. See Figure 9-9 for an example of a process model that has transaction structure; notice how it contains many efferent processes and few afferent processes.



**FIGURE 9-10**  
Transaction structure.

### Transform Structure

A second type of module structure, called a *transform structure*, has a control module that calls several subordinate modules in some sequence, after which something “happens.” These modules are related because together they form a process that transforms some input into an output. Often, each module accepts an input from the module preceding it, works on the input, then passes it to the next module for more processing. For example, Figure 9-8 shows a control module that calls five subordinates. The control module describes what the subordinates will do (e.g., create student grade listing), and the subordinates are invoked from left to right and transform the student grade records into two types of listings for student grades.

In a leveled DFD, the lowest levels usually represent transform structures. If a leveled DFD approach is not used, then you should look for the processes on the DFD for which an input is changed into an output of a different form. In this situation, the process in which the change is made likely will become a control module. All the processes leading up to the control module are subordinates that are performed first by the control module, followed by the processes that come after the control module. See Figure 9-9 for an example of transform structure; notice how there are many afferent processes and few efferent processes.

## Applying the Concepts at DrōnTeq

Now that you are familiar with the basic components of the structure chart, the best way to learn how to build the diagram is to walk through an example that shows how to create one. Creating a structure chart is usually a four-step process. First, the analyst identifies the top-level modules and then decomposes them into lower levels. (This process is similar in some ways to identifying high-level processes in a DFD and then decomposing them into lower-level processes.) Second, the analyst adds the control connections among modules, such as loops and conditional lines that show when modules call subordinates. Third, he or she adds couples, the information that modules pass among themselves. Finally, the analyst reviews the structure chart and revises it again and again until it is complete.

The goal for this example is to create a structure chart that contains the modules of code that need to be programmed and shows how they need to be organized. The physical process model can be used as its starting point. Although it may neither map exactly into the future program nor contain enough levels of detail, the DFD will form a good rough-draft structure chart that can then be changed and improved. The requirements definition and use cases will provide additional detail. Let’s walk through a structure chart example for DrōnTeq.

### Step 1: Identify Modules and Levels

First, identify the modules that belong on the diagram by converting the DFD processes into structure chart modules. Modules should perform only one function, so if, for some reason, a process contains more than one function, it should be split into more than one module.

The various levels of the DFD generally translate into different levels of the structure chart. Look back at the DFDs that we created for DrōnTeq in Chapter 4 (Figures 4-26 to 4-31). The DFD for event-handling process 3: Assign Flight Requests to Pilots, is placed at the top of the structure chart in Figure 9-11 to represent the overall control module of the system that manages the highest level of system functions. Then, the level 1 DFD processes are placed below it as subordinates. You should recognize that this particular structure of modules is a transaction structure, because the subordinates represent different functions that can be called by the control module.

This pattern continues through all the DFD levels. For example, the level 2 DFD that we created for the notify pilots of new flight request process is placed below the notify pilots process control module. The subordinate modules retrieve the flight request, locate candidate pilots,

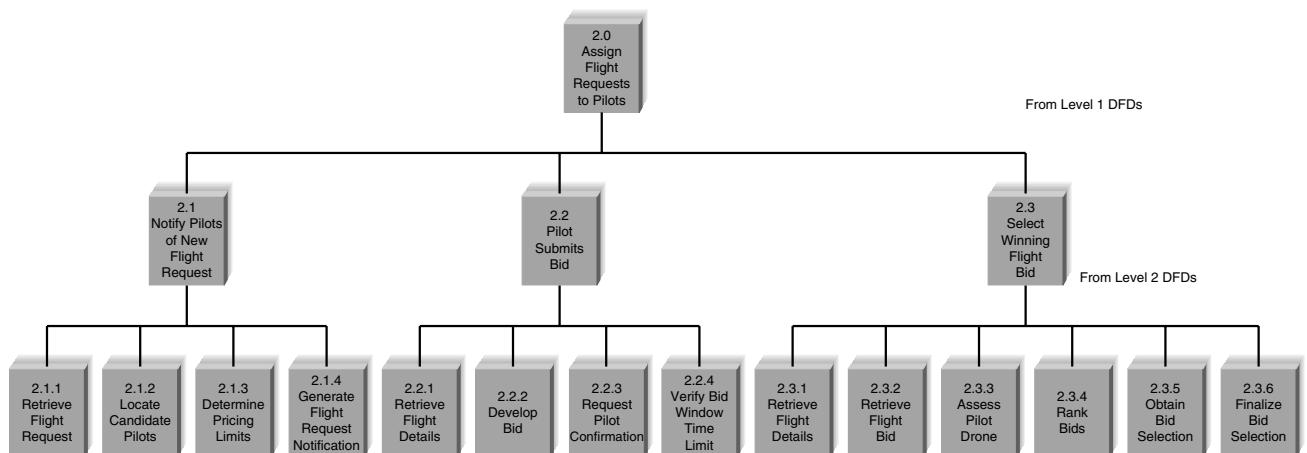


FIGURE 9-11 Step 1: Identify modules and levels for the structure chart.

determine pricing limits, and generate the flight request notification, the four processes from the notify pilots or new flight request process level 1 DFD. Note that this structure of modules is a transform structure because the subordinate modules are carried out in a sequence to perform the process that is represented by the control module (Figure 9-11).

Likely, you will need to include additional levels of detail on the structure chart, until modules have enough detail so that they each perform only one function. Additional detail for the structure can be found within the use cases (Chapter 4) and requirements definition (Chapter 3) for the system.

Finally, you must determine whether any modules on the diagram are reusable; if they are, they should be represented as library modules. In this particular portion of the structure chart, Jiang has marked two modules as library modules, with vertical lines on the sides. These two modules perform the same task and so should be implemented as library modules so that the code can be reused.

### Step 2: Identify Special Connections

The next step is to add loops and conditional lines to represent modules that are repeated or optional. For example, the process of identifying candidate pilots repeats until all pilots meeting the selection criteria are found. Thus in Figure 9-12, we place a curved arrow around the line under the locate candidate pilots process to show that module 2.1.2 can be repeated several times. Can you think of other modules on the structure chart that will be iterated? According to Figure 9-12, one module under the select winning flight bid process also can happen several times as the system retrieves flight bids submitted by pilots.

A diamond-shaped symbol indicates a decision process. We have added three such symbols in Figure 9-12 to document the conditional nature of processes 2.2.3, 2.3.3, and 2.3.5.

### Step 3: Add Couples

Next, we must identify the information that has to pass among the modules. This information can be data attributes (denoted by an arrow with an empty circle) or special control parameters (denoted by an arrow with a filled-in circle). The arrowheads on the arrows indicate which way information is passed along. The DFD data flows provide us with some guidance about the couples to add, because the information that flows in and out of the DFD processes likely will also flow in and out of the corresponding structure chart modules.

We will illustrate the addition of couples to our structure chart by focusing just on the select winning flight bid module and its subordinate modules. The DFD in Figure 4-31 shows the series of tasks that are performed to determine which pilot's bid will be selected for assignment to a flight request. Therefore, the structure chart shown in Figure 9-13 depicts the way the control module (2.3) calls the subordinates to complete this process. One library module on our structure chart (2.3.1) returns the details of the flight request, and one module (2.3.2) returns all submitted flight bids for that flight request. The driver module (2.3) then calls the subordinate module to evaluate whether the drone used on a bid has the correct capacity for the flight requirements. The result of the assessment is returned to the driver in terms of a status *flag*. The driver module then calls the rank bids module (2.3.4). This module returns the bids in rank order. These are then passed to the obtain bid selection module (2.3.5), which obtains the final selected bid. Finally, status regarding each bid (selected/not selected) is passed to the finalize bid selection module (2.3.6) to complete the pilot assignment process.

### Revise Structure Chart

By now we have created the initial version of the structure chart based on the DFDs, use cases, and requirements definition, but rarely is a structure chart completed in one attempt. There are

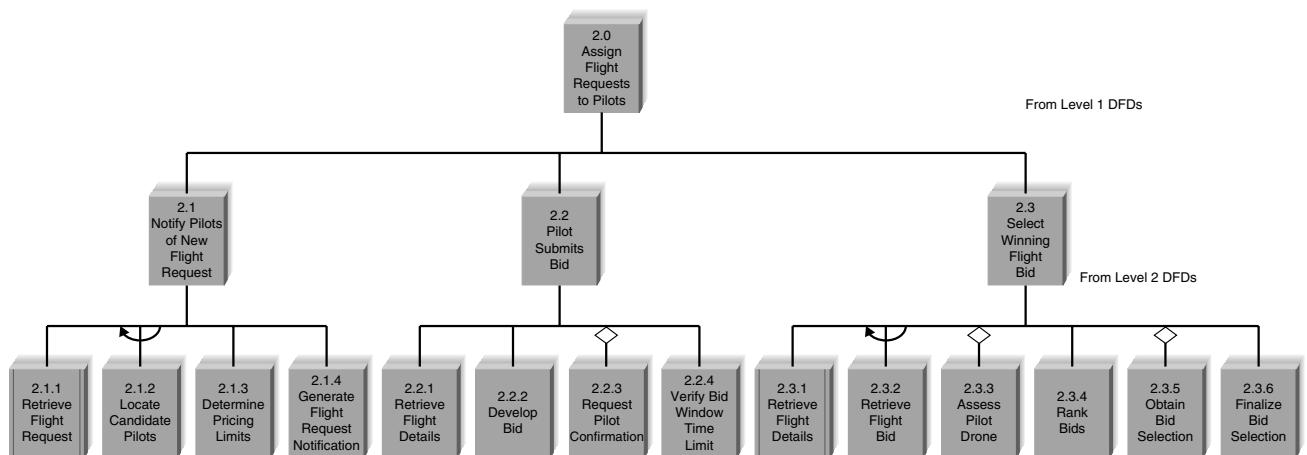


FIGURE 9-12 Step 2: Add special connections to the structure chart.

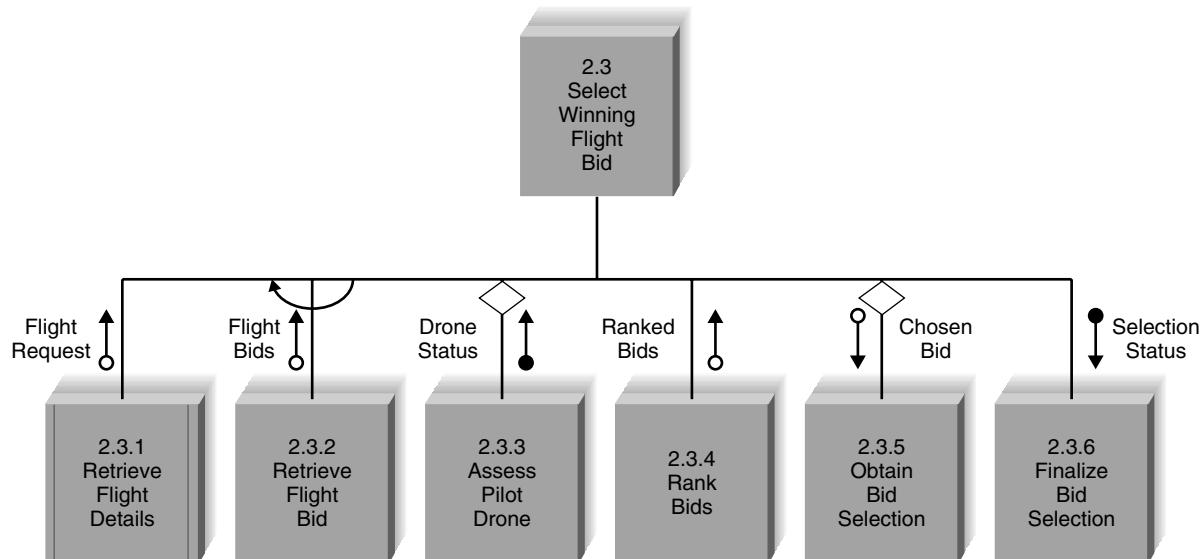


FIGURE 9-13 Step 3: Add couples to the structure chart.

many gray areas and decisions that need to be confirmed by other information gleaned during analysis. There are several tools that can help when we are fine-tuning the structure chart. First, we can look at the process descriptions in the CASE repository to see whether there are any details of the processes that have not yet been captured on the diagram. The process descriptions may uncover couples that were overlooked or explain more about how modules should be broken down. Second, we can examine the data model to confirm that the right records and specific fields have been passed using the data couples. This exercise also will confirm that data being passed are actually being captured by the system.

As with most diagrams about which you have learned, the structure chart will evolve and contain more detail as new information is uncovered over the course of the project. Structure charts are not easy. The example that we have presented is much more straightforward than charts found in the real world. The following section explains some guidelines and good practices that you should apply to the chart as you work to improve it.

## Design Guidelines

As you construct a structure chart, there are several guidelines that you can use to improve its quality. High-quality structure charts result in programs that are modular, reusable, and easy

### YOUR TURN 9-1

### Structure Chart

Using the structure chart in Figure 9-13 as a starting point, add modules that correspond to other parts of the Assign Pilots to Flights process. Use the DFDs and the use case in Chapter 4 to help you.

#### Question

- Do the modules that you added have a transform structure or a transaction structure—or both? Add any special connections to the chart as appropriate. Add necessary data and control couples.

to implement. Measures of good design include cohesion, coupling, and appropriate levels of fan-in and/or fan-out.

### Build Modules with High Cohesion

**Cohesion** refers to how well the lines of code within each structure chart module relate to each other. Ideally, a module should perform only one task, making it highly cohesive. Cohesive modules are easy to understand and build because their code performs one function, and they are built to perform that function very efficiently. The more tasks that a module has to perform, the more complex the logic in the code must be to implement the tasks correctly. Typically, you can detect modules that are not cohesive from titles that have an *and* in them, signaling that the module performs multiple tasks.

Look back at the example in Figure 9-6. Currently, each module has good cohesion. Imagine, however, that module 1.3 actually said *calculate current and cumulative GPA* and that module 1.4 was *display grade listing and dean's list*. The *and* in both cases would signal a problem. These modules would not be considered cohesive, because they each perform two different tasks, limiting the flexibility of the modules and making the modules much more difficult to build and understand. If the program had to calculate only the current GPA while the module performed both functions, it would require much more complex logic in the code to make that happen.

Another signal of poor cohesion is the presence of control flags that are passed down to subordinate modules; their presence suggests that the subordinate has multiple functions from which one is chosen. Placing this kind of power in a subordinate module is not advisable, because it requires complex logic within the module to determine what functions to perform. In the previous example, if our subordinate module were *display grade listing and dean's list*, then a control flag would need to be sent to the subordinate module so that it could determine which report (or both) to display. The subordinate would have to make decisions regarding how to perform its functions.

There are various types of cohesion, some of which are better than others. For example, **functional cohesion** occurs when all elements of the module contribute to performing a single task, and this form of cohesion is highly desirable. By contrast, **temporal cohesion** takes place when functions within a module may not have much in common other than being invoked at the same time, and **coincidental cohesion** occurs when there is no apparent relationship among a module's functions (definitely something to avoid). Figure 9-14 lists seven types of cohesion, along with examples of each type. If you have difficulty differentiating different types of cohesion, use the decision tree in Figure 9-15 for guidance.

**Factoring** is the process of separating out a function from one module into a module of its own. If you find that a module is not cohesive or that it displays characteristics of a “bad” form of cohesion, you can apply factoring to create a better structure. For example, a more cohesive design for the *display grade listing and dean's list* example would be to factor out display dean's list and display grade listing into two separate modules. A control flag is not needed for this approach because subordinate modules would not have to make any kind of decision; each would perform one task—to display a report.

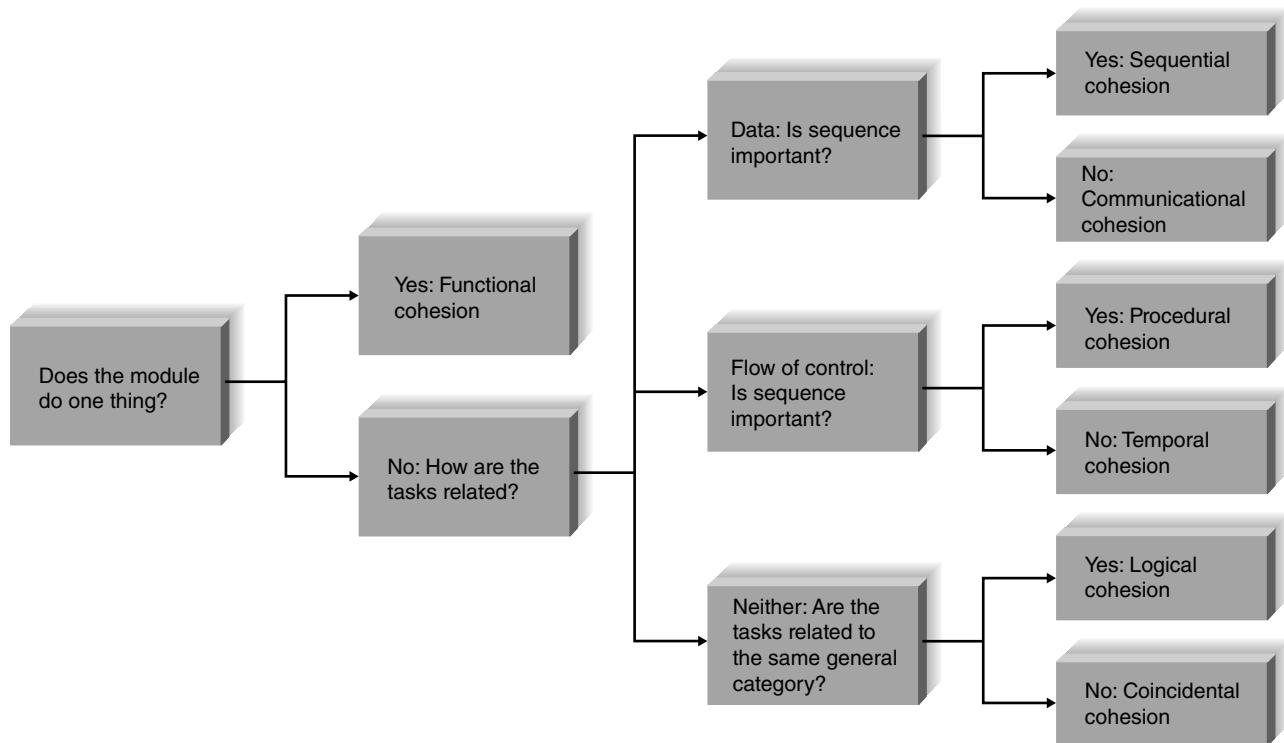
### Build Loosely Coupled Modules

**Coupling** involves how closely modules are interrelated, and the second guideline for good structure chart design states that modules should be loosely coupled. In this way, modules are independent from each other, which keeps code changes in one module from rippling throughout the program. The numbers and kinds of couples on the structure chart reveal the presence of coupling between modules. Basically, the fewer the arrows on the diagrams, the easier it will be to make future alterations to the program.



Type	Definition	Example
<b>Good</b>	Functional Sequential Communicational Procedural Temporal Logical Coincidental	Module performs one problem-related task. Output from one task is used by the next. Elements contribute to activities that use the same inputs or outputs. Elements are performed in sequence but do not share data. Activities are related in time. List of activities; which one to perform is chosen outside of module. No apparent relationship.
		<b>Calculate Current GPA</b> The module calculates current GPA only.
		<b>Format and Validate Current GPA</b> Two tasks are performed, and the formatted GPA from the first task is the input for the second task.
		<b>Calculate Current and Cumulative GPA</b> Two tasks are performed because they both use the student grade record as input.
		<b>Print Grade Listing</b> The module includes the following: housekeeping, produce report.
		<b>Initialize Program Variables</b> Although the tasks occur at the same time, each task is unrelated.
		<b>Perform Customer Transaction</b> This module will open a checking account, open a savings account, or calculate a loan, depending on the message that is sent by its control module.
<b>Bad</b>		<b>Perform Activities</b> This module performs different functions that have nothing to do with each other: update customer record, calculate loan payment, print exception report, analyze competitor pricing structure.

**FIGURE 9-14**  
Types of cohesion  
(GPA = grade-point average).



**FIGURE 9-15** Cohesion decision tree (adapted from Page-Jones, 1980).

Notice the coupling in the structure chart in Figure 9-8. The data couples (e.g., grade record) denote data that are passed among modules, and the control couple (e.g., end of file) shows that a message is being sent. Although the modules are communicating with one another, notice that the communication is quite limited (only one data couple passed in and out of the module) and there are no superfluous couples (data that are passed for no reason).

There are five types of coupling, each falling on different parts of a good-to-bad continuum. **Data coupling** occurs when modules pass parameters or specific pieces of data to each other, and this is a form of coupling that you want to see on your structure chart. A bad coupling type is **content coupling**, whereby one module actually refers to the inside of another module. Figure 9-16 presents the types of coupling and examples of each type.

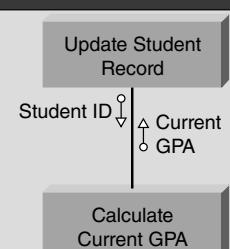
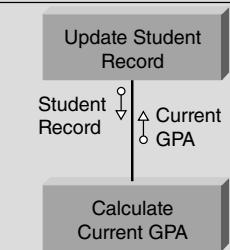
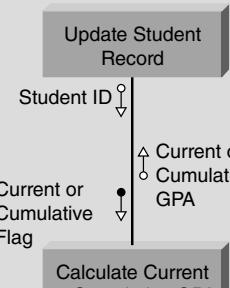
### Create High Fan-In

**Fan-in** describes the number of control modules that communicate with a subordinate; a module with high fan-in has many different control modules that call it. This is a very good situation because high fan-in indicates that a module is reused in many places on the structure chart, which suggests that the module contains well-written generic code. (Fan-in also occurs when library modules are used.) Structures with high fan-in promote the reusability of modules and make it easier for programmers to recode when changes are made or mistakes are uncovered, because a change can be made in one place. Figures 9-17a and 9-17b show two different approaches for representing the functionality of reading an employee record. Example a is better.

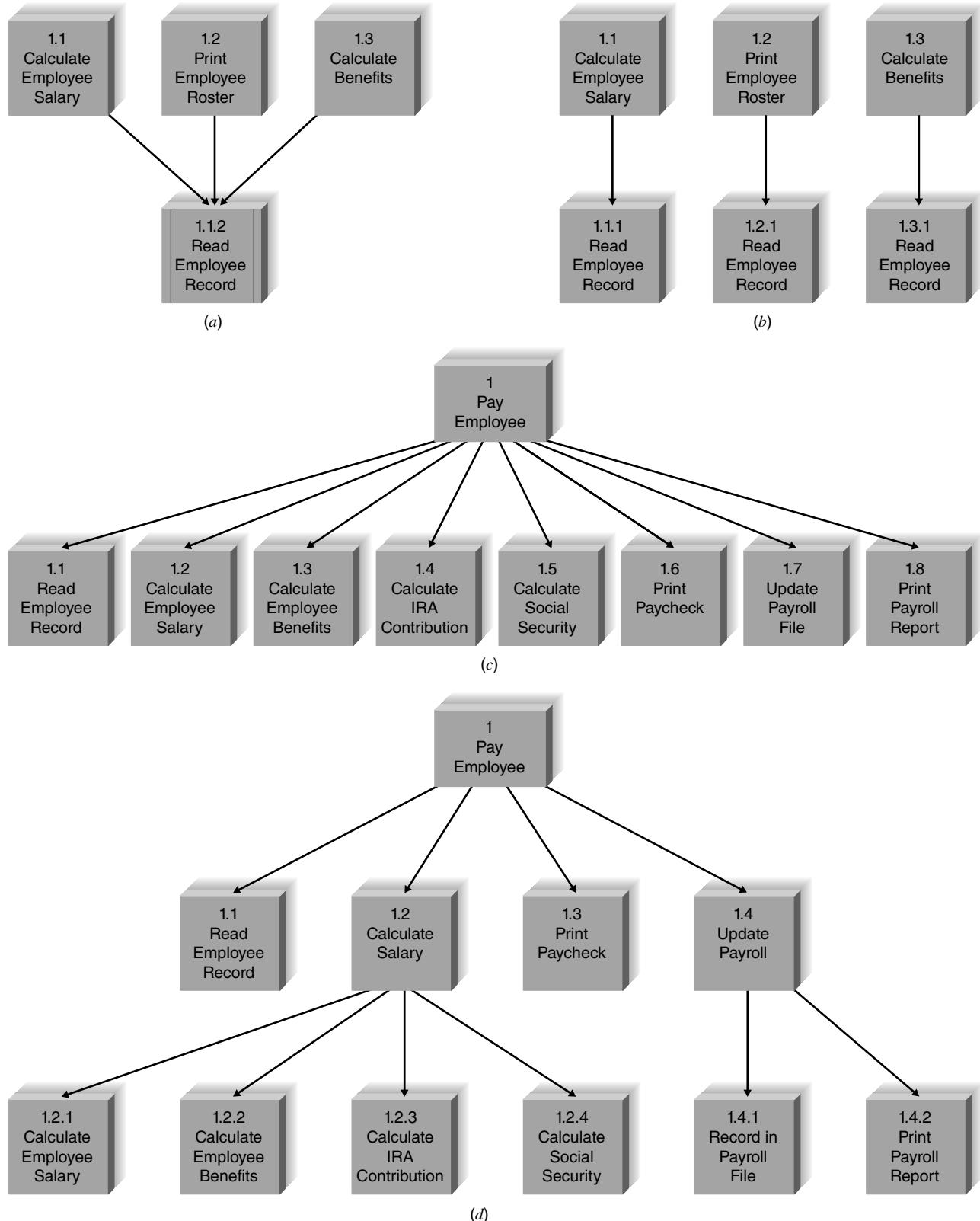
### Avoid High Fan-Out

Although we desire a subordinate to have multiple control modules, we want to avoid a large number of subordinates associated with a single control. Think of the management concept “span

↓  
Bad

Type	Definition	Example
<b>Good</b>	Data	<p>Modules pass fields of data or messages.</p>  <p>All couples that are passed are used by the receiving module.</p>
	Stamp	<p>Modules pass record structures.</p>  <p>Not all of the student record is used by the receiving module; only the <i>student ID</i> field is.</p>
	Control	<p>Module passes a piece of information that intends to control logic.</p>  <p>The receiving module has to determine which GPA to calculate.</p>
	Common	<p>Modules refer to the same global data area.</p> <p>Typically, common coupling cannot be shown on the structure chart; it occurs when modules access the same data areas, and errors made in those areas can ripple through all the modules that use the data.</p>
	Content	<p>Module refers to the inside of another module.</p> <pre> Module A: Update Student If student = new Then go to Module B  Module B: Create Student  At all costs, avoid modules referring to each other in this way. </pre>

**FIGURE 9-16**  
 Types of coupling  
 (GPA = grade-point average).



**FIGURE 9-17** Examples of fan-in and fan-out: (a) high fan-in; (b) low fan-in; (c) high fan-out; (d) low fan-out (IRA = individual retirement account).

of control,” which states that there is a limit to the number of employees that a boss can effectively manage. This concept applies to structure charts as well, in that a control module will become much less effective when given large numbers of modules to control. The general rule of thumb is to limit a control module’s subordinates to approximately seven. One exception to this is a control module within a transaction structure. If a control module coordinates the invocation of subordinates, each of which performs unique functions, then it usually can handle whatever number of transactions exist. Figures 9-17c and 9-17d show high and low **fan-out** situations, respectively.

### Assess the Chart for Quality

Finally, we have compiled a checklist (Figure 9-18) that may help you assess the quality of your structure chart. In addition, you should be aware that some CASE tools will critique the quality of your structure chart by using predetermined heuristics. Visible Analyst, for example, checks to make sure that all modules are labeled and connected and that data couples are labeled. It then reviews the connections between modules for correctness of connection, complexity of interface, and completeness of design. The analyzer gives warnings for low fan-in and high fan-out situations.

## Program Specification

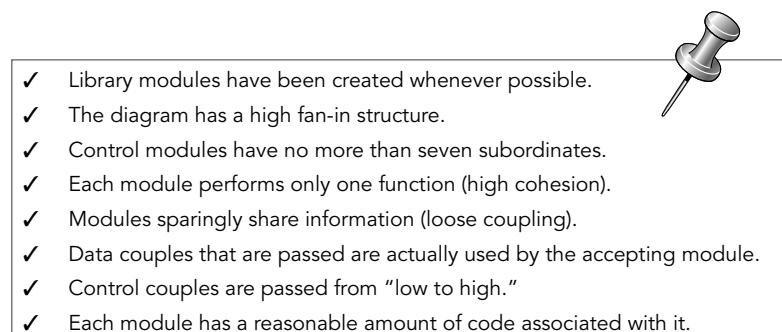
Once the analyst has communicated the big picture of how the program should be put together, he or she must describe the individual modules in enough detail so that programmers can take over and begin writing code. Modules on the structure chart are described by the use of *program specifications*, written documents that include explicit instructions on how to program pieces of code. Typically, project team members write one program specification for each module on the structure chart and then pass them along to programmers, who write the code during the implementation phase of the project. Specifications must be very clear and easy to understand, or else programmers will be slowed down trying to decipher vague or incomplete instructions.

Also, program specifications can pinpoint design problems that exist in the structure chart. At a high level, the structure chart may make sense, but when the analyst begins writing the detail behind the modules, he or she may find better ways for arranging the modules or may uncover missing or unnecessary couples.

### Syntax

There is no formal syntax for a program specification, so every organization uses its own format, often a form like the one in Figure 9-19. Most program specification forms contain four components that convey the information that programmers will need to write the appropriate code.

A template for this figure is available on the student website.



**FIGURE 9-18**  
Checklist for structure chart quality.

**Program Specification 1.1 for ABC System**

Module \_\_\_\_\_

Name: \_\_\_\_\_

Purpose: \_\_\_\_\_

Programmer: \_\_\_\_\_

Date due: \_\_\_\_\_

C      PowerScript      HTML/PHP      Visual Basic

Events \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Input Name	Type	Used by	Notes

Output Name	Type	Used by	Notes

Pseudocode \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Other \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**FIGURE 9-19** Program specification form.

### Program Information

The top of the form in Figure 9-19 contains basic program information, such as the name of the module, its purpose, the deadline, the programmer, and the target programming language. This information is used to help manage the programming effort.

### Events

The second section of the form is used to list the events that trigger the functionality in the program. An **event** is a thing that happens or takes place. Clicking the mouse generates a mouse event; pressing a key generates a keystroke event—in fact, almost everything the user does causes an event to occur.

In the past, programmers used procedural programming languages (e.g., COBOL, C) containing instructions that were implemented in a predefined order, as determined by the computer system, and users were not allowed to deviate from the order. With structured programming, the event portion of the program specification is irrelevant. However, many programs today are **event-driven** (e.g., Visual Basic.Net, C++), and event-driven programs include procedures that are executed in response to an event initiated by the user, system, or program code. After initialization, the program waits for some kind of event to happen, and when it does, the program carries out the appropriate task, then waits once again.

We have found that many programmers still use program specifications when programming in event-driven languages, and they include the event section on the form to capture when the program will be invoked. Other programmers have switched to other design tools that capture event-driven programming instructions.

### Inputs and Outputs

Next, the program specification describes the inputs and outputs to the program, which are identified by the data couples and control couples found on the structure chart. Programmers must understand what information is being passed and why, because that information ultimately will translate into variables and data structures within the actual program.

### Pseudocode

**Pseudocode** is a detailed outline of the lines of code that need to be written, and it is presented in the next section of the form. If you remember, when we had to describe the processes on the DFDs, we used a technique called structured English, a language with syntax based on English and structured programming. These DFD descriptions in structured English are now used as the primary input to produce pseudocode.

Pseudocode is a language that contains logical structures, including sequential statements, conditional statements, and iteration. It differs from structured English in that pseudocode contains details that are programming specific, such as initialization instructions or linking, and it also is more extensive so that a programmer can write the module by mirroring the pseudocode instructions. In general, pseudocode is much more like real code, and its audience is the programmer as opposed to the analyst. Its format is not as important as the information it conveys. Figure 9-20 shows a short example of pseudocode for a module that is responsible for calculating a discount on a purchase transaction.

Writing good pseudocode can be difficult—imagine creating instructions that someone else can follow without having to ask for clarification or making a wrong assumption. For example, have you ever given a friend directions to your house, but your friend ended up getting lost? To you, the directions might have been clear, but that is because of your personal assumptions. To you, the instruction “take the first left turn” may really mean “take a left turn at the first stop-light.” Someone else’s interpretation might be “take a left turn at the first road, with or without

```
Calculate_discount_amount (total_price, discount_amount)
If total_price < 50 THEN
    discount_amount = 0
ELSE
    If total_price < 500 THEN
        discount_amount = total_price *.10
    ELSE
        discount_amount = total_price *.20
    END IF
END
```

**FIGURE 9-20**  
Pseudocode.

### YOUR TURN 9-2

### Program Specification

Create a program specification for module 2.3.3, assess pilot drone, on the structure chart shown in Figure 9-13.

*Question*

1. On the basis of your specification, are there any changes to the structure chart that you would recommend?

a light.” (Barbara has a very bad sense of direction and has been known to make a first left turn into a driveway!)

Therefore, when writing pseudocode, pay special attention to detail and readability.

The last section of the program specification provides space for other information that must be communicated to the programmer, such as calculations, special business rules, calls to subroutines or libraries, and other relevant issues. This also can point out changes or improvements that will be made to the structure chart based on problems that the analyst detected during the specification process.

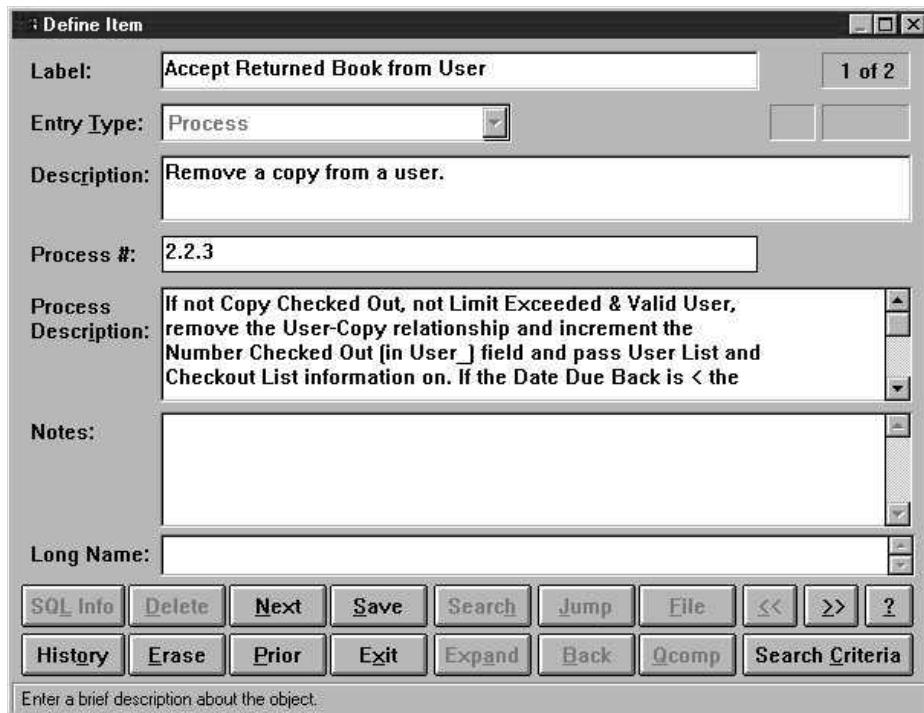
Some project teams do not create program specifications by using forms, but instead input the specification information directly into a CASE tool. In these cases, the information is added to the description for the appropriate module on the structure chart (or to its corresponding process on the DFD). Figure 9-21 illustrates how the CASE repository can be used to capture program design information.

## Applying the Concepts at DrōnTeq

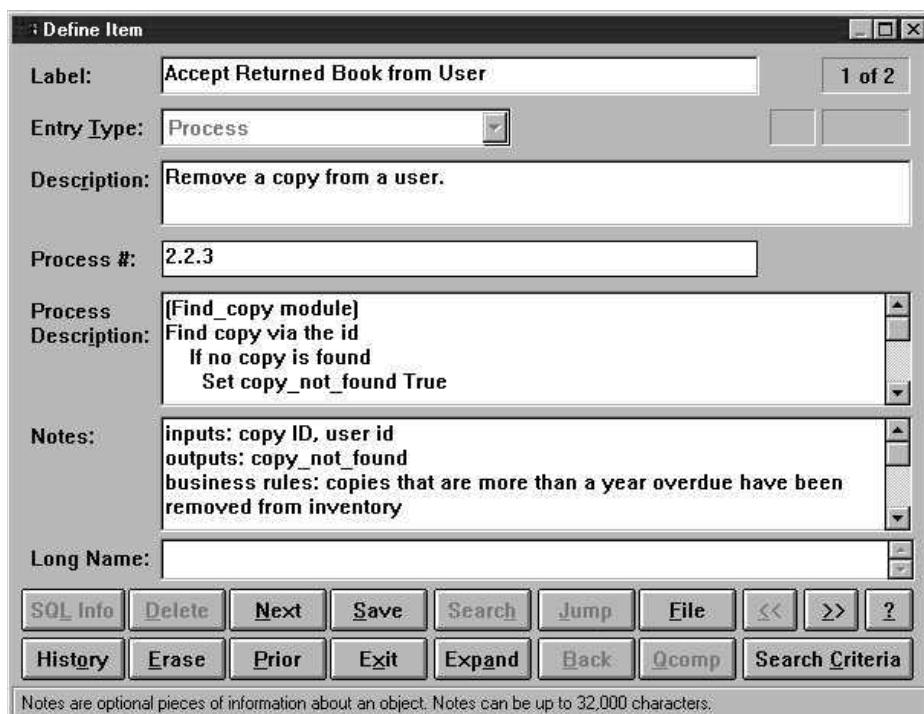
We will describe the creation of a program specification for module 2.1.2, locate candidate pilots. Refer to the structure chart in Figure 9-12 to remind yourself of the purpose of this program—find all pilots located within a reasonable proximity to the flight request’s location.

The top part of the form (Figure 9-22) contains basic information about the specification, such as its name and purpose. Because an event-driven programming language will be used, we list the events that will trigger the program to run (i.e., a mouse click, a menu selection, a call by another module). The inputs and outputs for the program correspond to the couple on the structure chart: the flight location is sent to module 2.1.2 and pilot IDs are returned by that module. We added these elements to the input and output sections of the form, respectively.

Next, we used the structured English description for the module that is found in the process description to develop the pseudocode that will communicate the code that should be written for the program. We added a business rule to the specification to explain to the programmer that



Analysis Phase  
Process Specification  
with structured English  
process description



Design Phase Process Specification:  

- Structured English has been changed to pseudocode.
- Relevant specification information like inputs, outputs, and business rules have been added to the Notes section.

FIGURE 9-21 Process description—analysis phase versus design phase.

**Program Specification 2.1.2 for Assign Pilot to Flight Request**

Module \_\_\_\_\_

Name: Locate Candidate Pilots

Purpose: Find the IDs of all pilots located in proximity to the flight location

Programmer: John Smith

Date due: April 26, 2020

 C Python Visual Basic Javascript

Events \_\_\_\_\_

Occurs upon submission of a new flight request by client

---

---

---

Input Name:	Type:	Provided by:	Notes:
Flight Location Latitude	Numeric	Program 2.1.1	

Output Name:	Type:	Used by	Notes:
Pilot ID	String (10)	Program 2.1.4	

Pseudocode \_\_\_\_\_

```
(Find_candidate_pilots module)
not_found = True
count = 0
Do Until not_found = False
    Define search region, radius from flight location lat/long = (radius * (count * expansion_factor))
    For all pilots in Pilot table
        If Pilot location lat/long is within search region,
            save Pilot ID
            not_found = False
    EndIf
    EndFor
    count += 1
EndDo
Return
```

Other \_\_\_\_\_

Business rule: Search for candidate pilots is performed until one candidate pilot ID is found.

Note: Management will need to determine if there is a maximum limit on the size of the search region. If there is, the module needs to return a control flag indicating that no pilots are capable of performing this flight request.

**FIGURE 9-22** Program specification for locate candidate pilots.

the search process should be repeated until at least one pilot is found. However, as we wrote the pseudocode and examined the process description, we discovered a potential problem—the structure chart does not appear to handle the situation in which the search region to find a candidate pilot becomes unreasonably large. There is no mechanism for the program to pass this result back to its calling program, plus it is unclear how large is “too large.” At this point, we made a note in the last section of the program specification to consult with management on how to best resolve this issue.

Once that remaining issue is resolved, the program specification is ready for the implementation phase, when the form will be passed off to a programmer who will develop the code that performs its requirements.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Identify and describe the five steps involved in converting the logical process models to physical process models.
  - Describe the purpose and components of a structure chart.
  - Explain the two primary structures shown in a structure chart and the purpose of each.
  - Discuss the four steps involved in creating structure charts.
  - Explain the structure chart design guideline of high cohesion.
- List and discuss the seven kinds of cohesion.

- Explain the structure chart design guideline of low coupling. List and discuss the five kinds of coupling.
- Explain how the concepts of fan-in and fan-out pertain to structure charts.
- Explain the recommended content of a program specification document.
- Describe pseudocode and explain how it differs from structured English.

## KEY TERMS

Afferent processes	Data couples	Library module	Pseudocode
central processes	Data coupling	Loop	Selection
Cohesion	Efferent processes	Module	Sequence
Coincidental cohesion	Event	Off-page connector	Structure chart
Conditional line	Event-driven	On-page connector	Subordinate module
Connector	Factoring	Physical data flow	Temporal cohesion
Content coupling	Fan-in	diagram (DFD)	Top-down modular approach
Control couples	Fan-out	Physical process	Transaction structure
Control module	Functional cohesion	model	Transform structure
Couples	Human-machine boundary	Program design	
Coupling	Iteration	Program specification	

## QUESTIONS

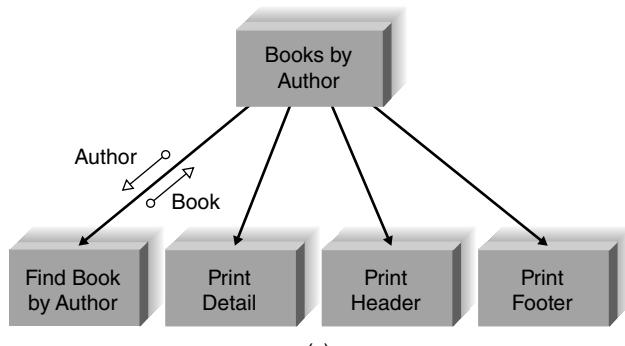
1. What is the purpose of creating a logical process model and then a physical process model?
2. What information is found on the physical DFD that is not included on the logical DFD?
3. What are some of the system-related data elements and data stores that may be needed on the physical DFD that were not a part of the logical DFD?
4. What is a human-machine boundary?
5. Why is using a top-down modular approach useful in program design?
6. Describe the primary deliverable produced during program design. What does it include and how is it used?
7. What is the purpose of the structure chart in program design?
8. Where does the analyst find the information needed to create a structure chart?

9. Distinguish between a control module, subordinate module, and library module on a structure chart. Can a particular module be all three? Why or why not?
10. What does a data couple depict on a structure chart? A control couple?
11. It is preferable for a control couple to flow in one particular direction on the structure chart. Which direction is preferred, and why?
12. What is the difference between a transaction structure and a transform structure? Can a module be a part of both types of structures? Why or why not?
13. What is meant by the characteristic of module cohesion? What is its role in structure chart quality?
14. List the seven types of cohesion. Why do the various types of cohesion range from good to bad? Give an example of good coupling and an example of bad coupling.
15. What is meant by the characteristic of module coupling? What is its role in structure chart quality?
16. List the seven types of coupling. Why do the various types of coupling range from good to bad? Give an example of good coupling and an example of bad coupling.
17. What is meant by the characteristics of fan-in and fan-out? What are their roles in structure chart quality?
18. List and discuss three ways to ensure the overall quality of a structure chart.
19. Describe the purpose of program specifications.
20. What is the difference between structured programming and event-driven programming?
21. Is program design more or less important when using event-driven languages such as Visual Basic?

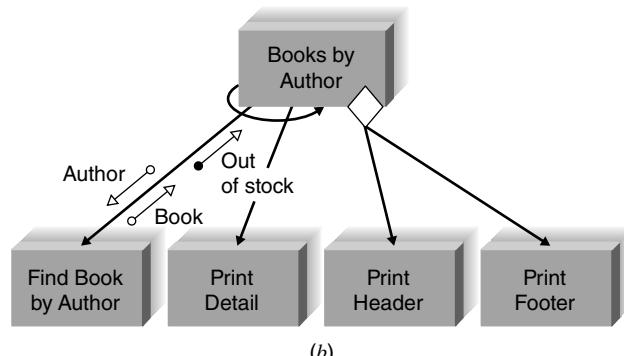
## EXERCISES

- A. Draw a physical level 0 data flow diagram (DFD) for the following dentist office system and compare it with the logical model that you created in Chapter 4: Whenever new patients are seen for the first time, they complete a patient information form that asks their name, address, phone number, and brief medical history, all of which are stored in the patient information file. When a patient calls to schedule a new appointment or change an existing appointment, the receptionist checks the appointment file for an available time. Once a good time is found for the patient, the appointment is scheduled. If the patient is a new patient, an incomplete entry is made in the patient file; the full information will be collected when the patient arrives for the appointment. Because appointments are often made so far in advance, the receptionist usually mails a reminder postcard to each patient two weeks before his or her appointment.
- B. Create a physical level 0 DFD for the following and compare it with the logical model that you created in Chapter 4: A Real Estate Inc. (AREI) sells houses. People who want to sell their houses sign a contract with AREI and provide information on the house. This information is kept in a database by AREI, and a subset of this information is sent to the citywide multiple listing service used by all real estate agents. AREI works with two types of potential buyers. Some buyers have an interest in one specific house. In this case, AREI prints information from its database, which the real estate agent uses to help show the house to the buyer (a process beyond the scope of the system to be modeled). Other buyers seek AREI's advice in finding a house that meets their needs. In this case, buyers complete a buyer information form. Information from it is entered into a buyer database, and AREI real estate agents use its information to search AREI's database and the multiple listing service for houses that meet their needs. The results of these searches are printed and used to help the real estate agents show houses to the buyers.
- C. Draw a physical level 0 DFD for the following system and compare it with the logical model that you created in Chapter 4. A Video Store (AVS) runs a series of fairly standard video stores. Before a video can be put on the shelf, it must be catalogued and entered into the video database. To rent a video, every customer must have a valid AVS customer card. Customers rent videos for three days at a time. Every time a customer rents a video, the system must ensure that he or she does not have any overdue videos. If so, the overdue videos must be returned and the customer must pay a fine before renting more videos. Likewise, if the customer has returned overdue videos, but has not paid the fine, the fine must be paid before new videos can be rented. Every morning, the store manager prints a report that lists overdue videos; if a video is two or more days overdue, the manager calls the customer to remind him or her to return the video. If a video is returned in damaged condition, the manager removes it from the video database and sometimes charges the customer.
- D. What symbols would you use to depict the following situations on a structure chart?
  - A function occurs multiple times before the next module is invoked.
  - A function is continued on the bottom of the page of the structure chart.

- A customer record is passed from one part of the program to another.
- The program will print a record either on screen or on a printer, depending on the user's preference.
- A customer's ID is passed from one part of the program to another.



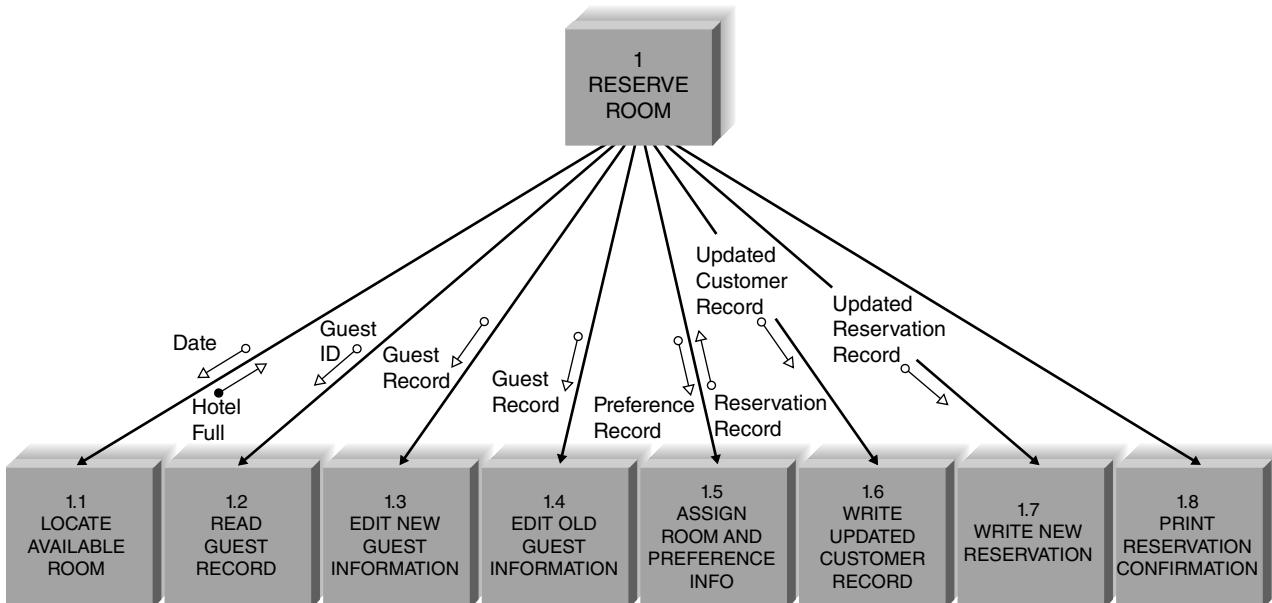
- E. • A function cannot fit on the current page of the structure chart.
- E. Describe the differences in the meanings between the two structure charts shown. How have the symbols changed the meanings?



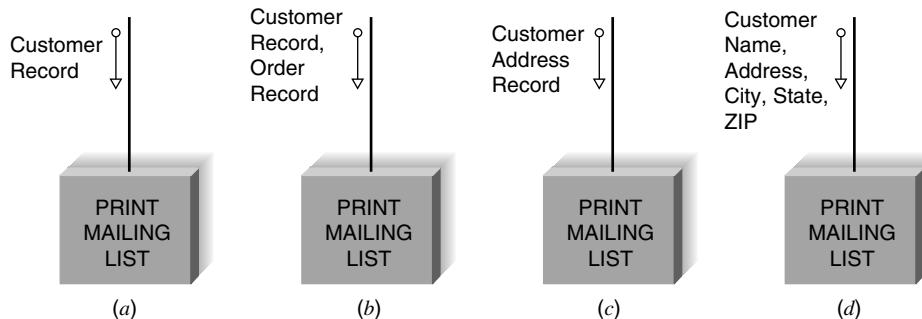
- F. Create a structure chart based on the DFDs that you created for the following exercises in Chapter 4:

- Question I
- Question K
- Question O
- Question Q
- Question S

- G. Critique the structure chart shown, which depicts a guest making a hotel reservation. Describe the chart in terms of fan-in, fan-out, coupling, and cohesion. Redraw the chart to improve the design.



- H. Identify the kinds of coupling that are represented in the following situations:

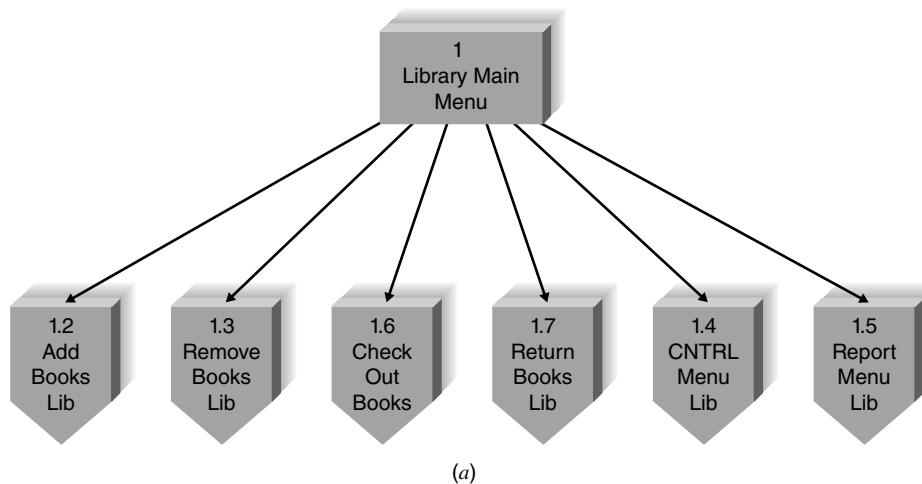


- I. Identify the kinds of cohesion that are represented in the following situations:

- accept customer address
- print mailing label record
- print customer address listing
- print marketing address report
- accept customer address
- validate zip code and state
- format customer address
- print customer address
- accept customer address

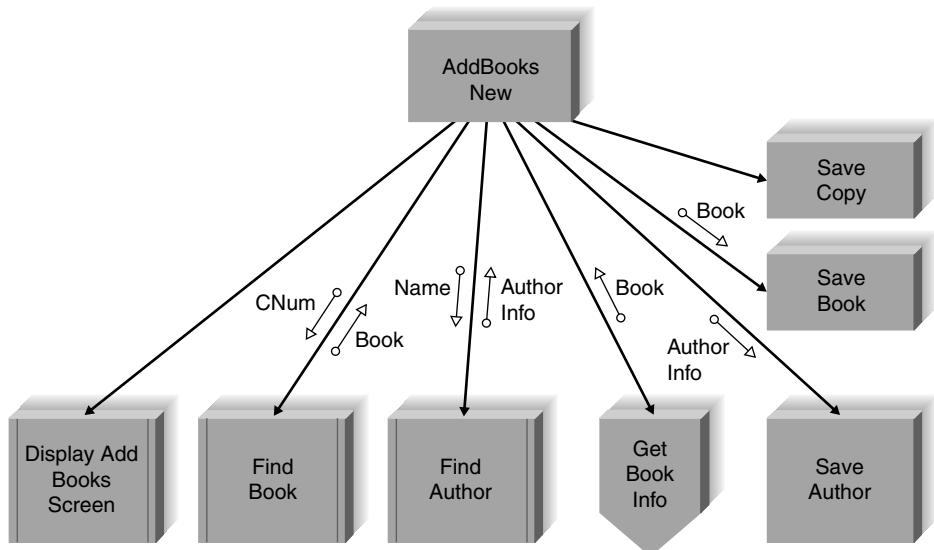
- print mailing label record
- accept customer address
- print mailing label record or
- print customer address listing or
- print marketing address report or
- validate customer address
- print mailing label record
- check customer balance
- print marketing address report
- record customer preference information

- J. Identify whether the following structures are transaction or transform and explain the reasoning behind your answers.<sup>2</sup>

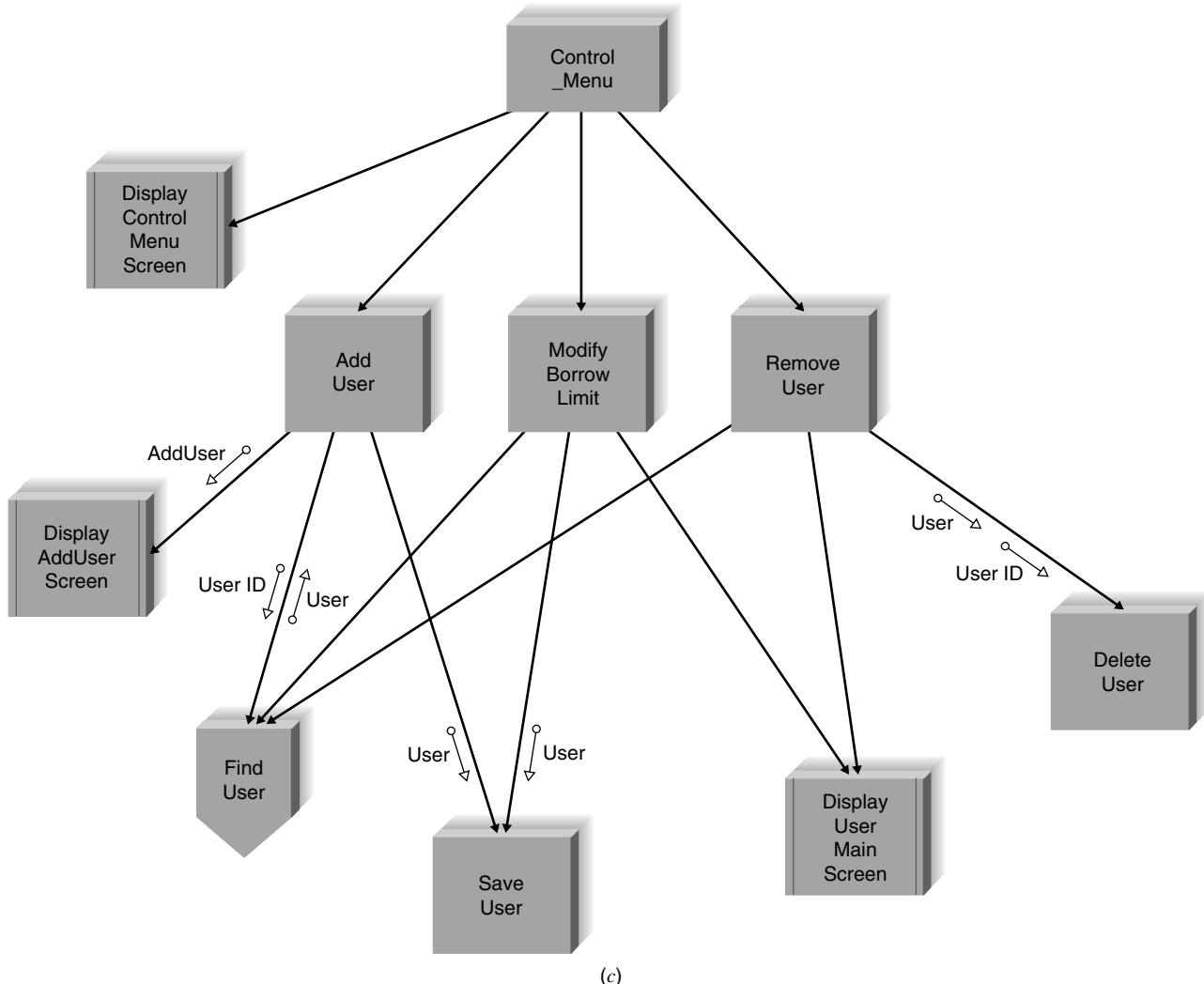


*(Continued on page 334)*

<sup>2</sup>The structure charts based on a library system are adapted from an example provided with the Visible Analyst software.



(b)



(c)

- K. Create a program specification for module 1.1.3.1 on the structure chart in Figure 9-12.
- L. Create a program specification for module 1.2.3.4 on the structure chart in Figure 9-12.
- M. Create pseudocode for the program specification that you wrote in Exercise K.
- N. Create pseudocode for the program specification that you wrote in Exercise L.
- O. Create pseudocode that explains how to start the computer at your computer lab and open a file in the word processor. Exchange your pseudocode with a classmate and follow the instructions exactly as they appear. Discuss the results with your classmate. At what points were each set of instructions vague or unclear? How would you improve the pseudocode that you created originally?

## MINICASES

- 1. In the new system for Holiday Travel Vehicles, the system users follow a two-stage process to record complete information on all the vehicles sold. When an RV or trailer first arrives at the company from the manufacturer, a clerk from the inventory department creates a new vehicle record for it in the computer system. The data entered at this time include basic descriptive information on the vehicle such as manufacturer, name, model, year, base cost, and freight charges. When the vehicle is sold, the new vehicle record is updated to reflect the final terms of the sale and the dealer-installed options added to the vehicle. This information is entered into the system at the time of sale when the salesperson completes the sales invoice.

When it is time for the clerk to finalize the new vehicle record, the clerk will select a menu option from the system, which is called “Finalize New Vehicle Record.” The tasks involved in this process are described next.

When the user selects the “Finalize New Vehicle Record” from the system menu, the user is immediately prompted for

the serial number of the new vehicle. This serial number is used to retrieve the new vehicle record for the vehicle from system storage. If a record cannot be found, the serial number is probably invalid. The vehicle serial number is then used to retrieve the option records that describe the dealer-installed options that were added to the vehicle at the customer’s request. There may be zero or more options. The cost of the option specified on the option record(s) is totaled. Then, the dealer cost is calculated, using the vehicle’s base cost, freight charge, and total option cost. The completed new vehicle record is passed back to the calling module.

- a. Develop a structure chart for this segment of the Holiday Travel Vehicles system.
- b. What type of structure chart have you drawn, a transaction structure or a transform structure? Why?
- 2. Develop a program specification for Module 4.2.5 (*Calculate Dealer Cost*) in Minicase 1.

# 10

## Data Storage Design

### DESIGN

#### TASK CHECKLIST

- Select Design Strategy.
- Design Architecture.
- Select Hardware and Software.
- Develop Use Scenarios.
- Design Interface Structure.
- Develop Interface Standards.
- Design Interface Prototype.
- Evaluate User Interface.
- Design User Interface.
- Develop Physical Data Flow Diagrams.
- Develop Program Structure Charts.
- Develop Program Specifications.
- Select Data Storage Format.
- Develop Physical Entity Relationship Diagram.
- Denormalize Entity Relationship Diagram.
- Performance Tune Data Storage.
- Size Data Storage.

Another important activity of the design phase is designing the data storage component of the system. This chapter describes the activities that are performed when developing the data storage design. First, the different ways in which data can be stored are described. Several important characteristics that should be considered when selecting the data storage format are discussed. The process of revising the logical data model into the physical data model is then outlined. Because one of the most popular data storage formats today is the relational database, optimization of relational databases from both storage and access perspectives is also included.

#### OBJECTIVES

- Become familiar with several file and database formats.
- Describe several goals of data storage.
- Be able to revise a logical ERD into a physical ERD.
- Be able to optimize a relational database for data storage and data access.

- Become familiar with indexes.
- Be able to estimate the size of a database.

## Introduction

As explained in Chapter 7, the work done by any application program can be divided into four general functions: data storage, data access logic, application logic, and presentation logic. The data storage function is concerned with how data is stored and handled by the programs that run the system.

Applications are of little use without the data that they support. How useful is a multimedia application that can't support images or sound? Why would users log into a system to find information if it took them less time to locate the information manually? It is essential to ensure that data storage is designed so that inefficient systems, long response times, and difficult-to-access information (several hallmarks of failed systems) are avoided.

As analysts turn their attention to the data storage that will be needed for the new system, several things must be done. First, the data storage format for the new system must be selected. This chapter describes a variety of data storage formats and explains how to select the appropriate one for your application. There are two basic types of data storage formats for application systems: files and databases. There are multiple types of each storage format; for example, databases can be object-oriented, relational, multidimensional, and so on. Each type has certain characteristics that make it preferable for certain situations.

Following the selection of the data storage format, the data model created during analysis is modified to reflect this implementation decision. The logical data model will be converted into a **physical data model**. CASE repository information is expanded to include much more detailed information about specific implementation details. The analysts will also want to ensure that the DFDs and ERDs balance properly, so the CRUD matrix will be revised, as necessary.

Finally, the selected data storage format must be designed to optimize its processing efficiency. One of the leading complaints by end users is that the final system is too slow. To avoid such complaints, project team members must allow time during the design phase to carefully make sure that the file or database performs as fast as possible. The team must carefully review the availability, reliability, and security nonfunctional requirements to identify issues that produce trade-offs in performance, cost, and storage space.

## Data Storage Formats

There are two main types of data storage formats: files and databases. **Files** are electronic lists of data that have been optimized to perform a particular transaction. For example, Figure 10-1 shows a patient appointment file with information about patient's appointments, in the form in which it is used, so that the information can be accessed and processed quickly by the system.

A **database** is a collection of groupings of information that are related to each other in some way (e.g., through common fields). Logical groupings of information could include such categories as customer data, information about an order, and product information. A **database management system (DBMS)** is software that creates and manipulates these databases (Figure 10-2). **End-user DBMSs** such as Microsoft Access support small-scale databases that are used to enhance personal productivity, and **enterprise DBMSs**, such as DB2, SQL Server, and Oracle, can manage huge volumes of data and support applications that run an entire company. An end-user DBMS is significantly less expensive and easier for novice users to use than its enterprise counterpart, but it does not have the features or capabilities that are necessary to support mission-critical or large-scale systems. Open-source DBMSs are also popular, such as MySQL.

Appointment Date	Appointment Time	Duration	Reason	Patient ID	First Name	Last Name	Phone Number	Doctor ID	Doctor Last Name
11/23/2023	2:30	0.25 hour	Flu	758843	Patrick	Dennis	548-9456	V524625587	Vroman
11/23/2023	2:30	1 hour	Physical	136136	Adelaide	Kin	548-7887	T445756225	Tantalo
11/23/2023	2:45	0.25 hour	Shot	544822	Chris	Pullig	525-5464	V524625587	Vroman
11/23/2023	3:00	1 hour	Physical	345344	Felicia	Marston	548-9333	B544742245	Brousseau
11/23/2023	3:00	0.5 hour	Migraine	236454	Thomas	Bateman	667-8955	V524625587	Vroman
11/23/2023	3:30	0.5 hour	Muscular	887777	Ryan	Nelson	525-4772	V524625587	Vroman
11/23/2023	3:30	0.25 hour	Shot	966233	Peter	Todd	667-2325	T445756225	Tantalo
11/23/2023	3:45	0.75 hour	Muscular	951657	Mike	Morris	663-8944	T445756225	Tantalo
11/23/2023	4:00	1 hour	Physical	223238	Ellen	Whitener	525-8874	B544742245	Brousseau
11/23/2023	4:00	0.5 hour	Flu	365548	Jerry	Starsia	548-9887	V524625587	Vroman
11/23/2023	4:30	1 hour	Minor surg	398633	Susan	Perry	525-6632	V524625587	Vroman
11/23/2023	4:30	0.5 hour	Migraine	222577	Elizabeth	Gray	667-8400	T445756225	Tantalo
11/24/2023	8:30	0.25 hour	Shot	858756	Elias	Awad	663-6364	T445756225	Tantalo
11/24/2023	8:30	1 hour	Minor surg	232158	Andy	Ruppel	525-9888	V524625587	Vroman
11/24/2023	8:30	0.25 hour	Flu	244875	Rick	Grenzi	548-2114	B544742245	Brousseau
11/24/2023	8:45	0.5 hour	Muscular	655683	Eric	Meier	667-0254	T445756225	Tantalo
11/24/2023	8:45	1 hour	Physical	447521	Jane	Pace	548-0025	B544742245	Brousseau
11/24/2023	9:30	0.5 hour	Flu	554263	Trey	Maxham	663-8547	V524625587	Vroman

**FIGURE 10-1** Appointment file.

The next section describes several different kinds of files and databases that can be used to handle a system's data storage requirements.

## Files

A *data file* contains an electronic list of information that is formatted for a particular transaction, and the information is changed and manipulated by programs that are written for those purposes. Files created by older, legacy systems are frequently in a proprietary format, while newer systems use a standard format such as CSV (comma separated value) or tab-delimited. Typically, files are organized sequentially, and new records are added to the file's end. These records can be associated with other records by a pointer, which is information about the location of the related record. A pointer is placed at the end of each record, and it "points" to the next record in a series or *set*. Sometimes files are called **linked lists** because of the way the records are linked together by the pointers. There are several types of files that differ in the way they are used to support an application: master files, look-up files, transaction files, audit files, and history files.

**Master files** store core information that is important to the business and, more specifically, to the application, such as order information or customer mailing information. They usually are kept for long periods, and new records are appended to the end of the file as new orders or new customers are captured by the system. If changes need to be made to existing records, programs must be written to update the old information.

**Look-up files** contain static values, such as a list of valid codes or the names of the US states. Typically, the list is used for validation. For example, if a customer's mailing address is entered into a master file, the state name is validated against a look-up file that contains US states to make sure that the value was entered correctly.

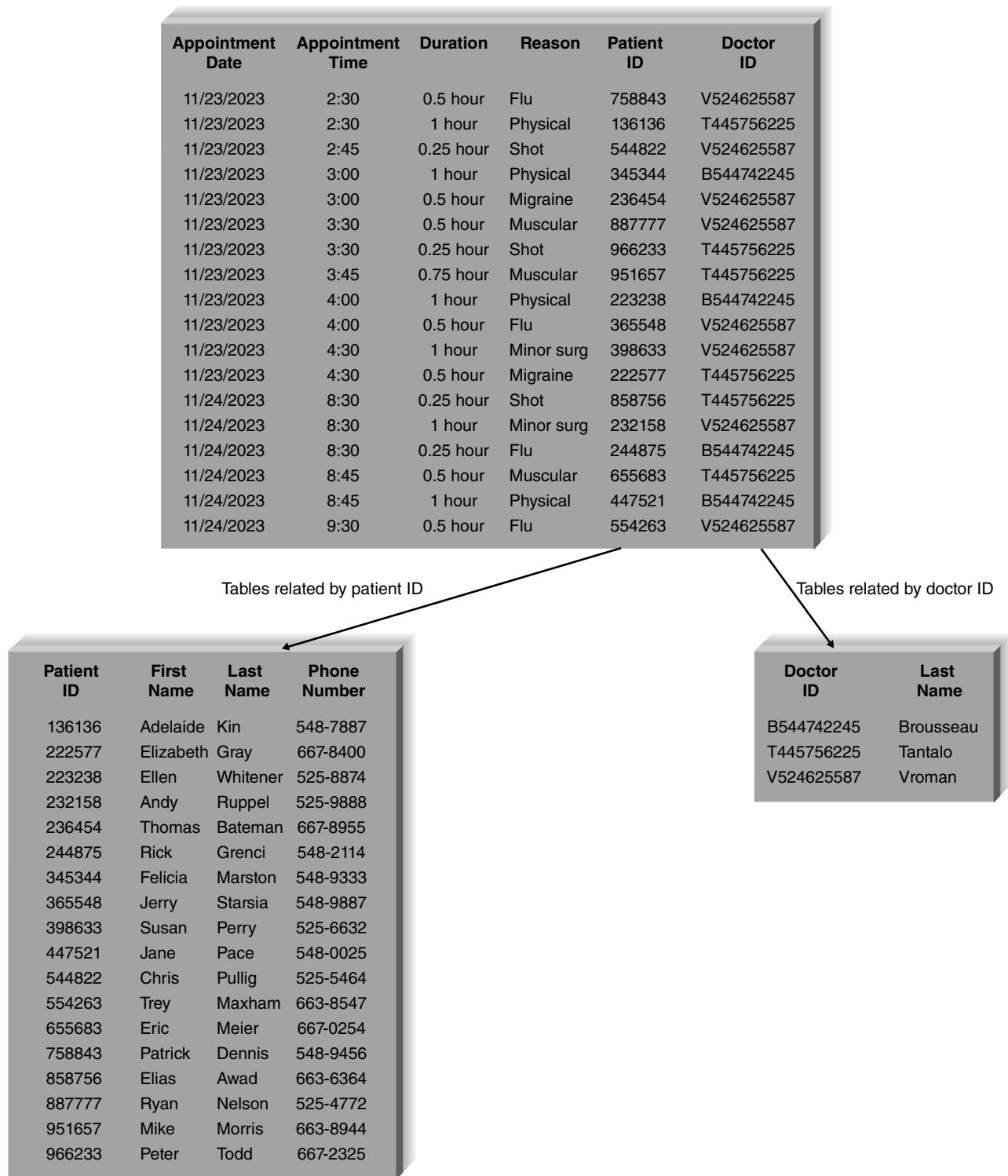


FIGURE 10-2 Appointment database.

A **transaction file** holds information that can be used to update a master file. The transaction file can be destroyed after changes are made, or the file may be saved in case the transactions need to be accessed again in the future. Customer address changes, for one, would be stored in a transaction file until a program is run that updates the customer address master file with the new information.

For control purposes, a company might need to store information about how data changes over time. For example, as human resources clerks change employee salaries in a human resources system, the system should record the person who made the changes to the salary amount, the date, and the actual change that was made. An **audit file** records “before” and “after” images of data as the data are altered, so that an audit can be performed if the integrity of the data is questioned.

Sometimes files become so large that they are unwieldy, and much of the information in the file is no longer used. The **history file** (or archive file) stores past transactions (e.g., inactive customers, past orders) that are no longer needed by system users. Typically, the file is stored off-line, yet it can be accessed on an as-needed basis. Other files, such as master files, can then be streamlined to include only active or very recent information.

## Databases

There are many different types of databases that exist on the market today. In this section, we provide a brief description of four databases with which you may come into contact: legacy, relational, object, and multidimensional. You will likely encounter a variety of ways to classify databases in your studies, but in this book we classify databases in terms of how they store and manipulate data.

### Legacy Databases

The name **legacy database** is given to those databases which are based on older technology. While these database types are not common today, you may come across them when maintaining or migrating from systems that already exist within your organization. Two examples of legacy databases include hierarchical databases and network databases.

**Hierarchical databases** (e.g., IDMS) use hierarchies, or inverted trees, to represent relationships (similar to the one-to-many (1:M) relationships described in Chapter 5). Hierarchical databases are known for rapid search capabilities, but cannot efficiently represent many-to-many (M:N) relationships or nonhierarchical associations—a major drawback—so network databases were developed to address this limitation (and others) of hierarchical technology. **Network databases** (e.g., IDMS/R, DBMS 10) are collections of records that are related to each other through **pointers**. Both kinds of legacy systems can handle data quite efficiently, but they require a great deal of programming effort. The application programs must understand how the database is built and must be written to follow the structure of the database. Years ago, when hardware was expensive and programmer time was cheap, hierarchical and network databases were good solutions for large systems; however, as hardware costs dropped and people costs skyrocketed, these solutions became much less cost-effective compared to other options.

### Relational Databases

The **relational database** is the most popular kind of database for application development today. Although it is less “machine efficient” than its legacy counterparts, it is much easier to work with from a development perspective. A relational database is based on collections of tables, each of which has a **primary key**—a field(s) whose value is different for every row of the table. The tables are related to each other by the placement of the primary key from one table into the related table as a **foreign key** (Figure 10-3).

Most relational database management systems (RDBMSs) support **referential integrity**, or the idea of ensuring that values linking the tables together through the primary and foreign keys are valid and correctly synchronized. For example, if a salesperson using the tables in Figure 10-3 attempted to add order 254 for customer number 1111, he or she would have made a mistake because no customer exists in the Customer table with that number. If the RDBMS supported referential integrity, it would check the customer numbers in the Customer table, discover that the number 1111 is invalid, and return an error. The salesperson would then go back to the original order form and recheck the customer information. Can you imagine the problems that would occur if the RDBMS let the user add the order with the wrong information? There would be no way to track down the name of the customer for order 254.

Cust ID is the primary key of Customer

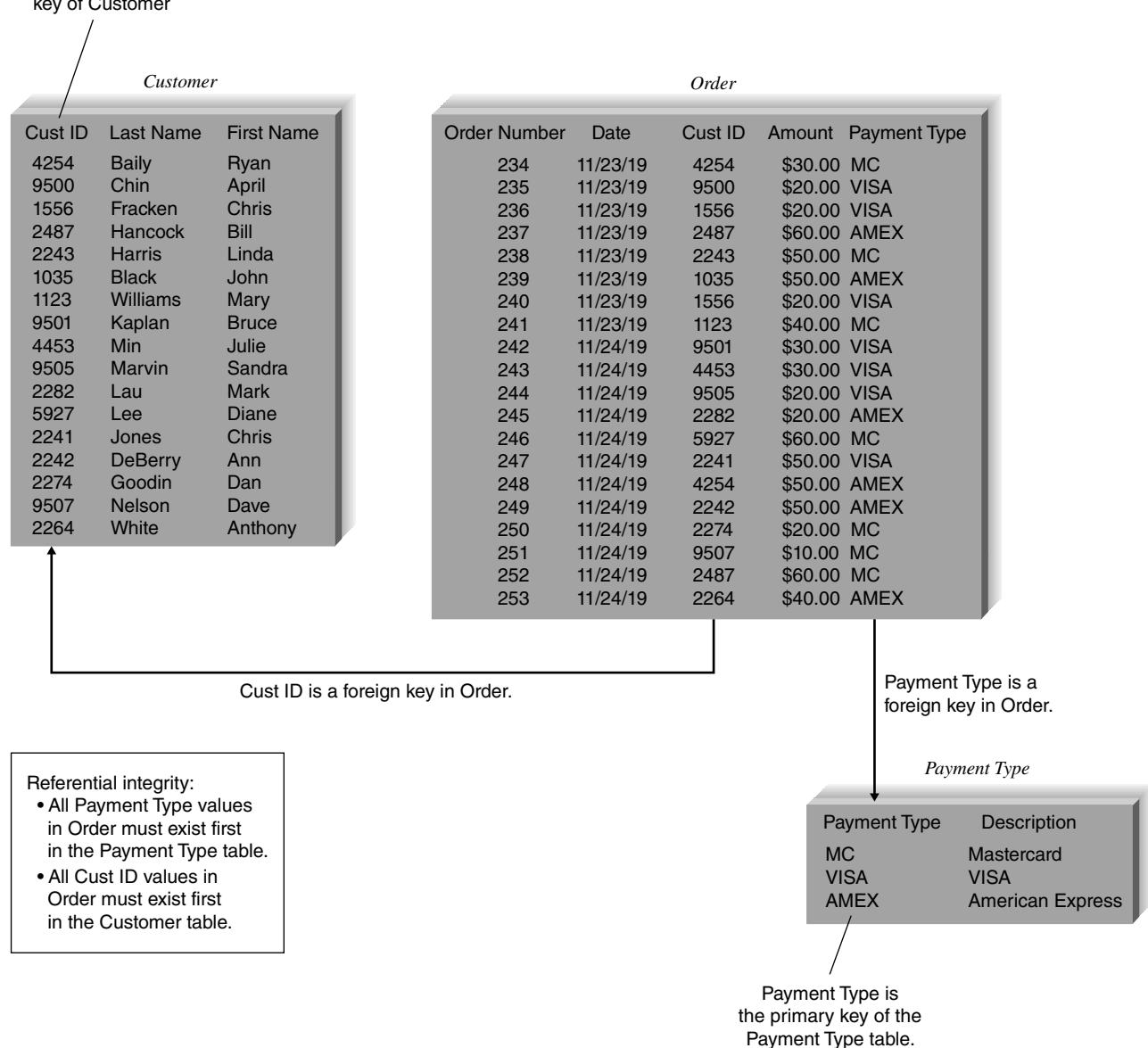


FIGURE 10-3 Relational database.

**YOUR TURN 10-1****Student Admissions System**

Pretend that you are building a Web-based system for the admissions office at your university. The system will be used to accept electronic applications from students. All the data for the system will be stored in a variety of files.

*Question*

1. Give an example using the preceding system for each of the following file types: master, look-up, transaction, audit, and history. What kind of information would each file contain and how would the file be used?

Tables have a set number of columns and a variable number of rows that contain occurrences of data. **Structured Query Language (SQL)** is the standard language for accessing the data in the tables, and it operates on complete tables, as opposed to the individual records in the tables. Thus, a query written in SQL is applied to all the records in a table all at once, which is different from a lot of programming languages that manipulate data record by record. When queries must include information from more than one table, the tables first are joined together based on their primary key and foreign key relationships and treated as if they were one large table. Examples of RDBMS software are Microsoft Access, Oracle, DB2, Sybase, Informix, Microsoft SQL Server, and MySQL.

### **Object Databases**

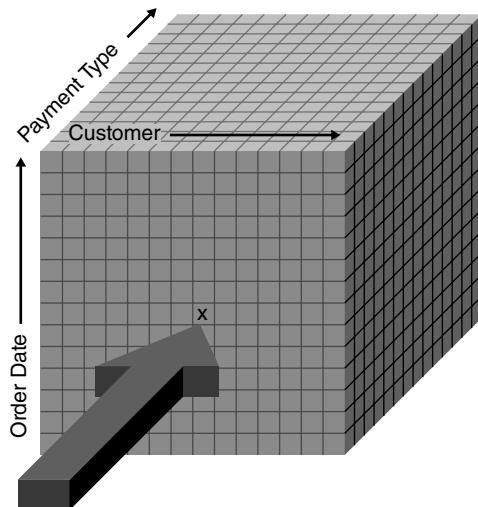
The next type of database is the **object database**, or object-oriented database. The basic premise of object orientation is that all things should be treated as objects that have both data (attributes) and processes (behaviors).

**Object-oriented database management systems (OODBMSs)** are mainly used to support multimedia applications or systems that involve complex data (e.g., graphics, video, and sound). Telecommunications, financial services, health care, and transportation have been the most receptive to object databases. Overall, OODBMSs play a minor role in the DBMS market.

### **Multidimensional Databases**

A **multidimensional database** is a type of relational database that is used extensively in data warehousing. **Data warehousing** is the practice of taking data from a company's transaction processing systems, transforming the data (e.g., cleaning them up, totaling them, aggregating them), and then storing the data for use in a data warehouse (i.e., a large database) that supports **business intelligence (BI) systems**. A data warehouse itself usually relies on relational technology as its storage format; however, companies can create **data marts**, which are smaller databases based on data warehouse data. Typically, a data mart receives downloads of data from the data warehouse regularly, and it supports BI for a specific department or functional area of the company. For example, the marketing department may have a data mart that supports its campaign management BI applications. Data marts are usually created with multidimensional databases.

Multidimensional databases allow a user to ask questions like "How many Toyota Prius automobiles have been sold in Nebraska so far this year?" and similar questions related to summarizing business operations and trends. Systems based on a multidimensional database display information that is **aggregated** (e.g., summed or averaged) across many records (e.g., "What was the average sales by quarter for product A?") Thus, data marts require that data be stored in a format in which they can be easily aggregated and manipulated across a variety of dimensions (e.g., time, product, region, sales rep). Unfortunately, legacy, object, and relational databases are designed and optimized to provide access to individual records, not to store data to support aggregations of data on multiple dimensions.



*Last quarter, how many customers placed more than one order, using an American Express card?*

**FIGURE 10-4**  
Multidimensional database.

When data are first loaded into a multidimensional database, the database precalculates the data across multiple dimensions and stores the answers, using arrays or some other technique. Although the initial loading of the data can be quite slow because of all the calculations that must take place, data access is extremely fast because the “answers” already exist in the arrays. For example, the cube in Figure 10-4 represents a multidimensional database containing data that have been organized by customer, payment type, and order date. Precalculated quantitative information (e.g., totals, averages) is stored at the intersection of the dimensions (in each block), and the BI application directly accesses those blocks. Because blocks contain precalculated information, there is much less processing that needs to occur to provide the BI application with aggregated results.

### NoSQL Databases

The relational database model has its roots in the technologies of the 1960s and 1970s, when storage space was limited and expensive and processing speeds were slow. The limitations of these older technologies have been largely eliminated. It is no longer necessary to break an organization’s data up into many tables that are linked with common fields for storage, only to have to recombine the tables to produce information. In addition, today organizations want to store audio, video, and image files which are large collections of bits. Such files do not fit well in a relational structure.

Consequently, several new databases have appeared in recent years that are collectively referred to as **NoSQL databases**. This category of databases contains a wide variety of database approaches that evolved for different purposes. The primary common theme is that the relational model and SQL are not used in these systems.

- *Document-oriented databases* manage collections of documents where those documents can have a variety of structures, including large bit files for image, audio, and video data. Records in these databases do not need to have a uniform structure, that is, different records may have different columns. The types of the values of individual columns can be different for each record, and columns can have more than one value (arrays). Records can also have a nested structure. Mongo DB is an open-source document-oriented database that is used by companies such as Craigslist and foursquare.

- *Wide column stores*, also called extensible record stores, store data in records with an ability to hold very large numbers of dynamic columns (potentially billions of columns). Google's Bigtable is considered the origin of this category of databases. Facebook developed a database called Cassandra. In 2008, Facebook turned Cassandra over to the open-source community, and now Apache has dubbed it a Top Level Project (TLP), giving it a high degree of respectability among open source projects. Amazon also developed its own database called Dynamo.
- *Graph databases* use graph theory to store, map, and query relationships. A graph database is essentially a collection of nodes and edges. Each node represents an entity (such as a person) and each edge represents a connection or relationship between two nodes. Graph databases are suitable for analyzing interconnections and are useful when mining data from social media. When you encounter the feature "Customers who bought this also looked at . . ." on websites, you have probably encountered the use of a graph database.

These NoSQL databases support very high transaction rates processing relatively simple data structures, replicated on many servers in the cloud. The market for DBMSs, however, is still heavily dominated by relational DBMSs, thanks to the strength of Oracle, Microsoft's SQL Server, and MySQL. A recent ranking of DBMSs by popularity found that the top four DBMSs were relational. Out of the remaining top 10 most popular products, two were relational and four were NoSQL. It seems clear that NoSQL databases are becoming more popular.<sup>1</sup>

## Selecting a Storage Format

Each of the file and database data storage formats has its strengths and weaknesses, and no one format is inherently better than the others. In fact, sometimes, a project team will choose multiple data storage formats (e.g., a relational database for one data store, a file for another, and a multidimensional database for a third). Thus, it is important to understand the strengths and weaknesses of each format and when to use each one (Figure 10-5).

### Data Types

Most applications need to store simple data types, such as text, dates, and numbers, and all DBMSs are equipped to handle this kind of data. The best choice for simple data storage, however, usually is the relational database because the technology has matured over time and has continuously improved to handle simple data very effectively.

Increasingly, applications are incorporating complex data, such as video, images, or audio, and NoSQL databases and object databases are best able to handle data of this type. Other applications require aggregated data (i.e., information that has been summed, averaged, or combined in some way). Multidimensional databases are specially designed to store data so that they can be "sliced and diced" and examined across important business dimensions. If the system is being built for analytical decision support, then this option likely will be most appropriate.

Many systems today utilize data collections that are characterized by huge *volume*, rapid *velocity*, and great *variety*. These data collections have become known as **Big Data**. Volume means the data sets are at least a petabyte in size; velocity means that it is generated rapidly; and varied means that the data collection may have structured data, but also may have free-form text, dozens of different formats of Web server and database log files, streams of data about user responses to page content, and possibly graphics, audio, and video files. NoSQL databases are designed to handle these types of data sets.

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<sup>1</sup>DB-Engines Ranking, found at db-engines.com/en/ranking, accessed May 31, 2018.



	<b>Files</b>	<b>Legacy databases</b>	<b>Relational databases</b>	<b>Object databases</b>	<b>Multidimensional databases</b>	<b>NoSQL databases</b>
Major strengths	Files can be designed for fast performance; good for short-term data storage.	Very mature products	Leader in the database market; can handle fast updating and querying needs	Able to handle complex data	Configured to answer business intelligence questions quickly	Designed for huge, varied data sets
Major weaknesses	Redundant data; data must be updated using programs.	Not able to store data as efficiently; limited future	Cannot handle complex data	Limited market acceptance; skills are hard to find.	Highly specialized use; skills are hard to find	New in the market, highly specialized use; skills are hard to find
Data types supported	Simple	Not recommended for new systems	Simple	Complex (e.g., video, audio, images)	Aggregated	Mixed data sets with structured and unstructured components
Application system types supported	Transaction processing	Not recommended for new systems	Transaction processing and decision making	Transaction processing	Business intelligence	Business intelligence; finding patterns and relationships in mixed data
Existing data formats	Organization dependent	Organization dependent	Organization dependent	Organization dependent	Organization dependent	Organization dependent
Future needs	Limited future prospects	Poor future prospects	Good future prospects	Uncertain future prospects	Uncertain future prospects	New, uncertain future prospects

**FIGURE 10-5** Comparison of data storage formats.

### Type of Application System

There are many kinds of application systems that can be developed. **Transaction processing systems** are designed to accept and process many simultaneous requests (e.g., order entry, distribution, payroll). In transaction processing systems, the data are continuously updated by many users, and the queries that are asked of the systems typically are predefined or targeted at a small subset of records (e.g., “List the orders that were back-ordered today”; “What products did customer #1234 order on May 12, 2021?”).

Another set of application systems comprises those designed to support decision making. This category, commonly called business intelligence (BI), includes **management information systems (MISs)**, **executive information systems (EISs)**, and **expert systems (ESs)**. These BI systems are built to support decision makers who need to examine large amounts of read-only historical data. The questions that they ask often are ad hoc, and they include hundreds or thousands of records at a time (e.g., “List all customers in the west region who purchased a product costing more than \$500 at least three times”; “What products have increased sales in the summer months but have not been classified as summer merchandise?”).

Transaction processing and BI systems thus have quite different data storage needs. Transaction processing systems need data storage formats that are tuned for a lot of data updates and fast retrieval of predefined, specific questions. Files, relational databases, and object databases can all support these kinds of requirements. By contrast, systems to support decision making are

usually only reading data (not updating it), often in ad hoc ways. The best choices for these systems usually are relational databases and multidimensional databases because these formats can be configured specially for needs that may be unclear and less apt to change the data. Finally, if the BI system has a data store with Big Data characteristics, a noSQL database will be needed.

### Existing Storage Formats

The data storage format should be selected primarily based on the kind of data and application system being developed. Project teams should also consider the existing data storage formats in the organization when making design decisions. In this way, they can better understand the technical skills that already exist and how steep the learning curve will be when the data storage format is adopted. For example, a company that is familiar with relational databases will have little problem adopting a relational database for the project, whereas a multidimensional, object, or NoSQL database may require substantial developer training. In the latter situation, the project team may have to plan for more time to integrate the new database with the company's relational systems.

### Future Needs

The project team should be aware of current trends and technologies that are being used by other organizations. Many installations of a type of data storage format suggests that the selection of that format is "safe," in that needed skills and products are available. For example, it would probably be easier and less expensive to find relational database expertise when implementing a system than to find help with a NoSQL data storage format. Legacy and object database skills, too, would likely be difficult to find. Many organizations are monitoring the developments in NoSQL databases because of their capabilities with huge, mixed datasets. The market for these products is still in its infancy; but we recommend staying abreast of developments in this area.

## Applying the Concepts at DrōnTeq

The DrōnTeq Drone Flight Services system needs to effectively present information about the Flight Services business to prospective clients and pilots. In addition, the transaction processing needed by registered clients and pilots needs to be processed securely, quickly, and accurately. Jiang Tsiao, senior systems analyst and project manager for the Drone Flight Services system, recognized that these goals were dependent on a good design of the data storage component for the new application.

The project team met to discuss two issues that would drive the data storage format selection: what kind of data would be in the system and how that data would be used by the application system. Using a white board, they listed the ideas presented in Figure 10-6. The project team agreed that the bulk of the data in the system would be text and numbers describing Clients, Pilots, Flight Requests, and Flight Bids. A relational database would be able to handle the data effectively, and the technology would be well received because of its widespread use.

The team recognized, however, that relational technology may not be optimized to handle complex data such as the geographic location data, image files, video files, and infrared image files associated with the Flight Services business. Jiang asked a project team member to investigate noSQL databases. It might be possible to utilize that database type with these types of data found in this business.

Of course, Jiang realized that other data needs would arise over time, but he felt confident that the major data issues were identified (e.g., the ability to handle complex data) and that the data storage design would be selected based on the proper storage technologies.

Data	Type	Use	Suggested Format
Client information	Simple, mostly text	Transactions	Relational
Pilot information	Simple, mostly text	Transactions	Relational
Flight Request information	Simple, text and numbers	Transactions	Relational
Flight Request Notification information	Simple, text and numbers	Transactions	Relational
Flight Bid information	Simple, text and numbers	Transactions	Relational
Location information	Geographic; geospatial	Transactions	Relational? Other?
Images	Image file formats	Product of Flight Service	NoSQL?
Video clips	Video file formats	Product of Flight Service	NoSQL?
Infrared Sensor data	IR Image files	Product of Flight Service	NoSQL?

**FIGURE 10-6** Types of data in the drone flight services system.

## Moving from Logical to Physical Data Models

During analysis, the analysts defined the data required by the application by creating **logical entity relationship diagrams (ERDs)**. These logical models depict the “business view” of the data, but omit any implementation details. Now, having determined the data storage format, **physical data models** are created to show implementation details and to explain more about the “how” of the final system. These to-be models describe characteristics of the system that will be created, communicating the “systems view” of the new system.

## The Physical Entity Relationship Diagram

Like the DFD, the ERD contains the same components for both the logical and physical models, including entities, relationships, and attributes. The difference lies in the fact that **physical ERDs** contain references to exactly how data will be stored in a file or database table and that much more metadata is added to the CASE repository to describe the data model components. The transition from the logical to physical data model is straightforward; see the steps in Figure 10-7.

### Step 1: Change Entities to Tables or Files

The first step is to change all the entities in the logical ERD to reflect the files or tables that will be used to store the data. Usually, project teams adhere to strict naming conventions for such things as tables, files, and fields, so the physical ERD would use the names that the real components will have when implemented. Metadata for the tables and files, like the expected size of the table, are added to the CASE repository. See Figure 10-8 for a physical ERD from the Custom Drone Ordering system that was described in Chapter 5.

Step	Explanation
1. Change entities to tables or files.	Beginning with the logical ERD, change the entities to tables or files and update the metadata.
2. Change attributes to fields.	Convert the attributes to fields and update the metadata.
3. Add primary keys.	Assign primary keys to all entities.
4. Add foreign keys.	Add foreign keys to represent the relationships among entities.
5. Add system-related components.	Add system-related tables and fields.

**FIGURE 10-7** Steps to moving from logical to physical entity relationship diagram.

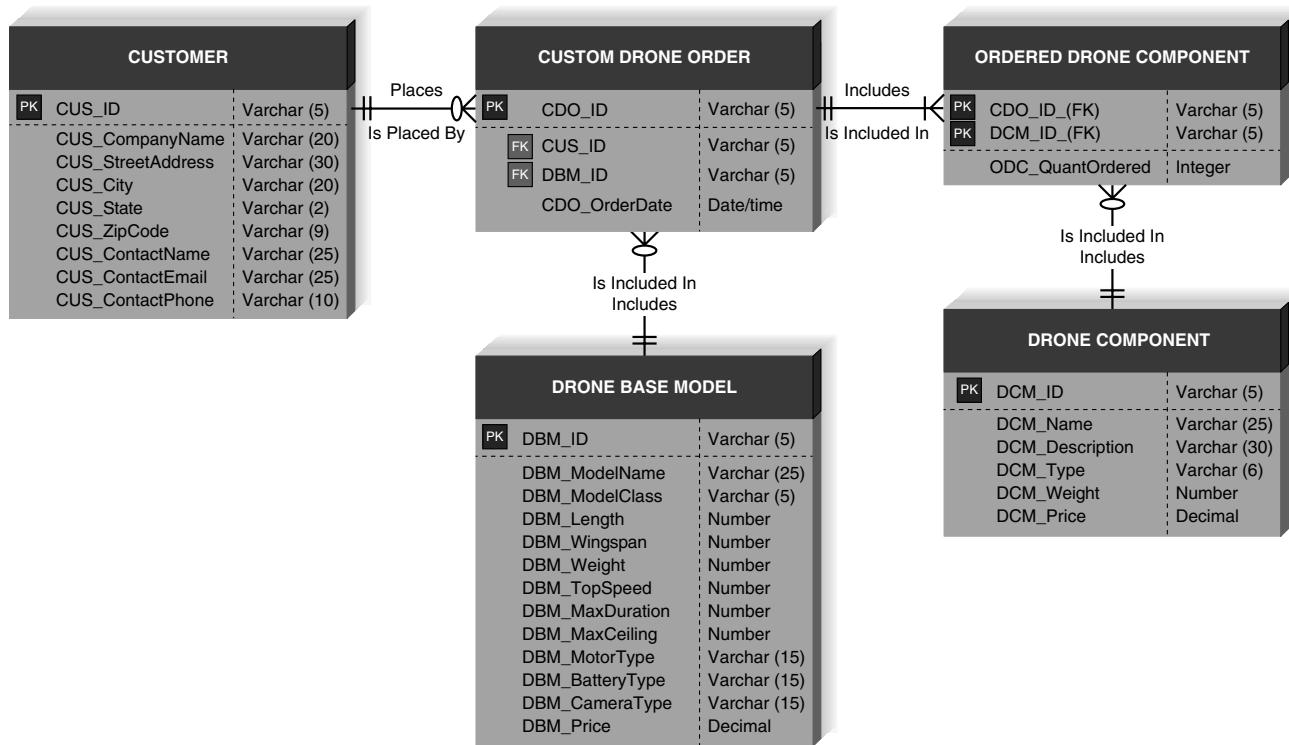
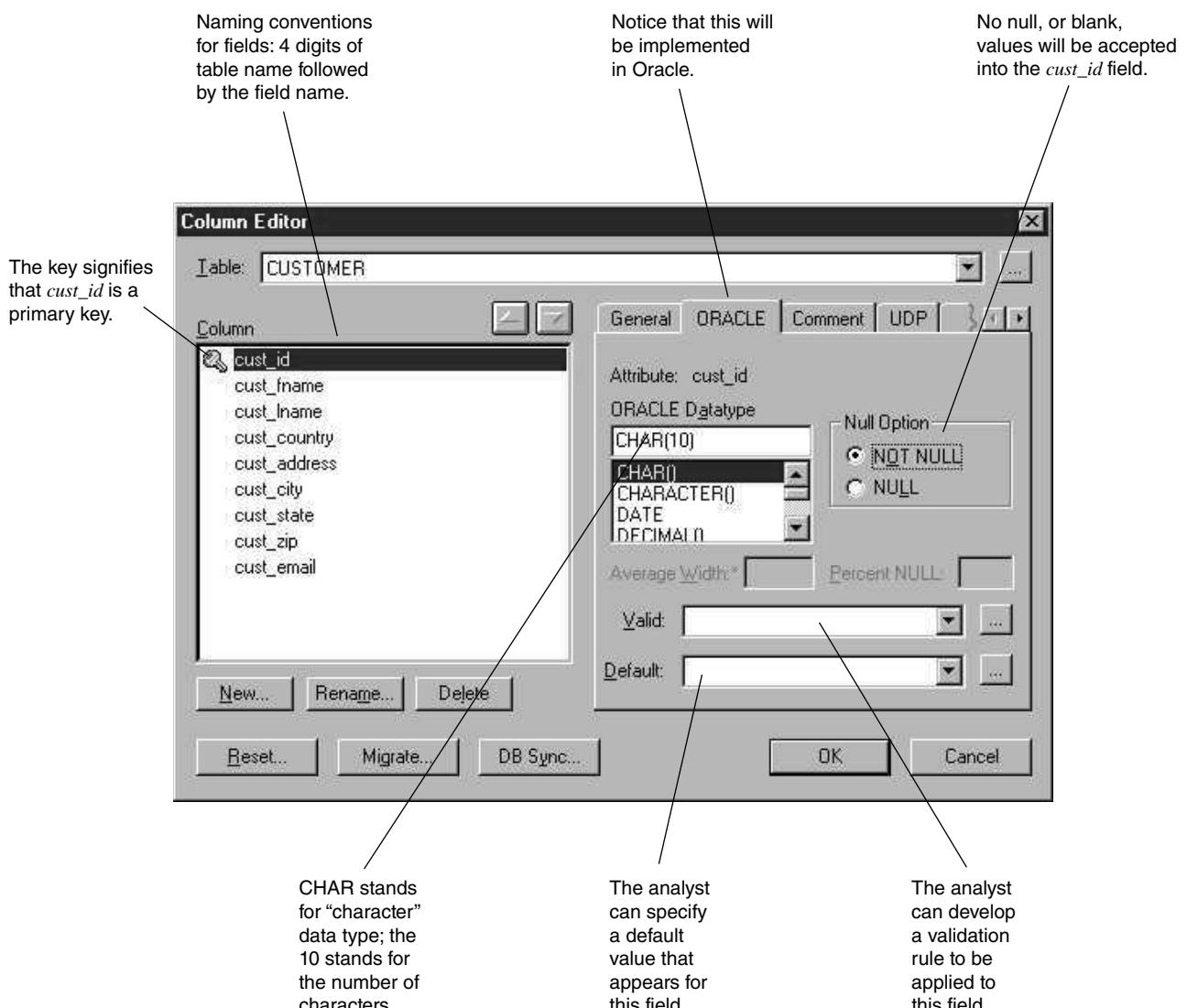


FIGURE 10-8 Custom drone ordering system physical ERD.

## Step 2: Change Attributes to Fields

Second, change the attributes to fields, which are columns in files or tables, and add information like the field's length, data type, default value, and valid value to the CASE repository. There are several different data types that fields can have, such as number, decimal, longint, character, and variable character. The analyst inputs the data type along with the size of the field into the CASE tool so that the system can be designed for the right kind of information. A **default value** specifies what should be placed in a column if no value is explicitly supplied when a record is inserted into the table. A **valid value** is a fixed list of valid values for a particular column, or an expression to define some form of data validation code for a column or table. Figure 10-9 shows a variety of metadata describing the *cust\_id* field in an Oracle Customer table.

Inputting complete information regarding the tables and columns into the CASE repository is particularly important. Many CASE tools will generate code to build tables and create files for



**FIGURE 10-9** Metadata for a *cust\_id* field.

the new system according to the information they contain for the physical models. By taking time to describe the physical data model in detail, the analyst can save a lot of time when the system is ready to be implemented.

### Step 3: Add Primary Keys

As a third step, the attributes that served as identifiers on the logical ERD are converted into *primary keys*, which are fields that contain a unique value for each record in the file or table. For instance, Student ID Number would serve as a good primary key for a Student table if every student record in the table will contain a unique value in the Student ID Number field. A unique identifier is mandatory for every table placed on the physical ERD; therefore, primary key fields must be created for entities that did not have identifiers previously. For example, if we did not choose an identifier for the customer entity on the logical ERD, we would now create a system-generated field (e.g., *cust\_id*) that could serve as the primary key for the customer table. This field would have no meaning or purpose other than ensuring that each record has a field that contains a unique value.

### Step 4: Add Foreign Keys

The relationships on the logical ERD show that pairs of entities are associated with each other, and in step 4, the analyst specifies how the associations are going to be maintained from a technical standpoint. In a relational database, for example, an association between two tables is maintained by a technique referred to as a *foreign key*. A foreign key is the primary key field(s) from one table that is added to another table to provide a common field between the two tables. The common field contains values that match a record in one table to a record in the other. For example, if we were to create two tables called Customer and Custom Drone Order that were related to each other, we could include the primary key field from Customer (*cus\_id*) in the Custom Drone Order table as well. In this way, if we want to find out customer information (e.g., name, address, phone number) when looking at someone's order, we can use the value for *cus\_id* that appears in the Custom Drone Order table to go back to the Customer table to locate the appropriate information.

Thus, on the physical ERD, the primary key fields in the parent tables (the “1” end of the relationship) are copied and placed as fields in the child tables (the “many” end of the relationship) and designated as foreign keys. The fields will contain values that are common between the two tables. Many times, the CASE tools that are used to draw ERDs will “migrate” foreign keys to the appropriate tables on the model automatically, and the database technology will ensure that the values in the two fields match appropriately, helping to ensure referential integrity.

### Step 5: Add System-Related Components

As the fifth and final step, components are added to the physical ERD to reflect special implementation needs, including components that were included on the DFD. We have mentioned balance between DFDs and ERDs in earlier chapters, and this balance must be maintained in the physical models as well. Therefore, implementation-specific data stores and data elements from the physical DFD should be included on the ERD as tables and fields.

## Revisiting the CRUD Matrix

As discussed in Chapter 5, it is important to verify that the system's DFD and ERD models are balanced. In other words, we must ensure that data needed in the systems processes are stored and that all stored data are used by at least one process. The CRUD matrix was introduced in Chapter 5 as a tool showing how data are used by processes in the system.

Often the CRUD matrix is created during analysis based on the logical process and data models. In design, as these models are converted to physical models, changes in the form of new processes, new data stores, and new data elements may occur. The CRUD matrix should be revised at this point to include the new components and ensure that balance is maintained between the physical ERD and DFDs.

If the CRUD matrix was not developed during analysis, it should be developed now prior to implementation. The matrix shows exactly how data are used and created by the major processes in the system, so it serves as an especially useful component of the system design materials.

## Applying the Concepts at DrōnTeq

Let us now apply some of the concepts that you have learned by creating a physical ERD, using the logical ERD that was created in Chapter 5.

When we use the logical model as a starting point, the first step is to rename the entities to match with the tables or files that will be used by the system (Figure 10-10). Outwardly, the data model does not look very different after this step but notice that several entities have been renamed to be consistent with DrōnTeq’s table naming standards. At this time, we will need to include metadata for the tables, such as their estimated size.

Next, the attributes for the entities become fields with such characteristics as data type, length, and valid values, and this is recorded in the CASE repository. For example, CLI\_State in the CLIENT table will be a text field with a size of two characters, and valid values are the 50 two-letter state abbreviations. If any fields have a value that is expected to be true in most cases, that value should be established as the default value and recorded in the CASE repository.

Step 3 suggests that we change the identifiers in the logical ERD to become primary keys, and entities without identifiers need to have a primary key created. At this time, we also can decide to use a system-generated primary key if it is more efficient than using logical attributes from the logical model.

The relationships on the logical ERD indicate where foreign key fields need to be placed. For example, CLI\_ID is placed as a field in FLT\_RQST to serve as the link between two entities, and FLT\_RQST gets the extra field because it is the child table (it exists at the “many” end of the relationship). Similarly, PIL\_ID is placed in the FLT\_RQST table to specify the pilot who is assigned to perform a specific flight request.

Finally, system-related components are included within the model. For example, fields that will capture when a record was last inserted or updated were added to many of the tables.

The project team also updated the CRUD matrix for the system. Figure 10-11 shows the CRUD matrix that was created for the DrōnTeq Assign Pilot to Flight Request process. Look at the original process models (Figures 4-26–4-31) and notice how the first process reads data from three data stores and writes (creates a new record) in one data store. This is illustrated on the CRUD matrix by an “R” placed in the relevant intersections of the matrix. Can you tell how data are used by the remaining processes?

## Optimizing Data Storage

The selected data storage format is now optimized for processing efficiency. The optimization methods will vary with the format that you select; however, the basic concepts will remain the same. Once you understand how to optimize a particular type of data storage, you will have some idea as to how to approach the optimization of other formats. This section focuses on the optimization of the most popular data storage format: relational databases.

There are two primary dimensions in which to optimize a relational database: for storage efficiency and for speed of access. Unfortunately, these two goals often conflict because the best

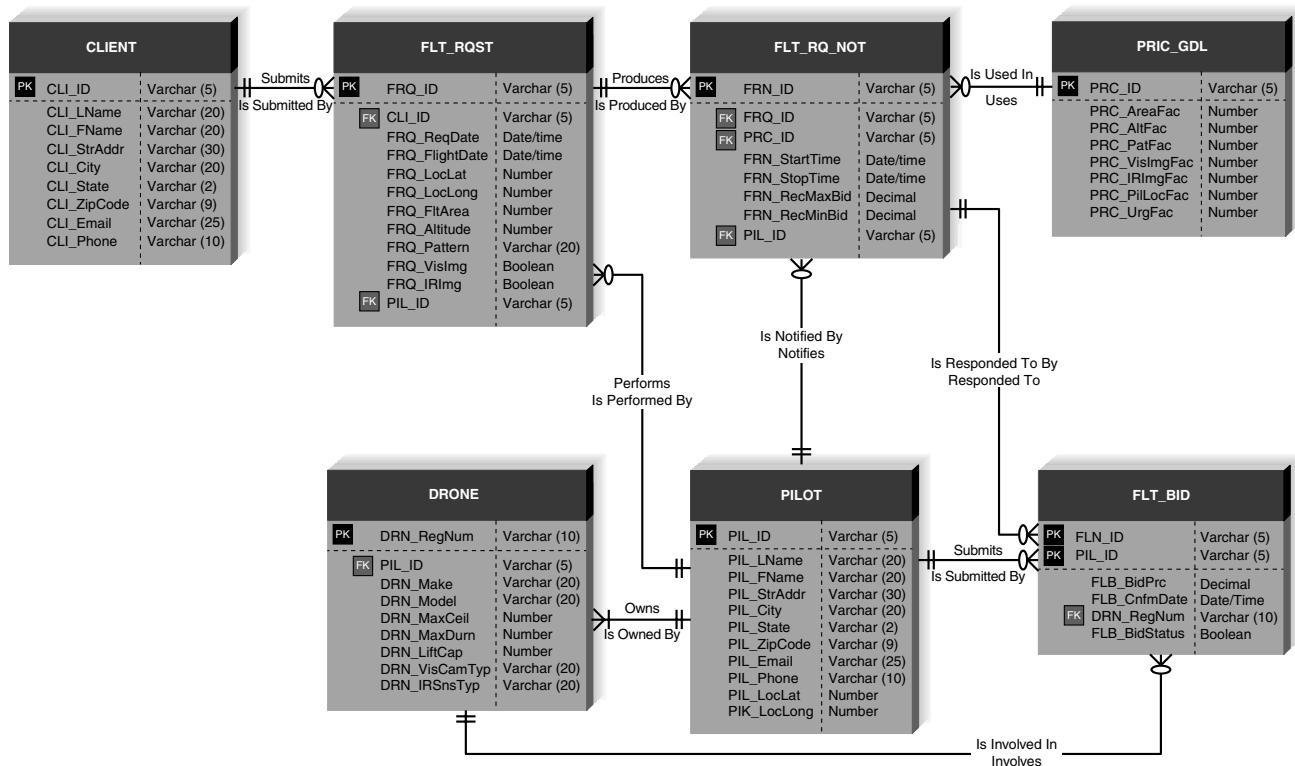


FIGURE 10-10 DrönTeq physical ERD.

	2.1 Notify Pilots of New Flight Request	2.2 Pilot Submits Bid	2.3 Select Winning Flight Bid
<b>FLT_RQST</b>			
FRQ_ID	R	R	R
CLI_ID	R	R	R
FRQ_ReqDate	R	R	R
FRQ_FlightDate	R	R	R
FRQ_LocLat	R	R	R
FRQ_LocLong	R	R	R
FRQ_FltArea	R	R	R
FRQ_Altitude	R	R	R
FRQ_Pattern	R	R	R
FRQ_VisImg	R	R	R
FRQ_IRImg	R	R	R
PIL_ID			U
<b>PILOT</b>			
PIL_ID			
PIL_LName	R		
PIL_FName	R		
PIL_StrAddr			
PIL_City			
PIL_State			
PIL_ZipCode			
PIL_Email	R		
PIL_Phone			
PIL_LocLat	R		
PIL_LocLong	R		
PRIC_GDL			
PRC_ID	R		
PRC_AreaFac	R		
PRC_AltFac	R		
PRC_PatFac	R		
PRC_VisImgFac	R		
PRC_IRImgFac	R		
PRC_PilLocFac	R		
PRC_UrgFac	R		
<b>FLT_RQ_NOT</b>			
FRN_ID	C	R	
FRQ_ID	C	R	
PRC_ID	C	R	
FRN_StartTime	C	R	
FRN_StopTime	C	R	
FRN_RecMaxBid	C	R	
FRN_RecMinBid	C	R	
PIL_ID	C	R	
<b>FLT_BID</b>			
FLN_ID		C	R
PIL_ID		C	R
FLB_BidPrc		C	R
FLB_CnfmDate		C	R
DRN_RegNum		C	R
FLB_BidStatus		C	U

**FIGURE 10-11**  
CRUD matrix for assign pilot to flight process.

**YOUR TURN 10-2****Island Charters**

In Chapter 5, you were asked to create a logical entity relationship diagram (ERD) for a charter company that owns boats that are used to charter trips to the islands (“Your Turn 5-8”). The company has created a computer system to track the boats it owns, including each boat’s ID number, name, and seating capacity. The company also tracks information about the various islands, such as name and population. Every time a boat is chartered, it is important to know the data about the trip that

takes place and the number of people on the trip. The company also keeps information about each captain, such as Social Security Number, name, birthdate, and how to contact next of kin. Boats travel to only one island per visit.

Create a physical ERD for this situation. Compare the diagram that you drew to the logical diagram that you created in Chapter 5.

design for access speed may take up a great deal of storage space as compared with other less speedy designs. This section describes how to use normalization (Chapter 5) to optimize data storage for storage efficiency. The next section presents design techniques, such as denormalization and indexing, which will quicken the performance of the system. Ultimately, the project team will go through a series of trade-offs until the ideal balance between both optimization dimensions is reached. Finally, the project team must estimate the size of the data storage needed to ensure that there is enough capacity on the server(s).

## Optimizing Storage Efficiency

The most efficient tables in a relational database in terms of storage space have no redundant data and very few null values because the presence of these suggest that space is being wasted (and more data to store means higher data storage hardware costs). For example, notice that the sample order table in Figure 10-12 repeats customer information, such as name and state, each time a customer places an order, and it contains many null values in the last four columns. These null values occur whenever a customer places an order for less than three items (the maximum number on an order).

In addition to wasting space, redundancy and null values also allow more room for error and increase the likelihood that problems will arise with the integrity of the data. What if customer 1135 moves from Maryland to Georgia? In the case of Figure 10-12, a program must be written to ensure that all instances of that customer are updated to show “GA” as the new state of residence. If some of the instances are overlooked, then the table will contain an update anomaly whereby some of the records contain the correctly updated value for state and other records contain the old information.

**YOUR TURN 10-3****Donation Tracking System**

A major public university graduates approximately 10,000 students per year, and its development office has decided to build a Web-based system that solicits and tracks donations from the university’s large alumni body. Ultimately, the development officers hope to use the information in the system to better understand the alumni giving patterns so that they can improve giving rates.

*Questions*

1. What kind of system is this?
2. Does it have characteristics of more than one?
3. What different kinds of data will this system use?
4. Based on your answers, what kind of data storage format(s) do you recommend for this system?

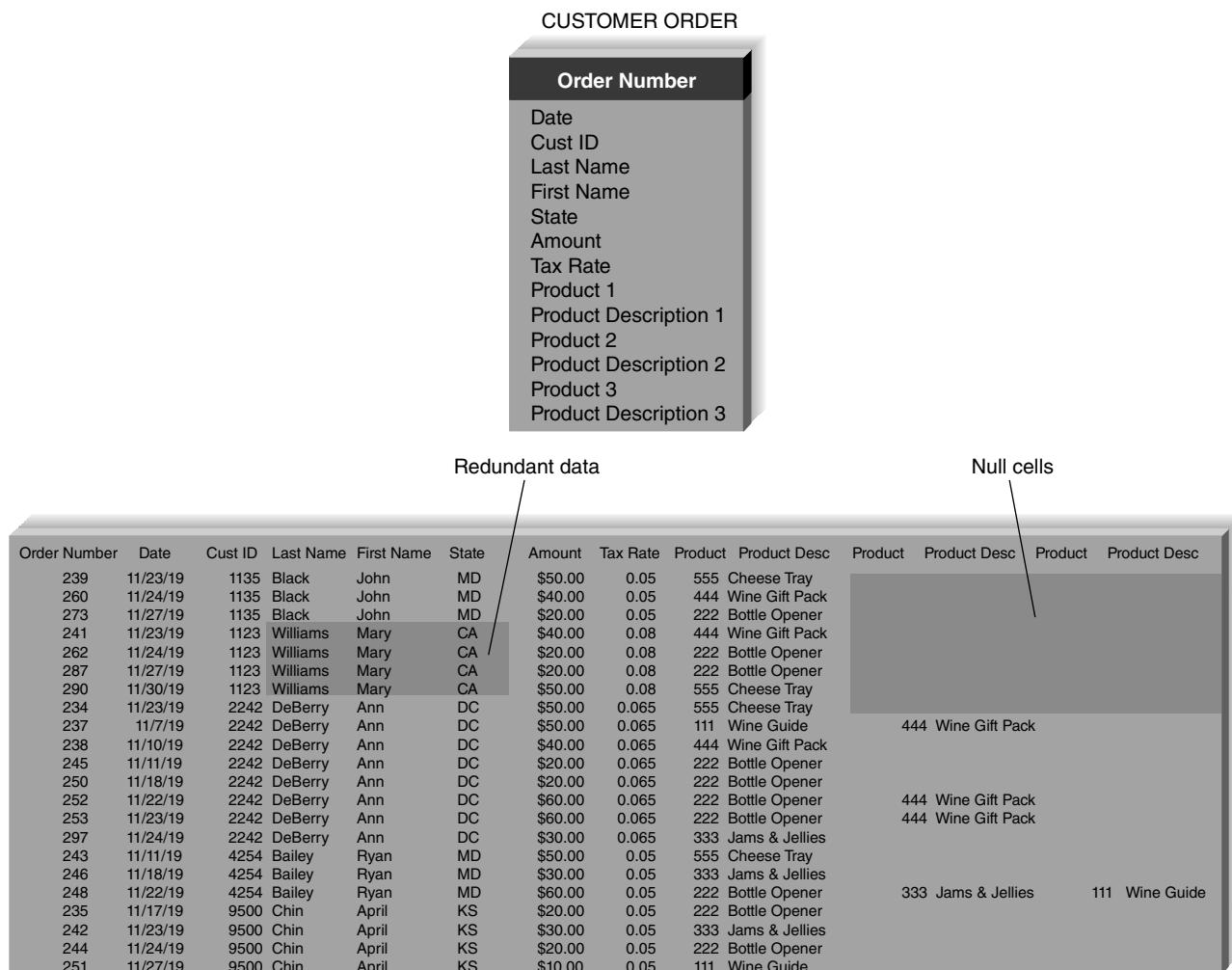


FIGURE 10-12 Optimizing data storage.

Null values threaten data integrity because they are difficult to interpret. A blank value in the customer order table's product fields could mean that (1) the customer did not want more than one or two products on his or her order, (2) the operator forgot to enter in all three products on the order, or (3) the customer canceled part of the order and the products were deleted by the operator. It is impossible to be sure of the actual meaning of the null values.

For both reasons—wasted storage space and data integrity threats—project teams should remove redundancy and null values from data storage design. During the design phase, the logical data model is used to examine the data storage design and optimize it for storage efficiency. If you follow the modeling instructions and guidelines that were presented in Chapter 5, you will have little trouble creating a design that is highly optimized in this way, because a well-formed logical data model does not contain redundancy or many null values.

Sometimes, however, a project team starts with a logical model that was poorly constructed or with a model that was created for files or a nonrelational type of data storage format. In these cases, the project team should follow the steps of the **normalization** process described in Chapter 5 (see Figure 5-17). Normalization is the best way to optimize data storage for efficiency.

## Optimizing Access Speed

After you have optimized your data model design for data storage efficiency, the result is data that are spread out across a number of tables. When data from multiple tables must be accessed or queried, the tables first must be joined together. For example, in Figure 10-2, before the office manager can print out a list of appointments with patient and doctor names on it, the patient and doctor tables need to be joined with the appointment table on the basis of the patient ID and doctor ID fields. Only then can appointment, patient, and doctor information be included in the query's output. Joins can take a lot of time, especially if the tables are large or if many tables are involved.

Consider an order system that stores information about 10,000 different products, 25,000 customers, and 100,000 orders, each order containing three products, on average. If an analyst wanted to investigate whether there were regional differences in buying preferences, he or she would need to combine all the tables to be able to look at products that have been ordered, while knowing the location of the customers placing the orders. A query of this information would result in a huge table with 300,000 rows (i.e., the number of products that have been ordered) and many columns representing columns from all three tables combined.

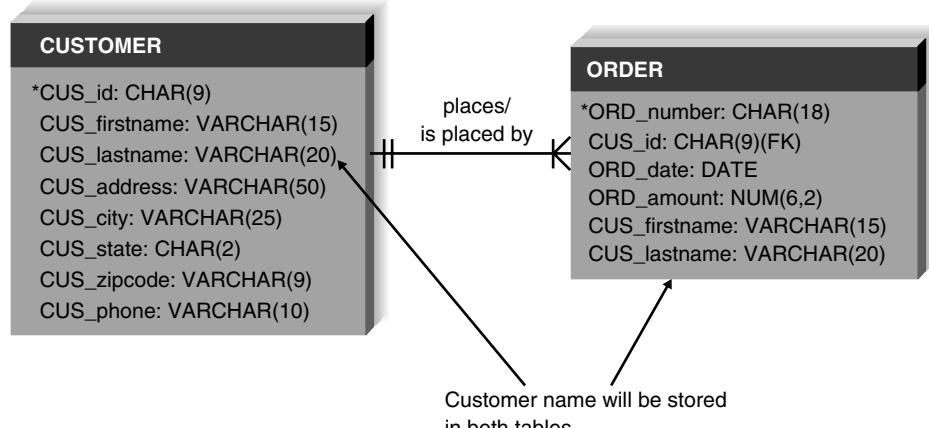
There are several techniques that the project team can use to try to speed up access to the data: denormalization, clustering, indexing, and estimating the size of the data for hardware planning purposes.

### Denormalization

After the logical data model is optimized in terms of data storage, the project team may decide to denormalize, or add redundancy back into the design that is depicted in the physical data model.

**Denormalization** reduces the number of joins that must be performed in a query, thus speeding up data access. Figure 10-13 shows a denormalized physical data model for customer orders. The customer name was added back into the Order table because the project team learned during the analysis phase that queries about orders usually require the customer's name. Instead of joining the Order table repeatedly to the Customer table, the system now needs to access only the Order table because it contains all the relevant information.

Of course, denormalization should be applied sparingly, for the reasons described in the previous section, but it is ideal in situations in which information is queried frequently yet updated rarely. There are four cases in which you may rely on denormalization to reduce joins and improve performance (Figure 10-14). First, denormalization can be applied in the case of



**FIGURE 10-13**  
Denormalized  
data model.

Reason	Description	Example
Look-up Table	Include a code's description in the table using that code if the description is often used.	<p><b>ORDER</b></p> <ul style="list-style-type: none"> <li>*ORD_number: CHAR(18)</li> <li>ORD_date: DATE</li> <li>ORD_amount: NUM(6,2)</li> <li>PAY_type: CHAR(2)(FK)</li> <li>PAY_description: VARCHAR(15)</li> </ul> <p><b>PAYMENT_TYPE</b></p> <ul style="list-style-type: none"> <li>*PAY_type: CHAR(2)</li> <li>PAY_description: VARCHAR(15)</li> </ul>
1:1 Relationships	Combine tables if they are related 1:1 and if they usually are accessed together.	<p><b>ORDER</b></p> <ul style="list-style-type: none"> <li>*ORD_number: CHAR(18)</li> <li>ORD_date: DATE</li> <li>ORD_amount: NUM(6,2)</li> <li>SHI_state: CHAR(2)</li> <li>SHI_method: CHAR(4)</li> </ul> <p><b>SHIPMENT</b></p> <ul style="list-style-type: none"> <li>*SHI_id: CHAR(9)</li> <li>SHI_num: CHAR(18) (FK)</li> <li>SHI_address: VARCHAR(50)</li> <li>SHI_city: VARCHAR(25)</li> <li>SHI_state: CHAR(2)</li> <li>SHI_zip: VARCHAR(9)</li> <li>SHI_method: CHAR(4)</li> </ul>
1:N Relationships	Place fields from the parent (1) table into the child (N) table if the parent fields are used frequently with child information.	<p><b>CUSTOMER</b></p> <ul style="list-style-type: none"> <li>*CUS_id: CHAR(9)</li> <li>CUS_firstname: VARCHAR(15)</li> <li>CUS_lastname: VARCHAR(20)</li> <li>CUS_address: VARCHAR(50)</li> <li>CUS_city: VARCHAR(25)</li> <li>CUS_state: CHAR(2)</li> <li>CUS_zipcode: VARCHAR(9)</li> <li>CUS_phone: VARCHAR(10)</li> </ul> <p><b>ORDER</b></p> <ul style="list-style-type: none"> <li>*ORD_number: CHAR(18)</li> <li>CUS_id: CHAR(9)(FK)</li> <li>ORD_date: DATE</li> <li>ORD_amount: NUM(6,2)</li> <li>CUS_firstname: VARCHAR(15)</li> <li>CUS_lastname: VARCHAR(20)</li> </ul>
Star Schema Design	Data marts often are modeled with star schema design, which uses denormalization to maximize BI query performance.	<p><b>CUSTOMER</b></p> <ul style="list-style-type: none"> <li>*CUS_id: CHAR(9)</li> <li>CUS_firstname: VARCHAR(15)</li> <li>CUS_lastname: VARCHAR(20)</li> <li>CUS_address: VARCHAR(50)</li> <li>CUS_city: VARCHAR(25)</li> <li>CUS_state: CHAR(2)</li> <li>CUS_zipcode: VARCHAR(9)</li> <li>CUS_phone: VARCHAR(10)</li> <li>CUS_gender: CHAR(1)</li> <li>CUS_birthdate: DATE</li> </ul> <p><b>TIME</b></p> <ul style="list-style-type: none"> <li>*TIM_date: DATE</li> <li>TIM_dayofweek: NUM(1)</li> <li>TIM_weeknumber: NUM(2)</li> <li>TIM_monthnumber: NUM(2)</li> <li>TIM_quarter: NUM(1)</li> <li>TIM_fiscalyear: NUM(4)</li> <li>TIM_holidayflag: CHAR(1)</li> </ul> <p><b>ORDER</b></p> <ul style="list-style-type: none"> <li>*ORD_number: CHAR(18)</li> <li>ORD_paytype: CHAR(2)</li> <li>ORD_shipstate: CHAR(2)</li> <li>ORD_shipmethod: VARCHAR(8)</li> </ul> <p><b>FACT</b></p> <ul style="list-style-type: none"> <li>*FACT_id: CHAR(8)</li> <li>FACT_orderamount: NUM(6,2)</li> <li>FACT_ordercost: NUM(6,2)</li> <li>CUS_id: CHAR(9)(FK)</li> <li>TIM_date: DATE (FK)</li> <li>ORD_number: CHAR(18)</li> </ul>

FIGURE 10-14 Reasons to denormalize.

**YOUR TURN 10-4****Denormalizing a Student Activity File**

Consider the logical data model that you created in Chapter 5 for “Your Turn 5-9.” Examine the model and describe possible opportunities for denormalization.

*Question*

1. How would you denormalize the physical data model, and what are the benefits of your changes?

**look-up tables**, which are tables that contain descriptions of values (e.g., a table of product descriptions, a table of payment types). Because descriptions of codes rarely change, it may be more efficient to include the description along with its respective code in the main table, to eliminate the need to join the look-up table each time a query is performed.

Second, 1:1 relationships are good candidates for denormalization. Although logically, two entities should be separated, from a practical standpoint the information from both entities may be regularly accessed together. Think about an order and its shipping information. Logically, it may make sense to separate the attributes related to shipping into a separate entity, but as a result, the queries regarding shipping likely will always need a join to the Order table. If the project team finds that certain shipping information, such as state and shipping method, are needed when orders are accessed, they may decide to combine the entities or include some shipping attributes in the order entity.

Third, at times it will be more efficient to include a parent entity’s attributes in its child entity on the physical data model. For example, consider a customer table and an order table that share a 1:N relationship, with customer as the parent and order as the child. If queries regarding orders continuously require customer information, the most popular customer fields can be placed to reduce the required joins to the customer table, as was done with customer name in Figure 10-14.

Finally, denormalization is applied when a popular data modeling technique called **star schema design** is used.<sup>2</sup> Learning how to model with star schema is beyond the scope of this book, but there are a number of Web resources and books available that are listed on the textbook website. Basically, star schema is a way to model data whereby the data are denormalized to speed up data access for BI. It uses two kinds of tables—fact tables and dimension tables—to store numerical, additive, and descriptive data, respectively. Star schema modeling is the way in which relational databases can be designed to emulate a multidimensional database. See Figure 10-14 for an example of a star schema design of a customer order database. The fact table contains order amount and cost (i.e., additive data), and the other tables contain information describing different dimensions of an order: the customer, the order itself, and time.

### Clustering

Speed of access also is influenced by the way in which the data are retrieved. Think about going shopping in a grocery store. If you have a list of items to buy, but you are unfamiliar with the store’s layout, then you need to walk down every aisle to make sure that you do not miss anything from your list. Likewise, if records are arranged on a hard disk in no particular order (or in an order that is unrelated to your data needs), then any query of the records results in a **table scan** in which the DBMS has to access every row in the table before retrieving the result set. Table scans are the most inefficient of data retrieval methods.

<sup>2</sup> A good book on star schema design is that by Claudia Imhoff, Nicholas Gallemmo, and Jonathan Geiger, *Mastering Data Warehouse Design: Relational and Dimensional Techniques*, John Wiley & Sons, 2003.

**CONCEPTS IN ACTION 10-A****Mail-Order Index**

A Virginia-based mail-order company sends out approximately 25 million catalogs each year, using a customer table with 10 million names. Although the primary key of the customer table is customer identification number, the table also contains an index of customer last names. Most people who call to place orders remember their last name, but not their customer identification number, so this index is used frequently.

An employee of the company explained that indexes are critical to reasonable response times. A complicated query was

written to locate customers by the state in which they lived, and it took over three weeks to return an answer. A customer state index was created, and that same query provided a response in 20 minutes; that is 1,512 times faster!

**Question**

1. As an analyst, how can you make sure that the proper indexes have been put in place so that users are not waiting for weeks to receive the answers to their questions?

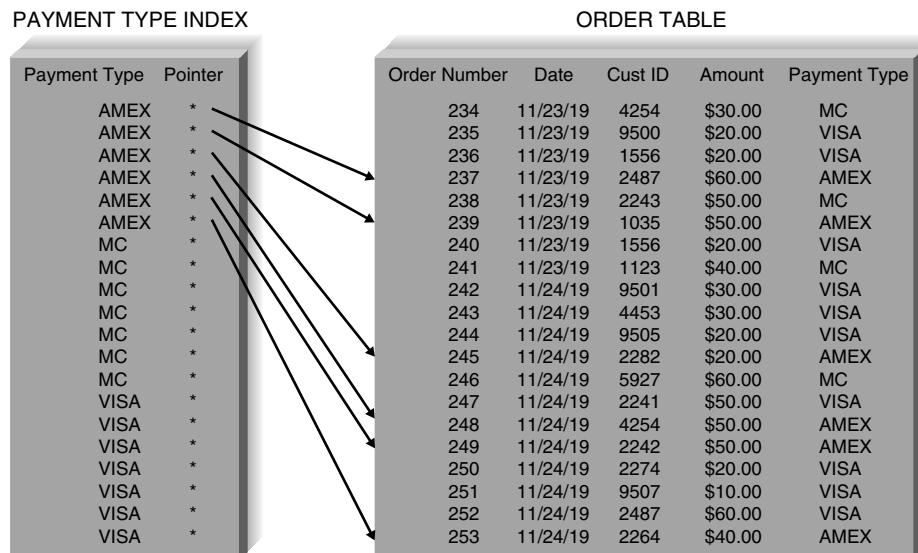
One way to improve access speed is to reduce the number of times that the storage medium must be accessed during a transaction. This can be accomplished by **clustering** records together physically so that like records are stored close together. With **intrafile clustering**, similar records in the table are stored together in some way, such as in order by primary key or, in the case of a grocery store, by item type. Thus, whenever a query looks for records, it can go directly to the right spot on the hard disk (or other storage medium) because it knows in what order the records are stored, just as we can walk directly to the bread aisle in the store to pick up a loaf of bread. Interfile clustering combines records from more than one table that typically are retrieved together. For example, if customer information is usually accessed with the related order information, then the records from the two tables may be physically stored in a way that preserves the customer order relationship. Returning to the grocery store scenario, an **interfile cluster** would be like storing peanut butter, jelly, and bread next to each other in the same aisle because they are usually purchased together, not because they are similar types of items. Of course, each table can have only one clustering strategy because the records can be arranged physically in only one way.

## **Indexing**

A time saver that you are familiar with is an index located in the back of a textbook, which points you directly to the page or pages that contain your topic of interest. Think of how long it would take to find all of the times that *relational database* appears in this textbook if you did not have the index to rely on. An **index** in data storage is like an index in the back of a textbook; it is a minitable that contains values from one or more columns in a table and the location of the values within the table. Instead of paging through the entire textbook, you can move directly to the right pages and get the information you need. Indexes are one of the most important ways to improve database performance. Whenever you have performance problems, the first place to look is an index.

A query can use an index to find the locations of only those records that are included in the query answer, and a table can have an unlimited number of indexes. Figure 10-15 shows an index that orders records by payment type. A query that searches for all the customers who used American Express can use this index to find the locations of the records that contain American Express as the payment type without having to scan the entire order table.

Project teams can make indexes perform even faster by placing them into the main memory of the data storage hardware. Retrieving information from memory is much faster than from another storage medium like a hard disk—think about how much faster it is to retrieve a phone number



**FIGURE 10-15**  
Payment type index.

that you have memorized versus one that you need to look up in a phone book. Similarly, when a database has an index in memory, it can locate records very, very quickly.

Of course, indexes require overhead in that they take up space on the storage medium. Also, they need to be updated as records in tables are inserted, deleted, or changed. Thus, although indexes lead to faster access to the data, they slow down the update process. In general, you should create indexes sparingly for transaction systems or systems that require a lot of updates, but apply indexes generously when designing systems for decision support (Figure 10-16).

Usually, CASE tools allow you to define indexes and clustering strategies within the design of the physical data model. Figure 10-17 shows the index screen in one CASE tool (ERwin) for the order table. In this example, three indexes have been designed for the table, and during the implementation phase, the CASE tool will generate the code that is necessary to construct these indexes in the DBMS.

## Estimating Storage Size

Even if you have denormalized your physical data model, clustered records, and created indexes appropriately, the system will perform poorly if the database server cannot handle its volume of data. Therefore, one last way to plan for good performance is to apply **volumetrics**, which means estimating the amount of data that the hardware will need to support. You can incorporate your estimates into the database server hardware specification to make sure that the database hardware is sufficient for the project's needs. The size of the database will be determined by the amount of raw data in the tables and the **overhead** requirements of the DBMS. To estimate size, you will need to have a good understanding of the initial size of your data as well as its expected growth rate over time.

- Use indexes sparingly for transaction systems.
- Use many indexes to improve response times in business intelligence systems.
- For each table, create a unique index that is based on the primary key.
- For each table, create an index that is based on the foreign key to improve the performance of joins.
- Create an index for fields that are used frequently for grouping, sorting, or criteria.

**FIGURE 10-16**  
Guidelines for creating indexes.

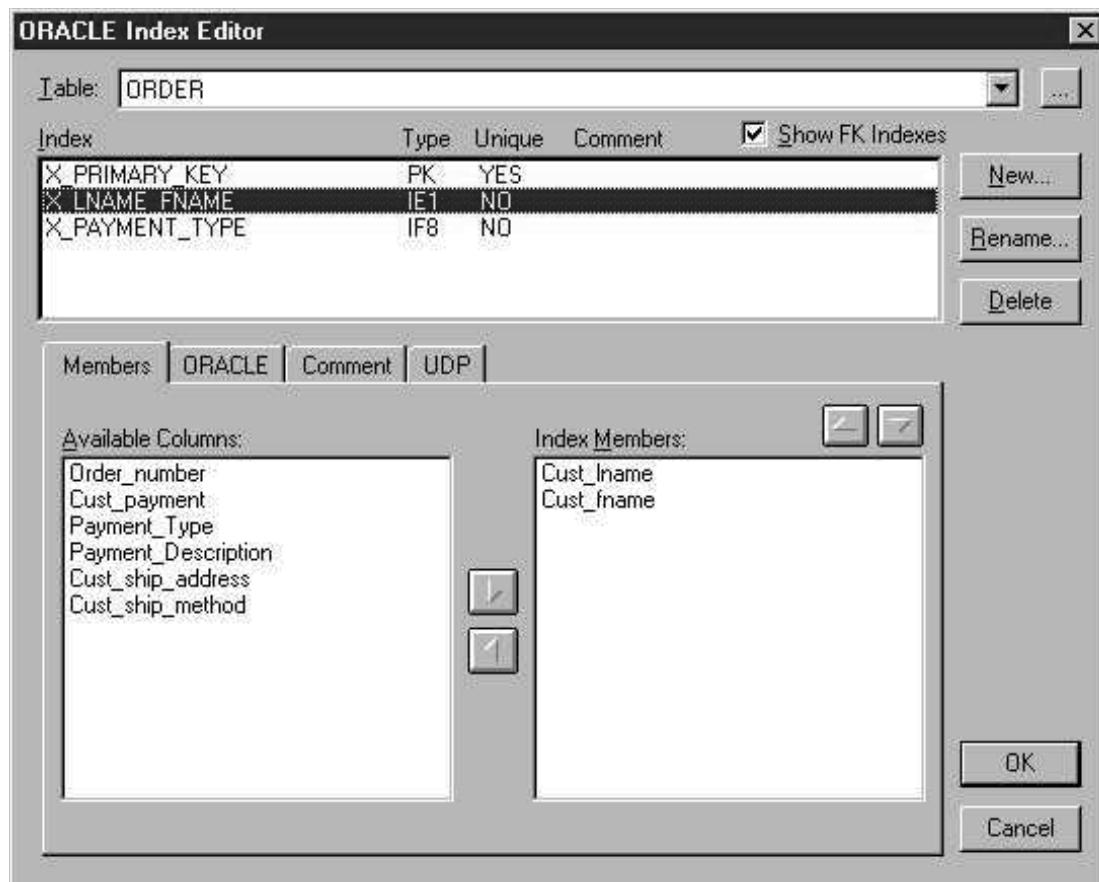


FIGURE 10-17 Indexes in ERwin.

**Raw data** refers to all the data that are stored within the tables of the database, and it is calculated via a bottom-up approach. First, write down the estimated average width for each column (field) in the table and sum the values, yielding a total record size (Figure 10-18). For example, if a variable-width last name column is assigned a width of 20 characters, you can enter 13 as the average character width of the column. In Figure 10-18, the estimated record size is 49.

Next, calculate the overhead for the table as a percentage of each record. Overhead includes the room needed by the DBMS to support such functions as administrative actions and indexes, and it should be assigned based on past experience, recommendations from technology vendors, or parameters that are built into software written to calculate volumetrics. For example, your DBMS vendor may recommend that you allocate 30% of the records' raw data size for overhead storage space, creating a total record size of 63.7 characters in Figure 10-18 example.

Finally, record the number of initial records that will be loaded into the table, as well as the expected growth per month. This information should have been collected during the analysis phase as a nonfunctional data requirement. As shown in Figure 10-18, the initial space required by the first table is 3,185,000 characters, and future sizes can be projected based on the growth figure. These steps are repeated for every table to get a total size for the entire database.

Many CASE tools will provide you with database size information based on how you set up the physical data model, and they will calculate volumetrics estimates automatically. Figure 10-19 shows a volumetrics screen for ERwin.

Field	Average Size (Characters)
Order number	8
Date	7
Cust ID	4
Last name	13
First name	9
State	2
Amount	4
Tax rate	2
<b>Record size</b>	49
Overhead	30%
<b>Total record size</b>	63.7
<b>Initial table size</b>	50,000
<b>Initial table volume</b>	3,185,000
<b>Growth rate/month</b>	1000
<b>Table volume @ 3 years</b>	5,478,200

**FIGURE 10-18**

Calculating  
volumetrics.

Ultimately, the size of the database needs to be shared with the design team so that the proper technology can be put in place to support the system's data, and potential performance problems can be addressed long before they affect the success of the system.

## Applying the Concepts at DrōnTeq

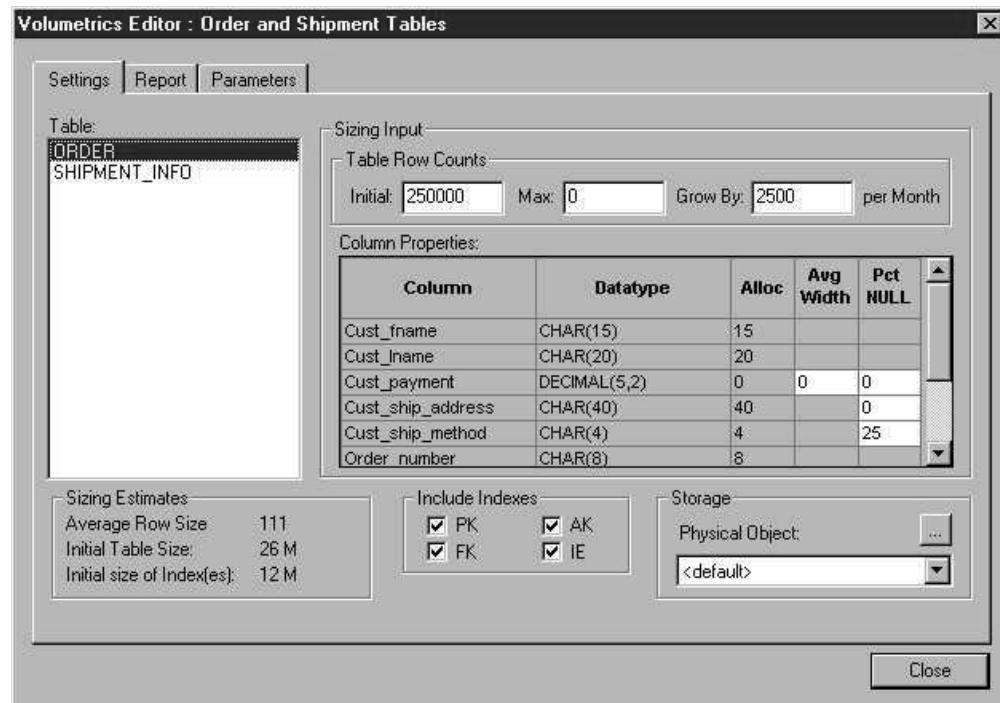
Now that the team members had a good idea of the type of data storage formats that would be used, they were ready to optimize the data for performance efficiency. Kenji was the analyst in charge of the logical data model, and Jiang wanted to be sure that the data model was optimized for storage efficiency before the team discussed access speed issues.

Kenji assured Jiang that the current data model was in third normal form. He was confident of this because the project team followed the data modeling guidelines that led to a well-formed logical model. Of course, a week or so earlier, he did apply the three rules of normalization to the data model as a check to make sure that no design errors were overlooked.

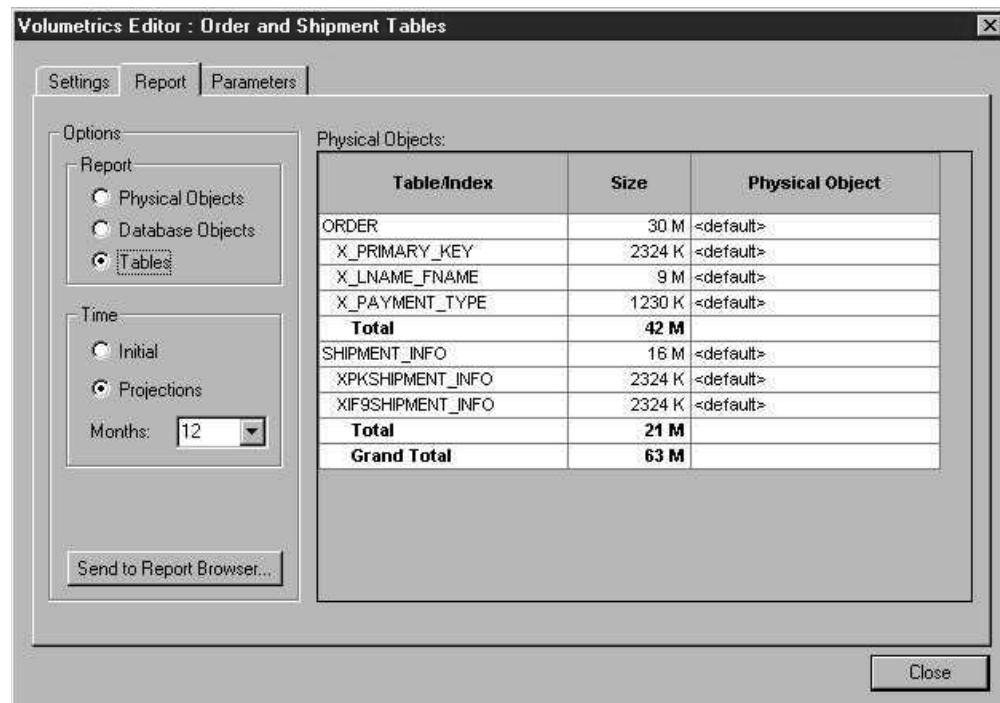
The last step of data storage design was to optimize the design for data access speed. Jiang met with the analysts on the data storage design team and talked about the techniques that were available to speed up access to data in the system. Together, the team listed all the data that would be supported by the Drone Flight Services system and discussed how all the data would be used. They developed the strategy laid out in Figure 10-20 to identify the specific techniques to put in place.

Ultimately, clustering strategies, indexes, and denormalization decisions were applied to the physical data model, and a volumetrics report was run from the CASE tool to estimate the initial and projected sizes of the database. The report suggested that an initial data storage capacity of about 5 GB would be needed for the system's first year. Additional storage capacity would be needed as the number of clients and pilots increase and the utilization of the system grows.

Jiang gave the estimates to the analyst in charge of managing the server hardware acquisition so that the person could ensure that the technology could handle the expected volume of data for the Drone Flight Services system. The estimates would also go to the DBMS vendor during the implementation of the software so that the DBMS could be configured properly.



(a)



(b)

**FIGURE 10-19** Volumetrics screen in ERwin.

(a) Information about columns and rows is entered into the ERwin. (b) Report is generated based on the information.

Target	Comments	Suggestions to Improve Data Access Speed
All tables	Basic table manipulation	Investigate whether records should be clustered physically by primary key. Create indexes for primary keys.
All tables	Sorts and grouping	Create indexes for foreign key fields. Create indexes for fields that are frequently sorted or grouped.
Entire physical model	Investigate denormalization opportunities for all fields that are not updated very often.	Investigate 1:1 relationships. Investigate look-up tables. Investigate 1:M relationships.

**FIGURE 10-20**  
Drone flight services system performance.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Identify and describe the purpose of the five type of files that are used to store business information.
- Identify and describe the purpose of the five type of databases that are used to store business information.
- Discuss the considerations to be made when selecting a data storage format.
- Discuss the five steps involved in converting the logical data model to a physical data model.
- Explain the modifications that may need to be made when updating the CRUD matrix.
- Explain how to optimize the data storage design for storage efficiency.
- Explain the several reasons to apply denormalization to the data storage design.
- Explain the purpose and types of clustering that can be applied to the data storage design.
- Explain the purpose of indexing when applied to the data storage design.

## KEY TERMS

Aggregated	Expert system (ES)	Management information system (MIS)	Primary key
Audit file	Files		Raw data
Business intelligence (BI)	Foreign key	Master files	Referential integrity
Clustering	Hierarchical	Multidimensional database	Relational database
Database	databases	Network databases	Set
Database management system (DBMS)	History file	Normalization	Star schema design
Data mart	Index	NoSQL databases	Structured Query Language (SQL)
Data warehousing	Interfile cluster	Object database	Table scan
Default value	Intrafile clustering	Object-oriented (DBMS)	Transaction file
Denormalization	Legacy database	Overhead	Transaction processing systems
End-user DBMS	Linked list	Physical data model	Valid value
Enterprise DBMS	Logical entity	Physical entity	Volumetrics
Executive information system (EIS)	relationship diagram	relationship diagram	
	Look-up files	Pointer	
	Look-up table		

## QUESTIONS

1. Describe the two steps to data storage design.
2. How are a file and a database different from each other?
3. What is the difference between an end-user database and an enterprise database? Provide an example of each one.
4. Name five types of files, and describe the primary purpose of each type.
5. Name two types of legacy databases and the main problems associated with each type.

6. What is the most popular kind of database today? Provide three examples of products that are based on this technology.
7. What is referential integrity, and how is it implemented in a relational database?
8. What is the biggest strength of the object database? Describe two of its weaknesses.
9. How does the multidimensional database store data?
10. What are the two most important factors in determining the type of data storage format that should be adopted for a system? Why are these factors so important?
11. Why should you consider the storage formats that already exist in an organization when deciding on a storage format for a new system?
12. What are the differences between the logical and physical ERDS?
13. Describe the metadata associated with the physical ERD.
14. Describe the purpose of the primary and foreign keys.
15. Name three ways that null values in a database can be interpreted. Why is this problematic?
16. What are the two dimensions in which to optimize a relational database?
17. What is the purpose of normalization?
18. Describe three situations that can be good candidates for denormalization.
19. Describe several techniques that can improve performance of a database.
20. What is the difference between interfile and intrafile clustering? Why are they used?
21. What is an index, and how can it improve the performance of a system?
22. Describe what should be considered when estimating the size of a database.
23. Why is it important to understand the initial and projected size of a database during the design phase?
24. What are the key issues in deciding between using perfectly normalized databases and denormalized databases?

## EXERCISES

- A. Using the Web or other resources, identify a product that can be classified as an end-user database and a product that can be classified as an enterprise database. How are the products described and marketed? What kinds of applications and users do they support? In what kinds of situations would an organization choose to implement an end-user database over an enterprise database?
- B. Visit any commercial website (e.g., BestBuy.com, Amazon.com). If files were being used to store the data supporting the application, what types of files would be needed? What data would they contain?
- C. Using the Web, review one of the products listed at the end of this exercise. What are the main features and functions of the software? In what companies has the database management system (DBMS) been implemented, and for what purposes? According to the information that you found, what are three strengths and weaknesses of the product?
  - Relational DBMS
  - NoSQL DBMS
  - Multidimensional DBMS
- D. You have been given a file that contains fields relating to CD information. Using the steps of normalization, create a logical data model that represents this file in third normal form. The fields include the following:
  - Musical group name
  - Musicians in group
  - Date group was formed
  - Group's agent
  - CD title 1
  - CD title 2
  - CD title 3
  - CD 1 length
  - CD 2 length
  - CD 3 lengthThe assumptions are as follows:
  - Musicians in group contains a list of the members in the musical group.
  - Musical groups can have more than one CD, so both group name and CD title are needed to uniquely identify a particular CD.
- E. Jim Smith's dealership sells Fords, Hondas, and Toyotas. The dealership keeps information about each car manufacturer with whom it deals so that employees can get in touch with manufacturers easily. The dealership staff also keeps information about the models of cars that the dealership carries from each manufacturer. They keep such information as list price, the price the dealership paid to obtain the model, and the model name and series (e.g., Honda Civic LX). They also keep information about all sales that they have made. (For instance, they will record the buyer's name, the car he or

- she bought, and the amount he or she paid for the car.) So that staff can contact the buyers in the future, contact information is also kept (e.g., address, phone number). Create a logical data model. (You may have done this already in Chapter 5.) Apply the rules of normalization to the model to check the model for processing efficiency.
- F. Describe how you would denormalize the model that you created in exercise E. Draw the new physical model on the basis of your suggested changes. How would performance be affected by your suggestions?
- G. Examine the physical data model that you created in exercise F. Develop a clustering and indexing strategy for this model. Describe how your strategy will improve the performance of the database.
- H. Investigate the volumetric interface with the computer-aided software engineering (CASE) tool that you are using for class. What information do you as an analyst need to input into the tool? How are size estimates calculated? If your CASE tool does not accept volumetric information, how can you calculate the size of the database?
- I. Calculate the size of the database that you created in exercise F. Provide size estimates for the initial size of the database as well as for the database in one year's time. Assume that the dealership sells 10 models of cars from each manufacturer to approximately 20,000 customers a year. The system will be set up initially with one year's worth of data.
- J. How would the following ERD be changed to incorporate the design decision listed next?
- The analyst wants to keep track of the user ID of anyone who changes a grade for a course.
  - A data store is added on the physical DFD so that information regarding the current semester's courses can be stored temporarily during the add/drop period before the courses become a part of the student's permanent record.
  - The system would like to archive alumni into a table, once they graduate, so that only active students are stored in the student table.
- K. Draw a physical process model (just the processes and data stores) for the following CRUD matrix:

Student	Register Student	Schedule Student	Create Transcript	Create Bill
Student	CRUD	R	R	R
Data Store				
Course		CRUD		R
Data Store				
Billing		CRUD		CRUD
Data Store				
Grade				CRUD
Data Store				

## MINICASES

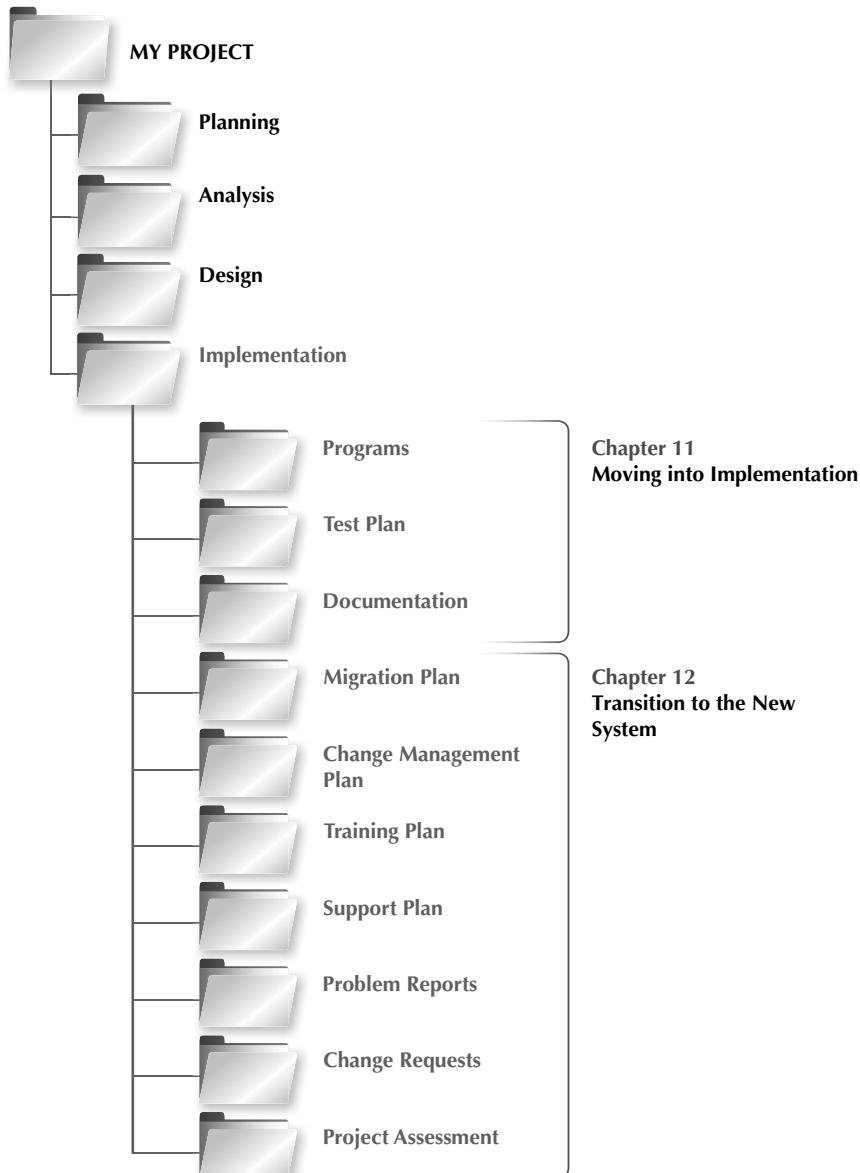
1. In the new system under development for Holiday Travel Vehicles, seven tables will be implemented in the new relational database. These tables are New Vehicle, Trade-in Vehicle, Sales Invoice, Customer, Salesperson, Installed Option, and Option. The expected average record size for these tables and the initial record count per table are given next.

Table Name	Average Record Size	Initial Table Size (records)
New Vehicle	65 characters	10,000
Trade-in Vehicle	48 characters	7,500
Sales Invoice	76 characters	16,000
Customer	61 characters	13,000
Salesperson	34 characters	100
Installed Option	16 characters	25,000
Option	28 characters	500

Perform a volumetrics analysis for the Holiday Travel Vehicles system. Assume that the DBMS that will be used to implement the system requires 35% overhead to be factored into the estimates. Also, assume a growth rate for the company of 10% per year. The systems development team wants to ensure that adequate hardware is obtained for the next 3 years.

# IMPLEMENTATION PHASE

PART 4



The final phase in the SDLC is the implementation phase, during which the system is actually built (or purchased, in the case of a packaged software design).

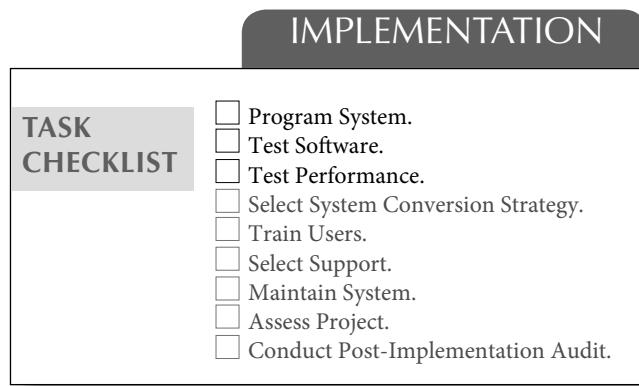
At the end of implementation, the final system is put into operation and supported and maintained.

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# Moving into Implementation

# 11



As the design phase is completed, the systems analyst begins to focus on the tasks associated with building the system, ensuring that it performs as designed and developing documentation for the system. Programmers will carry out the time-consuming and costly task of writing programs, while the systems analyst prepares plans for a variety of tests that will verify that the system performs as expected. Several different types of documentation will also be designed and written during this part of the systems development life cycle.

## OBJECTIVES

- Be familiar with the system construction process.
- Explain different types of tests and when to use them.
- Describe how to develop user documentation.

## Introduction

As the implementation phase begins, foremost on people's minds is **construction** of the new system. A major component of building the system is writing programs. In fact, some people mistakenly believe that programming is the focal point of systems development. We hope you agree that doing a good, thorough job on the analysis and design phases is essential to a smooth and successful implementation phase.

The implementation phase consists of developing and testing the system's software, documentation, and new operating procedures. These topics are presented in this chapter. Chapter 12 discusses additional issues that are essential to a successful system implementation, including

installation of the new system, selection of the most suitable conversion approach, preparing the organization and the users to adapt to the new system, and ensuring that the system is supported after it is put into production.

Developing the system's software (writing programs) can be the largest single component of any systems development project in terms of both time and cost. It is generally the best understood component and may offer the fewest problems of all the aspects of the SDLC. Since the systems analyst is usually not actually doing the programming (programmers are), in this chapter we concentrate our attention on managing the programming process.

While programmers are transforming program specifications into working program code, the systems analysts will be designing a variety of tests that will be performed on the new system. As the programs are finalized, the systems analysts may conduct these tests to verify that the system actually does what it was designed to do. Testing may be a major element of the implementation phase for the systems analysts. (In some organizations, testing is performed by specialized quality assurance personnel.)

During this phase, it is also the responsibility of the systems analysts to finalize the system documentation and develop the user documentation. The final section of this chapter discusses the various types of documentation that must be prepared.

## Managing the Programming Process

The programming process is quite well understood and generally flows smoothly. When system development projects fail, it is usually not because the programmers were unable to write the programs. Flaws in analysis, design, or project management are the leading contributors to project failure. To ensure that the process of programming is conducted successfully, we discuss several tasks that the project manager must do to manage the programming effort: assigning programming tasks, coordinating the activities, and managing the programming schedule.<sup>1</sup>

### Assigning Programming Tasks

During project planning (Chapter 2), the project manager identified the programming support required for constructing the system in terms of the numbers and skill levels of programmers. Now the project manager must assign program modules to the programming staff. As discussed in Chapter 9, each programming module should be as separate and distinct as possible from the other modules. The project manager first groups together modules that are related. These groups of modules are then assigned to programmers based on their experience and skill level. Experienced, skilled programmers will be assigned the most complex modules, while novice programmers will be given less complex ones.

It is quite likely that there will be a mismatch between the available programming skills and the programming skills that are needed to complete the programming. Consequently, the project manager must take steps at this time to ensure that skill deficiencies are eliminated through additional training or through mentoring arrangements with more experienced, skilled programmers. When the required skills are not readily available, the project manager must incorporate additional time in the project schedule.

While it will be tempting to speed up the programming process by adding more programming staff to the project, an ironic fact of system development is that the more programmers who are involved, the longer the project will take. As the size of the programming team increases, the

<sup>1</sup> One of the best books on managing programming (even though it was first written in 1975) is that by Frederick P. Brooks Jr. *The Mythical Man-Month*, 20th anniversary ed., Reading, MA: Addison-Wesley, 1995.

**CONCEPTS IN ACTION 11-A****The Cost of a Bug**

My first programming job in 1977 was to convert a set of application systems from one version of COBOL to another version of COBOL for the government of Prince Edward Island. The testing approach was to first run a set of test data through the old system and then run it through the new system to ensure that the results from the two matched. If they matched, then the last 3 months of production data were run through both to ensure they, too, matched.

Things went well until I began to convert the gas tax system that kept records on everyone authorized to purchase gasoline without paying tax. The test data ran fine, but the results using the production data were peculiar. The old and new systems matched, but rather than listing several thousand records, the report listed only 50. I checked the production data file and found it listed only 50 records, not the thousands that were supposed to be there.

The system worked by copying the existing gas tax records file into a new file and making changes in the new file. The old file was then copied to tape backup. There was a bug in the program such that if there were no changes to the file, a new file was created, but no records were copied into it.

I checked the tape backups and found one with the full set of data that was scheduled to be overwritten 3 days after I discovered the problem. The government was only 3 days away from losing all gas tax records. *Alan Dennis*

**Question**

1. What might have happened if this bug hadn't been caught and all gas tax records were lost?

need for coordination increases exponentially, and the more coordination that is required, the less time programmers can spend actually writing programs. The best size is the smallest feasible programming team. When projects are so complex that they require a large team, the best strategy is to try to break the project into a series of smaller parts that can function as independently as possible.

## Coordinating Activities

Coordination can be done through both high-tech and low-tech means. The simplest approach is to have a weekly project meeting to discuss any changes to the system that have arisen during the past week—or just any issues that have come up. Regular meetings, even if they are brief, encourage the widespread communication and discussion of issues before they become problems.

Another important way to improve coordination is to create and follow standards that can range from formal rules for naming files to forms that must be completed when goals are reached to programming guidelines (see Chapter 2). When a team establishes and follows standards, the project can be completed faster because task coordination is less complex.

The project manager must put mechanisms in place to keep the programming effort well organized. Many project teams set up three “areas” in which programmers can work: a development area, a testing area, and a production area. These areas can be different directories on a server hard disk, different servers, or different physical locations, but the point is that files, data, and programs are separated based on their status of completion. At first, programmers access and build files within the development area. Then they copy them to the testing area when they are “finished.” If a program does not pass a test, it is sent back to development. Once all the programs are tested and ready to support the new system, they are copied into the production area—the location where the final system will reside.

Keeping files and programs in different places according to completion status helps manage **change control**, the action of coordinating a program as it changes through construction. Another change control technique is keeping track of what programs are being changed by whom, using a **program log**. The log is merely a form on which programmers sign out programs

to write (or modify), and sign in the programs when they are completed. Both the programming areas and program log help the analysts understand exactly who has worked on what and the program's status. Without these techniques, files can be put into production without the proper testing, two programmers can start working on the same program at the same time, and files can be overlooked, and so on. Code management systems are available that facilitate the "checkout" of programs and help maintain control over the various versions of program modules.

Many CASE tools are set up to track the status of programs and help manage programmers as they work. In most cases, maintaining coordination is not conceptually complex. It just requires a lot of attention and discipline to track small details.

## Managing the Schedule

The time estimates that were produced during the initial planning phase and refined during the analysis and design phases must almost always be refined as the project progresses during construction, because it is virtually impossible to develop an exact assessment of the project's schedule. As we discussed in Chapter 2, a well-done set of time estimates will usually have a 10% margin of error by the time implementation is reached. It is critical that the time estimates be revised as the construction step proceeds. If a program module takes longer to develop than expected, then the prudent response is to move the expected completion date later by the same amount of time.

The issue of **scope creep**, discussed in Chapter 2, becomes particularly troublesome at this stage. Scope creep occurs when new requirements are added to the project after the system design has been finalized. Changes made late in the SDLC can require much of the completed system design (and even programs already written) to be redone, a very expensive chore. Any proposed change during construction should only be approved after a quick cost–benefit analysis has been done.

Another common cause is the unnoticed day-by-day slippages in the schedule. One module is a day late here; another one, a day late there. Pretty soon these minor delays add up, and the project is noticeably behind schedule. Once again, the key to managing the programming effort is to watch these minor slippages carefully and update the schedule accordingly. It is especially critical to monitor slippage of all tasks on the critical path, since falling behind on these tasks will affect the final completion date for the project.

Typically, a project manager will create a risk assessment that tracks potential risks, along with an evaluation of their likelihood and potential impact. As programming progresses, the list of risks will change as some items are removed and others surface. The best project managers, however, work hard to keep risks from having an impact on the schedule and costs associated with the project.

## Testing

Writing programs is a fun, creative activity. Novice programmers tend to get caught up in the development of the programs themselves and are often much less enchanted with the tasks of testing and documenting their work. Testing and documentation are not fun; consequently, they receive less attention than writing the programs.

Programming and testing are similar to writing and editing. No professional writer (or serious student writing an important term paper) would stop after writing the first draft. Rereading, editing, and revising the initial draft into a good paper is the hallmark of good writing. Likewise, thorough testing is the hallmark of professional software developers. Most professional organizations devote more time and money to testing (and to revision and retesting) than to writing the programs in the first place.

**PRACTICAL TIP 11-1****Avoiding Classic Implementation Mistakes**

In previous chapters, we discussed classic mistakes and how to avoid them. Here, we summarize four classic mistakes in the implementation phase:

- 1. Research-oriented development:** Using state-of-the-art technology requires research-oriented development that explores the new technology, because “bleeding-edge” tools and techniques are not well understood, are not well documented, and do not function exactly as promised. **Solution:** If you use state-of-the-art technology, you should significantly increase the project’s time and cost estimates even if (some experts would say *especially if*) such technologies claim to reduce time and effort.
- 2. Using low-cost personnel:** You get what you pay for. The lowest-cost consultant or staff member is significantly less productive than the best staff. Several studies have shown that the best programmers produce software six to eight times faster than the least productive (yet cost only 50–100% more). **Solution:** If cost is a critical issue, assign the best, most expensive personnel; never assign entry-level personnel to save costs.

**3. Lack of code control:** On large projects, programmers must coordinate changes to the program source code (so that two programmers don’t try to change the same program simultaneously and one doesn’t overwrite the other’s changes). Although manual procedures appear to work (e.g., sending e-mail notes to others when you work on a program to tell them not to work on that program), mistakes are inevitable.

**Solution:** Use a source code library that requires programmers to check out programs and prohibits others from working on them at the same time.

- 4. Inadequate testing:** The number-one reason for project failure during implementation is ad hoc testing—in which programmers and analysts test the system without formal test plans. **Solution:** Always allocate sufficient time in the project plan for formal testing.

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Adapted from: *Rapid Development*, Redmond, WA: Microsoft Press, 1996, pp. 29–50, by Steve McConnell.

The attention paid to testing is justified by the high costs associated with downtime and failures caused by software bugs.<sup>2</sup> Although the costs vary widely, one recent study<sup>3</sup> suggests that 98% of organizations consider the cost of an hour of downtime to be over \$100,000; 81% consider the cost to exceed \$300,000. Testing is therefore a form of insurance. Organizations are willing to spend a lot of time and money to prevent the possibility of major failures after the system is installed.

A program is not considered finished until it has passed its testing. For this reason, programming and testing are tightly coupled. Testing is frequently the primary focus of the systems analysts as the system is being constructed. The analysts must resist the temptation to rush into testing as soon as the very first program module is complete, however. Spontaneously testing different events and possibilities without spending time to develop a comprehensive test plan is dangerous, because important tests may be overlooked. If an error does occur, it may be difficult to reproduce the exact sequence of events that caused it. Instead, testing must be performed and documented systematically so that the project team always knows what has and has not been tested.

The sections that follow describe several different types of tests that must be performed prior to installing the new system. Each type of test checks different features and/or scope of the system, until ultimately it is tested for acceptance by the users.

---

<sup>2</sup>When I was an undergraduate, I had the opportunity to hear Admiral Grace Hopper tell how the term *bug* was introduced. She was working on one of the early US Navy computers when suddenly it failed. The computer would not restart properly, so she began to search for failed vacuum tubes. She found a moth inside one tube and recorded in the log book that a bug had caused the computer to crash. From then on, every computer crash was jokingly blamed on a bug (as opposed to programmer error), and eventually the term *bug* entered the general language of computing.

<sup>3</sup>“Cost of Hourly Downtime Soars: 81% of Enterprises Say It Exceeds \$33K on Average,” [www.itic-corp.com](http://www.itic-corp.com), accessed 6/1/2018).

## Test Planning

Testing starts with the tester developing a **test plan** that defines a series of tests that will be conducted.<sup>4</sup>

Figure 11-1 shows a typical test plan form. A test plan often has 20–30 pages, with a separate page for each individual test in the plan. Each individual test has a specific objective, describes a set of specific **test cases** to examine, and defines the expected results and the actual results observed. The test objective is taken directly from the program specification or from the program source code. For example, suppose that the program specification stated that the order quantity must be between 10 and 100 units. The tester would develop a series of test cases to ensure that the quantity is validated before the system accepts it.

A template for this figure is available on the student website.

Today, automated testing tools enable comprehensive testing of all relevant test conditions. In this example of an order quantity that must be between 10 and 100 units, the test requires a minimum of three test cases: one with a valid value (e.g., 15), one with an invalid value too low (e.g., 7), and one with an invalid value too high (e.g., 110). Most tests would also include a test case with a non-numeric value to ensure that the data types were checked (e.g., ABCD). An especially good test would include a test case with nonsensical, but potentially valid, data (e.g., 21.4).

In some cases, test cases cannot be conducted by entering data values, but must instead be handled by selecting certain combinations of commands or menu choices. The script area on the test plan is used to describe the sequence of keystrokes or mouse clicks and movements for this type of test. Many automated testing tools support this type of testing procedure as well.

Not all program modules are likely to be finished at the same time, so the programmer usually writes **stubs** for the unfinished modules to enable the modules around them to be tested. A stub is a placeholder for a module that usually displays a simple test message on the screen or returns some **hardcoded** value<sup>5</sup> when it is selected. For example, consider an application system that provides the five standard functions discussed in Chapter 4 for some data objects such as clients, drones, or pilots: creating, changing, deleting, finding, and displaying. Each of these functions could be a separate module that needs to be tested, and in fact, displaying might be two separate modules, one for an on-screen list and one for the printer (Figure 11-2).

Suppose that the main menu module in Figure 11-2 was complete. It would be impossible to test it properly without the other modules, because the function of the main menu is to navigate to the other modules. In this case, a stub would be written for each of the other modules. These stubs would simply display a message on the screen when they were activated (e.g., “Delete item module reached”). In this way, the main menu module could pass module testing before the other modules were completed.

There are four general stages of tests: unit tests, integration tests, system tests, and acceptance tests. Although each application system is different, most errors are found during integration and system testing (Figure 11-3).

## Unit Tests

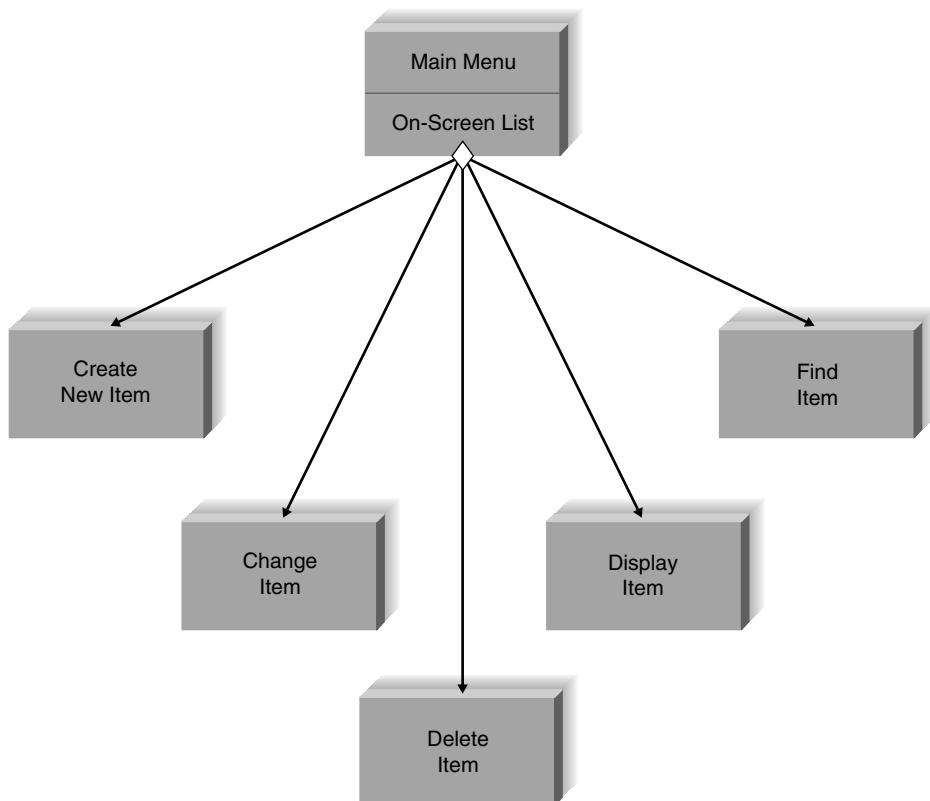
**Unit tests** focus on one unit—a program or a program module that performs a specific function that can be tested. The purpose of a unit test is to ensure that the module or program performs its function as defined in the program specification. Unit testing is performed after the programmer

<sup>4</sup>For more information on testing, see William Perry, *Effective Methods for Software Testing*, 3rd ed., 2006.

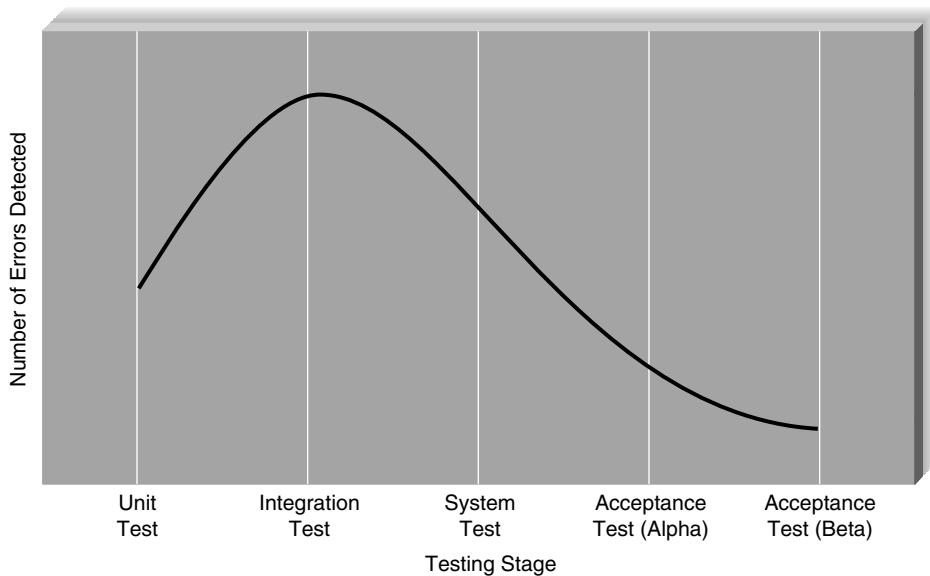
<sup>5</sup>The word *hardcoded* means “written into the program.” For example, suppose that you were writing a unit to calculate the net present value of a loan. The stub might be written to always display (or return to the calling module) a value of 100 regardless of the input values. In this case, we would say that the 100 was hardcoded.

<b>Test Plan</b>	Page ____ of ____	
<b>Program ID:</b> _____ <b>Version number:</b> _____		
<b>Tester:</b> _____	<b>Date designed:</b> _____	
<b>Results:</b> <input type="checkbox"/> <b>Passed</b> <input type="checkbox"/> <b>Open items:</b> _____		
<b>Test ID:</b> _____	<b>Requirement addressed:</b> _____	
<b>Objective:</b> _____		
<b>Test cases</b>		
Interface ID	Data Field	Value Entered
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____
5. _____	_____	_____
6. _____	_____	_____
<b>Script</b> _____		
<b>Expected results/notes</b> _____		
<b>Actual results/notes</b> _____		

FIGURE 11-1 Test plan.



**FIGURE 11-2**  
Testing separate  
modules.



**FIGURE 11-3** Error  
discovery rates for dif-  
ferent stages of tests.

**YOUR TURN 11-1****Test Planning for an Automated Teller Machine**

Pretend that you are a project manager for a bank developing software for automated teller machines (ATMs). Develop a unit test plan for the user interface component of the ATM.

has developed and tested the code and believes it to be error free. These tests are based strictly on the program specification and may discover errors resulting from the programmer's misinterpretation of the specifications. Unit tests are often conducted by the systems analyst or, sometimes, by the programmer who developed the unit.

There are two approaches to unit testing: **black-box testing** and **white-box testing**. Black-box testing is the most used. In this case, the test plan is developed directly from the program specification: each item in the program specification becomes a test, and several test cases are developed for it. White-box testing is reserved for special circumstances in which the tester wants to review the actual program code, usually when complexity is high.

## Integration Tests

**Integration tests** assess whether a set of modules or programs that must work together do so without error. They ensure that the interfaces and linkages between different parts of the system work properly. At this point, the modules have passed their individual unit tests, so the focus now is on the flow of control among modules and on the data exchanged among them. Integration testing follows the same general procedures as unit testing: the tester develops a test plan that has a series of tests. Integration testing is often done by a set of programmers and/or systems analysts.

There are four approaches to integration testing: **user interface testing**, **use scenario testing**, **data flow testing**, and **system interface testing** (Figure 11-4). Most projects use all four approaches.

## System Tests

**System tests** are usually conducted by the systems analysts to ensure that all modules and programs work together without error. System testing is similar to integration testing but is much broader in scope. Whereas integration testing focuses on whether the modules work together without error, system tests examine how well the system meets business requirements and its usability, security, and performance under heavy load (Figure 11-4). It also tests the system's documentation.

## Acceptance Tests

**Acceptance tests** are done primarily by the users with support from the project team. The goal is to confirm that the system is complete, meets the business needs that prompted the system to be developed, and is acceptable to the users. Acceptance testing is done in two stages: **alpha testing**, in which users test the system using made-up data, and **beta testing**, in which users begin to use the system with real data and carefully monitor the system for errors (Figure 11-4).

The users' perceptions of the new system will be significantly influenced by their experiences during acceptance testing. Since first impressions are sometimes difficult to change, analysts should strive to ensure that acceptance testing is conducted only following rigorous (and



Stage	Types of Tests	Test Plan Source	When to Use	Notes
Unit Testing	<b>Black-box testing:</b> treats program as black box.	Program specifications	For normal unit testing	The tester focuses on whether the unit meets the requirements stated in the program specifications.
	<b>White-box testing:</b> looks inside the program to test its major elements.	Program source code	When complexity is high	By looking inside the unit to review the code itself, the tester may discover errors or assumptions not immediately obvious to someone treating the unit as a black box.
	<b>User interface testing:</b> The tester tests each interface function.	Interface design	For normal integration testing	Testing is done by moving through each and every menu item in the interface either in a top-down or bottom-up manner.
Integration Testing	<b>Use scenario testing:</b> The tester tests each use scenario.	Use scenario	When the user interface is important	Testing is done by moving through each use scenario to ensure that it works correctly. Use scenario testing is usually combined with user interface testing because it does not test all interfaces.
	<b>Data flow testing:</b> Tests each process in a step-by-step fashion.	Physical DFDs	When the system performs data processing	The entire system begins as a set of stubs. Each unit is added in turn, and the results of the unit are compared with the correct result from the test data; when a unit passes, the next unit is added and the test is rerun.
	<b>System interface testing:</b> tests the exchange of data with other systems.	Physical DFDs	When the system exchanges data	Because data transfers between systems are often automated and not monitored directly by the users, it is critical to design tests to ensure that they are being done correctly.
System Testing	<b>Requirements testing:</b> tests whether original business requirements are met.	System design, unit tests, and integration tests	For normal system testing	This test ensures that changes made because of integration testing did not create new errors. Testers often pretend to be uninformed users and perform improper actions to ensure that the system is immune to invalid actions (e.g., adding blank records).
	<b>Usability testing:</b> tests how convenient the system is to use.	Interface design and use scenarios	When user interface is important	This test is often done by analysts with experience in how users think and in good interface design. This test sometimes uses the formal usability testing procedures discussed in Chapter 8.
	<b>Security testing:</b> tests disaster recovery and unauthorized access.	Infrastructure design	When the system is important	Security testing is a complex task, usually done by an infrastructure analyst assigned to the project. In extreme cases, a professional firm may be hired.
Acceptance Testing	<b>Performance testing:</b> examines the ability to perform under high loads.	System proposal and infrastructure design	When the system is important	High volumes of transactions are generated and given to the system. This test is often done using special-purpose testing software.
	<b>Documentation testing:</b> tests the accuracy of the documentation.	Help system, procedures, tutorials	For normal system testing	Analysts spot-check or check every item on every page in all documentation to ensure that the documentation items and examples work properly.
	<b>Alpha testing:</b> conducted by users to ensure that they accept the system.	System tests	For normal acceptance testing	Alpha tests often repeat previous tests but are conducted by users themselves to ensure that they accept the system.
	<b>Beta testing:</b> uses real data, not test data.	No plan	When the system is important	Users closely monitor the system for errors or useful improvements

DFD = data flow diagram.

FIGURE 11-4 Types of tests.

**CONCEPTS IN ACTION 11-B****Managing a Database Project**

A consulting project involved a credit card “bottom feeder” (let’s call it Credit Wonder). This company bought credit card accounts that were written off as uncollectable debts by major banks. Credit Wonder would buy the write-off accounts for 1 or 2% of their value and then would call the owners of the written-off accounts and “offer a deal” to the credit card account holders.

Credit Wonder wanted a database for these accounts. Legally, it did own them and so could contact the people who had owed the money—but as prescribed in credit law. For example, Credit Wonder could call only during certain hours and no more than once a week, and they had to speak to the actual account holder. Any amount collected over the 1–2%

of the original debt would be considered a gain. In its database, Credit Wonder wanted a history of what settlement was offered, the date the account holder was contacted, and additional notes.

*Questions*

1. How might a systems analyst manage such a system project?
2. Who would the systems analyst need to interview to get the system requirements?
3. How would a database analyst help in structuring the database requirements?

successful) system testing. In addition, listening to and responding to user feedback will be essential in shaping a positive reaction to and acceptance of the new system by the users.

## Developing Documentation

There are two fundamentally different types of documentation. **System documentation** is intended to help programmers and systems analysts understand the application software and enable them to build it or maintain it after the system is installed. System documentation is a by-product of the systems analysis and design process and is created as the project unfolds. Each step and phase produce documents that are essential in understanding how the system is built or is to be built, and these documents are stored in the project binder(s).

**User documentation** (such as user manuals, training manuals, and online help systems) is designed to help the user operate the system. Although most project teams expect users to have received training and to have read the user manuals before operating the system, unfortunately, this is not always the case. It is more common today—especially in the case of commercial software packages for microcomputers—for users to begin using the software without training or reading the user manuals. In this section, we focus on user documentation.<sup>6</sup>

User documentation is often left until the end of the project, which is a dangerous strategy. Developing good documentation takes longer than many people expect, because it requires much more than simply writing a few pages. Producing documentation requires designing the documents (whether paper or online), writing the text, editing them, and testing them. For good-quality documentation, this process usually takes about 3 hours per page (single-spaced) for paper-based documentation or 2 hours per screen for online documentation. Thus, a “simple” set of documentation such as a 10-page user manual and a set of 20 help screens takes 70 hours. Of course, lower-quality documentation can be produced faster.

The time required to develop and test user documentation should be built into the project plan. Most organizations plan for documentation development to start once the interface design and program specifications are complete. The initial draft of documentation is usually scheduled for completion immediately after the unit tests are complete. This reduces—but does not

<sup>6</sup>For more information on developing documentation, see Thomas T. Barker, *Writing Software Documentation*, Boston: Allyn & Bacon, 1998.

eliminate—the chance that the documentation will need to be changed because of software changes, and it still leaves enough time for the documentation to be tested and revised before the acceptance tests are started.

Although paper-based manuals are still found, online documentation is the predominant form. Paper-based documentation is simpler to use because it is more familiar to users, especially novices who have less computer experience; online documentation requires the users to learn one more set of commands. Paper-based documentation also is easier to flip through to gain a general understanding of its organization and topics and can be used far away from the computer itself.

There are four key strengths of online documentation that guarantee its position as the dominant form for the foreseeable future. First, searching for information is often simpler (provided that the help search index is well designed). The user can type in a variety of keywords to view information almost instantaneously, rather than having to search through the index or table of contents in a paper document. Second, the same information can be presented several times in many different formats, so that the user can find and read the information in the most informative way. (Such redundancy is possible in paper documentation, but the cost and intimidating size of the resulting manual make it impractical.) Third, online documentation enables the user to interact with the documentation in many new ways that are not possible with static paper documentation. For example, it is possible to use links or “tool tips” (i.e., pop-up text; see Chapter 8) to explain unfamiliar terms, and programmers can write “show me” routines that demonstrate on the screen exactly what buttons to click and what text to type. Finally, online documentation is significantly less expensive to distribute and keep up to date than paper documentation.

## Types of Documentation

There are three fundamentally different types of user documentation: reference documents, procedures manuals, and tutorials. **Reference documents** (also called the help system) are designed to be used when the user needs to learn how to perform a specific function (e.g., updating a field, adding a new record). Typically, people read reference information only after they have tried and failed to perform the function. Writing reference documents requires special care because users are often impatient or frustrated when they begin to read them.

**Procedures manuals** describe how to perform business tasks (e.g., printing a monthly report, taking a customer order). Each item in the procedures manual typically guides the user through a task that requires several functions or steps in the system. Therefore, each entry is typically much longer than an entry in a reference document.

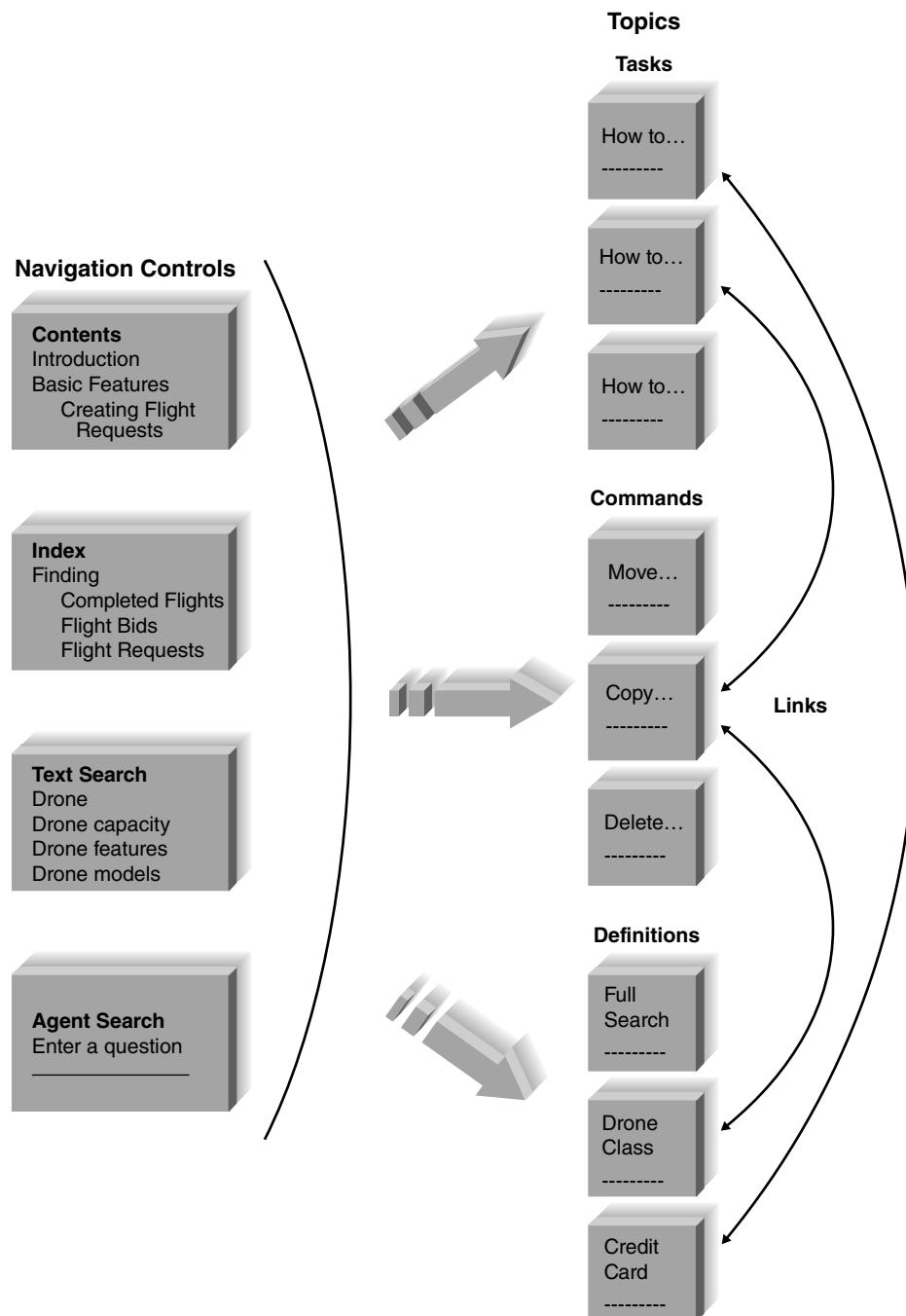
**Tutorials** teach people how to use major components of the system (e.g., an introduction to the basic operations of the system). Each entry in the tutorial is typically longer still than the entries in procedures manuals, and the entries are usually designed to be read in sequence, whereas entries in reference documents and procedures manuals are designed to be read individually.

Regardless of the type of user documentation, the overall process for developing it is like the process of developing interfaces (see Chapter 8). The developer first designs the general structure for the documentation and then develops the individual components within it.

## Designing Documentation Structure

In this section, we focus on the development of online documentation because we believe that it is the most common form of user documentation. The general structure used in most online documentation, whether reference documents, procedures manuals, or tutorials, is to develop a set of **documentation navigation controls** that lead the user to **documentation topics**. The documentation topics are the material that users want to read, whereas the navigation controls are the way in which users locate and access a specific topic.

Designing the structure of the documentation begins by identifying the different types of topics and navigation controls that must be included. Figure 11-5 shows a commonly used structure for online reference documents (i.e., the help system). The documentation topics generally come from three sources. The first and most obvious source of topics is the set of commands and menus in the user interface. This set of topics is especially useful if the user wants to understand how a particular command or menu is used.



**FIGURE 11-5**  
Organizing online reference documents.

However, users often do not know what commands to look for or where they are in the system's menu structure. Instead, users have tasks they want to perform, and rather than thinking in terms of commands, they think in terms of their business tasks. Therefore, the second and often more useful set of topics focuses on how to perform certain tasks, usually those in the use scenarios from the user interface design (see Chapter 8). These topics walk the user through the set of steps (often involving several keystrokes or mouse clicks) needed to perform some task.

The third set of topics are definitions of important terms. These terms are usually the entities and data elements in the system, but sometimes they also include commands.

There are five general types of navigation controls for topics, but not all systems use all five types (Figure 11-5). The first is the table of contents that organizes the information in a logical form, as though the users were to read the reference documentation from start to finish. The second, the index, provides access into the topics via important keywords, in the same way that the index at the back of a book helps you to find topics. Third, text search provides the ability to search through the topics either for any text the user types or for words that match a developer-specified set of words that is much larger than the list of words in the index. Unlike the index, text search typically provides no organization to the words (other than alphabetic). Fourth, some systems provide the ability to use an intelligent agent to help in the search. The fifth and final navigation control to topics are the Web-like links between topics that enable the user to click and move among topics.

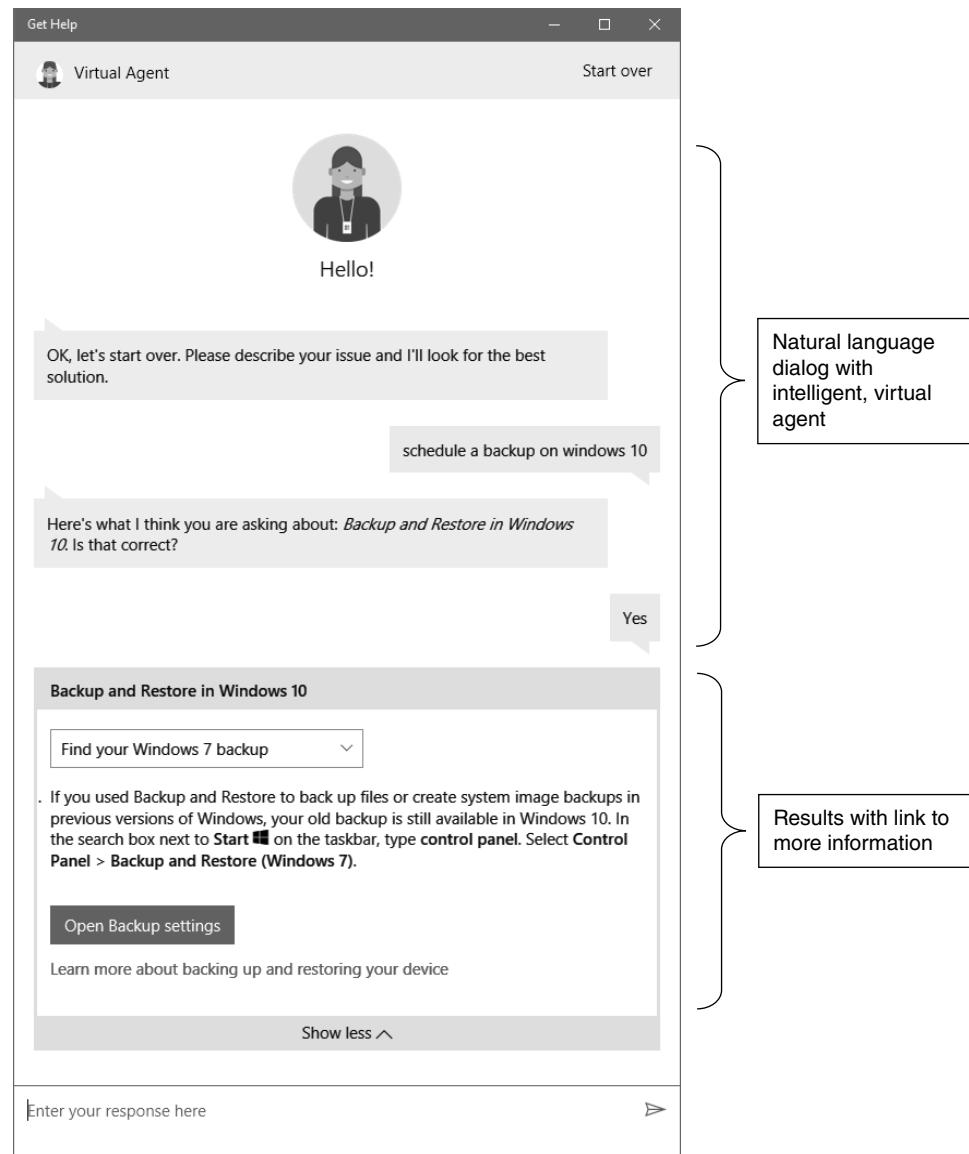
Procedures manuals and tutorials are similar, but often simpler in structure. When the new system significantly changes the way things are done, these resources are essential. Topics for procedures manuals usually come from the use scenarios developed during interface design and from other basic tasks the users must perform. Topics for tutorials are usually organized around major sections of the system and the level of experience of the user. Most tutorials start with basic, most used commands, and then move into more complex and less frequently used commands.

## Writing Documentation Topics

The general format for topics is similar across application systems and operating systems. Today, many creative approaches are used to improve users' ability to get answers to questions easily. Figure 11-6 shown an example of a virtual agent who communicates with the user to clarify the information needed before returning results. Many topics include screen images to help the user find items on the screen; some also have "show me" examples in which the series of keystrokes and/or mouse movements and clicks needed to perform the function are demonstrated to the user. Most also include navigation controls to enable movement among topics, usually at the top of the window, plus links to other topics. Some also have links to related topics that include options or other commands and tasks the user may want to perform in concert with the topic being read.

Writing the topic content can be challenging. It requires a good understanding of the users (or, more accurately, the range of users) and a knowledge of what skills the users currently have and can be expected to import from other systems and tools they are using or have used (including the system the new system is replacing). Topics should always be written from the viewpoint of the user and describe what the user wants to accomplish, not what the system can do. Figure 11-7 provides some general guidelines to improve the quality of documentation text.<sup>7</sup>

<sup>7</sup>One of the best books to explain the art of writing is that by William Strunk Jr., and E. B. White, *Elements of Style*, 3d ed., Needham Heights, MA: Allyn & Bacon, 1995.



**FIGURE 11-6**  
Virtual agent help dialog in Windows 10.

### YOUR TURN 11-2

### Documentation for an Automated Teller

Pretend that you are a project manager for a bank, developing software for automated teller machines. Develop an online help system.

## Identifying Navigation Terms

As you write the documentation topics, you also begin to identify the terms that will be used to help users find topics. The table of contents is usually the most straightforward because it is developed from the logical structure of the documentation topics, whether reference topics,

Guideline	Before the Guideline	After the Guideline
<b>Use the active voice:</b> The active voice creates more active and readable text by putting the subject at the start of the sentence, the verb in the middle, and the object at the end.	Finding drones is done using the drone model name or model class.	Find a drone by the drone model or model class.
<b>Use e-prime style:</b> E-prime style creates more active writing by omitting all forms of the verb to be.	The text you want to copy must be selected before you click on the copy button.	Select the text you want to copy before you click on the copy button.
<b>Use consistent terms:</b> Always use the same term to refer to the same items, rather than switching among synonyms (e.g., change, modify, update).	Select the text you want to copy. Pressing the copy button will copy the marked text to the new location.	Select the text you want to copy. Press the copy button to copy the selected text. Press the paste button to place the text into the new location.
<b>Use simple language:</b> Always use the simplest language possible to accurately convey the meaning. This does not mean that you should "dumb down" the text, but that you should avoid artificially inflating its complexity. Avoid separating subjects and verbs and try to use the fewest words possible. (When you encounter a complex piece of text, try eliminating words; you may be surprised at how few words are really needed to convey meaning.)	The Georgia Statewide Academic and Medical System (GSAMS) is a cooperative and collaborative distance learning network in the state of Georgia. The organization in Atlanta that administers and manages the technical and overall operations of the currently more than 300 interactive audio and video teleconferencing classrooms throughout the Georgia system is the Department of Administrative Service (DOAS). (56 words)	The Department of Administrative Service (DOAS) in Atlanta manages the Georgia Statewide Academic and Medical System (GSAMS), a distance learning network with more than 300 teleconferencing classrooms throughout Georgia. (29 words)
<b>Use friendly language:</b> Too often, documentation is cold and sterile because it is written in a very formal manner. Remember, you are writing for a person, not a computer.	Blank disks have been provided to you by the operations department. It is suggested that you make backup copies of all essential data to ensure that your data are not lost.	Make a backup copy of all data that is important to you. If you need more diskettes, contact the operations department.
<b>Use parallel grammatical structures:</b> Parallel grammatical structures indicate the similarity among items in lists and help the reader understand content.	Opening files Saving a document How to delete files	Opening a file Saving a file Deleting a file
<b>Use steps correctly:</b> Novices often intersperse actions and the results of actions when describing a step-by-step process. Steps are always actions.	1. Press the customer button. 2. The customer dialogue box will appear. 3. Type the customer ID and press the submit button and the customer record will appear.	1. Press the customer button. 2. Type the customer ID in the customer dialogue box when it appears. 3. Press the submit button to view the customer record for this customer.
<b>Use short paragraphs:</b> Readers of documentation usually quickly scan text to find the information they need, so the text in the middle of long paragraphs is often overlooked. Use numerous separate paragraphs to help readers find information more quickly.		

Adapted from: *Writing Software Documentation*, Boston: Allyn & Bacon, 1998, by T. T. Barker.

**FIGURE 11-7** Guidelines for crafting documentation topics.

procedure topics, or tutorial topics. The items for the index and search engine require more care because they are developed from the major parts of the system and the users' business functions. Every time you write a topic, you must also list the terms that will be used to find the topic. Terms for the index and search engine can come from four distinct sources.

The first source for index terms is the set of commands in the user interface, such as *open file*, *modify customer*, and *print open orders*. All commands contain two parts (action and object).

**CONCEPTS IN ACTION 11-C****Systems for Complex Electrical Systems**

Systems integration across platforms and companies grows more complex with time. In a case study from Florida in 2008, an electrical company realtime system detected a minor problem in the power grid and shut down the entire system, plunging over two million people into the dark. The system experts placed the blame on a substation software system that detected the minor fluctuation but had the ability to immediately shut the entire system down. Although there may be times when such a rapid response is vital (such as the nuclear disasters in

Chernobyl Ukraine and Three Mile Island), this was a case where such a response was not warranted.

**Questions**

1. Since software controls substation operations, how might a systems analyst approach this problem as a systems project?
2. Are there special considerations that a systems analyst needs to think about when dealing with realtime systems?

It is important to develop the index for both parts because users could search for information using either part. A user looking for more information about saving files, for example, might search using the term *save* or the term *files*.

The second source is the set of major concepts in the system, which are often the entities, data stores, and data elements in the data flow diagrams. In the case of DrōnTeq, for example, this might include *clients*, *flight requests*, and *pilots*.

A third source is the set of business tasks the user performs, such as ordering replacement units or making an appointment. Often these will be contained in the command set, but sometimes they require several commands and use terms that do not always appear in the system. A good source for these terms is the use scenarios developed by interface design (see Chapter 8).

A fourth, often controversial, source is the set of synonyms for the three sets of items mentioned previously. Users sometimes don't think in terms of the nicely defined terms used by the system. They may try to find information on how to *stop* or *quit* rather than *exit*, or on how to *erase* rather than *delete*. Including synonyms in the index increases the complexity and size of the documentation system but can greatly improve the value of the system to the users.

## Applying the Concepts at DrōnTeq

### Managing Programming

As mentioned previously, the public, informational site focused on DrōnTeq's Client Services system was contracted out for design and development to the Web development company that had developed DrōnTeq's main website. Consistency with the main company site was important, and the Web development firm could create a consistent site that communicated the excitement of drone applications through many visual features and effects. Jiang's project team followed the throwaway prototyping approach with the private, client and pilot portions of the Flight Services system. Exploratory prototypes of the major elements of the system were especially useful in developing the pilots' flight bidding process and in uploading/downloading data files following completion of a flight. Now, these prototypes provided the team with the design foundation for the actual system. Maria took the lead on the client-focused website and Dawn and Kenji tackled the pilot-focused site. Programming went smoothly and, despite a few minor problems, according to plan.

### Testing

While the developers were working, Jiang divided his time between helping with development and creating the test plans and user documentation. The test plans for the two sites were similar, but

Test Stage	Client-Focused Site	Pilot-Focused Site
Unit tests	Black-box tests	Black-box and white-box tests
Integration tests	User interface tests; use scenario tests	User interface tests; use scenario tests
System tests	Requirements tests; security tests; performance tests; usability tests	Requirements tests; security tests; performance tests; usability tests
Acceptance tests	Alpha test; beta test	Alpha test; beta test

**FIGURE 11-8** Flight services test plan.

slightly more extensive for the pilot-facing site (Figure 11-8). Unit testing by black-box testing from program specifications was planned for all components. Some modules from the pilot-focused site will be evaluated using white box testing to ensure they are easily maintained in the future. Jiang expects some changes will be needed once the system is used by real pilots in the field. Figure 11-9 shows part of one unit test for the client-focused flight request data entry component.

Integration testing for the two sites would encompass all user interface and use scenario tests to ensure that the interfaces worked properly. Jiang planned to bring in Carmella and her management team to help perform some of these tests. An important element of integration is to ensure that the pilots' uploaded data files are properly accessible by DrōnTeq's proprietary data analytics system.

Systems tests, by definition, are tests of the entire system—all components together. However, not all parts of the system would receive the same level of testing. Requirements tests would be conducted on all parts of the system to ensure that all requirements were met. Security was a critical issue, so the security of all aspects of the system would be tested. Security tests would be developed by DrōnTeq's infrastructure team, and once the system passed those tests, an external security consulting firm would be hired to verify the system's security.

Performance was an important issue for both clients and pilots; however, the main areas to evaluate were the uploading of completed flight data files and the downloading of files and data analyses. These client- and pilot-facing components would undergo rigorous performance testing. Jiang also ensured that the architecture design included an upgrade plan so that, as demand on the system increased, there was a clear plan for when and how to increase the processing capability of the system.

Finally, usability tests would be conducted on the user interface portion of the system, with six potential client and pilot users involved (both novice and expert Internet users). Acceptance tests would be conducted in two stages, alpha and beta. This state of testing is harder to accomplish, since all users of these new websites are external to the organization. Carmella's management team was asked to identify prospective users of both the client and pilot systems to volunteer for final testing. Carmella would work together with Jiang to develop a series of tests and training exercises to show these volunteers how to use the system. Alpha tests would focus on these users and the feedback they provided.

Beta testing would begin by “going live” with the same group of volunteers plus any other volunteers they could recruit to participate. At this stage, the volunteers were asked to enter “real” data representing their own knowledge and experiences. A small monetary incentive was provided in return for evaluating the system. Once Carmella and her management team were satisfied with the response from the volunteer testers and were confident in the sites' capabilities, the websites would go live to registered users via the public Flight Services website.

## Developing User Documentation

There were three types of documentation (reference documents, procedures manuals, and tutorials) that could be produced for the websites. Since users of these systems are external to the

<b>Test Plan</b>		
Program ID: <u>ORD56</u>	Version Number: <u>3</u>	Page: <u>12</u> of <u>32</u>
Tester: <u>Smith</u>	Date Designed: <u>9/9</u>	Date Conducted: <u>9/9</u>
Results: <input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Open Items	
Test ID: <u>12</u> Requirement Addressed: <u>Verify flight location latitute requirement information</u>		
Objective: Ensure that the information entered by client on the Flight Request form is valid.		
Test Cases		
Interface ID	Data Field	Value Entered
1) <u>REQ56-3.5</u>	<u>FRQ_LocLat</u>	<u>Blank</u>
2) <u>REQ56-3.5</u>	<u>FRQ_LocLat</u>	<u>4233</u>
3) <u>REQ56-3.5</u>	<u>FRQ_LocLat</u>	<u>42ee</u>
4) <u>REQ56-3.5</u>	<u>FRQ_LocLat</u>	<u>42.33</u>
5)		
6)		
Script		
Expected Results/Notes <i>Test 4 is valid; all others are invalid.</i>		
Actual Results/Notes <i>Test 4 accepted. Tests 1, 2, and 3 were rejected with correct error message.</i>		

**FIGURE 11-9** Client's flight request unit test plan example.

DrōnTeq organization, Jiang realized that the reference documentation (an online help system) would be most critical. Both registered Clients and enrolled Pilots would be provided with downloadable procedures manuals as well.

Jiang decided that the reference documents for both websites would contain help topics for user tasks, commands, and definitions. He also decided that the documentation component would contain four types of navigation controls: a table of contents, an index, a finder, and links to definitions. He did not think that the system was complex enough to benefit from a search agent.

After these decisions were made, Jiang assigned the development of the reference documents and procedures manuals to a technical writer assigned to the project team. Figure 11-10 shows examples of the topics the writer developed. The tasks and commands were taken directly from the interface design. The list of definitions was put together, once the tasks and commands were developed, based on the writer's experience in understanding what terms might be confusing to the user. Once the topic list was developed, the technical writer then began writing the topics themselves and the navigation controls to access. Figure 11-11 shows an example of one topic

Tasks	Commands	Terms
Create Flight Request	Create	Flight Request
Check Flight Request Status	Check Status	Status
View Flight Request Notifications	View	Flight Request Notifications
Submit Flight Bid	Submit	Flight Bid

FIGURE 11-10 Sample help topics for DrōnTeq.

**Help Topic**

### How to Place a Flight Request

There are three steps when you are ready to submit a Flight Request

- 1. Start at the Flight Services—Clients Page.**

Click on the Flight Request menu option, then select the Create New menu option.

- 2. Enter the data to describe the flight you want.**

Use the fields provided in the form to describe when and where you want the flight to occur and then features of the flight you need (pattern, area, imaging, etc.).

- 3. Submit Your Request**

When you have reviewed your entries, click the Submit Request button. If you have a question, click on the Live Chat button to be immediately connected to a Flight Service expert.

**Navigation Controls**

**Table of Contents** list:  
How to Submit a Flight Bid

**Index** list:  
Checking Flight Bid Status  
Downloading Flight Data  
View Flight History

**Search** find by:  
Flight Request  
Flight Bid  
Flight Request Notification  
Completed Flights

**Links:**  
Reports

FIGURE 11-11  
Example documentation topic for DrōnTeq.

taken from the task list: how to place a flight request. This topic presents a brief description of what it is and then leads the user through the step-by-step process needed to complete the task. The topic also lists the navigation controls that will be used to find the topic, in terms of the table of contents entries, index entries, and search entries. It also lists what words in the topic itself will have links to other topics.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Identify and describe the essential aspects of managing the programming process.
- Identify and describe the elements of a test plan.
- Identify and describe the focus and types of unit testing.

- Identify and describe the focus and types of integration testing.
- Identify and describe the focus and types of system testing.
- Identify and describe the focus and types of acceptance testing.
- Identify and describe the focus and types of user documentation.

## KEY TERMS

Acceptance tests

Alpha testing

Beta testing

Black-box testing

Change control

Construction

Data flow testing

Documentation navigation control

Documentation testing

Documentation topic

Hardcoded

Integration tests

Performance testing

Procedures manuals

Program log

Reference documents

Requirements testing

Scope creep

Security testing

Stub

System documentation

System interface

testing

System tests

Test case

Test plan

Tutorials

Unit tests

Usability testing

User documentation

User interface testing

Use scenario testing

White-box testing

## QUESTIONS

1. Discuss the issues that the project manager must consider when assigning programming tasks to the programmers.
2. If the project manager feels that programming is falling behind schedule, should more programmers be assigned to the project? Why or why not?
3. Describe the typical way that project managers organize the programmers' work storage areas. Why is this approach useful?
4. What is meant by change control? How is it helpful to the programming effort?
5. Discuss why testing is so essential to the development of the new system.
6. Explain how a test case relates to a test plan.
7. What is the primary goal of unit testing?
8. How are test cases developed for unit tests?
9. What is the primary goal of integration testing?
10. Describe the four approaches to integration testing.
11. How are the test cases developed for integration tests?
12. Compare and contrast black-box testing and white-box testing.
13. Compare and contrast system testing and acceptance testing.
14. Describe the five approaches to systems testing.
15. Discuss the role users play in testing.
16. What is the difference between alpha testing and beta testing?
17. Explain the difference between user documentation and system documentation.
18. What are the reasons underlying the popularity of online documentation?
19. Are there any limitations to online documentation? Explain.
20. Distinguish between these types of user documentation: reference documents, procedures manuals, and tutorials.
21. Describe the five types of documentation navigation controls.
22. What are the commonly used sources of documentation topics? Which is the most important? Why?
23. What are the commonly used sources of documentation navigation controls? Which is the most important? Why?
24. What do you think are three common mistakes made by novice systems analysts during programming and testing?

25. What do you think are three common mistakes made by novice systems analysts in preparing user documentation?
26. In our experience, documentation is left to the very end of most projects. Why do you think this happens? How could it be avoided?
27. In our experience, few organizations perform as thorough testing as they should. Why do you think this happens? How could it be avoided?
28. Create several guidelines for developing good documentation.

Hint: Think about behaviors that might lead to developing poor documentation.

## EXERCISES

- A. Develop a unit test plan for the calculator program in Windows (or a similar program for the Mac or Linux).
- B. Develop a unit test plan for a website that enables you to perform some function (e.g., make travel reservations, order books).
- C. If the registration system at your university does not have a good online help system, develop one for one screen of the user interface.
- D. Examine and prepare a report on the online help system for the calculator program in Windows (or a similar program for the Mac or Linux). (You may be surprised at the amount of help that is available for such a simple program.)
- E. Compare and contrast the online help resources at two different websites that enable you to perform the same function (e.g., make travel reservations, order books).

## MINICASES

1. A new systems development project is Pete's first experience as a project manager, and he has led his team successfully to the programming phase of the project. The project has not always gone smoothly, and Pete has made a few mistakes, but he is generally pleased with the progress of his team and the quality of the system being developed. Now that programming has begun, Pete has been hoping for a little break in the hectic pace of his workday.

Before beginning programming, Pete recognized that the time estimates made earlier in the project were too optimistic. However, he was firmly committed to meeting the project deadline because of his desire for his first project to be a success. In anticipation of this time-pressure problem, Pete arranged with the human resources department to bring in two new college graduates and two college interns to beef up the programming staff. Pete would have liked to find some staff with more experience, but the budget was too tight and he was committed to keeping the project budget under control.

Pete made his programming assignments, and work on the programs began about 2 weeks ago. Now, Pete has started to hear some rumbles from the programming team leaders that may signal trouble. It seems that the programmers have reported several instances where they wrote programs, only to be unable to find them when they went to test them. Also, several programmers have opened programs that they had written, only to find that someone had changed portions of their programs without their knowledge.

- a. Is the programming phase of a project a time for the project manager to relax? Why or why not?
  - b. What problems can you identify in this situation?
  - c. What advice do you have for the project manager?
  - d. How likely does it seem that Pete will achieve his desired goals of being on time and within budget if nothing is done?
2. The systems analysts are developing the test plan for the user interface for the Holiday Travel Vehicles system. As the salespeople are entering a sales invoice into the system, they will be able to either enter an option code into a text box or select an option code from a drop-down list. A combo box was used to implement this, since it was felt that the salespeople would quickly become familiar with the most common option codes and would prefer entering them directly to speed up the entry process.

It is now time to develop the test for validating the option code field during data entry. If the customer did not request any dealer-installed options for the vehicle, the salesperson should enter "none"; the field should not be blank. The valid option codes are four-character alphabetic codes and should be matched against a list of valid codes.

Prepare a test plan for the test of the option code field during data entry.

# Transition to the New System

# 12

## IMPLEMENTATION

TASK CHECKLIST
<input checked="" type="checkbox"/> Program System. <input checked="" type="checkbox"/> Test Software. <input checked="" type="checkbox"/> Test Performance. <input type="checkbox"/> Select System Conversion Strategy. <input type="checkbox"/> Train Users. <input type="checkbox"/> Select Support. <input type="checkbox"/> Maintain System. <input type="checkbox"/> Assess Project. <input type="checkbox"/> Conduct Postimplementation Audit.

This chapter examines the activities needed to install the information system and successfully convert the organization to using it. It also discusses postimplementation activities, such as system support, system maintenance, and project assessment. Installing the system and making it available for use from a technical perspective is relatively straightforward. However, the training and organizational issues surrounding the installation are more complex and challenging because they focus on people, not computers.

### OBJECTIVES

- Explain the system installation process.
- Describe the elements of a migration plan.
- Explain different types of conversion strategies and when to use them.
- Describe several techniques for managing change.
- Outline postinstallation processes.

### Introduction

*It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system. For the initiator has the animosity of all who would profit by the preservation of the old institution and merely lukewarm defenders in those who would gain by the new.*

—Machiavelli, *The Prince*, 1513

Although written over 500 years ago, Machiavelli's comments are still true today. Managing the change to a new system—whether or not it is computerized—is one of the most difficult tasks in any organization. There are business issues, technical issues, and people issues that must be addressed to prepare for and successfully adapt to the change. Because of these challenges, planning for the transition from old to new systems begins while the programmers are still developing the software. Leaving this planning to the last minute is a recipe for failure.

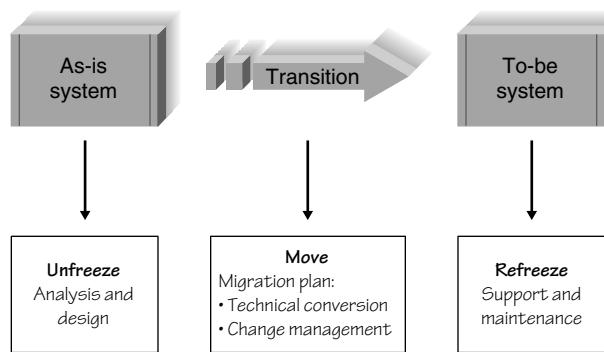
This chapter discusses the transition from the as-is system to the to-be system and ways to successfully manage this process. The migration plan encompasses activities that will be performed to prepare for the technical and business transition, and to prepare the people for the transition. We also present several important support and follow-up activities that should be performed following the **installation** of the new system.

## Making the Transition to the New System

In many ways, using a computer system or set of work processes is much like driving on a dirt road. Over time with repeated use, the road begins to develop ruts in the most used parts of the road. Although these ruts show where to drive, they make change difficult. As people use a computer system or set of work processes, those system/work processes begin to become habits or norms; people learn them and become comfortable with them. These system or work processes then begin to limit people's activities and make it difficult for them to change because they begin to see their jobs in terms of these processes rather than in terms of the final business goal of serving customers.

One of the earliest models for managing organizational change was developed by Kurt Lewin.<sup>1</sup> Lewin argued that change is a three-step process: unfreeze, move, refreeze (Figure 12-1). First, the project team must **unfreeze** the existing habits and norms (the as-is system) so that change is possible. Most of the SDLC to this point has laid the groundwork for unfreezing. Users are aware of the new system being developed, some have participated in an analysis of the current system (and so are aware of its problems), and some have helped design the new system (and so have some sense of the potential benefits of the new system). These activities have helped to unfreeze the current habits and norms.

The second step of Lewin's three-step model is to **move**, or **transition**, from the old system to the new. The **migration plan** incorporates many issues that must be addressed to facilitate



**FIGURE 12-1** Implementing change.

<sup>1</sup> Kurt Lewin, "Frontiers in Group Dynamics," *Human Relations*, 1947, 1:5–41; and Kurt Lewin, "Group Decision and Social Change," in E. E. Maccoby, T. M. Newcomb, and E. L. Hartley, eds., *Readings in Social Psychology*, New York: Holt, Rinehart & Winston, 1958, pp. 197–211.

this transition. First, the **conversion strategy** needs to be selected, determining the style of the switch from the old to the new system, what parts of the organization will be converted when, and how much of the system is converted at a time. Plans to handle potential business disruption due to technical problems during conversion should be outlined in the **business contingency plan**. Arrangements for the hardware and software installation should be completed, and decisions about how the data will be converted into the new system will be made. The final major segment of the migration plan involves helping the people who are affected by the new system understand the change and motivating them to adopt the new system. The next section of this chapter discusses these aspects of the migration plan.

Lewin's third step is to **refreeze** the new system as the habitual way of performing the work processes—ensuring that the new system successfully becomes the standard way of performing the business functions it supports. This refreezing process is a key goal of the **postimplementation** activities discussed in the final section of this chapter. By providing ongoing support for the new system and immediately beginning to identify improvements for the next version of the system, the organization helps solidify the new system as the new habitual way of doing business. Post-implementation activities include **system support**, which means providing help desk and telephone support for users with problems; **system maintenance**, which means fixing bugs and improving the system after it has been installed; and **project assessment**, which is the process of evaluating the project to identify what went well and what could be improved for the next system development project.

## The Migration Plan

The transition from the old business processes and computer programs to the new business processes and computer programs will be facilitated by ensuring that a number of business, technical, and people issues are addressed. The decisions, plans, and procedures that will guide the transition are outlined in the *migration plan* (Figure 12-2). The migration plan specifies what activities will be performed when and by whom as the transition is made from the old to the new system.

To ensure that business is ready to make the transition, the project team must determine the best conversion strategy to use as the new system is introduced to the organization. Also, plans should be made to ensure that the business can continue its operations even in the event of technical glitches in the new system. These plans are termed *business contingency plans*.

Technical readiness is achieved by arranging for and installing any needed hardware and software, and converting data as needed for the new system. These arrangements, while essential, are usually the least difficult of all the issues dealt with in the migration plan.

Ensuring that the people who will be affected by the new system are ready and able to use it is the most complex element of the migration plan. Managing the “people” side of change requires

Migration Plan		
Preparing the Business	Preparing the Technology	Preparing the People
<input checked="" type="checkbox"/> Select a conversion strategy.	<input checked="" type="checkbox"/> Install hardware.	<input checked="" type="checkbox"/> Revise management policies.
<input checked="" type="checkbox"/> Prepare a business contingency plan.	<input checked="" type="checkbox"/> Install software.	<input checked="" type="checkbox"/> Assess costs and benefits.
	<input checked="" type="checkbox"/> Convert data.	<input checked="" type="checkbox"/> Motivate adoption.
		<input checked="" type="checkbox"/> Conduct training.

**FIGURE 12-2**  
Elements of a migration plan.

the team to understand the potential for resistance to the new system, develop organizational support and encouragement for the change, and prepare the users through appropriate training activities.

## Selecting the Conversion Strategy

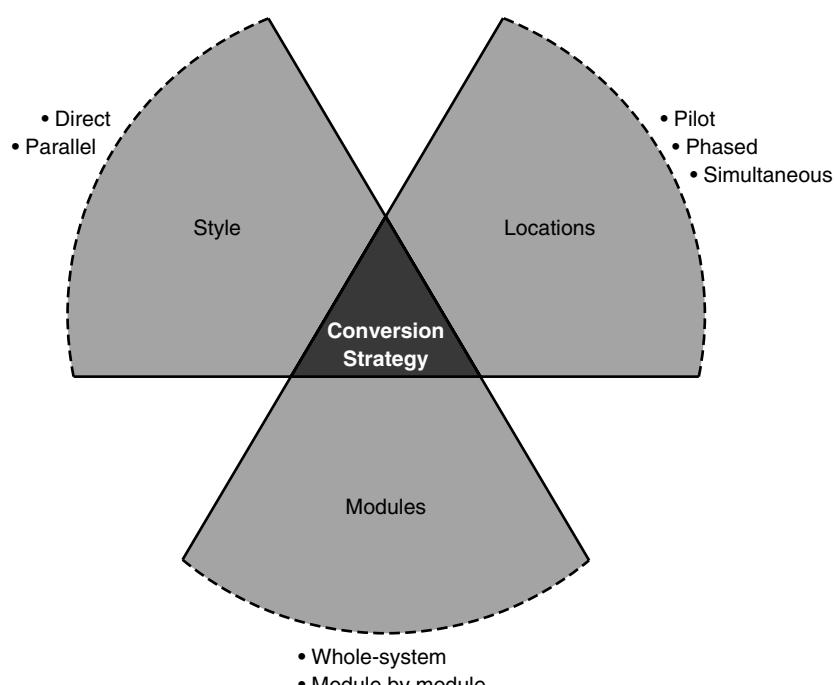
The process by which the new system is introduced into the organization is called the conversion strategy. Those implementing this strategy must consider three different aspects of introducing the system: how abruptly the change is made (the **conversion style**), the organizational span of the introduction (**conversion locations**), and the extent of the system that is introduced (**conversion modules**). The choices made in these three dimensions will affect the cost, time, and risk associated with the transition, as explained in the sections that follow (Figure 12-3).

### Conversion Style

The switch from the old system to the new system can be made abruptly or gradually. An abrupt change is called **direct conversion**, and, as the name implies, involves the instant replacement of the old system with the new system. In essence, the old system is turned off and the new system is turned on, often coinciding with a fiscal-year change or other calendar event.

Direct conversion is simple and straightforward, but also risky. Any problems with the new system that have not been detected during testing may seriously disrupt the organization's ability to function.

A more gradual introduction is made with **parallel conversion**, in which both the old and the new systems are used simultaneously for a period of time. The two systems are operated side by side, and users must work with both the old and new systems. For example, if a new accounting system is introduced with a parallel conversion style, data must be entered into both systems. Output from both systems is carefully compared to ensure that the new system is performing



**FIGURE 12-3**  
Conversion strategies.

correctly. After some period (often 1–2 months) of parallel operation and intense comparison between the two systems, use of the old system is discontinued.

Parallel conversion reduces risk by providing the organization with a fallback position if major problems are encountered with the new system. It adds expense, however, as users are required to do their job tasks twice: once with each system that performs the same function.

### Conversion Locations

The new system can be introduced to different parts of the organization at different times, or it can be introduced throughout the organization at the same time. A **pilot conversion** selects one or more locations (or units or work groups within a location) to be converted first as a part of a pilot test. If the conversion at the pilot location is successful, then the system is installed at the remaining locations.

Pilot conversion has the advantage of limiting the effect of the new system to just the pilot location. In essence, an additional level of testing is provided before the new system is introduced organizationwide. This type of conversion can be done only in organizations that can tolerate different locations using different systems and business processes for a certain length of time. It also obviously requires a considerable time before the system is installed at all organizational locations.

In some situations, it is preferable to introduce the system to different locations, in phases. With **phased conversion**, a first set of locations is converted, then a second set, then a third set, and so on, until all locations are converted. Sometimes there is a deliberate delay between the phases, so that any problems with the system are detected before too much of the organization is affected. In other circumstances, the project team may begin a new phase immediately following the completion of the previous phase.

Phased conversion has the same advantages and disadvantages as pilot conversion. It also involves a smaller set of people to perform the actual conversion (and any associated training) than if all locations were converted at once.

It may be necessary to convert all locations at the same time, suggesting the need for **simultaneous conversion**. The new system is installed at all locations at once, thus eliminating the problem of having different organizational units using different systems and processes. The drawback of this option is that there must be sufficient staff to perform the conversion and train the users at all locations simultaneously.

### Conversion Modules

Although we typically expect that systems are installed in their entirety, this is not always the case. It may be desirable to decide how much of the new system will be introduced into the

#### CONCEPTS IN ACTION 12-A

#### Converting to the Euro (Part 1)

When the European Union decided to introduce the euro, the European Central Bank had to develop a new computer system (called Target) to provide a currency settlement system for use by investment banks and brokerages. Prior to the introduction of the euro, settlement was performed between the central banks of the countries involved. After the introduction, the Target system, which consists of 15 national banking systems, would settle trades and perform currency conversions for cross-border payments for stocks and bonds.

Adapted from: "Debut of Euro Nearly Flawless," *Computerworld*, 33(2), p. 16, January 11, 1999, by Thomas Hoffman.

#### Question

1. Implementing Target was a major undertaking for a number of reasons. If you were an analyst on the project, what kinds of issues would you have to address to make sure the conversion happened successfully?

organization at a time. When the modules within the system are separate and distinct, organizations may convert to the new system one module at a time, using **modular conversion**. Modular conversion requires special care in developing the system (and usually adds extra cost), because each module must be written to work with both the old and the new systems. When modules are tightly integrated, this is particularly challenging and is therefore seldom done. When the software is written with loose association between modules, however, it becomes easier.

Modular conversion reduces the amount of **training** needed for people to begin using the new system, since users need to be trained only for the new module being implemented. Modular conversion does require significant time to introduce each module of the system in sequence.

**Whole-system conversion**, installing the entire system at one time, is most common. This approach is simple and straightforward and is required if the system consists of tightly integrated modules. If the system is large and/or extremely complex, however (e.g., an enterprise resource planning system such as SAP or Oracle), the whole system may prove too difficult for users to learn in one conversion step.

### Evaluating the Strategy Choices

Each of the segments in Figure 12-3 are independent, so a conversion strategy can be developed by combining any of the options just discussed.

For example, one commonly used approach is to begin with a pilot conversion of the whole system, using parallel conversion in a handful of test locations. Once the system has passed the pilot test at these locations, it is then installed in the remaining locations by phased conversion with direct cutover. There are three important factors to consider in selecting a conversion strategy: risk, cost, and the time required (Figure 12-4).

### Risk

The introduction of the new system exposes the organization to risk associated with problems and errors that may impede business operations. After the system has passed a rigorous battery of unit, integration, system, and acceptance testing, it should be bug free—maybe. Because humans make mistakes, undiscovered bugs may exist. Depending on the choices made, the conversion process provides one last step in which bugs can be detected and fixed before the system is in widespread use.

The parallel conversion strategy is less risky than direct conversion because of the security of continuing to operate the old system. If bugs are encountered, the new system can be shut down and fixed while the old system continues to function. Converting a pilot location is less risky than phased conversion or simultaneous conversion because the effects of bugs are limited to the pilot location. Those involved, knowing the installation is a pilot test, expect to encounter bugs. Finally, converting by modules is less risky than simultaneous conversion. The number of bugs encountered at any one time should be fewer when a few modules at a time are converted, making it easier to deal with problems as they occur. If numerous bugs are experienced together



Characteristic	Conversion Style			Conversion Location			Conversion Modules	
	Direct Conversion	Parallel Conversion	Pilot Conversion	Phased Conversion	Simultaneous Conversion	Whole-System Conversion	Modular Conversion	
Risk	High	Low	Low	Medium	High	High	Medium	
Cost	Low	High	Medium	Medium	High	Medium	High	
Time	Short	Long	Medium	Long	Short	Short	Long	

FIGURE 12-4 Characteristics of conversion strategies.

during simultaneous conversion, the total effect may be more disruptive than if the bugs were encountered gradually.

The significance of the risk factor in selecting a conversion strategy depends on the system being implemented. The team must weigh the probability of undetected bugs remaining in the system against the potential consequences of those undetected bugs. If the system has undergone extensive methodical testing, including alpha and beta testing, then the probability of undetected bugs is lower than if testing were less rigorous. There remains the chance, however, that mistakes were made in analysis and that the new system may not properly fulfill the business requirements.

Assessing the consequences (or cost) of a bug is challenging. Most analysts and senior managers can make a reasonable guess at the relative significance of a bug, however. For example, it is obvious that the importance of negative consequences of a bug in an automated stock market trading system or a medical life-support system is much greater than in a computer game or word processing program (recall Figure 11-1). Therefore, risk is likely to be an especially important factor in the selection of a conversion strategy if the system has had limited testing and/or if the significance of bugs is high. If the system has been thoroughly tested and/or the cost of bugs is not too high, then risk becomes less important to the conversion strategy decision.

### Cost

The various conversion strategies have different costs. These costs can include salaries for people who work with the system (e.g., users, trainers, system administrators, external consultants), travel expenses, operation expenses, communication costs, and hardware leases. Parallel conversion is more expensive than direct cutover because it requires that two systems (the old and the new) be operated at the same time. Employees must now perform twice the usual work and cross-check the results of the two systems.

Pilot conversion and phased conversion have somewhat similar costs. Simultaneous conversion has higher costs because more staff are required to support all the locations as they simultaneously switch from the old to the new system. Modular conversion is more expensive than whole system conversion because it requires more programming. The old system must be updated to work with selected modules in the new system, and modules in the new system must be programmed to work with selected modules in both the old and new systems.

### Time

The final factor is the amount of time required to convert between the old and the new system. Direct conversion is the fastest because it is immediate. Parallel conversion takes longer because the full advantages of the new system do not become available until the old system is turned off. Simultaneous conversion is fastest because all locations are converted at the same time. Phased conversion generally takes longer than pilot conversion because usually (but not always), once the pilot test is complete, all remaining locations are simultaneously converted. Phased conversion proceeds in waves, often requiring several months before all locations are converted. Likewise, modular conversion takes longer than whole-system conversion because the modules are introduced one after another.

#### YOUR TURN 12-1

#### Developing a Conversion Strategy

Suppose that you are leading the conversion from one word processor to another at your university. Develop a conversion strategy. You have also been asked to develop a conversion strategy for the university's new Web-based course registration

system. How would the second conversion strategy be similar to or different from the one you developed for the word processor?

**CONCEPTS IN ACTION 12-B****US Army Installation Support**

Throughout the 1960s, 1970s, and 1980s, the US Army automated its installations (“army bases,” in civilian terms). Automation was usually a local effort at each of the more than 100 bases. Although some bases had developed software together (or borrowed software developed at other bases), each base often had software that performed different functions or performed the same function in different ways. In 1989, the army decided to standardize the software so that the same software would be used everywhere. This would greatly reduce software maintenance and also reduce training when soldiers were transferred between bases.

The software took four years to develop. The system was quite complex, and the project manager was concerned that there was a high risk that not all requirements of all installations had been properly captured. Cost and time were less important since the project had already run four years and cost \$100 million.

Therefore, the project manager chose a modular pilot conversion using parallel conversion. The manager selected seven installations, each representing a different type of army installation (e.g., training base, arsenal, depot) and began the conversion. All went well, but several new features were identified that had been overlooked during the analysis, design, and construction. These were added and the pilot testing resumed. Finally, the system was installed in the rest of the army installations using a phased direct conversion of the whole system. *Alan Dennis*

*Questions*

1. Do you think the conversion strategy was appropriate?
2. Regardless of whether you agree, what other conversion strategy could have been used?

## Preparing a Business Contingency Plan

It is tempting to believe that doing careful and thorough work in analysis and design and managing the IT project correctly will produce a successful system implementation. It is common for the team to view their prospects for success with optimism. With new systems, however, it may be more appropriate to always expect the worst. Keeping small technology glitches in the new system from turning into major business disasters is known as *business contingency planning*. Contingency plans help the business withstand relatively small problems with the new system so that major business disruptions are prevented.

Some might say that business disasters are prevented with good project management and migration planning; therefore, developing contingency plans to cope with disasters is unnecessary. Large projects spanning multiple business processes and involving huge amounts of code, however, provide numerous combinations of relatively small technical problems that together can have devastating consequences. Enterprise resource planning software projects are good examples. In 2004, Hewlett-Packard experienced an estimated \$160 million financial impact when a \$30-million SAP project in the Industry Standard Server division experienced relatively minor programming problems. In 2001, Nike experienced small IT problems in an SAP installation

**YOUR TURN 12-2****Comparing Conversion Strategies**

- Develop the combination of conversion strategy dimensions that produces the least risk; the most risk.
- Develop the combination of conversion strategy dimensions that produces the least cost; the most cost.
- Develop the combination of conversion strategy dimensions that requires the least time; the most time.

Now, compare these strategies. Do you see any relationships? Based on your analysis, what advice might you give a team selecting a conversion strategy?

that cost the company \$100 million in lost revenue.<sup>2</sup> It may be less risky to plan for how to cope with system failure (contingency plan) than to try to prevent failure purely through project management techniques.

Choosing parallel conversion is one approach to contingency planning. Operating the old and new systems together for a time ensures that a fallback system is available if problems occur with the new system. Parallel conversion is not always feasible, however. Consequently, the worst-case outcome—*no system at all*—should be imagined and planned for, potentially going back to simple manual procedures.

One of the limitations of problem prevention through perfect project management techniques is the constant pressure of budget constraints and limited time that most projects face. With no budget or time pressure, it might be possible to prevent problems from occurring, but this is rarely the situation. Therefore, during the development of the migration plan, the project team should devote some attention to identifying the worst-case scenarios for the project, understanding the total business impact of those worst-case scenarios, and developing procedures and work-arounds that will enable the business to withstand those events. Since the contingency plan focuses on keeping the business up and running in the event of IT problems, it will be important to involve key business managers and users in the plan development.

## Preparing the Technology

There are three major steps involved in preparing the technical aspects of the new system for operations: install the hardware, install the software, and convert the data (Figure 12-2). Although it may be possible to do some of these steps in parallel, they usually must be performed sequentially at any one location.

The first step is to buy and install any needed hardware. In many cases, no new hardware is needed, but sometimes the project requires new servers, client computers, printers, and networking equipment. The new hardware requirements should have been defined in the hardware and software specifications during design (see Chapter 7) and used to acquire the needed resources. It is now critical to work closely with vendors who are supplying needed hardware and software to ensure that the deliveries are coordinated with the conversion schedule so that the equipment is available when it is needed. Nothing can stop a conversion plan in its tracks as easily as the failure of a vendor to deliver needed equipment.

Once the hardware is installed, tested, and certified as being operational, the second step is to install the software. This includes the to-be system under development, and sometimes, additional software that must be installed to make the system operational. For example, the DrönTeq Client Flight Services system needs Web server software. At this point, the system is usually tested again to ensure that it operates as planned.

The third step is to convert the data from the as-is system to the to-be system. Data conversion is usually the most technically complicated step in the migration plan. Often, separate programs must be written to convert the data from the as-is system to the new formats required in the to-be system and store it in the to-be system files and databases. This process is often complicated by the fact that the files and databases in the to-be system do not exactly match the files and databases in the as-is system (e.g., the to-be system may use several tables in a database to store customer data that was contained in one file in the as-is system). Formal test plans are always required for data conversion efforts (see Chapter 11).

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<sup>2</sup>Christopher Koch, “When Bad Things Happen to Good Projects,” CIO Magazine, December 1, 2004.

## Preparing People for the New System

In the context of a systems development project, people who will use the new system need help to adopt and adapt to the new system. The process of helping them adjust to the new system and its new work processes without undue stress is called **change management**.<sup>3</sup> There are three key roles in any major organizational change. The first is the **sponsor** of the change—the person who wants the change. This person is the business sponsor who first initiated the request for the new system (see Chapter 1). Usually, the sponsor is a senior manager of the part of the organization that must adopt and use the new system. It is critical that the sponsor be active in the change management process because a change that is clearly being driven by the sponsor, not by the project team or the IS organization, has greater legitimacy in the eyes of the users. The sponsor has direct management authority over those who will adopt the system.

The second role is that of the **change agent**—the person(s) leading the change effort. The change agent, charged with actually planning and implementing the change, is usually someone outside of the business unit adopting the system and therefore has no direct management authority over the potential adopters. Because the change agent is an outsider from a different organizational culture, he or she has less credibility than do the sponsor and other members of the business unit. After all, once the system has been installed, the change agent usually leaves and thus has no ongoing impact.

The third role is that of **potential adopter**, or target of the change—the people who actually must change. These are the people for whom the new system is designed and who will ultimately choose to use or not use the system.

In the early days of computing, many project teams simply assumed that their job ended when the old system was converted to the new system at a technical level. The philosophy was “build it and they will come.” Unfortunately, that happens only in the movies. Resistance to change is common in most organizations. Therefore, the change management plan is an important part of the overall migration plan that glues together the key steps in the change management process. Successful change requires that people want to adopt the change and can adopt the change. The change management plan has four basic steps: revising management policies, assessing the cost and benefit models of potential adopters, motivating adoption, and enabling people to adopt through training (Figure 12-2). Before we can discuss the change management plan, however, we must first understand why people resist change.

## Understanding Resistance to Change

People resist change—even change for the better—for very rational reasons.<sup>4</sup> What is good for the organization is not necessarily good for the people who work there. For example, consider an order-processing clerk who used to receive orders to be shipped on paper shipping documents, but now uses a computer to receive the same information. Rather than typing shipping labels with a typewriter, the clerk now clicks on the print button on the computer and the label is produced automatically. The clerk can now ship many more orders each day, which is a clear benefit to the organization. The clerk, however, probably doesn’t really care how many packages are shipped. His or her pay doesn’t change; it’s just a question of whether the clerk prefers a computer or typewriter. Learning to use the new system and work processes—even if the change

<sup>3</sup>Many books have been written on change management. Some of our favorites are the following: Patrick Connor and Linda Lake, *Managing Organizational Change*, 2nd ed., Westport, CT: Praeger, 1994; Douglas Smith, *Taking Charge of Change*, Reading, MA: Addison-Wesley, 1996; and Daryl Conner, *Managing at the Speed of Change*, New York: Villard Books, 1992.

<sup>4</sup>This section benefited from conversations with Dr. Robert Briggs, research scientist at the Center for the Management of Information at the University of Arizona.

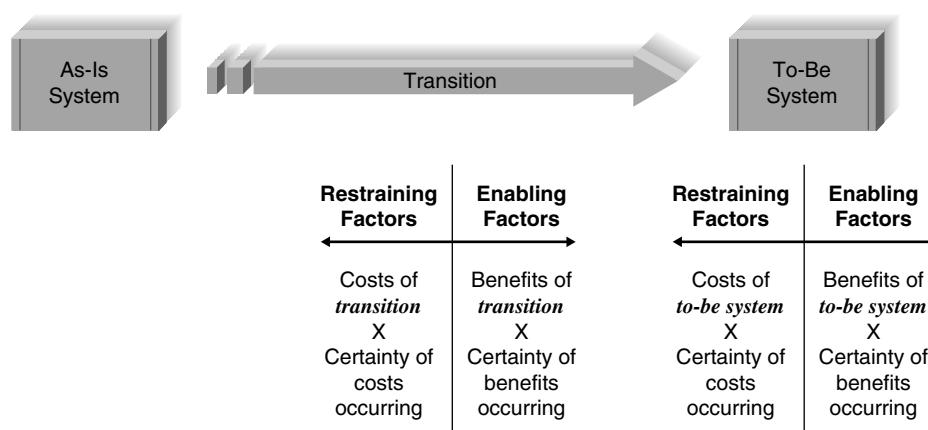
is minor—requires more effort than continuing to use the existing, well-understood system and work processes.

So why do people accept change? Simply put, every change has a set of costs and benefits associated with it. If the benefits of accepting the change outweigh the costs of the change, then people change. And sometimes the benefit of change is avoidance of the pain that you would experience if you did not adopt the change (e.g., if you don't change, you are fired, so one of the benefits of adopting the change is that you still have a job).

In general, when people are presented with an opportunity for change, they perform a cost-benefit analysis (sometimes consciously, sometimes subconsciously) and decide the extent to which they will embrace and adopt the change. They identify the costs of and benefits from the system and decide whether the change is worthwhile. However, it is not that simple, because most costs and benefits are not certain. There is some uncertainty as to whether a certain benefit or cost will actually occur; so both the costs of and benefits from the new system will need to be weighted by the degree of certainty associated with them (Figure 12-5). Unfortunately, most humans tend to overestimate the probability of costs and underestimate the probability of benefits.

There are also costs and benefits associated with the actual transition process itself. For example, suppose that you found a nicer house or apartment than your current one. Even if you liked it better, you might decide not to move, simply because the cost of moving outweighed the benefits of the new house or apartment itself. Likewise, adopting a new computer system might require you to learn new skills, which could be seen as a cost by some people, but as a benefit by others who perceive that those skills may somehow provide other benefits beyond the use of the system itself. Once again, any costs and benefits from the transition process must be weighted by the certainty with which they will occur (Figure 12-5).

Taken together, these two sets of costs and benefits (and their relative certainties) affect the acceptance of change or resistance to change that project teams encounter when installing new systems in organizations. The first step in change management is to understand the factors that inhibit change—the factors that affect the *perception* of costs and benefits and certainty that they will be generated by the new system. It is critical to understand that the “real” costs and benefits are far less important than the perceived costs and benefits. People act on what they *believe* to be true, not on what *is* true. Thus, any understanding of how to motivate change must be developed from the viewpoint of the people expected to change, not from the viewpoint of those leading the change.



**FIGURE 12-5** The costs and benefits of change.

## Revising Management Policies

The first major step in the change management plan is to change the management policies that were designed for the as-is system to new management policies designed to support the to-be system. **Management policies** provide goals, define how work processes should be performed, and determine how organizational members are rewarded. No computer system will be successfully adopted unless management policies support its adoption. Many new computer systems bring changes to business processes; they enable new ways of working. Unless the policies that provide the rules and rewards for those processes are revised to reflect the new opportunities that the system permits, potential adopters cannot easily use it.

Management has three basic tools for structuring work processes in organizations.<sup>5</sup> The first is the **standard operating procedures (SOPs)** that become the habitual routines for how work is performed. The SOPs are both formal and informal. Formal SOPs define proper behavior. Informal SOPs are the norms that have developed over time for how processes are actually performed. Management must ensure that the formal SOPs are revised to match the to-be system. The informal SOPs will then evolve to refine and fill in details absent in the formal SOPs.

The second aspect of management policy is defining how people assign meaning to events. What does it mean to “be successful” or “do good work”? Policies help people understand meaning by defining **measurements** and **rewards**. Measurements explicitly define meaning because they provide clear and concrete evidence about what is important to the organization. Rewards reinforce measurements because “what gets measured gets done” (an overused, but accurate, saying). Measurements must be carefully designed to motivate desired behavior. The IBM credit example (“Your Turn 3-3” in Chapter 3) illustrates the problem when flawed measurements drive improper behavior. (When the credit analysts became too busy to handle credit requests, they would “find” nonexistent errors so that they could return the requests unprocessed.)

A third aspect of management policy is **resource allocation**. Managers can have a clear and immediate impact on behavior by allocating resources. They can redirect funds and staff from one project to another, create an infrastructure that supports the new system, and invest in training programs. Each of these activities has both a direct and a symbolic effect. The direct effect comes from the actual reallocation of resources. The symbolic effect shows that management is serious about its intentions. There is less uncertainty about management’s long-term commitment to a new system when potential adopters see resources being committed to support it.

## Assessing Costs and Benefits

The next step in developing a change management plan is to develop two clear and concise lists of costs and benefits provided by the new system (and the transition to it), compared with the as-is system. The first list is developed from the perspective of the organization, which should flow easily from the business case developed during the feasibility study and refined over the life of the project (see Chapter 1). This set of organizational costs and benefits should be distributed widely so that everyone expected to adopt the new system clearly understands why the new system is valuable to the organization.

The second list of costs and benefits is developed from the viewpoints of the different potential adopters expected to change, or stakeholders in the change. For example, one set of potential adopters may be the front-line employees, another may be the first-line supervisors, and yet

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<sup>5</sup>This section builds on the work of Anthony Giddons, *The Constitution of Society: Outline of the Theory of Structure*, Berkeley: University of California Press, 1984. A good summary of Giddons’ theory that has been revised and adapted for use in understanding information systems is an article by Wanda Orlikowski and Dan Robey, “Information Technology and the Structuring of Organizations,” *Information Systems Research*, 1991, 2(2):143–169.

**YOUR TURN 12-3** || Standard Operating Procedures

Identify and explain three SOPs for the course in which you are using this book. Discuss whether they are formal or informal.

another might be middle management. Each of these potential adopters or stakeholders may have a different set of costs and benefits associated with the change—costs and benefits that can differ widely from those of the organization. In some situations, unions may be key stakeholders that can make or break successful change.

Many systems analysts naturally assume that front-line employees are the ones whose set of costs and benefits are the most likely to diverge from those of the organization and thus are the ones who most resist change. However, these employees usually bear the brunt of problems with the current system. When problems occur, they often experience them firsthand. Middle managers and first-line supervisors are the most likely to have a divergent set of costs and benefits; therefore, they resist change because new computer systems often change how much power those individuals have. For example, a new computer system may improve the organization's control over a work process (a benefit to the organization), but reduce the decision-making power of middle management (a clear cost to middle managers).

An analysis of the costs and benefits for each set of potential adopters or stakeholders will help pinpoint those who will likely support the change and those who may resist the change. The challenge at this point is to try to change the balance of the costs and benefits for those expected to resist the change so that they support it (or at least do not actively resist it).

This analysis may uncover some serious problems that have the potential to block the successful adoption of the system. It may be necessary to reexamine the management policies and make significant changes to ensure that the balance of costs and benefits is such that important potential adopters are motivated to adopt the system.

Figure 12-6 summarizes some of the factors that are important to successful change. The first and most important is a compelling personal reason to change. All change is made by individuals, not organizations. If there are compelling reasons for the key groups of individual stakeholders to want the change, then the change is more likely to be successful. Factors such as increased salary, reduced unpleasantness, and—depending on the individuals—opportunities for promotion and personal development can be important motivators. If the change makes current skills less valuable, however, individuals may resist the change because they have invested a lot of time and energy in acquiring those skills and anything that diminishes those skills may be perceived as diminishing the individual (because important skills bring respect and power).

There must also be a compelling reason for the organization to need the change; otherwise, individuals become skeptical regarding whether the change is important and are less certain that it will in fact occur. Probably the hardest organization to change is an organization that has been successful because individuals come to believe that what worked in the past will continue to work. By contrast, in an organization that is on the brink of bankruptcy, it is easier to convince individuals that change is needed. Commitment and support from credible business sponsors and top management are also important in increasing the certainty that the change will occur.

The likelihood of successful change is increased when the cost of the transition to individuals who must change is low. The need for significantly different new skills or disruptions in operations and work habits may create resistance. A clear migration plan developed by a credible change agent who has support from the business sponsor is an important factor in increasing the certainty about the costs of the transition process.



	<b>Factor</b>	<b>Examples</b>	<b>Effects</b>	<b>Actions to Take</b>
<b>Benefits of to-be system</b>	Compelling personal reason(s) for change	Increased pay, fewer unpleasant aspects, opportunity for promotion, most existing skills remain valuable	If the new system provides clear personal benefits to those who must adopt it, they are more likely to embrace the change.	Perform a cost-benefit analysis from the viewpoint of the stakeholders, make changes where needed, and actively promote the benefits.
<b>Certainty of benefits</b>	Compelling organizational reason(s) for change	Risk of bankruptcy, acquisition, government regulation	If adopters do not understand why the organization is implementing the change, they are less certain that the change will occur.	Perform a cost-benefit analysis from the viewpoint of the organization and launch a vigorous information campaign to explain the results to everyone.
	Demonstrated top management support	Active involvement, frequent mentions in speeches	If top management is not seen to actively support the change, there is less certainty that the change will occur.	Encourage top management to participate in the information campaign.
	Committed and involved business sponsor	Active involvement, frequent visits to users and project team, championing	If the business sponsor (the functional manager who initiated the project) is not seen to actively support the change, there is less certainty that the change will occur.	Encourage the business sponsor to participate in the information campaign and play an active role in the change management plan.
	Credible top management and business sponsor	Management and sponsor who do what they say instead of being members of the "management fad of the month" club	If the business sponsor and top management have credibility in the eyes of the adopters, the certainty of the claimed benefits is higher.	Ensure that the business sponsor and/or top management has credibility so that such involvement will help; if there is no credibility, involvement will have little effect.
<b>Costs of transition</b>	Low personal costs of change	Few new skills needed	The cost of the change is not borne equally by all stakeholders; the costs are likely to be higher for some.	Perform a cost-benefit analysis from the viewpoint of the stakeholders, make changes where needed, and actively promote the low costs.
<b>Certainty of costs</b>	Clear plan for change	Clear dates and instructions for change, clear expectations	If there is a clear migration plan, it will likely lower the perceived costs of transition.	Publicize the migration plan.
	Credible change agent	Previous experience with change, does what he or she promises to do	If the change agent has credibility in the eyes of the adopters, the certainty of the claimed costs is higher.	If the change agent is not credible, then change will be difficult.
	Clear mandate for change agent from sponsor	Open support for change agent when disagreements occur	If the change agent has a clear mandate from the business sponsor, the certainty of the claimed costs is higher.	The business sponsor must actively demonstrate support for the change agent.

**FIGURE 12-6** Major factors in successful change.

**CONCEPTS IN ACTION 12-C****Managing Global Projects**

Shamrock Foods is a major food distributor centered in Tralee, Ireland. Originally a dairy cooperative, Shamrock branched into various food components (dried milk, cheese solids, flavorings (or flavourings, as the Irish would spell it)) and has had substantial growth in the past 10 years, most of which came by way of acquisition of existing companies or facilities. For example, Iowa Soybean in the United States is now a subsidiary of Shamrock Foods, as is a large dairy cooperative in Wisconsin.

Shamrock has processing facilities in over 12 countries and distribution and sales in over 30 countries. With the rapid growth by acquisition, the company has generally adopted a “hands-off” policy keeping the systems separated and not integrated into a unified ERP system. Thus, each acquired company is still largely autonomous, although it reports to Shamrock Foods and is managed by Shamrock Foods.

This separation concept has been a problem for Conor Lynch, CFO of Shamrock Foods. The board of directors would like some aggregated data for direction and analysis

of acquired businesses. Conor has the reports from the various subsidiaries but has to have his staff convert the figures reported in them to a consistent basis (generally, either Euros or American dollars).

**Questions**

1. When should a multinational/multisite business consolidate data systems?
2. There are costs associated with consolidating data systems that have a variety of hardware and software systems. For example, the various acquired companies already had their own functioning accounting systems. What justification should Conor use to push for a consolidated, unified ERP system?
3. At times, Conor has to deal with incomplete and incompatible data. For instance, inventory systems might be FIFO for some of the subsidiaries and LIFO for other subsidiaries. How might a CFO with multinational interests deal with incomplete and incompatible data?

## Motivating Adoption

The single most important factor in motivating a change is providing clear and convincing evidence of the need for change. Simply put, everyone who is expected to adopt the change must be convinced that the benefits from the to-be system outweigh the costs of changing.

There are two basic strategies to motivating adoption: informational and political. Both strategies are often used simultaneously. With an **informational strategy**, the goal is to convince potential adopters that the change is for the better. This strategy works when the cost–benefit set of the target adopters has more benefits than costs. In other words, there really are clear reasons for the potential adopters to welcome the change.

Using this approach, the project team provides clear and convincing evidence of the costs and benefits of moving to the to-be system. The project team writes memos and develops presentations that outline the costs and benefits of adopting the system from the perspective of the organization and from the perspective of the target group of potential adopters. This information is disseminated widely throughout the target group, much like an advertising or public relations campaign. It must emphasize the benefits as well as increase the certainty in the minds of potential adopters that these benefits will be achieved. In our experience, it is always easier to sell painkillers than vitamins; that is, it is easier to convince potential adopters that a new system will remove a major problem (or other source of pain) than that it will provide new benefits

**YOUR TURN 12-4****Overcoming Resistance to a New Executive Information System**

How would you motivate adoption if you were the developer of a new executive information system designed to provide your

organization’s top executives with key performance measures and economic trend information?

(e.g., increase sales). Therefore, informational campaigns are more likely to be successful if they stress the reduction or elimination of problems, rather than focus on the provision of new opportunities.

The other strategy to motivate change is a **political strategy**. With a political strategy, organizational power, not information, is used to motivate change. This approach is often used when the cost–benefit set of the target adopters has more costs than benefits. In other words, although the change may benefit the organization, there are no reasons for the potential adopters to welcome the change.

The political strategy is usually beyond the control of the project team. It requires someone in the organization who holds legitimate power over the target group to influence the group to adopt the change. This may be done in a coercive manner (e.g., “adopt the system or you’re fired”) or in a negotiated manner, in which the target group gains benefits in other ways that are linked to the adoption of the system (e.g., linking system adoption to increased training opportunities). Management policies can play a key role in a political strategy by linking salary to certain behaviors desired with the new system.

In general, for any change that has true organizational benefits, about 20–30% of potential adopters will be **ready adopters**. They recognize the benefits, quickly adopt the system, and become proponents of the system. Another 20–30% are **resistant adopters**. They simply refuse to accept the change, and they fight against it, either because the new system has more costs than benefits for them personally or because they place such a high cost on the transition process itself that no amount of benefits from the new system can outweigh the change costs. The remaining 40–60% are **reluctant adopters**. They tend to be apathetic and will go with the flow to either support or resist the system, depending on how the project evolves and how their coworkers react to the system. Figure 12-7 illustrates the actors who are involved in the change management process.

The goal of change management is to actively support and encourage the ready adopters and help them win over the reluctant adopters. There is usually little that can be done about the resistant adopters because their set of costs and benefits may be divergent from those of the organization. Unless there are simple steps that can be taken to rebalance their costs and benefits or the organization chooses to adopt a strong political strategy, it is often best to ignore this small minority of resistant adopters and focus on the larger majority of ready and reluctant adopters.

## Enabling Adoption: Training

Potential adopters may want to adopt the change, but unless they are capable of adopting it, they won’t. Adoption is enabled by providing employees the skills needed to adopt the change through careful *training*. Training is probably the most self-evident part of any change management initiative. How can an organization expect its staff members to adopt a new system if they are not trained? We have found that training is one of the most overlooked parts of the process, however. Many organizations and project managers simply expect potential adopters to find the system easy to learn. Since the system is presumed to be so simple, it is taken for granted that potential adopters should be able to learn with little effort. Unfortunately, this is usually an overly optimistic assumption.

Sponsor	Change Agent	Potential Adopters
The sponsor wants the change to occur.	The change agent leads the change effort.	Potential adopters are the people who must change. 20–30% are ready adopters. 20–30% are resistant adopters. 40–60% are reluctant adopters.

**FIGURE 12-7** Actors in the change management process.

**YOUR TURN 12-5****Developing a Training Plan**

Suppose that you are leading the conversion from one word processor to another in your organization. Develop an outline of topics that would be included in the training. Develop a plan for training delivery.

Every new system requires new skills, either because the basic work processes have changed (sometimes radically in the case of business process reengineering (BPR); see Chapter 3) or because the computer system used to support the processes is different. The more radical the changes to the business processes, the more important it is to ensure that the organization has the new skills required to operate the new business processes and supporting information system. In general, there are three ways to get these new skills. One is to hire new employees who have the needed skills that the existing staff does not. Another is to outsource the processes to an organization that has the skills that the existing staff does not. Both approaches are controversial and are usually considered only in the case of BPR when the new skills needed are likely to be the most different from the set of skills of the current staff. In most cases, organizations choose the third alternative: training existing staff in the new business processes and the to-be system. Every training plan must consider what to train and how to deliver the training.

**What to Train**

What training should you provide to the system users? It is obvious: how to use the system. The training should cover all the capabilities of the new system, so that users understand what each module does, right?

Wrong. Training for business systems should focus on helping the users to accomplish their jobs, not on how to use the system. The system is simply a means to an end, not the end in itself. This focus on performing the job (i.e., the business processes), not using the system, has two important implications. First, the training must focus on those activities around the system, as well as on the system itself. The training must help the users understand how the computer fits into the bigger picture of their jobs. The use of the system must be put in the context of the manual and computerized business processes, and it must also cover the new management policies that were implemented along with the new computer system.

Second, the training should focus on what the user needs to do, not on what the system can do. This is a subtle—but very important—distinction. Most systems will provide far more capabilities than the users will need to use (e.g., when was the last time you wrote a macro in Microsoft Word?). Rather than attempting to teach the users all the features of the system, training should instead focus on the much smaller set of activities that users perform on a regular basis and ensure that users are truly expert in those. When the focus is on the 20% of functions that the users will use 80% of the time (instead of attempting to cover all functions), users become confident about their ability to use the system. Training should mention the other little-used functions, but only so that users are aware of their existence and know how to learn about them when their use becomes necessary.

One source of guidance for designing training materials is the use cases and use scenarios. The use cases and use scenarios outline the common activities that users perform and thus can clarify the business processes and system functions that are likely to be most important to the users.

**How to Train**

There are many ways to deliver training. The most used approach is **classroom training**. This has the advantage of training many users at one time with only one instructor and creates a shared experience among the users.

**CONCEPTS IN ACTION 12-D****Finishing the Process**

As a great analyst, you have planned, analyzed, and designed a good solution. Now you need to implement it. As a part of implementation, do you think that training is just a wasted expense?

Stress is common in a help-desk call center. Users of computing services call to get access to locked accounts, get help when technology is not working as planned, and frequently can become quite upset. Employees of the help-desk call center can get stressed out, and this can result in a greater number of sick days, less productivity, and higher turnover. Max Productivity Incorporated (MPI) is a training company that works with people in high-stress jobs. MPI's training program helps

employees learn how to relax, how to "shake off" tough users, and how to create "win-win" scenarios. MPI claims to be able to reduce employee turnover by 50%, increase productivity by 20%, and reduce stress, anger, and depression by 75%.

*Questions*

1. How would you challenge MPI to verify its claims regarding reducing turnover, increasing productivity, and decreasing stress and anger?
2. How would you conduct a "cost-benefit" analysis aimed at deciding whether to hire MPI to do ongoing training for your help-desk call center employees?

It is also possible to provide **one-on-one training** in which one trainer works closely with one user at a time. This is obviously more expensive, but the trainer can design the training program to meet the needs of individual users and can better ensure that the users really do understand the material. This approach is typically used only when the users are particularly important or when there are very few users.

Another common approach is to use some form of **computer-based training (CBT)**, in which the training program is delivered via computer, either on DVD or over the Web. CBT programs can include text slides, audio, and even video and animation. CBT is typically more costly to develop but is cheaper to deliver because no instructor is needed to actually provide the training.

Figure 12-8 summarizes four important factors to consider in selecting a training method. CBT is typically more expensive to develop than one-on-one or classroom training, but it is less expensive to deliver. One-on-one training has the most impact on the user because it can be customized to the user's precise needs, knowledge, and abilities, whereas CBT has the least impact. However, CBT has the greatest reach—the ability to train the most users over the widest distance in the shortest time—because it is so much simpler to distribute, compared with classroom and one-on-one training, since no instructors are needed.

Figure 12-8 suggests a clear pattern for most organizations. If there are only a few users to train, one-on-one training is the most effective. If there are many users to train, many organizations turn to CBT. We believe that the use of CBT will increase in the future. Quite often, large organizations use a combination of all three methods. Regardless of which approach is used, it is important to leave the users with a set of easily accessible materials that can be referred to long after the training has ended (usually a quick reference guide and a set of manuals, whether on paper or in electronic form).



	<b>One-On-One Training</b>	<b>Classroom Training</b>	<b>Computer-Based Training</b>
Cost to develop	Low–medium	Medium	High
Cost to deliver	High	Medium	Low
Impact	High	Medium–high	Low–medium
Reach	Low	Medium	High

**FIGURE 12-8** Selecting a training method.

## Postimplementation Activities

The goal of postimplementation activities is to **institutionalize** the use of the new system—that is, to make it the normal, accepted, routine way of performing the business processes. The postimplementation activities attempt to refreeze the organization after the successful transition to the new system. Although the work of the project team naturally winds down after implementation, the business sponsor and, sometimes, the project manager are actively involved in refreezing. These two—and, ideally, many other stakeholders—actively promote the new system and monitor its adoption and usage. They usually provide a steady flow of information about the system and encourage users to contact them to discuss issues.

In this section, we examine three key postimplementation activities; support (aiding in the use of the system), maintenance (continuing to refine and improve the system), and project assessment (analyzing the project to understand what activities were done well—and should be repeated—and what activities need improvement in future projects).

### System Support

Once the project team has installed the system and performed the change management activities, the system is officially turned over to the **operations group**. This group is responsible for the operation of the system, whereas the project team is responsible for the development of the system. Members of the operations group usually are integrally involved in the installation activities because they are the ones who must ensure that the system actually works. After the system is installed, the project team leaves but the operations group remains.

Providing system support means helping the users to use the system. Usually, this means providing answers to questions and helping users understand how to perform a certain function; this type of support can be thought of as **on-demand training**.

**Online support** is the most common form of on-demand training. This includes the documentation and help screens built into the system, as well as separate websites that provide answers to **frequently asked questions (FAQs)** that enable users to find answers without contacting a person. Obviously, the goal of most systems is to provide sufficiently good online support so that the user does not need to contact a person, because providing online support is much less expensive than is providing a person to answer questions.

Most organizations provide a **help desk** that provides a place for a user to talk with a person who can answer questions (usually over the phone, but sometimes in person). The help desk supports all systems, not just one specific system, so it receives calls about a wide variety of software and hardware. The help desk is operated by **level 1 support** staff who have very broad computer skills and are able to respond to a wide range of requests, from network problems and hardware problems to problems with commercial software and with the business application software developed in house.

The goal of most help desks is to have the level 1 support staff resolve 80% of the help requests they receive on the first call. If the issue cannot be resolved by level 1 support staff, a **problem report** (Figure 12-9) is completed (often using a special computer system designed to track problem reports) and passed to a **level 2 support** staff member.

- Time and date of the report
- Name, e-mail address, and telephone number of the support person taking the report
- Name, e-mail address, and telephone number of the person who reported the problem
- Software and/or hardware causing the problem
- Location of the problem
- Description of the problem
- Action taken
- Disposition (problem fixed or forwarded to system maintenance)

**FIGURE 12-9**  
Elements of a  
problem report.

The level 2 support staff members are people who know the application system well and can provide expert advice. For a new system, they are usually selected during the implementation phase and become familiar with the system as it is being tested. Sometimes, the level 2 support staff members participate in training during the change management process to become more knowledgeable with the system, the new business processes, and the users themselves.

The level 2 support staff works with users to resolve problems. Most problems are successfully resolved by the level 2 staff. In the first few months after the system is installed, however, the problem may turn out to be a bug in the software that must be fixed. In this case, the problem report becomes a **change request** that is passed to the system maintenance group.

## System Maintenance

System maintenance is the process of refining the system to make sure it continues to meet business needs. Over a system's lifetime, more money and effort are devoted to system maintenance than to the initial development of the system, simply because a system continues to change and evolve as it is used. Most beginning systems analysts and programmers work first on maintenance projects; usually only after they have gained some experience are they assigned to new development projects.

Every system is "owned" by a project manager in the IS group (Figure 12-10). This individual is responsible for coordinating the systems maintenance effort for that system. Whenever a potential change to the system is identified, a change request is prepared and forwarded to the project manager. The change request is a "smaller" version of the **system request** discussed in Chapters 1 and 2. It describes the change requested and explains why the change is important.

Changes can be small or large. Change requests that are likely to require a significant effort are typically handled in the same manner as system requests: They follow the same process as the project described in this book, starting with project initiation in Chapter 1 and following through installation in this chapter. Minor changes typically follow a "smaller" version of this same process. There is an initial assessment of feasibility and of costs and benefits, and the change request is prioritized. Then a systems analyst (or a programmer/analyst) performs the analysis, which may include interviewing users, and prepares an initial design before programming begins. The new (or revised) program is then extensively tested before it is put into production.

Change requests typically come from five sources. The most common source is problem reports from the operations group that identify bugs in the system that must be fixed. These are usually given immediate priority because a bug can cause significant problems. Even a minor bug

### CONCEPTS IN ACTION 12-E

### Converting to the Euro (Part 2)

When the European Union decided to introduce the euro, the European Central Bank had to develop a new computer system (called Target) to provide a currency settlement system for use by investment banks and brokerages. The euro opened at an exchange rate of US \$1.167. However, a rumor that the Target system malfunctioned sent the value of the euro plunging two days later.

That evening, it was determined that the malfunction was not due to system problems. Instead, operators at some German banks had misunderstood how to use the system and had entered incorrect data. Once the problems were identified and

the operators quickly retrained, the Target system continued to operate and the euro quickly regained its lost value.

Adapted from: "Debut of Euro Nearly Flawless," *Computerworld*, January 11, 1999, 33(2), p. 16, by Thomas Hoffman.

#### Question

1. Target could be considered a high-risk system because of its effects on the European economy. What kinds of system support activities could be put in place to mitigate problems with Target?

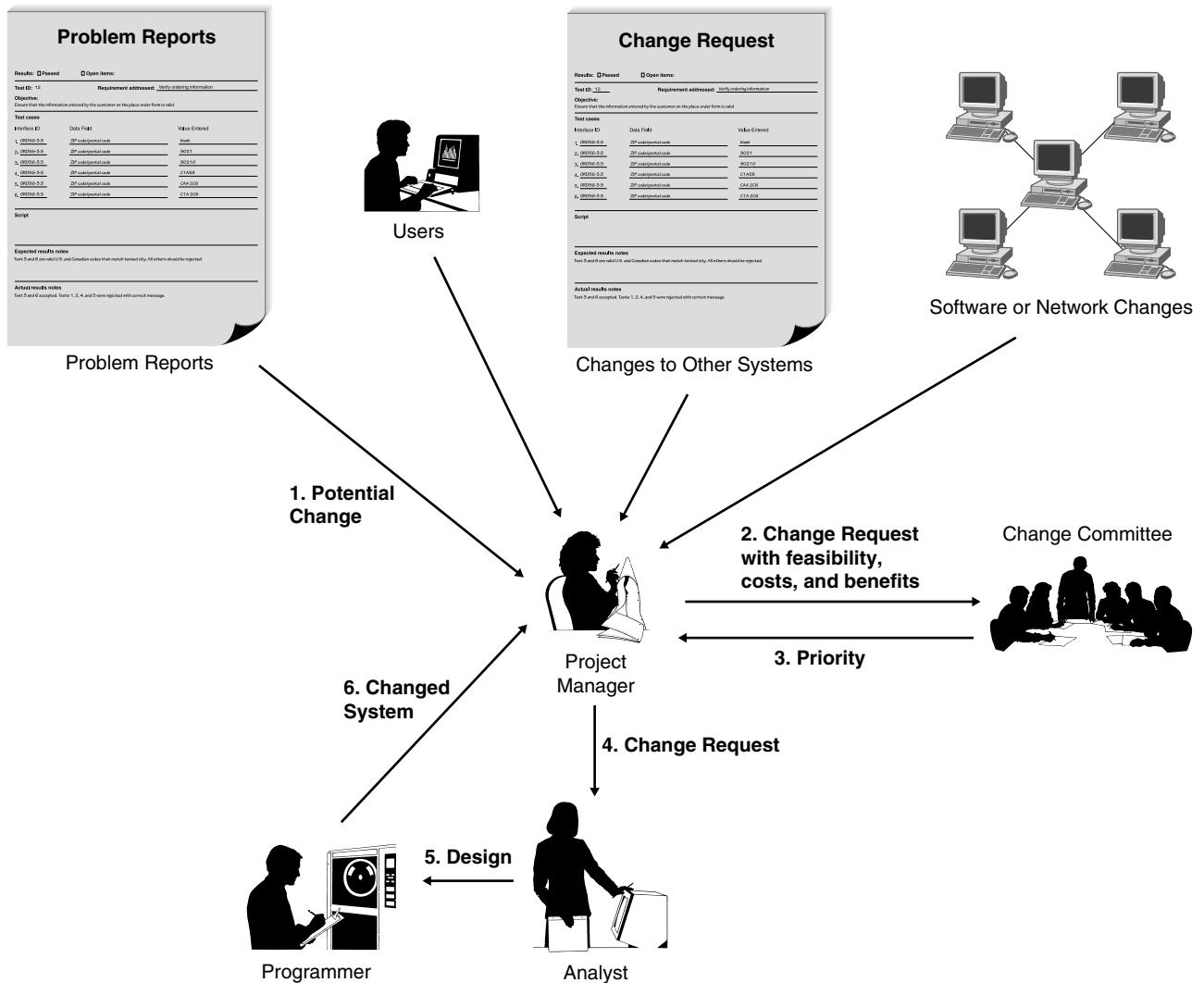


FIGURE 12-10 Processing a change request.

can cause major problems by upsetting users and reducing their acceptance of and confidence in the system.

The second most common source of change requests is enhancements to the system from users. As users work with the system, they often identify minor changes in the design that can make the system easier to use or identify additional functions that are needed. These enhancements are important in satisfying the users and are often key in ensuring that the system changes as the business requirements change. Enhancements are often given second priority after bug fixes.

A third source of change requests is other system development projects. For example, the Client Flight Services system needs to integrate with the proprietary data analysis systems offered by DrōnTeq. If changes occur to those data analysis systems in the future, then changes may also result in the Flight Services systems.

A fourth source of change requests is those that occur when underlying software or networks change. For example, a new version of Windows often will require an application to change the way it interacts with Windows or enable application systems to take advantage of new features that improve efficiency. While users may never see these changes (because most changes

**CONCEPTS IN ACTION 12-F****Software Bugs**

The awful truth is that every operating system and application system is defective. System complexity, the competitive pressure to hurry applications to market, and simple incompetence contribute to the problem.

Will software ever be bug free? Not likely. Microsoft Windows Group General Manager Chris Jones believes that bigger programs breed more bugs. Each revision is usually bigger and more complex than its predecessor, which means that there will always be new places for bugs to hide. Former Microsoft product manager Richard Freedman agrees that the potential for defects increases as software becomes more complex, but he believes that users ultimately win more than they lose. “I’d say the features have gotten exponentially better, and the product quality has degraded a fractional amount.”

Still, the majority of users who responded to our survey said they’d buy a software program with fewer features if it were bug free. This sentiment runs counter to what most software developers believe. “People buy features, plain and simple,” explains Freedman. “There have been attempts to release stripped-down word processors and spreadsheets, and they don’t sell.” Freedman says a trend toward smaller, less-bug-prone software with fewer features will “never happen.”

Eventually, the software ships and the bug reports start rolling in. What happens next is what separates the companies you want to patronize from the slackers. While almost every vendor provides bug fixes eventually, some companies do a better job of it than others. Some observers view Microsoft’s market dominance as a roadblock to bug-free software. Todd Paglia, an attorney with the Washington, D.C.-based Consumer Project on Technology, says, “If actual competition for operating systems existed and we had greater competition for some of the software that runs on the Microsoft operating system, we would have higher quality than we have now.”

Adapted from: “Software Bugs Run Rampant,” *PC World*, January 1999, 17(1), p. 46, by Scott Spanbauer.

*Question*

1. If commercial systems contain the number of bugs that this article suggests, what are the implications for systems developed in-house? Would in-house systems be more likely to have a lower or higher quality than commercial systems? Explain.

are inside the system and do not affect its user interface or functionality), these changes can be among the most challenging to implement because analysts and programmers must learn about the new system characteristics, understand how application systems use (or can use) those characteristics, and then make the needed programming changes.

The fifth source of change requests is senior management. These change requests are often driven by major changes in the organization’s strategy (e.g., the new DrönTeq Flight Services project) or operations. These significant change requests are typically treated as separate projects, but the project manager responsible for the initial system is often placed in charge of the new project.

## Project Assessment

The goal of *project assessment* is to understand what was successful about the system and the project activities (and therefore should be continued in the next system or project) and what needs to be improved. Project assessment is not routine in most organizations, except for military organizations, which are accustomed to preparing after-action reports. Nonetheless, assessment can be an important component in organizational learning because it helps organizations and people understand how to improve their work. It is particularly important for junior staff members because it helps promote faster learning. There are two primary parts to project assessment—project team review and system review.

### Project Team Review

**Project team review** focuses on the way the project team carried out its activities. Each project member prepares a short two- to three-page document that reports on and analyzes his or her

performance. The focus is on performance improvement, not penalties for mistakes made. By explicitly identifying mistakes and understanding their causes, project team members will, it is hoped, be better prepared for the next time they encounter a similar situation—and less likely to repeat the same mistakes. Likewise, by identifying excellent performance, team members will be able to understand why their actions worked well and how to repeat them in future projects.

The documents prepared by each team member are assessed by the project manager, who meets with the team members to help them understand how to improve their performance. The project manager then prepares a summary document that outlines the key learnings from the project. This summary identifies what actions should be taken in future projects to improve performance but is not intended to identify team members who made mistakes. The summary is widely circulated among all project managers to help them understand how to manage their projects better. Often, it is also circulated among regular staff members who did not work on the project so that they, too, can learn from projects outside their scope.

### System Review

The focus of the **system review** is understanding the extent to which the proposed costs and benefits from the new system that were identified during project initiation were recognized from the implemented system. Project team review is usually conducted immediately after the system is installed, while key events are still fresh in team members' minds, but system review is often undertaken several months after the system is installed, because it often takes a while before the system can be accurately assessed.

System review starts with the system request and feasibility analysis prepared at the start of the project. The detailed analyses prepared for the expected business value (both tangible and intangible), as well as the economic feasibility analysis, are reexamined, and a new analysis is prepared after the system has been installed. The objective is to compare the anticipated business value against the actual realized business value from the system. This helps the organization assess whether the system provided the value it was planned to provide. Whether or not the system provides the expected value, future projects can benefit from an improved understanding of the true costs and benefits.

#### PRACTICAL TIP 12-1

#### Beating Buggy Software



How do you avoid bugs in the commercial software you buy? Here are six tips:

1. **Know your software:** Find out if the few programs you use day in and day out have known bugs and patches and track the websites that offer the latest information on them.
2. **Back up your data:** This dictum should be tattooed on every monitor. Stop reading right now and copy the data you cannot afford to lose onto a CD, second hard disk, or Web server. We will wait.
3. **Don't upgrade—yet:** It is tempting to upgrade to the latest and greatest version of your favorite software, but why chance it? Wait a few months, check out other users' experiences with the upgrade on Usenet newsgroups or the vendor's own discussion forum, and then go for it. But only if you must.

4. **Upgrade slowly:** If you decide to upgrade, allow yourself at least a month to test the upgrade on a separate system before you install it on all the computers in your home or office.
5. **Forget the betas:** Installing beta software on your primary computer is a game of Russian roulette. If you really have to play with beta software, get a second computer.
6. **Complain:** The more you complain about bugs and demand remedies, the more costly it is for vendors to ship buggy products. It's like voting—the more people participate, the better are the results.

Adapted from: "Software Bugs Run Rampant," *PC World*, January, 1999, 17(1), p. 46, Scott Spanbauer.

A formal system review also has important behavioral implications for project initiation. Since everyone involved with the project knows that all statements about business value and the financial estimates prepared during project initiation will be evaluated at the end of the project, they have an incentive to be conservative in their assessments. No one wants to be the project sponsor or project manager for a project that goes radically over budget or fails to deliver promised benefits.

## Applying the Concepts at DrōnTeq

Installation of the Client Flight Services system at DrōnTeq was somewhat simpler than the installation of most systems because the system was new; there was no as-is system. Jiang did not expect any major problems in this area.

### Implementation Process

Jiang chose to use direct conversion with a whole-system conversion, but with a pilot phase first. You will recall from the last chapter that the system was beta tested with volunteer prospective clients and potential pilot partners. Jiang chose to use the beta test as the pilot conversion.

After evaluating the experiences and feedback from the volunteer testers, Carmella and her management team believed the new Flight Services system was ready. Promotional campaigns were launched and the public website that describes the new drone flight service business was opened. The two private websites were ready for use as soon as clients and pilots enrolled.

### Preparing the People

There were few change management issues because this system supports a new business line for DrōnTeq. New staff were hired, most by internal transfer from other groups within DrōnTeq, to serve as Flight Services experts and provide support to clients and pilots using the system. Carmella and Jiang developed an information campaign (distributed through the employee newsletter and internal website) that discussed the background and business goals of this new business line, primarily to enable all employees to understand its purpose and role within DrōnTeq.

### Postimplementation Activities

Support of the system was turned over to the DrōnTeq operations group, who had hired four additional support staff members with expertise in networking and Web-based systems. System maintenance began almost immediately, with Jiang designated as the project manager responsible for maintenance of the system.

Project team review uncovered several key learnings, mostly involving Web-based programming and the difficulties in optimizing searches and providing fast, flawless file transfer protocols. The project was delivered on budget, with the exception that more was spent on programming than was anticipated.

A preliminary system review was conducted after two months of operations. Thanks to an advertising campaign, revenue from pilots and clients was \$68,000 for the first month and \$174,000 for the second, showing a gradual increase. (Remember that the goal for the first year of operations was \$922,500.) Operating expenses averaged \$47,000 per month, a bit higher than the projected average, owing to startup costs. Nonetheless, Carmella Herrera, director of the Client Services business unit and the project sponsor, was quite pleased. She was happy to report to the company's leaders, Eric Chen and Peter Lyons, that the websites created to support the new

business line were working very effectively. Jiang and his project team were given many accolades (and a nice bonus!) for a job well done.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Identify and describe Lewin's three-step model of organizational change.
  - Explain how the activities of systems analysis and design help with the unfreezing process.
  - What is the purpose of the migration plan?
  - Identify and describe the three dimensions of the conversion strategy and how choices made will impact the cost, time, and risk of conversion.
- Discuss the role and importance of business contingency planning during system migration.
  - Identify and discuss the main reasons underlying people's resistance to change.
  - Identify and describe ways to overcome resistance to change.
  - Discuss the role and purpose of postimplementation support.
  - Describe the sources of change requests.
  - Discuss the best way to provide ongoing system maintenance.
  - Discuss what is gained from conducting a post-project review?

## KEY TERMS

Business contingency plan	Help desk	Parallel conversion	Rewards
Change agent	Informational strategy	Phased conversion	Simultaneous conversion
Change management	Installation	Pilot conversion	Sponsor
Change request	Institutionalize	Political strategy	Standard operating procedures (SOPs)
Classroom training	Level 1 support	Postimplementation	System maintenance
Computer-based training (CBT)	Level 2 support	Potential adopter	System request
Conversion location	Management policies	Problem report	System review
Conversion modules	Measurements	Project assessment	System support
Conversion strategy	Migration plan	Project team review	Training
Conversion style	Modular conversion	Ready adopters	Transition
Direct conversion	One-on-one training	Refreeze	Unfreeze
Frequently asked questions (FAQs)	On-demand training	Reluctant adopters	Whole-system conversion
	Online support	Resistant adopters	
	Operations group	Resource allocation	

## QUESTIONS

1. What are the three basic steps in managing organizational change?
2. What are the major components of a migration plan?
3. Compare and contrast direct conversion and parallel conversion.
4. Compare and contrast pilot conversion, phased conversion, and simultaneous conversion.
5. Compare and contrast modular conversion and whole-system conversion.
6. Explain the trade-offs among selecting between the types of conversion in Questions 3, 4, and 5.
7. What are the three key roles in any change management initiative?
8. Why do people resist change? Explain the basic model for understanding why people accept or resist change.
9. What are the three major elements of management policies that must be considered when implementing a new system?
10. Compare and contrast an information change management strategy with a political change management strategy. Is one better than the other?
11. Explain the three categories of adopters you are likely to encounter in any change management initiative.
12. How should you decide what items to include in your training plan?
13. Compare and contrast three basic approaches to training.
14. What is the role of the operations group in the systems development life cycle (SDLC)?
15. Compare and contrast two major ways to provide system support.

16. How is a problem report different from a change request?
17. What are the major sources of change requests?
18. Why is project assessment important?
19. How is project team review different from system review?
20. What do you think are three common mistakes that novice analysts make in migrating from the as-is to the to-be system?

21. Some experts argue that change management is more important than any other part of the SDLC. Do you agree or not? Explain.
22. In our experience, change management planning often receives less attention than conversion planning. Why do you think this happens?

## EXERCISES

- A. Suppose that you are installing a new accounting package in your small business. What conversion strategy would you use? Develop a conversion plan (i.e., technical aspects only).
- B. Suppose that you are installing a new room reservation system for your university that tracks which courses are assigned to which rooms. Assume that all the rooms in each building are “owned” by one college or department and only one person in that college or department has permission to assign them. What conversion strategy would you use? Develop a conversion plan (i.e., technical aspects only).
- C. Suppose you are installing a new payroll system in a very large multinational corporation. What conversion strategy would you use? Develop a conversion plan (i.e., technical aspects only).
- D. Consider a major change you have experienced in your life (e.g., taking a new job, starting a new school). Prepare a cost-benefit analysis of the change in terms of both the change and the transition to the change.
- E. Suppose that you are the project manager for a new library system for your university. The system will improve the way in which students, faculty, and staff can search for books by enabling them to search over the Web, rather than using only the current text-based system available on the computer terminals in the library. Prepare a cost-benefit analysis of the change in terms of both the change and the transition to the change for the major stakeholders.
- F. Prepare a plan to motivate the adoption of the system described in Exercise E.
- G. Prepare a training plan that includes both what you would train and how the training would be delivered for the system described in Exercise E.
- H. Suppose that you are leading the installation of a new decision support system to help admissions officers manage the admissions process at your university. Develop a change management plan (i.e., organizational aspects only).
- I. Suppose that you are the project leader for the development of a new Web-based course registration system for your university that replaces an old system in which students had to go to the coliseum at certain times and stand in line to get permission slips for each course they wanted to take. Develop a migration plan (including both technical conversion and change management).
- J. Suppose that you are the project leader for the development of a new airline reservation system that will be used by the airline’s in-house reservation agents. The system will replace the current command-driven system designed in the 1970s that uses terminals. The new system uses PCs with a Web-based interface. Develop a migration plan (including both conversion and change management) for your telephone operators.
- K. Suppose that you are the project leader for the scenario described in Exercise J. Develop a migration plan (including both conversion and change management) for the independent travel agencies who use your system.

## MINICASES

1. Nancy is the IS department head at MOTO Inc., a human resources management firm. The IS staff at MOTO Inc. completed work on a new client management software system about a month ago. Nancy was impressed with the performance

of her staff on this project because the firm had not previously undertaken a project of this scale in house. One of Nancy’s weekly tasks is to evaluate and prioritize the change requests that have come in for the various applications used by the firm.

Right now, Nancy has on her desk five change requests for the client system. One request is from a system user who would like some formatting changes made to a daily report produced by the system. Another request is from a user who would like the sequence of menu options changed on one of the system menus to more closely reflect the frequency of use for those options. A third request came in from the billing department. This department performs billing through the use of a billing software package. A major upgrade of this software is being planned, and the interface between the client system and the billing system will need to be changed to accommodate the new software's data structures. The fourth request seems to be a system bug that occurs whenever a client cancels a contract (a rare occurrence, fortunately). The last request came from Susan, the company president. This request confirms the rumor that MOTO Inc. is about to acquire another new business. The new business specializes in the temporary placement of skilled professional and scientific employees, and represents a new business area for MOTO Inc. The client management software system will need to be modified to incorporate the special client arrangements that are associated with the acquired firm.

How do you recommend that Nancy prioritize these change requests for the client/management system?

2. Sky View Aerial Photography offers a wide range of aerial photographic, video, and infrared imaging services. The company has grown from its early days of snapping pictures of client houses to its current status as a full-service aerial image specialist. Sky View now maintains numerous contracts with various governmental agencies for aerial mapping and surveying work. Sky View has its offices at the airport

where its fleet of specially equipped aircraft are hangared. Sky View contracts with several freelance pilots and photographers for some of its aerial work and also employs several full-time pilots and photographers.

The owners of Sky View Aerial Photography recently contracted with a systems development consulting firm to develop a new information system for the business. As the number of contracts, aircraft flights, pilots, and photographers increased, the company experienced difficulty keeping accurate records of its business activity and the utilization of its fleet of aircraft. The new system will require all pilots and photographers to swipe an ID badge through a reader at the beginning and conclusion of each photo flight, along with recording information about the aircraft used and the client served on that flight. These records would be reconciled against the actual aircraft utilization logs maintained and recorded by the hangar personnel.

The office staff was eagerly awaiting the installation of the new system. Their general attitude was that the system would reduce the number of problems and errors that they encountered and would make their work easier. The pilots, photographers, and hangar staff were less enthusiastic, being unaccustomed to having their activities monitored in this way.

- a. Discuss the factors that may inhibit the acceptance of this new system by the pilots, photographers, and hangar staff.
- b. Discuss how an informational strategy could be used to motivate adoption of the new system at Sky View Aerial Photography.
- c. Discuss how an informational strategy could be used to motivate adoption of the new system at Sky View Aerial Photography.

# 13

# Agile Development Methods

In this textbook, we have focused on structured information system development methods. We have used the traditional systems development life cycle (SDLC) as the organizing framework to present a coherent overview of the phases, steps, tasks, and tools of systems development. As we saw in Chapter 2, however, the process of developing information systems has continuously evolved over time, from the earliest waterfall method through rapid application development methods to our current emphasis on development approaches with agility. Many organizations have adopted or are experimenting with Agile development approaches, and we conclude our textbook with a more comprehensive look at this important category of development approaches.

## OBJECTIVES

- Be able to describe the Agile values and principles expressed in the Agile Manifesto
- Be able to explain the benefits organizations gain by using Agile development approaches
- Be able to describe the overall structure of the Scrum development approach
- Be able to list and explain four key characteristics of Scrum
- Be able to describe the roles of product owner, ScrumMaster, and the team in Scrum
- Be able to discuss the key unique features of Scrum: sprints, user stories, acceptance criteria, story points, and team velocity
- Be able to explain the sprint planning process
- Be able to explain the product backlog grooming process
- Be able to discuss the purpose and contribution of Scrum's six distinctive meeting types
- Be able to briefly describe other common Agile approaches
- Be able to describe the factors that limit the adoption of Agile development approaches in organizations today

## Introduction

The concept of business agility is not new. Global competitive pressures have led many organizations to reexamine their business operations to improve competitive responsiveness. Being able to respond quickly and effectively to a dynamic business environment and customer demand is increasingly essential. The COVID-19 pandemic that began in 2020 propelled organizations to move rapidly to adopt remote work practices, reimagine how they serve customers, build new

business models, and enhance technological capabilities in unprecedented ways. Companies will need to determine how to keep that momentum and maintain the speed and agility they gained through the pressures imposed by the pandemic.

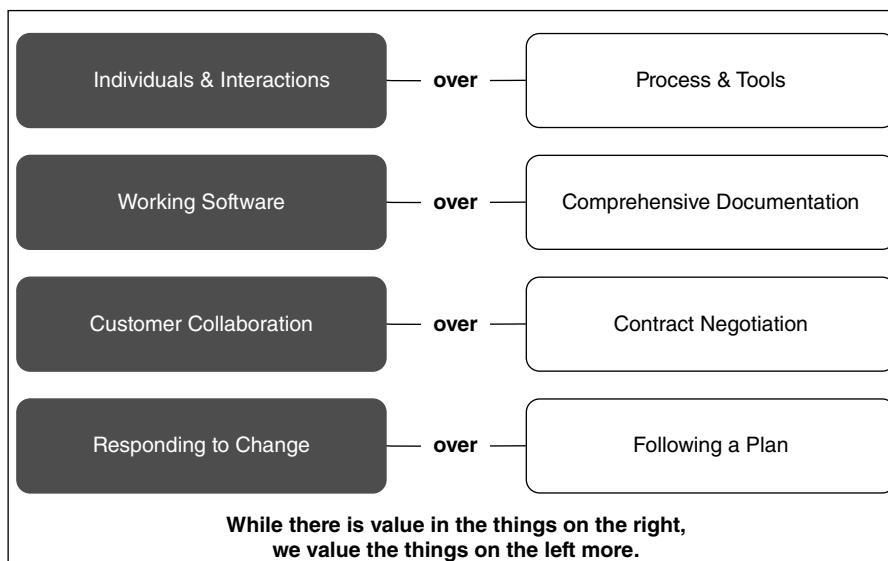
Because today's business environment includes so many customer-facing systems that are intended to support new and evolving business models, the traditional systems development methodologies are often deemed too rigid, slow, and inflexible. Agile systems development methods have evolved to address these limitations.

Prior to the pandemic, the primary business areas that employed Agile business practices were software development and IT in general. A significant reason for this "head start" in systems development and IT is the fact that a set of values known as the Agile Manifesto were first expressed by a group of software developers. These ideas will be discussed in the next section of this chapter. Companies today recognize the importance of their information systems capabilities in enabling and supporting business strategies. As businesses seek to innovate, strategically, the information systems leadership must be capable of responding with rapid and adaptable systems development practices. Agile systems development methodologies have been an important contributor to that capability in recent years.

In this chapter, we discuss the foundation values and principles expressed by the **Agile Manifesto**. We utilize the results of a recent survey to explore the adoption rate of Agile in organizations today and the benefits those organizations report they have experienced. We then look at the use of specific Agile methodologies today. Since **Scrum** is the most used Agile method, we discuss Scrum's characteristics, features, and unique processes in detail. We conclude the chapter with a brief look at several other Agile methodologies.

## Origins of Agile

As discussed previously, a group of software developers came together in 2001 to propose a new way of developing software "by doing it and helping others do it."<sup>1</sup> The essential values stated by the members of this group are listed in Figure 13-1.



**FIGURE 13-1**  
Agile Manifesto values.  
Source: [www.Agile-manifesto.org](http://www.Agile-manifesto.org)

<sup>1</sup><https://www.scrumalliance.org/resources/agile-manifesto>.

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Businesspeople and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

**FIGURE 13-2**  
Agile Manifesto  
principles.

Source: "The Agile Manifesto", The key values and principles of agile, Scrum Alliance Inc. Retrieve from <https://www.scrumalliance.org/resources/agile-manifesto>

As stated by these software developers, the elements in the right column of Figure 13-1 reflect the values of traditional systems development approaches. These software developers valued those elements but value the elements in the left column of the figure much more strongly. These value statements resonated with the software development community at large as ideas whose time had come. In addition, these ideas spread beyond the field of software development to be adopted by a wide array of organizations. The Agile Manifesto became the foundation upon which business and organizational agility was built.

The value statements of the Agile Manifesto are expanded upon in a set of Agile Principles, listed in Figure 13-2. These principles can be applied in a broad range of settings and are easily learned. It is not always easy to completely master them, however.

Take a moment to read through the principles listed in Figure 13-2. These principles are summarized in the following list of Agile characteristics:

- Close collaboration between the project team and business experts
- Face-to-face communication
- Frequent delivery of new, deployable business value
- Tight, self-organizing teams
- Reduced impact of changes in requirements

Reflect on the differences these characteristics have with the more traditional information system development approaches. As you will see, these principles provide the foundation for all the Agile methodologies that have evolved since the Agile Manifesto first appeared.

## Evolution of Agile Development

The software developers who signed the Agile Manifesto believed its values and principles would lead to a software development approach that would be more successful for the developers themselves and the organizations in which they worked. The adoption of Agile development has proceeded gradually over the decades since 2001.

## Adoption of the Agile Approach

In a recent survey of the state of Agile in 2020,<sup>2</sup> researchers found that just a quarter of the respondents work in companies that have been practicing Agile development for five or more years. The widespread use of Agile varies, with just 18% reporting that all their company's teams are Agile. As mentioned before, the predominant use of Agile methods is in Software Development (reported in 37% of respondents' companies) and IT (reported in 26% of respondents' companies). Most respondents (84%) said their companies were below a high level of competency with Agile practices.

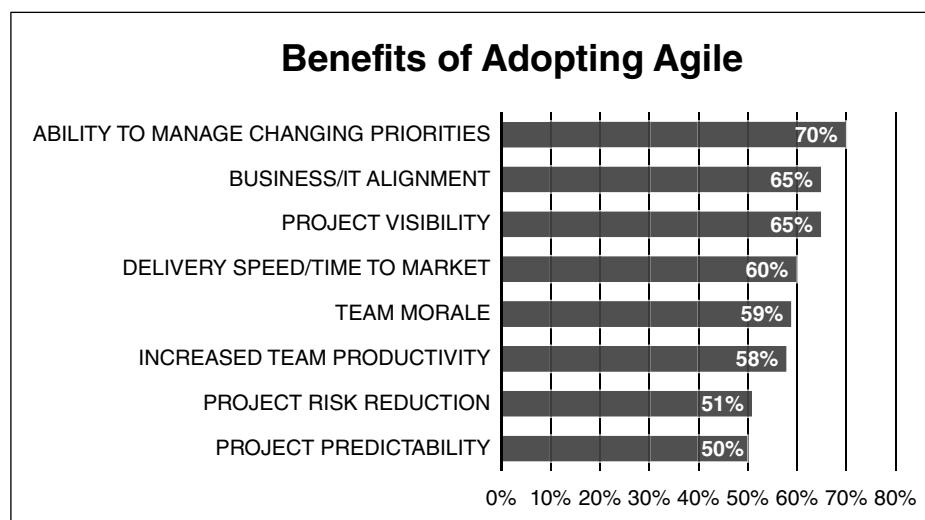
The survey found that the predominant reasons for adopting Agile were (1) to accelerate software delivery and (2) to enhance the ability to manage changing priorities. Interestingly, when looking at individual projects, the respondents reported that business value delivered and customer/user satisfaction were the top two cited measures of success.

## Benefits of Agile Methods

Another element of the state of Agile survey was the reported benefits realized by the organizations adopting Agile. Figure 13-3 lists the benefits reported by at least half of the responding organizations. Adaptability is considered a significant benefit of Agile, which corresponds closely to the second Agile principle stated in Figure 13-2.

## Adoption of Specific Agile Methodologies

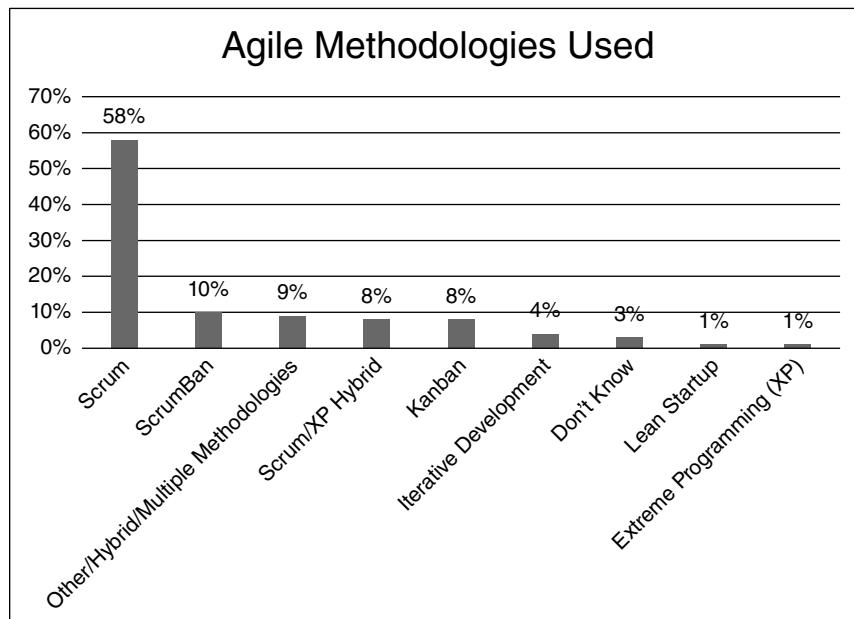
Respondents to the state of Agile survey reported that Scrum is by far the most common Agile methodology in use in their organizations. Figure 13-4 shows that Scrum is reported as the prevailing methodology in 58% of the responding organizations. Other methods are much less widely used. Note too that several of the categories (ScrumBan, Other/hybrid/multiple methodologies, Scrum/XP hybrid) suggest that there is quite a bit of experimentation in how Agile is implemented, and organizations do seem to “mix and match” aspects of these Agile methodologies to arrive at an approach that is best suited to that organization’s needs.



**FIGURE 13-3**  
Benefits of adopting Agile.

Source: Modified from 14th Annual State of agile report, of Digital.ai Software, Inc. Available at <https://stateofagile.com/#ufh-i-615706098-14th-annual-state-of-agile-report/7027494>

<sup>2</sup>VersionOne, “14th Annual State of Agile™ Report,” VersionOne.com, May 26, 2020, accessed March 23, 2021, <https://stateofagile.com/#ufh-7027494-state-of-agile>.



**FIGURE 13-4** Agile methods in use.

Source: Modified from 14th Annual State of agile report, of Digital.ai Software, Inc. Available at <https://stateofagile.com/#ufh-i-615706098-14th-annual-state-of-agile-report/> 7027494

Because of the predominant use of Scrum in practice, in the next section we provide a detailed look at the features and characteristics of the Scrum Agile methodology.

## Scrum

Scrum is an Agile approach that is designed to enable delivery of working software providing the highest business value in the shortest amount of time. Scrum is structured so that the development team rapidly and repeatedly produces actual working software that is ready for inspection in two-week to four-week cycles. Priorities established by the business define the development team's "to-do" list. The team self-organizes to determine the best way to deliver the features in response to those priorities. Every two to four weeks, the team demonstrates real working software. At that point, business users can decide to release that software as-is or continue to enhance it for another two- to four-week cycle.

Scrum is a versatile approach to developing software. Scrum has been used by many organizations, both large and small, in an array of industries ranging from software development to financial services to industrial manufacturing. It has also been used in a wide range of software applications. Scrum has been used in data-heavy projects, website and video game development, commercial software, financial applications, embedded systems, and FDA-approved, life-critical systems, just to name a few categories.

## Overview of Scrum

To begin to understand the Scrum development process, it is useful to look at the big picture. In Figure 13-5, we present a synopsis view of Scrum. We will briefly discuss Scrum at a high level and follow that with more details about its characteristics, roles, features, and processes.

As depicted in Figure 13-5, ideas for features of the new system are provided by end-users, customers, the development team, and other stakeholders. These ideas represent the system's requirements. These items are gathered and managed by the **product owner**, who represents the organization's interests in this project. The product owner develops and manages a prioritized feature list, also called a **product backlog**, that serves as the development teams' to-do list.

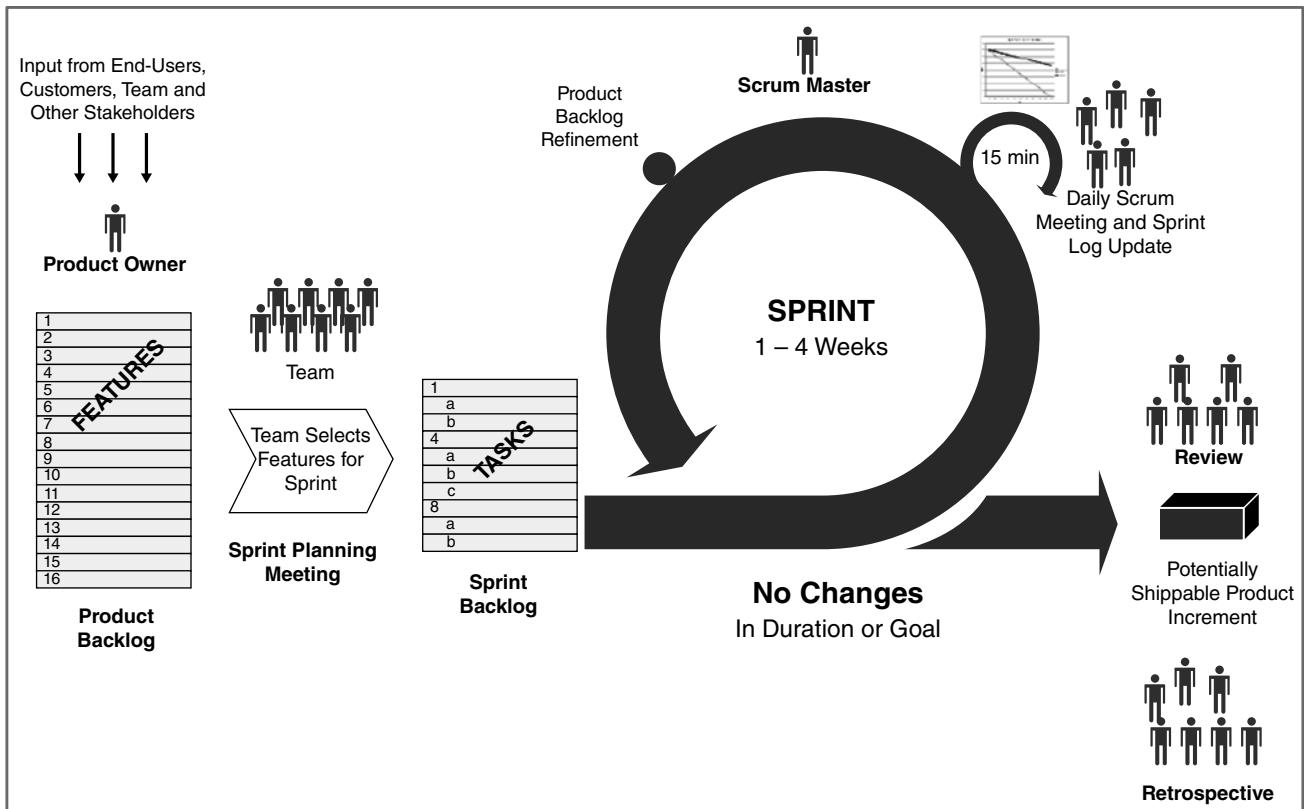


FIGURE 13-5 Scrum overview.

The development cycles in the Scrum development process are called **sprints**. A sprint's duration can range from one week to four weeks. At the beginning of a sprint, each development team assigned to the project conducts a **sprint planning meeting**. Each team reviews the product backlog in consultation with the product owner and selects the feature(s) that will be developed in that sprint. The feature(s) are then refined into a more detailed set of tasks, called the **sprint backlog**. The sprint backlog represents that team's specific responsibility for that sprint.

When the sprint period begins, the team self-organizes to address the tasks on its sprint backlog. Each team member selects the task they will begin working on and the team begins to design, code, and test the software being developed. A standard feature of Scrum is the daily scrum meeting, called a **daily standup**. This brief meeting is attended by all team members, a team member called the **ScrumMaster**, and possibly, the product owner. In the daily standup, each team member states what they worked on the previous day and commits to goals for that day of the sprint. If a team member has completed a task, they will select another task to begin from the sprint backlog. The team may decide to modify task assignments if changes are deemed necessary to improve team performance. The ScrumMaster helps the team identify and resolve any roadblocks that may be impeding their progress in the sprint. As the team completes tasks and features during the sprint, the ScrumMaster and product owner will refine the prioritized product backlog to reflect the team's accomplishments.

At the end of the sprint, potentially shippable software should be produced. The team will demonstrate its completed work in a sprint review meeting. The product owner and any interested end-users attend the sprint review and determine if the work product is ready for release into production or if it requires more work in the next sprint.

As a final aspect of the sprint, the team performs a **sprint retrospective** on its performance in the just-completed sprint. In this meeting, the team evaluates its accomplishments and determines if it wants to change any aspects of its work process. As stated previously, the team is expected to be self-organizing and can modify its way of working to achieve optimal performance for that team.

## Scrum Characteristics

Scrum has several distinctive characteristics. First is the use of dedicated, **self-organizing teams**. The development team membership is expected to be relatively stable over time so that the team learns how to work together effectively. The team is trusted to organize itself in ways that will produce high team performance.

Second, the software product development is accomplished in a series of short work cycles, called sprints. The team selects a subset of features from the product backlog that provides an ambitious, but doable set of tasks to accomplish in the sprint. Team performance is enhanced by limiting its focus to just that set of features. The team is expected to create high-quality, working software at the end of each sprint.

Third, the system's requirements are captured from end-users, customers, and other interested stakeholders in a list called a product backlog. The product backlog is prioritized and managed by the product owner. Pieces of product backlog are worked on in each sprint until the backlog is empty or the product owner determines that "enough" has been completed and the project should be ended.

Finally, it should be noted that no specific software engineering practices are prescribed in the Scrum methodology. This makes it possible to use Scrum as an organizing framework that can accommodate different software engineering practices.

## Scrum Roles

The previous discussion of Scrum mentions several distinct and unique roles that are part of the Scrum practice. Scrum roles are different from the roles found in a traditional systems development project. The intent of these roles is to facilitate and enhance collaboration so that the Scrum team can rapidly deliver business value.

### Product Owner

The first such role is that of product owner. The product owner role is a unique aspect of Scrum. The person designated as product owner is typically a representative of the business area for which the system is being developed. The product owner is the "holder of business value," determining what needs to be done and setting priorities.

The product owner is instrumental in defining the features of the product that will be included in the product backlog. Many other people may contribute ideas for the feature list, but the product owner has ultimate authority and responsibility for that list. The product owner has overall responsibility for the profitability of the product and monitors the return on investment of the product. The market value of each feature should be determined as the foundation for feature priority in the product backlog. As the project progresses, the product owner adjusts features and priorities for every sprint as needed. Business conditions may be very dynamic and the ability to alter the feature list and change priorities is the way that Scrum accommodates a shifting competitive landscape. Finally, the product owner has final authority to accept or reject the results of the team's work. The product owner authorizes the completed work to be "shipped," or put into production, or may determine that work needs to continue for another sprint.

## ScrumMaster

Another unique role in Scrum is that of ScrumMaster. It is important not to confuse this role with that of project manager or team leader. The ScrumMaster is seen as a servant leader, providing guidance in the use of Scrum by the team. Typically, the ScrumMaster has significant training and experience in Scrum practices and is responsible for ensuring the team utilizes Scrum values and practices effectively.

The ScrumMaster monitors the team's progress and performance with an eye toward removing obstacles and impediments to progress. For example, if the team is awaiting a decision from someone outside the team, the ScrumMaster often follows up with that person to obtain the needed information so that the team can move forward.

As mentioned previously, Scrum teams are self-organizing, and the ScrumMaster does not direct the team's decisions. However, the ScrumMaster does ensure that the team is fully functional and productive. The ScrumMaster participates in the team's daily standup, and if a team member's performance seems to be lagging, the ScrumMaster will engage the team in a discussion on how to resolve that situation.

Since effective collaboration is essential to the success of Scrum, the ScrumMaster works to facilitate close cooperation across all roles and functions that are associated with the project. In addition, the ScrumMaster helps to shield the team from external interference so that the team can focus on achieving the tasks of each sprint cycle.

Finally, the ScrumMaster works closely with the project owner to refine the product backlog and to accept or reject work results.

## Development Team

The last major role in Scrum is that of the development team. In Scrum, the development team is not told by others what they should be doing or how they should work. Instead, the team is free to organize itself as it sees fit and to take on and deliver chunks of work in frequent increments.

The development team typically consists of 5–9 people. The team members may have different skill sets and backgrounds. For example, some members may be programmers. Others may specialize in business analysis, quality assurance, or subject matter expertise. Team members are expected to do whatever is needed on the team, however; so flexibility and a range of capabilities is required.

Normally, team members should be exclusively assigned and dedicated to a single team. This enables the team to develop a deep understanding of how each member can contribute to the success of the team. There may be members assigned to the team temporarily so that they can contribute their specific knowledge, such as a user experience (UX) expert providing guidance during the design of the customer-facing aspects of the system. Teams with a stable membership over time are much more likely to develop into a high performing team compared to teams whose membership is constantly changing.

Tuckman's four-stage model of group development<sup>3</sup> is useful for thinking about how stable, dedicated Scrum teams may coalesce into highly productive development teams. When first assembled, the team may go through "forming," or learning about each other's skills and work styles. The team may experience a period of "storming," during which differences and conflicts are discovered, addressed, and resolved. Teamwork patterns and processes stabilize during "norming." Ultimately, the team settles into "performing" during which time highly effective, productive work is achieved.

Keep in mind that no one on the team tells other team members what to do. Team members are expected to step forward to take on tasks during the daily standup meetings. Performance by each member is not monitored by a team leader or project manager as might be found in a traditional project. In Scrum, team members trust each other to follow through on commitments. The team

<sup>3</sup>Tuckman, Bruce W. (1965). "Developmental sequence in small groups," *Psychological Bulletin*, 63(6): 384–399.

collectively and organically evaluates each team member's performance and contributions to the team. If performance deficiencies are found, the team works to correct the situation collectively through mentoring or additional training.

## Scrum Features

In this section, several important features of the Scrum method will be explained in more detail.

### Sprints

We have already discussed the sprint concept. In Scrum, projects make progress through a series of work cycles called sprints. Typically, the duration of a sprint is two weeks to four weeks, or a calendar month at the most. Generally, a constant duration leads to a better rhythm for the team. The short interval, repetitive nature of sprints is a defining feature of Scrum.

### User Stories

Another important feature of Scrum is that of **user stories**. In Scrum (and other Agile approaches), requirements are expressed through user stories. A user story is a short, simple description of a feature that is told from the perspective of a person who desires the new or enhanced feature in the new system.

User stories are stated in a standard structure:

- As a <type of user>
- I want <some goal>
- So that <some reason>

For example,

- As a student at XYZ University
- I want to enroll in the classes in my degree program
- So that I will earn my degree and graduate on time.

Another simple example that demonstrates user type, what they want, and why is:

- As an online shopper
- I want to add an item to my shopping cart
- So that I can purchase the item.

These simple examples demonstrate the power of a user story. First, we know the point of view of the person in the story. We also know what that user is trying to achieve or their goal in using the system. Finally, we know why the user has the need to achieve that goal, helping us to understand the importance of this user story.

At first glance, it may be easy to underestimate the value of user stories since they may not seem very elaborate or precise. Remember that effective collaboration is essential to the success of Scrum, and user stories invite conversations or collaborative communication. Think of user stories as something like a vacation photo. Say you return from a trip to France with several friends and show your family a photo of you and your friends in Paris, standing in front of the Eiffel Tower. As you share the photo, you recall and talk about many aspects of the day that photo was taken: the train you took to arrive in Paris, the beautiful spring weather, interesting people you saw, foods you ate, how one of your friends became lost temporarily, and so on. That one photo triggers a lengthy conversation covering a wealth of details about your trip.

In Scrum, the user story is intended to represent a conversation that will also include a wealth of details about the software feature that is desired by the user. In the traditional systems development approach presented earlier in the book, we focused on writing about requirements. With user stories the focus is shifted to discussing features through conversation and collaboration. Remember that in the Agile principles (Figure 13-2) face-to-face conversations are stressed.

The product owner can ask end-users, customers, and other stakeholders to express their needs from the system in terms of user stories. The user story concept is easy to grasp. Often, stakeholders are assembled in a meeting area, taught the user story concept, and then begin writing their user stories on sticky notes, one story per note. Then, the sticky notes are stuck to the walls and the group begins discussing and organizing the notes in a collective effort. In short order, the group will have developed a significant set of ideas for the system and the product owner has a good start on the feature list and product backlog for the new system. The product owner should ensure that the user stories they retain focus on real business value.

In addition, the product owner should not really worry about whether the feature list is complete. This is a significant departure from traditional development methods. Instead, we acknowledge that all requirements are not known up front. A user story advantage is the fact that design options and solutions are kept open. It is best to leave the technical functions and decisions to the technical team members and not overwhelm the end-users with technical considerations and constraints.

Another user story advantage is the way that many user perspectives are sought, helping to broaden our scope and improve our understanding of the things that are needed from the project. We can vary the users we include in several ways, such as:

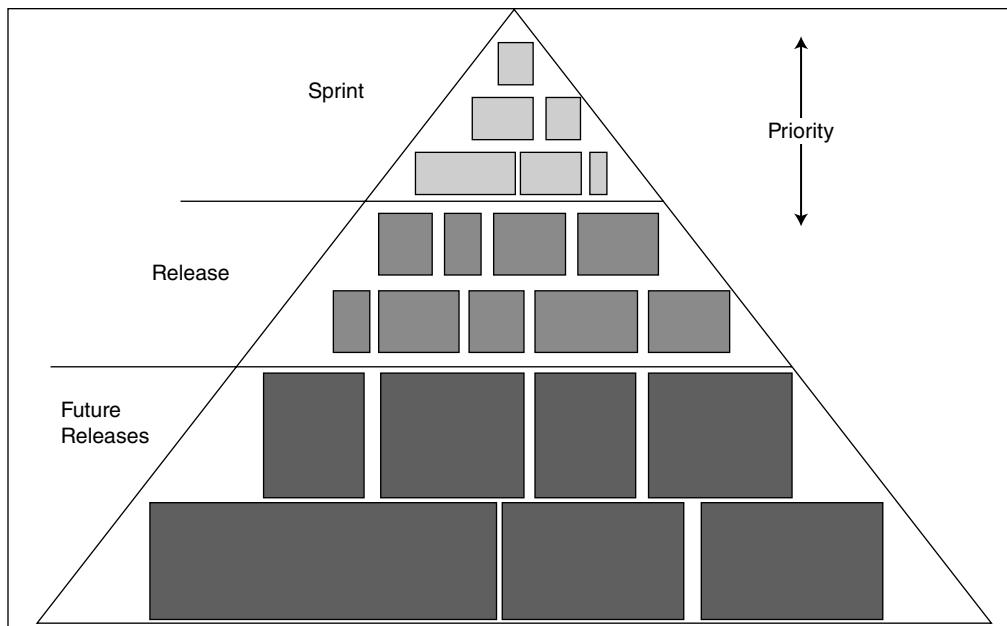
- What they use the software for
- How they use the software
- Background
- Familiarity with software/computers

By thinking about user needs expressed through the user stories, the users of the system become more tangible. The development team begins to think of the software they are developing as software that solves real needs of real people. In addition, the future end-user of the system is no longer just a vague generic “user,” but takes on a more meaningful persona, such as “a forgetful user,” “a customer support manager,” “a novice claims examiner,” or “a mobile-savvy field agent.”

As users are invited to create and write user stories that convey their goals and purposes in using the system, the stories inevitably will vary in terms of scale and scope. A large story, termed an **epic**, is one that may take many weeks or more to implement. On the other hand, an **implementation size story** will take days or less to implement. Most user stories begin as an epic and are then broken down into implementation size stories as they move through the product backlog. In fact, user story refinement is expected as larger stories are broken into smaller sized stories that add more details. As shown in Figure 13-6, the product backlog will evolve over time, with high priority, implementation size user stories at the top of the pyramid; all user stories associated with the current release in the middle of the pyramid; and large, epic-sized stories at the bottom that form the basis of future releases.

## Acceptance Criteria

Even implementation size user stories may be lacking in detail. So, Scrum includes the **acceptance criteria** feature to provide more detailed requirements. Acceptance criteria, or “conditions of satisfaction” help the team understand the story and set expectations as to when the team can consider something “done.” Acceptance criteria also help the team develop acceptance tests and provide documentation about the requirement.



**FIGURE 13-6**  
User stories in the product backlog.

Good acceptance criteria help the team clarify what should be built before the work starts. Everyone on the team should understand the situation fully through the details provided by the acceptance criteria.

Figure 13-7 demonstrates an implementation size user story that is clarified through detailed acceptance criteria. As you can see, the acceptance criteria provide more specifics about the user story and explain exactly what should be developed. Ultimately, the acceptance criteria provide a script for the sprint review meeting where the team demonstrates the working software that implements the feature.

Anyone on the Scrum team can write acceptance criteria using input from the team on the details of the feature. The end-user who created the user story in the first place should also be consulted to ensure there is clear understanding about how to satisfy the user story need.

The product owner, in consultation with end-users, customers, the development team, and other interested parties, is responsible for creating and maintaining the product backlog. As previously mentioned, the product backlog is essentially a list of features (expressed through user stories) that represent the new system's requirements. Collectively, the list encompasses all the desired work on the project.

#### User Story:

As a mutual fund investor, I want a strong password, so that my investment account information is secure.

#### Acceptance Criteria:

- The password must be at least 10 characters
- The password must contain at least 1 character from each of the following groups:
  - Lower case alphabet
  - Upper case alphabet
  - Numeric characters
  - Special characters (!, @, #, \$, %, ^, &, \*)

**FIGURE 13-7** User story and acceptance criteria example.

Since the product owner is responsible for the overall return on investment of the project, the product backlog content should be stated so that each item has value to the users or customers of the product. Generally, the highest value user stories are at the top of the list. The product owner assigns priority to the user stories and priorities can be modified as the project progresses. Typically, the product backlog is reprioritized at the end of every sprint.

## Story Points

Inevitably, the amount of work needed to implement the requirements expressed in a user story will vary widely. In Scrum, the size of a story is not expressed in terms of hours of work to complete the development of the solution to the story. A feature of Scrum is the **story point**, which is used to measure the size of a story. A story point does not have a precise meaning. In practice, each team defines what a story point means to them. Even within the same organization, different development teams may define story points differently.

The story point method involves the team systematically comparing one user story to another to determine their relative size. Then, the team assigns story points denoting that size. The usual practice is to use a range of story points based on a modified Fibonacci sequence, consisting of 1, 2, 3, 5, 8, 13, 20, 40, 100.

User stories with large story point values are considered epics, and will need to be broken down into smaller, more detailed user stories over time. User stories with smaller story point values are considered implementation size user stories. Figure 13-8 shows a sample product backlog with story points assigned.

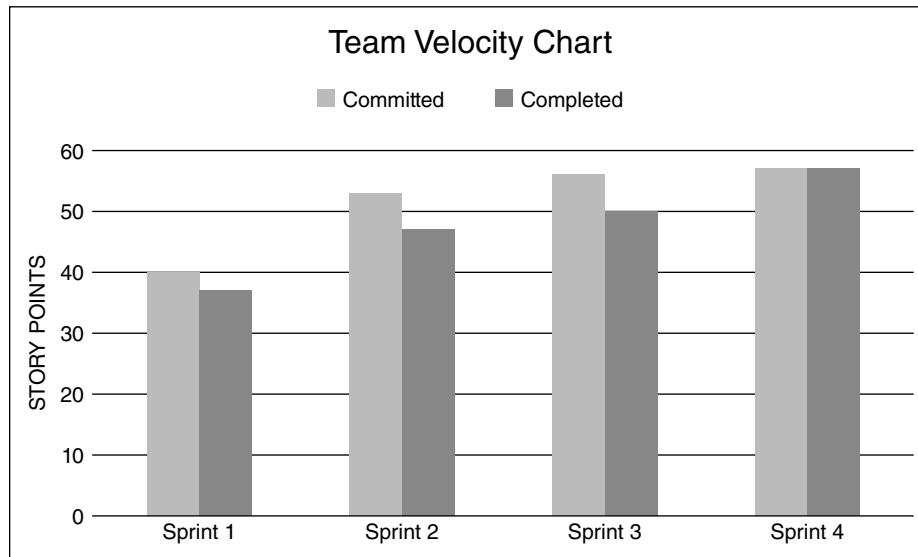
## Team Velocity

The number of story points that a team can successfully complete during a sprint is termed the **team velocity**. Over time, teams develop their velocity history by monitoring the number of story points they committed to complete during a sprint and the actual number of story points completed in that sprint. For example, in Figure 13-9, we see the performance of a team in terms of committed and completed story points over a period of four sprints.

As shown in Figure 13-9, in the first sprint, the team members may have been learning about each other's strengths and weaknesses and figuring out how to work well together. A relatively low number of story points were committed to in sprint 1, and the team was unable to complete all those story points. In the second sprint, the team set a much higher story point goal, and although more story points were completed in sprint 2 compared to sprint 1, the team still did not fulfill its commitment. A similar performance is seen in the third sprint. The fourth sprint shows the team committing to and completing 57 story points, suggesting that the team is establishing its team velocity by becoming a more effective, productive development team. The team can track its velocity history over time and base future sprint planning on its velocity record.

Backlog Item	Size
As a registered user, I want to log in with my username and password, so that I can access my account.	3
As a customer service manager, I want to automate password resets, so that I can reduce support calls.	5
As a system administrator, I want to log each time a user logs in, so that I can track system usage.	3
As a system administrator, I want to require users to change passwords every 90 days, so that I can increase site security.	5
As a new user, I want to create a new account, so that I can access the site's content.	8

**FIGURE 13-8**  
Product backlog with story points.



**FIGURE 13-9**  
Team velocity history.

Sprint	Committed	Completed
Sprint 1	40	37
Sprint 2	53	47
Sprint 3	56	50
Sprint 4	57	57

A final feature of Scrum is the **definition of “done.”** Each team establishes for itself the agreed upon way it defines being “done” with development of the user story solution. Although there is no standard list of elements in the definition of “done,” it usually includes all these definitions:

- Feature is complete
- Code is complete
- Fully tested
- No known defects—fully documented

Other elements can be added to this list to further define the details of how each team determines when it has completed its work.

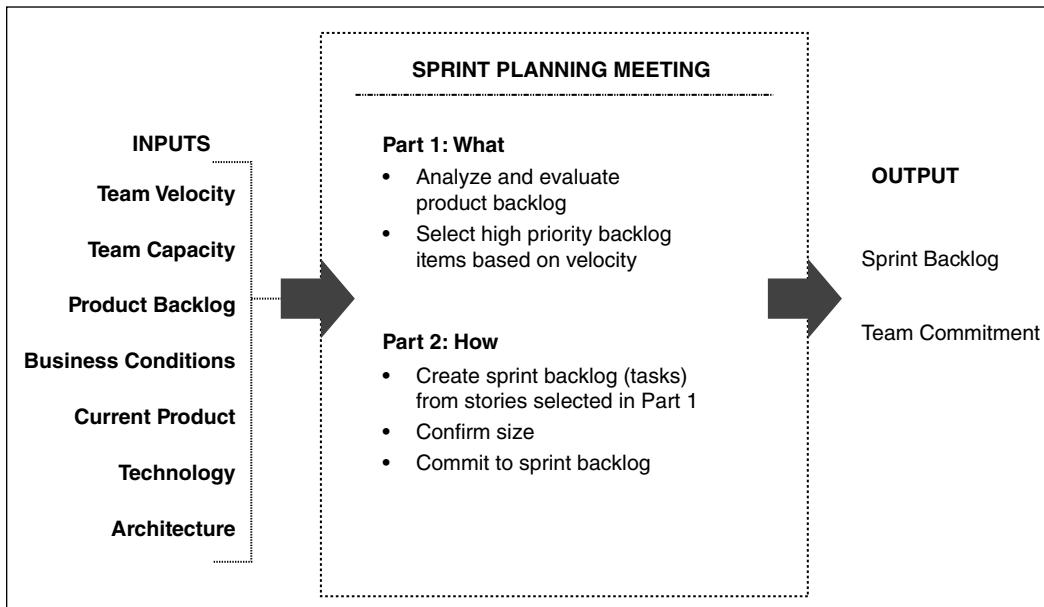
## Scrum Processes

In this section, we discuss several unique processes associated with Scrum.

### Sprint Planning

The sprint planning process is performed at the beginning of every sprint. In the sprint planning process, the team reviews the product backlog and selects the features it commits to completing during the upcoming sprint. Figure 13-10 provides the outline of the sprint planning process.

As can be seen in Figure 13-10, there are several important inputs into the sprint planning process. The team should have an estimate of the team’s velocity. The velocity may be moderated by the **team capacity** for the upcoming sprint. For example, the team may be temporarily short



**FIGURE 13-10** Sprint planning process.

a member due to a vacation or medical issue. The product backlog is also an essential input into the process. In addition, the team must recognize other factors in its environment, such as current and changing business conditions, the status of the current product (how much is complete; the urgency of completion), and technology and architecture considerations.

The team will conduct a sprint planning meeting. Using the inputs and in consultation with the product owner, the team will analyze the product backlog and select the high priority backlog items. The team will use the story point assignments and its team velocity to determine how many features it can commit to for the upcoming sprint. This first part of the meeting is termed, “determining the what.”

In the second part of the meeting, the team “determines the how.” The user stories selected in part 1 are broken down into more detailed sets of tasks. This allows the team to more fully understand the actual things that must be completed for each user story. The team should verify that after elaborating on the tasks involved in each user story, it is still able to commit to the selected user stories. The team makes a final commitment to the sprint backlog to complete the sprint planning.

Figure 13-11 provides an illustration of sprint planning. As shown in the figure, the team has a team velocity of 20 story points. In the left column of the figure, eight features are listed in the product backlog in order of priority, with story points assigned. Based on the team velocity, the top four user stories (features) are selected for the **Sprint Commitment** (center column) for a total of 18 story points. The right column of the figure shows the Sprint Backlog, in which each feature is more fully described in terms of detailed tasks.

When the sprint begins, team members will select and commit to tasks from the list in the sprint backlog to complete during the sprint.

### Product Backlog Grooming

Another important and unique process of Scrum is **product backlog grooming**. This is a collaborative process involving the product owner, ScrumMaster, and team. During this process, the participants review the product backlog with the intent to refine and improve it. For example, the epics (large user stories) in the backlog may be broken down into smaller, more focused user stories, especially if the epic has a high priority. The team may also evaluate existing user stories

Velocity—20 points			
Product Backlog		Sprint Commitment	Sprint Backlog
<b>Cancels</b>	<b>5 pts</b>	<b>Cancels</b> <b>5 pts</b>	<b>Cancels</b>
<b>Returns</b>	<b>8 pts</b>		<b>Returns</b>
<b>Gift Wrap</b>	<b>3 pts</b>		<b>Gift Wrap</b>
<b>Coupons</b>	<b>2 pts</b>		<b>Coupons</b>
<b>Wish List</b>	<b>13 pts</b>		
<b>Product Reviews</b>	<b>8 pts</b>		
<b>Tracking</b>	<b>20 pts</b>		
<b>Recommendations</b>	<b>5 pts</b>		<b>Coupons</b>

**FIGURE 13-11**  
Sprint planning illustration.

and rewrite them for clarity. Story points will be assigned to backlog items through the sizing process. Acceptance criteria may be developed to further clarify user stories.

Another aspect of this process is consideration of **technical debt**. Technical debt represents a change or improvement to the technical environment of the team that should be done but has been delayed or deferred. Technical debt does not relate to any user story but does represent something that is important to the team's overall operating environment and performance. Issues of technical debt should be discussed during product backlog grooming so that these issues are addressed appropriately.

The participants may also look deeper into the backlog to do longer-range planning. Looking back at Figure 13-6, the larger epics at the base of the pyramid form the basis of future product releases. The product owner and team can begin to formulate longer-range plans for those releases during the product backlog grooming process.

Performing product backlog grooming regularly ensures that the backlog contains prioritized, correctly sized user stories, clarified with acceptance criteria. This helps ensure productive and efficient sprint planning meetings.

### Scrum Meetings

A final unique process of Scrum is found in the deliberate and distinctive use of meetings. Scrum includes a limited number of meetings, each with a specific purpose and role in the Scrum process. Figure 13-12 summarizes the key aspects of the meetings included in Scrum.

Since we have described the Sprint Planning meeting and the Product Backlog Grooming meeting previously, we will describe the other meetings in Figure 13-12 here. The **Release Planning meeting** occurs periodically when the next release of the product is being planned. The product owner, ScrumMaster, key stakeholders, system architect, and (optionally) the team will meet to determine the features from the product backlog that should be included in the upcoming release. Usually, these are several large epics that have significant priority and value. The timing of the release is also determined in this meeting, which generally requires 2–4 hours.

The daily standup is an important component of the team process in Scrum. This short, 15-minute, daily meeting includes the team, ScrumMaster, and product owner. Other interested parties may observe but may not talk.

The daily standup is not a status reporting or a problem-solving meeting. Its purpose is to allow each team member, in turn, to state what he or she completed yesterday, commit to

Session	Purpose	Timing/Duration	Participants
Release Planning	Determine what a release should include and when it should be delivered	Start of release 2–4 hours	Product owner, ScrumMaster, key stakeholders, architect, team (optional)
Sprint Planning	Elaborate, estimate, and prioritize highest-value product backlog items for a sprint	Start of each sprint 2–4 hours	Team, ScrumMaster, product owner
Daily Standup	Facilitate rapid coordination between team member and product owner	Daily 15 minutes	Team, ScrumMaster, product owner
Sprint Review (or Demo)	Demonstrate completed functionality to interested stakeholders and users to show progress and get feedback	End of each sprint 1–1½ hours	Team, ScrumMaster, product owner, interested stakeholders and users
Sprint Retrospective	Reflect on project and process issues within team and act as appropriate	End of each sprint 30–45 minutes	Team, ScrumMaster, product owner
Product Backlog Grooming	Review upcoming user stories to confirm size and clarify team questions and decompose to execution level	Each sprint 1–2 hours	Team, ScrumMaster, product owner

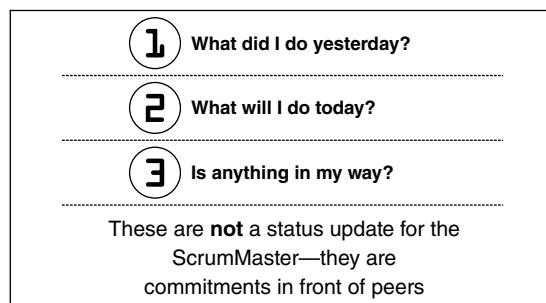
**FIGURE 13-12** Scrum meetings.

today's tasks, and identify any roadblocks. As shown in Figure 13-13, these brief comments are commitments made by each team member to the other members. Any impediments reported in the meeting become the ScrumMaster's task list. These daily meetings facilitate rapid coordination between the team members and the product owner and generally significantly reduce the need for other meetings.

The **Sprint Review (or Demo) meeting** occurs at the end of the sprint. Since the goal of the sprint is to produce functional software, this meeting allows the team to present and demonstrate what it accomplished during the sprint. These are informal meetings involving demonstrations and walk-throughs of the completed software. Often, the team demonstrates how the software satisfies the acceptance criteria for the user story. Some organizations prohibit the team from preparing slides or spending more than two hours on meeting preparation. All team members should participate, and everyone is invited to attend. If feedback from the audience determines that any actions are deemed necessary, the team commits to making changes in the next sprint.

Finally, the Sprint Retrospective meeting occurs at the conclusion of a Sprint. This meeting's purpose is for the team to celebrate its success and accomplishments in the previous sprint. The entire team participates. This meeting is not just a party, however, because it also embodies the spirit of continuous improvement. The team discusses the processes that it used in the sprint and identifies areas (if any) where the team's work processes need to be revised or the process implementation needs improving.

To illustrate, say the team has been using the practice of paired programming. **Paired programming** involves two programmers working together to design, code, and test the program code. The team may recognize that it faces certain situations where mob programming might be advantageous.



**FIGURE 13-13**  
The daily standup.

**Mob programming** involves all team members contributing simultaneously to the design, coding, and testing of the program code. Typically, team members sit at a horseshoe-shaped table, all focused on one or two large display screens. Each team member takes a 10-minute turn to “drive,” or have control of the keyboard. The keyboard is passed from one member to the next to change drivers.

If the team decides to incorporate a new work process in its way of working, the ScrumMaster will take on responsibility to obtain the facilities, equipment, and training needed to support that new work process. The team commits to making changes to adopt the new process in future sprints.

## How Does Scrum End?

One of the challenges of a development approach such as Scrum is determining when the project is finished. This question may seem strange, at first. After all, the project is over when all the requirements have been satisfied, right?

This issue is not as straightforward as it sounds, however, because one of the tenets of any Agile methodology is to continually respond and adapt to changing requirements. Therefore, the requirements listed in the product backlog are constantly evolving and changing as conditions and needs change. Some existing user stories may be deleted, having become irrelevant, while others take their place. In a real sense, we never run out of requirements. So how do we know when to stop?

To answer this question, remember that the product owner is responsible for managing the product backlog and judging the value of the features in the backlog. This value assessment is continuous and enables the product owner to change the priority of user stories in the backlog when appropriate. As a result, the team has developed the highest priority features throughout the various sprints. If at any point the product owner determines that the remaining features in the product backlog have little value, then the project should be terminated.

From a practical standpoint, the project sometimes must be terminated because the project budget is exhausted. In other cases, the organization determines that the team needs to be reassigned to a different, higher value project and the project is ended.

## Other Types of Agile Methodologies

The Agile Manifesto did not prescribe a specific methodology to implement Agile values and principles, and many variations of Agile methods have evolved. In Chapter 2, The Agile method called extreme programming (XP) was introduced, and we have just presented an extensive discussion of Scrum. Here, several other Agile methods are briefly described. As you read the following paragraphs, consider how each approach implements the values and principles stated in the Agile Manifesto.

## Crystal Development Methodology

The **Crystal Development Methodology**<sup>4</sup> is a lightweight and flexible approach to develop software. Crystal consists of several Agile processes, including Clear, Crystal Yellow, Crystal Orange, and other uniquely characterized methods. The characteristics of these variations are decided based on a variety of factors, such as team size, project criticality, and project priority.

Crystal incorporates several essential properties:

- Teamwork is essential to Crystal and team members are encouraged to work on tasks as a team rather than individually.
- Communication is considered the most critical aspect of the project. Communication spans both developer–customer interactions and interactions between team members.

<sup>4</sup><https://www.toolsqa.com/agile/crystal-method/>.

- Simplicity is stressed in terms of product design, requirements, and other project elements.
- Reflection is incorporated so that team members respond, and report as needed; valid reasoning is provided for every action; and work can be revised and reconstructed when necessary.
- Frequent adjustments are expected.
- Process improvements are performed continuously.

Like other Agile methods, Crystal promotes frequent delivery of functional software, adaptability, and removal of distractions. A distinction from Scrum is that Scrum relies on all team members being able to handle any task. Crystal allows the processes and methods to fit team members' skills and expertise.

## Dynamic Systems Development Methodology

**Dynamic Systems Development Methodology (DSDM)**<sup>5</sup> is an iterative, incremental approach based on a four-phrase framework:

- Feasibility and business study
- Functional model/prototype iteration
- Design and build iteration
- Implementation

DSDM relies upon direct and frequent collaboration between the developers and users. Teams must demonstrate visibility and transparency to all stakeholders through regular communication and collaboration. Teams are self-managed and have the authority to make critical project-related decisions. Software deliverables focus on critical, current business needs rather than less critical, future business needs. Teams focus on producing working software frequently and incrementally; perfectly working software is not expected. High quality is expected throughout the project, and all changes introduced during development must be reversible.

## Feature Driven Development

**Feature Driven Development (FDD)**<sup>6</sup> is an Agile framework that organizes software development around completing features. In FDD, a feature is like the user story in Scrum. FDD provides a framework that enables larger teams to rapidly move products forward with success. The FDD framework involves:

1. Develop an overall model
2. Build a features list
3. Plan by feature
4. Design by feature
5. Build by feature

FDD has a more top-down decision-making approach compared to most other Agile methods. It highly depends on chief developers. It has been shown to be useful for large-scale development projects but does not work efficiently for smaller projects.

<sup>5</sup><https://www.solutionsiq.com/agile-glossary/dynamic-systems-development-method-dsdm/>.

<sup>6</sup><http://agilemodeling.com/essays/fdd.htm>.

## Lean Software Development

**Lean Software Development (LSD)**<sup>7</sup> draws from the lean development process in manufacturing, where production and assembly lines are optimized to minimize waste and maximize customer value. LSD focuses on optimizing software development time and resources, eliminating waste, and delivering only what the project needs (the Minimum Viable Product strategy).

Teams following LSD release a bare-minimum version of its product to the market, learn from user feedback (likes, dislikes, and new requests), then iterate based on this feedback. LSD ruthlessly cuts away any activity that does not directly affect the final product.

Lean software development has seven main features:

1. Eliminate everything that is not necessary for completing the project.
2. Build quality into the product from the outset.
3. Improve team knowledge about the project.
4. Commit to rapid development.
5. Plan for fast product delivery.
6. Treat all team members and stakeholders with respect.
7. Optimize the value of the project as a whole.

LSD enables development teams to deliver more functionality in less time because of its streamlined approach. Unnecessary activities are eliminated, resulting in reduced costs. In addition, development teams are empowered to make decisions, which can enhance team morale.

## Comparing the SDLC with Agile Methodologies

It should be clear by now that Scrum and the other Agile methodologies that were briefly included here are quite different approaches to developing information systems compared to the SDLC. The transition from traditional methods to effective employment of Agile methods is not a trivial process. The difficulty organizations face with this transition is evidenced by the statistics reported earlier in the chapter about the slow and gradual adoption rate of Agile.

There are a few parallels between concepts in traditional development approaches and Agile development approaches. For example, as we studied the SDLC, we stressed discovering and stating requirements, especially user requirements and functional requirements, as the foundation of our new system. Agile methods such as Scrum and FDD focus on features expressed as user stories to represent user requirements. In the SDLC, we employed functional requirements statements to express a more detailed understanding of user requirements. Agile methods add detail to user stories through acceptance criteria.

In a traditional project, we attempt to develop a complete understanding of the project's requirements through a requirements document. This requirements document was intended to be complete and fixed once created. Since this expectation is difficult to achieve, Agile methods like Scrum utilize a product backlog to encompass all desired features. In Scrum, the product backlog can change in terms of content and priority as the project progresses, which solves the rigidity problems of the SDLC.

We saw earlier in the chapter that the adoption of Agile development practices has been slow and gradual. What factors contribute to the challenges experienced by organizations when

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<sup>7</sup><https://www.productplan.com/glossary/lean-software-development/>.

moving away from more traditional development approaches and adopting Agile practices? The state of Agile survey<sup>8</sup> lists several significant issues, several suggesting that internal culture remains a major obstacle:

- General organizational resistance to change.
- Not enough leadership participation.
- Inconsistent processes and practices across teams.
- Organizational culture at odds with Agile values.
- Inadequate management support and sponsorship.
- Lack of skills/experience with Agile methods.

The challenges of today's global, highly competitive business environment and the significant importance of information systems in today's organizations' operational performance and competitive strategies have led to the shift toward new, more Agile ways to develop systems. As the technologies our systems are based on continue to evolve, we can expect development approaches to continue to evolve. The tools and methods you use as you begin your career will be vastly different when you end your career. We hope that you will view this with a sense of excitement. Being flexible, adaptable, and open to innovative ideas and approaches will guarantee your success in the interesting and challenging career you have chosen.

## CHAPTER REVIEW

After reading and studying this chapter, you should be able to:

- Describe the Agile values and principles expressed in the Agile Manifesto.
- Explain the benefits organizations gain by using Agile development approaches.
- Describe the overall structure of the Scrum development approach.
- List and explain four key characteristics of Scrum.
- Describe the roles of product owner, ScrumMaster, and the team in Scrum.
- Discuss the key unique features of Scrum: sprints, user stories, acceptance criteria, story points, and team velocity.
- Explain the sprint planning process.
- Explain the product backlog grooming process.
- Discuss the purpose and contribution of Scrum's six distinctive meeting types.
- Briefly describe other common Agile approaches.
- Describe the factors that limit the adoption of Agile development approaches in organizations today.

## KEY TERMS

Acceptance criteria	Epic	Product backlog grooming	Sprint planning meeting
Agile Manifesto	Feature Driven Development (FDD)	Product owner	Sprint retrospective
Crystal Development Methodology	Implementation size story (LSD)	Release Planning meeting	Sprint Review (or Demo) meeting
Daily standup	Lean Software Development (LSD)	Scrum	Story point
Definition of "done"	Mob programming	ScrumMaster	Team capacity
Dynamic Systems Development Methodology (DSDM)	Paired programming	Self-organizing teams	Team velocity
	Product backlog	Sprint	Technical debt
		Sprint backlog	User stories
		Sprint Commitment	

<sup>8</sup>ibid.

## QUESTIONS

1. What was the Agile Manifesto? Why was it created?
2. Summarize the value statements of the Agile Manifesto.
3. What are the key benefits organizations that adopt Agile methods report experiencing?
4. Which Agile method is most widely used in practice?
5. What is the development cycle called in Scrum? How much time does it take? How does this contribute to the success of Scrum projects?
6. What element of Scrum compiles all the necessary features in the new software?
7. What is the purpose of the product owner role in Scrum? How does this role contribute to the Scrum process?
8. What is the purpose of the role of ScrumMaster in Scrum? Compare and contrast this role with that of a traditional project manager.
9. What is meant by self-organizing teams? How does this characteristic contribute to the Scrum process?
10. Explain the purpose and structure of a user story. Why is the user story an effective way to capture a feature of the new software?
11. What is an epic? What is the difference between an epic and an implementation size user story?
12. User stories are sometimes compared to a “vacation photo.” Explain this comparison and why it is important in understanding the value of user stories.
13. What is the hierarchy of user stories typically found in the product backlog?
14. What is the purpose of acceptance criteria? How do they contribute to a successful Scrum project?
15. What is the purpose of a story point? How is the assignment of story points to a user story determined?
16. What is the meaning of the term “team velocity”? How does this measure contribute to the Scrum process?
17. In what way does a Scrum team determine whether it is “done” with something? What are some typical components in the definition of “done”?
18. What is the purpose of the sprint planning meeting? What are its key inputs, parts, and outputs?
19. How does the Sprint Commitment differ from the Sprint Backlog in sprint planning?
20. What is the purpose of product backlog grooming? Who is involved with this activity? What exactly does it entail?
21. What is the daily standup in Scrum? Why is this meeting held? Who is involved? What does it contribute to the team?
22. What is the Sprint Review in Scrum? Why is this meeting held? Who is involved? What does it contribute to the project?
23. What is the Sprint Retrospective in Scrum? Why is this meeting held? Who is involved? What does it contribute to the team?
24. How do projects end in Scrum?
25. What are the main characteristics of the Crystal Development Methodology?
26. What are the main characteristics of the Dynamic Systems Development Methodology?
27. What are the main characteristics of Feature Driven Development?
28. What are the main characteristics of Lean Software Development?
29. What are the main barriers to adoption of Agile methods reported by organizations? How do these barriers impede Agile adoption?

## EXERCISES

- A. Review Minicase 4 at the end of Chapter 4. Develop a complete set of epic user stories for the situation described in this minicase.
- B. Select one of the epic user stories you developed in Exercise A that you believe has high value to the organization. Break this user story into implementation size user stories.
- C. Select two of the implementation size user stories you developed in Exercise B. Develop a set of acceptance criteria for each of these user stories.

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