INT 2840-SYSTEMS ANALYSIS AND PROJECT MANAGEMENT

Technology Engineering and Construction

Prince George's Community College

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INT 2840:Systems Analysis and Project Management

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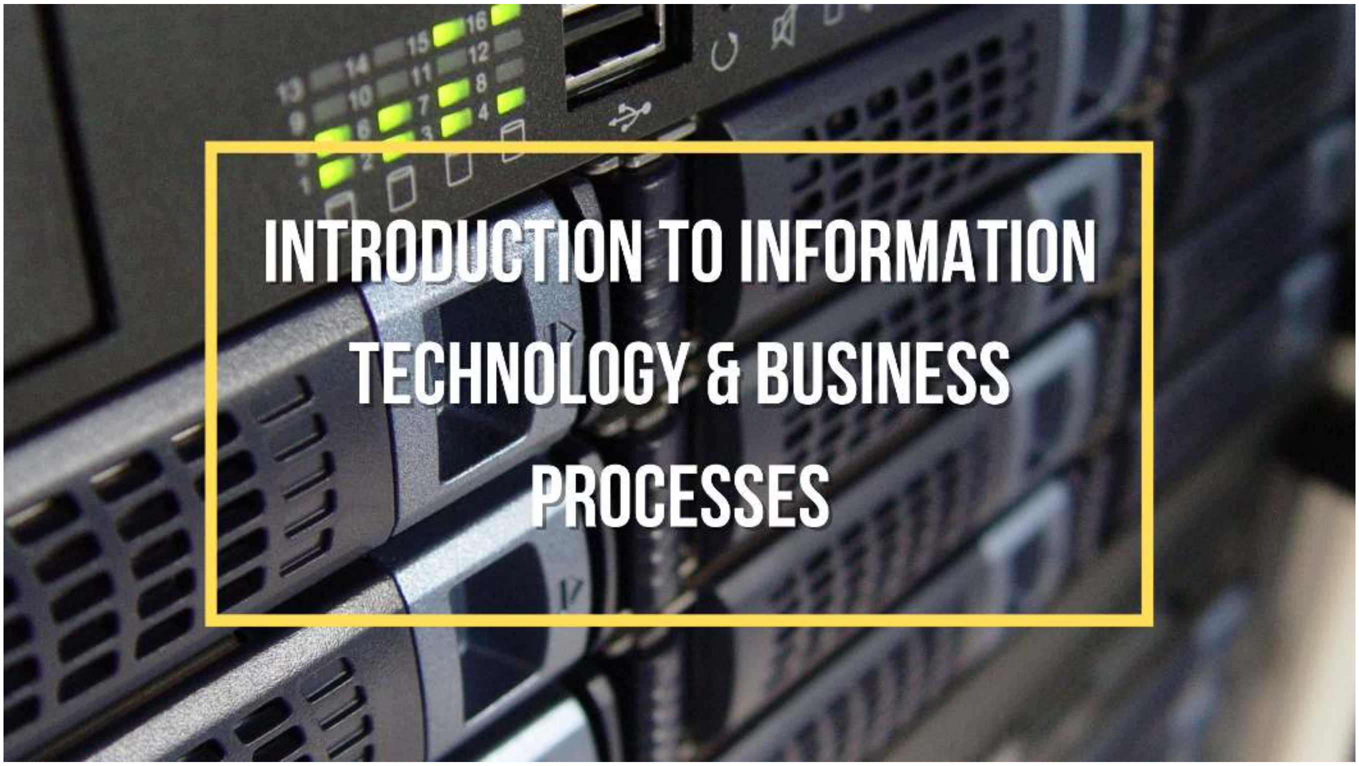
CHAPTER OVERVIEW

1: Introduction to Information Systems and Business Processes

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Define what an Information System is by identifying its major components
- Describe the basic history of information systems
- Understand the different careers & people involved Information Systems
- Understand business process management.



Introduction

Businesses have always been about serving their customers and community by offering products or services. Companies such as Apple, Microsoft, Google, Ford, Toyota, and many other companies have greatly shifted the world into what we see today and in the future; however, do not think these companies achieved these successes overnight.

Information systems have helped businesses be more efficient, organized, and up to date on daily operations. As you continue your studies in Information Technology, Cybersecurity, & Network Engineering, you may potentially be tasked to lead a team of developers to create a software program, implement a new security policy, redesign an entire network infrastructure, or become an entrepreneur and create a new company or new branch to provide new services!

These companies, like many others, have many working parts aiding their growth. This chapter will be divided into two sections, ***The components of Information Systems*** & ***Business Processes*** will introduce you to the building blocks of what you as a Project Manager or Systems Analysts will need to think of and take care of for the company you will work for.

Before we begin, let us first clear up what an Information System is...

Defining Information Systems

Almost all programs in business require students to take a course in something called *information systems*. But what exactly does that term mean? Let's take a look at some of the more popular definitions, first from Wikipedia and then from a couple of textbooks:

- "Information systems (IS) is the study of complementary networks of hardware and software that people and organizations use to collect, filter, process, create, and distribute data."[1]
- "Information systems are combinations of hardware, software, and telecommunications networks that people build and use to collect, create, and distribute useful data, typically in organizational settings."[2]
- "Information systems are interrelated components working together to collect, process, store, and disseminate information to support decision making, coordination, control, analysis, and visualization in an organization."[3]

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1.1: Components of an Information System

The Components of Information Systems

As we have learned in the previous section, Information systems deal with the overall combination of different parts that work together such as hardware, software, telecommunications technologies, and people to process data for, typically, organization needs or settings. Learning and having been taught that Information Systems deal with current technologies and software programs is one minor aspect of a bigger picture. Information systems deal with four major components: ***Technology, People, Data, and Process.***

Technology

Technology can be thought of as the application of scientific knowledge for practical purposes. From the invention of the wheel to the harnessing of electricity for artificial lighting, technology is a part of our lives in so many ways that we tend to take it for granted. The development of ***Hardware & Software*** created brand new opportunities for organizations and clients to perform day-to-day tasks with ease.

Hardware

Hardware is the part of an information system you can touch – the physical components of the technology. Computers, keyboards, disk drives, iPads, and flash drives are all examples of information systems hardware. As a Project Manager or Systems Analyst, you will not be responsible for developing the hardware of systems or designing a brand new computer, but you will be expected to be familiar with computer hardware components and how they work. Computer Engineers will be responsible for developing these systems for the vendors from which you will choose to buy their systems.


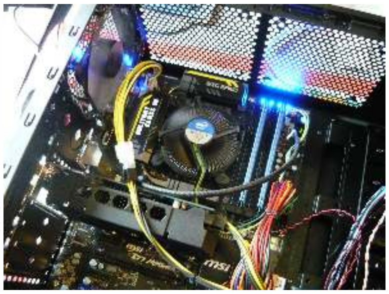

Figure 1: Computer with keyboard, Figure 2: Motherboard with other components.

mouse, screen & chassis.

Software

Software is a set of instructions that tells the hardware what to do. Software is not tangible – it cannot be touched. Programmers create software that sends series of instructions for the computerfollow. There are several categories of software, with the two main categories being operating-system software, which makes the hardware usable, and application software, which does something useful. Examples of operating systems include Microsoft Windows on a personal computer and Google's Android on a mobile phone. Examples of application software are Microsoft Excel and Angry Birds. Software will be explored more thoroughly in chapter 3.


Figure 3: Windows 8 OS Software Figure 3: Audio Mixing application software

with preinstalled application software

Hardware and Software have come a really long way throughout time, thanks to the innovator and inventors of these two components. Communication and data transmission has been made possible. ***Computer networking, Networking, Or network communication*** is the concept of being able to connect with other individuals or organizations to share and communicate data over computer systems called a ***Computer network.*** Information systems in the present heavily rely on being able to communicate with other systems through this means. The concept of the internet was not always around, so computer systems were not always able to communicate with others in remote locations like we see today. Computer networking will be covered in greater detail in chapter 3.

The development of ***Cloud Computing*** is another benefit that has emerged. Cloud computing is the use of IT resources of a vendor or company through the internet (also called "the cloud") usually through a subscription-based model. These IT resources are not locally stored on the client's premises and provide copious amounts of advantages as well as disadvantages. Cloud computing will be discussed in greater detail in chapter 3 as well**.**

Data

The second component is **data.** You can think of data as a collection of facts. For example, your street address, the city you live in, and your phone number are all pieces of data. Like software, data is also intangible. By themselves, pieces of data are not really very useful. But aggregated, indexed, and organized together into a database, data can become a powerful tool for businesses. In fact, all of the definitions presented at the beginning of this chapter focused on how information systems manage data. Organizations collect all kinds of data and use it to make decisions. These decisions can then be analyzed as to their effectiveness and the organization can be improved. Chapter 4 will focus on data and databases, and their uses in organizations.

People

Where does the information come from? Is it from science? Or from computers? By no means! It comes from us! People!

People have been the conveyors of creating information out of raw data. It is out of the data that people collect that we are able to get information that is used to develop useful tools and products that are used daily. It is people that create buildings, agricultural products, and so much more. From this, you can understand the crucial roles that people in your organization and in other parts affect the way you will manage or develop an information system

When thinking about information systems, it is easy to get focused on the technology components and forget that we must look beyond these tools to fully understand how they integrate into an organization. A focus on the people involved in information systems is the next step. From the front-line help-desk workers to systems analysts, to programmers, all the way up to the chief information officer (CIO), the people involved with information systems are an essential element that must not be overlooked.

Process

The last component of information systems is ***process***. A process is a series of steps undertaken to achieve a desired outcome or goal. Information systems are becoming more and more integrated with organizational processes, bringing more productivity and better control to those processes. But simply automating activities using technology is not enough – businesses looking to effectively utilize information systems do more. Using technology to manage and improve processes, both within a company and externally with suppliers and customers is the ultimate goal. Technology buzzwords such as "business process reengineering," "business process management," and "enterprise resource planning" all have to do with the continued improvement of these business procedures and the integration of technology with them. Businesses hoping to gain an advantage over their competitors are highly focused on this component of information systems. We will discuss processes in greater detail in the second part of this chapter.

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SECTION OVERVIEW

1.1.1: The People in Information Systems

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- describe each of the different roles that people play in the design, development, and use of information systems
- understand the different career paths available to those who work with information systems
- explain the importance of where the information-systems function is placed in an organization
- describe the different types of users of information systems.

Introduction

In the opening chapters of this text, we focused on some of the major components in information systems such as ***Technology, data, and process***. Now we will discuss the ***people*** component of Information Systems in this section. It is because of a team of diversely skilled individuals that organizations are able to advance the way that they could.

People are involved in information systems in just about every way you can think of: people imagine information systems, people develop information systems, people support information systems, and, perhaps most importantly, people *use* information systems.

Keep in mind: The proceeding jobs mentioned does not represent all possible jobs within an information systems organization. Larger organizations will have more specialized roles; smaller organizations may combine some of these roles. Many of these roles may exist outside of a traditional information-systems organization, as we will discuss below.

Working with information systems can be a rewarding career choice. Whether you want to be involved in very technical jobs (programmer, database administrator), or you want to be involved in working with people (systems analyst, trainer), there are many different career paths available.

Many times, those in technical jobs who want career advancement find themselves in a dilemma: do they want to continue doing technical work, where sometimes their advancement options are limited or do they want to become a manager of other employees and put themselves on a management career track? In many cases, those proficient in technical skills are not gifted with managerial skills. Some organizations, especially those that highly value their technically skilled employees, will create a technical track that exists in parallel to the management track so that they can retain employees who are contributing to the organization with their technical skills.

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1.1.1.1: Developers and Designers

Developers and Designers

The first group of people we are going to look at play a role in designing, developing, and building information systems. These people are generally very technical and have a background in programming and mathematics. Just about everyone who works in the creation of information systems has a minimum of a bachelor's degree in computer science or information systems, though that is not necessarily a requirement. We will be looking at the process of creating information systems in more detail in chapter 2.

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1.1.1.1.1: System Analyst

Systems Analyst

The role of the systems analyst is to straddle the divide between identifying business needs and imagining a new or redesigned computer-based system to fulfill those needs. This individual will work with a person, team, or department with business requirements and identify the specific details of a system that needs to be built. Generally, this will require the analyst to have a good understanding of the business itself, the business processes involved, and the ability to document them well. The analyst will identify the different stakeholders in the system and work to involve the appropriate individuals in the process.

Once the requirements are determined, the analyst will begin the process of translating these requirements into an information-systems design. A good analyst will understand what different technological solutions will work and provide several different alternatives to the requester, based on the company's budgetary constraints, technology constraints, and culture. Once the solution is selected, the analyst will create a detailed document describing the new system. This new document will require that the analyst understand how to speak in the technical language of systems developers.

A systems analyst generally is not the one who does the actual development of the information system. The design document created by the systems analyst provides the detail needed to create the system and is handed off to a programmer (or team of programmers) to do the actual creation of the system. In some cases, however, a systems analyst may go ahead and create the system that he or she designed. This person is sometimes referred to as a programmer-analyst.

In other cases, the system may be assembled from off-the-shelf components by a person called a systems integrator. This is a specific type of systems analyst that understands how to get different software packages to work with each other.

To become a systems analyst, you should have a background both in the business and in systems design. Many analysts first worked as programmers and/or had to experience in the business before becoming systems analysts.

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1.1.1.1.2: System Programmer

Programmer

System Programmers are the people who write software and programs in computer language (C/C#/C++, Python, Pearl, Swift, Java, etc.) to complete or automate a specific request. They are also called Software Developers, Coders, Programmers, or Scripters. In the case of systems development, programmers generally attempt to fulfill the design specifications given to them by a Systems Analyst.

The System Programmer will need to have a deep understanding of more than one programming language as businesses may need a wide variety of IT solutions. For example, one company may need its own private web browser: as well as custom file management software. Not all programming languages can complete these two tasks because as Information Technology has evolved, Computer Engineers throughout history created specific languages for specific tasks and hardware.

For anyone interested in becoming a System Programmer, doing research on current business needs from organizations and industries will assist in guiding which languages to begin studying. Having strong mathematical skills and a bachelor's degree is a common criterion for most organizations.

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1.1.1.1.3: Computer Engineer

Computer Engineer

Computer engineers design the computing devices that we use every day. There are many types of computer engineers, who work on a variety of different types of devices and systems. Some of the more prominent engineering jobs are as follows:

- Hardware engineer. A hardware engineer designs hardware components, such as microprocessors. Many times, a hardware engineer is at the cutting edge of computing technology, creating something brand new. Other times, the hardware engineer's job is to engineer an existing component to work faster or use less power. Many times, a hardware engineer's job is to write code to create a program that will be implemented directly on a computer chip.
- Software engineer. Software engineers do not actually design devices; instead, they create new programming languages and operating systems, working at the lowest levels of the hardware to develop new kinds of software to run on the hardware.
- Systems engineer. A systems engineer takes the components designed by other engineers and makes them all work together. For example, to build a computer, the mother board, processor, memory, and hard disk all have to work together. A systems engineer has experience with many different types of hardware and software and knows how to integrate them to create new functionality.
- Network engineer. A network engineer's job is to understand the networking requirements of an organization and then design a communications system to meet those needs, using the networking hardware and software available.

There are many different types of computer engineers, and often the job descriptions overlap. While many may call themselves engineers based on a company job title, there is also a professional designation of "professional engineer," which has specific requirements behind it. In the US, each state has its own set of requirements for the use of this title, as do different countries around the world. Most often, it involves a professional licensing exam.

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SECTION OVERVIEW

1.1.1.2: Administrators and Operators

Information-Systems Operations and Administration

Another group of information-systems professionals is involved in the day-to-day operations and administration of IT. These people must keep the systems running and up-to-date so that the rest of the organization can make the most effective use of these resources. As a Project Manager or System Analyst, you must ensure those who will use the information system are capable of running them, able to maintain the systems, and are open to learning more about the system.

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1.1.1.2.1: Database Administrator

Database Administrator

A database administrator (DBA) is the person who manages the databases for an organization through the use of either application software and existing systems, or design, engineer, install, and maintain a brand new database. The DBA must have an extensive understanding of database queries, theories, server systems, and computing skills in order to work successfully for a company. Oftentimes, it may be a requirement that a Database Administrator has at least a bachelor's or master's degree in computer science in addition to certifications in database administration.

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1.1.1.2.2: Support Desk

Help-Desk/Support Analyst

Most mid-size to large organizations have their own information-technology help desk. The help desk is the first line of support for computer users in the company. Computer users who are having problems or need information can contact the help desk for assistance. Many times, a help-desk worker is a junior-level employee who does not necessarily know how to answer all of the questions that come his or her way. In these cases, help-desk analysts work with senior-level support analysts or have a computer knowledge base at their disposal to help them investigate the problem at hand. The help desk is a great place to break into working in IT because it exposes you to all of the different technologies within the company. A successful help-desk analyst should have good people and communications skills, as well as at least junior-level IT skills.

References

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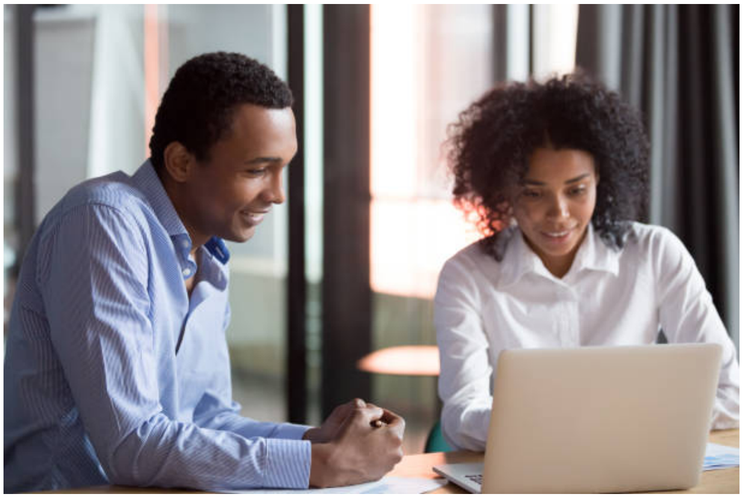
1.1.1.2.3: Trainer

Trainer

A computer trainer conducts classes to teach people specific computer skills. For example, if a new ERP system is being installed in an organization, one part of the implementation process is to teach all of the users how to use the new system. A trainer may work for a software company and be contracted to come in to conduct classes when needed; a trainer may work for a company that offers regular training sessions; or a trainer may be employed full time for an organization to handle all of their computer instruction needs. To be successful as a trainer, you need to be able to communicate technical concepts well and also have a lot of patience!



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1.1.1.3: Managers

Managing Information Systems

The management of information-systems functions is critical to the success of information systems within the organization. Here are some of the jobs associated with the management of information systems.

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1.1.1.3.1: CIO

CIO

The CIO, or chief information officer, is the head of the information-systems function. This person aligns the plans and operations of the information systems with the strategic goals of the organization. This includes tasks such as budgeting, strategic planning, and personnel decisions for the information-systems function. The CIO must also be the face of the IT department within the organization. This involves working with senior leaders in all parts of the organization to ensure good communication and planning.

Interestingly, the CIO position does not necessarily require a lot of technical expertise. While helpful, it is more important for this person to have good management skills and understand the business. Many organizations do not have someone with the title of CIO; instead, the head of the information-systems function is called vice president of information systems or director of information systems.

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1.1.1.3.2: Functional Manager

Functional Manager

As an information-systems organization becomes larger, many of the different functions are grouped together and led by a manager. These functional managers report to the CIO and manage the employees specific to their function. For example, in a large organization, there is a group of systems analysts who report to a manager of the systems-analysis function. For more insight into how this might look, see the discussion later in the chapter of how information systems are organized.

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1.1.1.3.3: ERP Manager

ERP Management

Organizations using an ERP require one or more individuals to manage these systems. These people make sure that the ERP system is completely up to date, work to implement any changes to the ERP that are needed, and consult with various user departments on needed reports or data extracts.

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1.1.1.3.4: Project Managers

Project Managers

Information-systems projects are notorious for going over budget and being delivered late. In many cases, a failed IT project can spell doom for a company. A project manager is responsible for keeping projects on time and on budget. This person works with the stakeholders of the project to keep the team organized and communicates the status of the project to management. A project manager does not have authority over the project team; instead, the project manager coordinates schedules and resources in order to maximize the project outcomes. A project manager must be a good communicator and an extremely organized person. A project manager should also have good people skills. Many organizations require each of their project managers to become certified as a project management professional(PMP).

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1.1.1.3.5: Info-Sec Officer

Information-Security Officer

An information-security officer is in charge of setting information-security policies for an organization, and then overseeing the implementation of those policies. This person may have one or more people reporting to them as part of the information-security team. As information has become a critical asset, this position has become highly valued. The information-security officer must ensure that the organization's information remains secure from both internal and external threats.

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1.1.1.3.6: Emerging Roles

Emerging Roles

As technology evolves, many new roles are becoming more common as other roles fade. For example, as we enter the age of “big data,” we are seeing the need for more data analysts and business-intelligence specialists. Many companies are now hiring social-media experts and mobile-technology specialists. The increased use of cloud computing and virtual-machine technologies also is breeding demand for expertise in those areas.

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1.1.1.4: Organization

Organizing the Information-Systems Function

In the early years of computing, the information-systems function (generally called data processing) was placed in the finance or accounting department of the organization. As computing became more important, a separate information-systems function was formed, but it still was generally placed under the CFO and considered to be an administrative function of the company. In the 1980s and 1990s, when companies began networking internally and then linking up to the Internet, the information-systems function was combined with the telecommunications functions and designated the information technology (IT) department. As the role of information technology continued to increase, its place in the organization also moved up the ladder. In many organizations today, the head of IT (the CIO) reports directly to the CEO.

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1.1.1.4.1: Where are we?

Where in the Organization Should IS Be?

Before the advent of the personal computer, the information-systems function was centralized within organizations in order to maximize control over computing resources. When the PC began proliferating, many departments within organizations saw it as a chance to gain some computing resources for themselves. Some departments created an internal information-systems group, complete with systems analysts, programmers, and even database administrators. These departmental-IS groups were dedicated to the information needs of their own departments, providing quicker turnaround and higher levels of service than a centralized IT department. However, having several IS groups within an organization led to a lot of inefficiencies: there were now several people performing the same jobs in different departments. This decentralization also led to company data being stored in several places all over the company. In some organizations, a "matrix" reporting structure has developed, in which IT personnel are placed within a department and report to both the department management and the functional management within IS. The advantages of dedicated IS personnel for each department are weighed against the need for more control over the strategic information resources of the company.

For many companies, these questions are resolved by the implementation of the ERP system (see discussion of ERP in chapter 8). Because an ERP system consolidates most corporate data back into a single database, the implementation of an ERP system requires organizations to find "islands" of data so that they can integrate them back into the corporate system. The ERP allows organizations to regain control of their information and influences organizational decisions throughout the company.

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1.1.1.4.2: New Thoughts

New Models of Organizations

The integration of information technology has influenced the structure of organizations. The increased ability to communicate and share information has led to a “flattening” of the organizational structure due to the removal of one or more layers of management.

Another organizational change enabled by information systems is the network-based organizational structure. In a networked-based organizational structure, groups of employees can work somewhat independently to accomplish a project. In a networked organization, people with the right skills are brought together for a project and then released to work on other projects when that project is over. These groups are somewhat informal and allow for all members of the group to maximize their effectiveness.

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1.1.1.4.3: Outsourcing

Outsourcing

Many times, an organization needs a specific skill for a limited period of time. Instead of training an existing employee or hiring someone new, it may make more sense to outsource the job. Outsourcing can be used in many different situations within the information-systems function, such as the design and creation of a new website or the upgrade of an ERP system. Some organizations see outsourcing as a cost-cutting move, contracting out a whole group or department.

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1.1.1.5: Summary

Summary

In this section, we have reviewed the many different categories of individuals who make up the people component of information systems. The world of information technology is changing so fast that new roles are being created all the time, and roles that have existed for decades are being phased out. That said, this section should have given you a good idea of the importance of the people component of information systems.

Study Questions

1. Describe the role of a systems analyst.
2. What are some of the different roles for a computer engineer?
3. What does the CIO do?
4. Describe the job of a project manager.
5. Explain the point of having two different career paths in information systems.
6. What are the advantages and disadvantages of centralizing the IT function?
7. What impact has information technology had on the way companies are organized?
8. Why would an organization outsource?

Exercises

1. Which IT job would you like to have? Do some original research and write a two-page paper describing the duties of the job you are interested in.
2. Spend a few minutes on Dice or Monster to find IT jobs in your area. What IT jobs are currently available? Write up a two-page paper describing three jobs, their starting salary (if listed), and the skills and education needed for the job.
3. How is the IT function organized in your school or place of employment? Create an organization chart showing how the IT organization fits into your overall organization. Comment on how centralized or decentralized the IT function is.
4. What type of IT user are you? Take a look at the five types of technology adopters and then write a one-page summary of where you think you fit in this model.

1. Rogers, E. M. (1962). Diffusion of innovations. New York: Free Press↵

Sidebar: Are Certifications Worth Pursuing?

As technology is becoming more and more important to businesses, hiring employees with technical skills is becoming critical. But how can an organization ensure that the person they are hiring has the necessary skills? These days, many organizations are including technical certifications as a prerequisite for getting hired.

Certifications are designations given by a certifying body that someone has a specific level of knowledge in a specific technology. This certifying body is often the vendor of the product itself, though independent certifying organizations, such as CompTIA, also exist. Many of these organizations offer certification tracks, allowing a beginning certificate as a prerequisite to getting more advanced certificates. To get a certificate, you generally attend one or more training classes and then take one or more certification exams. Passing the exams with a certain score will qualify you for a certificate. In most cases, these classes and certificates are not free and, in fact, can run into the thousands of dollars. Some examples of the certifications in highest demand include Microsoft (software certifications), Cisco (networking), and SANS (security).

For many working in IT (or thinking about an IT career), determining whether to pursue one or more of these certifications is an important question. For many jobs, such as those involving networking or security, a certificate will be required by the employer as a way to determine which potential employees have a basic level of skill. For those who are already in an IT career, a more advanced certificate may lead to a promotion. There are other cases, however, when experience with a certain technology will negate the need for certification. For those wondering about the importance of certification, the best solution is to talk to potential employers and those already working in the field to determine the best choice.

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1.1.2: Data Asset in Action- Harrah's Solid Gold CRM for the Service Sector

Learning Objectives

After studying this section you should be able to do the following:

1. Understand how Harrah's has used IT to move from an also-ran chain of casinos to become the largest gaming company based on revenue.
2. Name some of the technology innovations that Harrah's is using to help it gather more data, and help push service quality and marketing program success.

Harrah's Entertainment provides an example of exceptional data asset leverage in the service sector, focusing on how this technology enables world-class service through customer relationship management.

Gary Loveman is a sort of management major trifecta. The CEO of Harrah's Entertainment is a former *operations* professor who has leveraged *information technology* to create what may be the most effective *marketing* organization in the service industry. If you ever needed an incentive to motivate you for cross-disciplinary thinking, Loveman provides it.

Harrah's has leveraged its data-powered prowess to move from an also-ran chain of casinos to become the largest gaming company by revenue. The firm operates some fifty-three casinos, employing more than eighty-five thousand workers on five continents. Brands include Harrah's, Caesars Palace, Bally's, Horseshoe, and Paris Las Vegas. Under Loveman, Harrah's has aggressively swallowed competitors, the firm's $9.4 billion buyout of Caesars Entertainment being its largest deal to date.

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Collecting Data

Data drives the firm. Harrah's collects customer data on just about everything you might do at their properties—gamble, eat, grab a drink, attend a show, stay in a room. The data's then used to track your preferences and to size up whether you're the kind of customer that's worth pursuing. Prove your worth, and the firm will surround you with top-tier service and develop a targeted marketing campaign to keep wooing you back (Magnini, et. al., 2003).

The ace in the firm's data collection hole is its Total Rewards loyalty card system. Launched over a decade ago, the system is constantly being enhanced by an IT staff of seven hundred, with an annual budget in excess of $100 million (Swabey, 2007). Total Rewards is an opt-in loyalty program, but customers consider the incentives to be so good that the card is used by some 80 percent of Harrah's patrons, collecting data on over forty-four million customers (Wagner, 2008; Haugsted, 2007).

Customers signing up for the card provide Harrah's with demographic information such as gender, age, and address. Visitors then present the card for various transactions. Slide it into a slot machine, show it to the restaurant hostess, present it to the parking valet, share your account number with a telephone reservation specialist—every contact point is an opportunity to collect data. Between three hundred thousand and one million customers come through Harrah's doors daily, adding to the firm's data stash and keeping that asset fresh (Hoover, 2007).

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Who Are the Most Valuable Customers?

All that data is heavily and relentlessly mined. Customer relationship management should include an assessment to determine which customers are worth having a relationship with. And because Harrah's has so much detailed historical data, the firm can make fairly accurate projections of customer lifetime value (CLV). CLV represents the present value of the likely future income stream generated by an individual purchaser[1]. Once you know this, you can get a sense of how much you should spend to keep that customer coming back. You can size them up next to their peer group and if they fall below expectations you can develop strategies to improve their spending.

The firm tracks over ninety demographic segments, and each responds differently to different marketing approaches. Identifying segments and figuring out how to deal with each involves an iterative model of mining the data to identify patterns, creating a hypothesis (customers in group X will respond to a free steak dinner; group Y will want ten dollars in casino chips), then testing that hypothesis against a control group, turning again to analytics to statistically verify the outcome.

The firm runs hundreds of these small, controlled experiments each year. Loveman says that when marketers suggest new initiatives, "I ask, did we test it first? And if I find out that we just whole-hogged, went after something without testing it, I'll kill 'em. No matter how clever they think it is, we test it" (Nickell, 2002). The former ops professor is known to often quote quality guru W. Edwards Deming, saying, "In God we trust; all others must bring data."

When Harrah's began diving into the data, they uncovered patterns that defied the conventional wisdom in the gaming industry. Big money didn't come from European princes, Hong Kong shipping heirs, or the *Ocean's 11* crowd—it came from locals. The less than 30 percent of customers who spent between one hundred and five hundred dollars per visit accounted for over 80 percent of revenues and nearly 100 percent of profits (Swabey, 2007).

The data also showed that the firm's most important customers weren't the families that many Vegas competitors were trying to woo with Disneyland-style theme casinos—it was Grandma! Harrah's focuses on customers forty-five years and older: twenty-somethings have no money, while thirty-somethings have kids and are too busy. To the premiddle-aged crowd, Loveman says, "God bless you, but we don't need you" (Haugsted, 2007).

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Data-Driven Service: Get Close (but Not Too Close) to Your Customers

The names for reward levels on the Total Rewards card convey increasing customer value—Gold, Diamond, and Platinum. Spend more money at Harrah's and you'll enjoy shorter lines, discounts, free items, and more. And if Harrah's systems determine you're a high-value customer, expect white-glove treatment. The firm will lavish you with attention, using technology to try to anticipate your every need. Customers notice the extra treatment that top-tier Total Rewards members receive and actively work to improve their status.

To illustrate this, Loveman points to the obituary of an Ashville, North Carolina, woman who frequented a casino Harrah's operates on a nearby Cherokee reservation. "Her obituary was published in the Asheville paper and indicated that at the time of her death, she had several grandchildren, she sang in the Baptist choir and she was *a holder of the Harrah's Diamond Total Rewards card*." Quipped Loveman, "When your loyalty card is listed in someone's obituary, I would maintain *you have traction*" (Loveman, 2005).

The degree of customer service pushed through the system is astonishing. Upon check in, a Harrah's customer who enjoys fine dining may find his or her table is reserved, along with tickets for a show afterward. Others may get suggestions or special offers throughout their stay, pushed via text message to their mobile device (Wagner, 2008). The firm even tracks gamblers to see if they're suffering unusual losses, and Harrah's will dispatch service people to intervene with a feel-good offer: "Having a bad day? Here's a free buffet coupon" (Davenport & Harris, 2007).

The firm's CRM effort monitors any customer behavior changes. If a customer who usually spends a few hundred a month hasn't shown up in a while, the firm's systems trigger follow-up contact methods such as sending a letter with a promotion offer, or having a rep make a phone call inviting them back (Loveman, 2005).

Customers come back to Harrah's because they feel that those casinos treat them better than the competition. And Harrah's laser-like focus on service quality and customer satisfaction are embedded into its information systems and operational procedures. Employees are measured on metrics that include speed and friendliness and are compensated based on guest satisfaction ratings. Hourly workers are notoriously difficult to motivate: they tend to be high-turnover, low-wage earners. But at Harrah's, incentive bonuses depend on an entire location's ratings. That encourages strong performers to share tips to bring the new guy up to speed. The process effectively changed the corporate culture at Harrah's from an every-property-for-itself mentality to a collaborative, customer-focused enterprise (Magnini & Honeycutt, 2003).

While Harrah's is committed to learning how to make your customer experience better, the firm is also keenly sensitive to respecting consumer data. The firm has never sold or given away any of its bits to third parties. And the firm admits that some of its efforts to track customers have misfired, requiring special attention to find the sometimes subtitle line between helpful and "too helpful." For example, the firm's CIO has mentioned that customers found it "creepy and Big Brother-ish" when employees tried to greet them by name and talk with them about their past business history at Harrah's, so the firm backed off (Wagner, 2008).

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Innovation

Harrah's is constantly tinkering with new innovations that help it gather more data and help push service quality and marketing program success. When the introduction of gaming in Pennsylvania threatened to divert lucrative New York City gamblers from Harrah's Atlantic City properties, the firm launched an interactive billboard in New York's Times Square, allowing passers-by to operate a virtual slot machine using text messages from their cell phones. Players dialing into the video billboard not only control the display, they receive text message offers promoting Harrah's sites in Atlantic City[2].

At Harrah's, tech experiments abound. RFID-enabled poker chips and under-table RFID readers allow pit bosses to track and rate game play far better than they could before. The firm is experimenting with using RFID-embedded bracelets for poolside purchases and Total Rewards tracking for when customers aren't carrying their wallets. The firm has also incorporated drink ordering into gaming machines—why make customers get up to quench their thirst? A break in gambling is a halt in revenue.

The firm was also one of the first to sign on to use Microsoft's Surface technology—a sort of touch-screen and sensor-equipped tabletop. Customers at these tables can play bowling and group pinball games and even pay for drinks using cards that the tables will automatically identify. Tech even helps Harrah's fight card counters and crooks, with facial recognition software scanning casino patrons to spot the bad guys (Lohr, 2007).

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Strategy

A walk around Vegas during Harrah's ascendency would find rivals with bigger, fancier casinos. Says Loveman, "We had to compete with the kind of place that God would build if he had the money.…The only thing we had was data" (Swabey, 2007).

That data advantage creates intelligence for a high-quality and highly personal customer experience. Data gives the firm a service differentiation edge. The loyalty program also represents a switching cost. And these assets combined to be leveraged across a firm that has gained so much scale that it's now the largest player in its industry, gaining the ability to cross-sell customers on a variety of properties—Vegas vacations, riverboat gambling, locally focused reservation properties, and more.

Harrah's chief marketing officer, David Norton, points out that when Total Rewards started, Harrah's was earning about thirty-six cents on every dollar customers spent gaming—the rest went to competitors. A climb to forty cents would be considered monstrous. By 2005 that number had climbed to forty-five cents, making Harrah's the biggest monster in the industry (Lundquist, 2005). Some of the firm's technology investments have paid back tenfold in just two years—bringing in hundreds of millions of dollars (Swabey, 2007).

The firm's technology has been pretty tough for others to match, too. Harrah's holds several patents covering key business methods and technologies used in its systems. After being acquired by Harrah's, employees of Caesars lamented that they had, for years, unsuccessfully attempted to replicate Harrah's systems without violating the firm's intellectual property (Hoover, 2007).

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Challenges

Harrah's efforts to gather data, extract information, and turn this into real profits is unparalleled, but it's not a cure-all. Broader events can often derail even the best strategy. Gaming is a discretionary spending item, and when the economy tanks, gambling is one of the first things consumers will cut. Harrah's has not been immune to the world financial crisis and experienced a loss in 2008.

Also note that if you look up Harrah's stock symbol you won't find it. The firm was taken private in January 2008, when buyout firms Apollo Management and TPG Capital paid $30.7 billion for all of the firm's shares. At that time Loveman signed a five-year deal to remain on as CEO, and he's spoken positively about the benefits of being private—primarily that with the distraction of quarterly earnings off the table, he's been able to focus on the long-term viability and health of the business (Knightly, 2009).

But the firm also holds $24 billion in debt from expansion projects and the buyout, all at a time when economic conditions have not been favorable to leveraged firms (Lattman, 2009). A brilliantly successful firm that developed best-in-class customer relationship management in now in a position many consider risky due to debt assumed as part of an overly optimistic buyout occurring at precisely the time when the economy went into a terrible funk. Harrah's awesome risk-reducing, profit-pushing analytics failed to offer any insight on the wisdom (or risk) in the debt and private equity deals.

Key Takeaways

- Harrah's Entertainment provides an example of exceptional data asset leverage in the service sector, focusing on how this technology enables world-class service through customer relationship management.
- Harrah's uses its Total Rewards loyalty card system to collect customer data on just about everything you might do at their properties—gamble, eat, drink, see a show, stay in a room, and so on.
- Individual customers signing up for the Total Rewards loyalty card provide Harrah's with demographic information such as gender, age, and address, which is combined with transactional data as the card is used.
- Data mining also provides information about ninety-plus customer demographic segments, each of which responds differently to different marketing approaches.
- If Harrah's systems determine you're a high-value customer, you can expect a higher level of perks and service.
- Harrah's CRM effort monitors any customer behavior changes.
- Harrah's uses its information systems and operating procedures to measure employees based on metrics that include speed and friendliness, and compensates them based on guest satisfaction ratings.

Questions and Exercises

1. What types of customer data does Harrah's gather?
2. How is the data that Harrah's collects used?
3. Describe Harrah's most valuable customers? Approximately what percentage of profits does this broad group deliver to the firm?
4. List the services a Rewards Card cardholder might expect.
5. What happens when a good, regular customer stops showing up?
6. Describe how Harrah's treats customer data.
7. List some of the technology innovations that Harrah's is using to help it gather more data, and help push service quality and marketing program success.
8. How does Harrah's Total Rewards loyalty card system represent a switching cost?
9. What is customer lifetime value? Do you think this is an easier metric to calculate at Harrah's or Wal-Mart? Why?
10. How did intellectual property protection benefit Harrah's?
11. Discuss the challenges Harrah's may have to confront in the near future.
12. Describe the role that testing plays in initiatives? What advantage does testing provide the firm? What's the CEO's attitude to testing? Do you agree with this level of commitment? Why or why not?

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1.1.3: The Role of Information Systems

The Role of Information Systems

Now that we have explored the different components of information systems, we need to turn our attention to the role that information systems play in an organization. So far we have looked at what the components of an information system are, but what do these components actually do for an organization? From our definitions above, we see that these components collect, store, organize, and distribute data throughout the organization. In fact, we might say that one of the roles of information systems is to take data and turn it into information, and then transform that into organizational knowledge. As technology has developed, this role has evolved into the backbone of the organization. To get a full appreciation of the role information systems play, we will review how they have changed over the years.

IBM 704 Mainframe (Copyright: Lawrence Livermore National Laboratory)

The Mainframe Era

From the late 1950s through the 1960s, computers were seen as a way to more efficiently do calculations. These first business computers were room-sized monsters, with several refrigerator-sized machines linked together. The primary work of these devices was to organize and store large volumes of information that were tedious to manage by hand. Only large businesses, universities, and government agencies could afford them, and they took a crew of specialized personnel and specialized facilities to maintain. These devices served dozens to hundreds of users at a time through a process called time-sharing. Typical functions included scientific calculations and accounting, under the broader umbrella of "data processing."

IBM

Registered trademark of International Business Machines

In the late 1960s, the Manufacturing Resources Planning (MRP) systems were introduced. This software, running on a mainframe computer, gave companies the ability to manage the manufacturing process, making it more efficient. From tracking inventory to creating bills of materials to scheduling production, the MRP systems (and later the MRP II systems) gave more businesses a reason to want to integrate computing into their processes. IBM became the dominant mainframe company. Nicknamed "Big Blue," the company became synonymous with business computing. Continued improvement in software and the availability of cheaper hardware eventually brought mainframe computers (and their little sibling, the minicomputer) into most large businesses.

The PC Revolution

In 1975, the first microcomputer was announced on the cover of *Popular Mechanics*: the Altair 8800. Its immediate popularity sparked the imagination of entrepreneurs everywhere, and there were quickly dozens of companies making these "personal computers." Though at first just a niche product for computer hobbyists, improvements in usability and the availability of practical software led to growing sales. The most prominent of these early personal computer makers was a little company known as Apple Computer, headed by Steve Jobs and Steve Wozniak, with the hugely successful "Apple II." Not wanting to be left out of the revol ution, in 1981 IBM (teaming with a little company called Microsoft for their operating-system software) hurriedly released their own version of the personal computer, simply called the "PC." Businesses, who had used IBM mainframes for years to run their businesses, finally had the permission they needed to bring personal computers into their companies, and the IBM PC took off. The IBM PC was named *Time* magazine's "Man of the Year" for 1982.

Because of the IBM PC's open architecture, it was easy for other companies to copy, or "clone" it. During the 1980s, many new computer companies sprang up, offering less expensive versions of the PC. This drove prices down and spurred innovation. Microsoft developed itsWindows operating system and made the PC even easier to use. Common uses for the PC during this period included word processing, spreadsheets, and databases. These early PCs were not connected to any sort of network; for the most part they stood alone as islands of innovation within the larger organization.

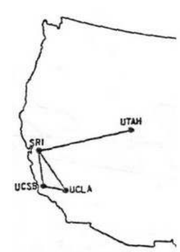
Client-Server

In the mid-1980s, businesses began to see the need to connect their computers together as a way to collaborate and share resources. This networking architecture was referred to as "client-server" because users would log in to the local area network (LAN) from their PC (the "client") by connecting to a powerful computer called a "server," which would then grant them rights to different resources on the network (such as shared file areas and a printer). Software companies began developing applications that allowed multiple users to access the same data at the same time. This evolved into software applications for communicating, with the first real popular use of electronic mail appearing at this time.

This networking and data sharing all stayed within the confines of each business, for the most part. While there was sharing of electronic data between companies, this was a very specialized function. Computers were now seen as tools to collaborate internally, within an organization. In fact, these networks of computers were becoming so powerful that they were replacing many of the functions previously performed by the larger mainframe computers at a fraction of the cost. It was during this era that the first Enterprise Resource Planning (ERP) systems were developed and run on the client-server architecture. An ERP system is a software application with a centralized database that can be used to run a company's entire business. With separate modules for accounting, finance, inventory, human resources, and many, many more, ERP systems, with Germany's SAP leading the way, represented the state of the art in information systems integration. We will discuss ERP systems as part of the chapter on process (chapter 9).

The World Wide Web and E-Commerce

First invented in 1969, the Internet was confined to use by universities, government agencies, and researchers for many years. Its ratherarcane commands and user applications made it unsuitable for mainstream use in business. One exception to this was the ability to expand electronic mail outside the confines of a single organization. While the first e-mail messages on the Internet were sent in the early 1970s, companies who wanted to expand their LAN-based e-mail started hooking up to the Internet in the 1980s. Companies began connecting their internal networks to the Internet in order to allow communication between their employees and employees at other companies. It was with these early Internet connections that the computer truly began to evolve from a computational device to a communications device.



In 1989, Tim Berners-Lee developed a simpler way for researchers to share information over the network at CERN laboratories, a concept he called the World Wide Web.[4] This invention became the launching point of the growth of the Internet as a way for businesses to share information about themselves. As web browsers and Internet connections became the norm, companies rushed to grab domain names and create websites.

Registered trademark of Amazon Technologies, Inc.

In 1991, the National Science Foundation, which governed how the Internet was used, lifted restrictions on its commercial use. The year 1994 saw the establishment of both eBay and Amazon.com, two true pioneers in the use of the new digital marketplace. A mad rush of investment in Internet-based businesses led to the dot-com boom through the late 1990s, and then the dot-com bust in 2000. While much can be learned from the speculation and crazy economic theories espoused during that bubble, one important outcome for businesses was that thousands of miles of Internet connections were laid around the world during that time. The world became truly “wired” heading into the new millenium, ushering in the era of globalization, which we will discuss in chapter 11.

As it became more expected for companies to be connected to the Internet, the digital world also became a more dangerous place. Computer viruses and worms, once slowly propagated through the sharing of computer disks, could now grow with tremendous speed via the Internet. Software written for a disconnected world found it very difficult to defend against these sorts of threats. A whole new industry of computer and Internet security arose. We will study information security in chapter 6.

Web 2.0

As the world recovered from the dot-com bust, the use of technology in business continued to evolve at a frantic pace. Websites became interactive; instead of just visiting a site to find out about a business and purchase its products, customers wanted to be able to customize their experience and interact with the business. This new type of interactive website, where you did not have to know how to create a web page or do any programming in order to put information online, became known as web 2.0. Web 2.0 is exemplified by blogging, social networking, and interactive comments being available on many websites. This new web-2.0 world, in which online interaction became expected, had a big impact on many businesses and even whole industries. Some industries, such as bookstores, found themselves relegated to a niche status. Others, such as video rental chains and travel agencies, simply began going out of business as they were replaced by online technologies. This process of technology replacing a middleman in a transaction is called disintermediation.

As the world became more connected, new questions arose. Should access to the Internet be considered a right? Can I copy a song that I downloaded from the Internet? How can I keep information that I have put on a website private? What information is acceptable to collect from children? Technology moved so fast that policymakers did not have enough time to enact appropriate laws, making for a Wild West–type atmosphere. Ethical issues surrounding information systems will be covered in chapter 12.

The Post-PC World

After thirty years as the primary computing device used in most businesses, sales of the PC are now beginning to decline as sales of tablets and smartphones are taking off. Just as the mainframe before it, the PC will continue to play a key role in business, but will no longer be the primary way that people interact and do business. The limited storage and processing power of these devices is being offset by a move to “cloud” computing, which allows for storage, sharing, and backup of the information on a massive scale. This will require new rounds of thinking and innovation on the part of businesses as technology continues to advance.

The Eras of Business Computing

Era	Hardware	Operating System	Applications
Mainframe (1970s)	Terminals connected to mainframe computer.	Time-sharing (TSO) on MVS	Custom-written MRP software
PC (mid-1980s)	IBM PC or compatible. Sometimes connected to mainframe computer via expansion card.	MS-DOS	WordPerfect, Lotus 1-2-3
Client-Server (late 80s to early 90s)	IBM PC “clone” on a Novell Network.	Windows for Workgroups	Microsoft Word, Microsoft Excel
World Wide Web (mid-90s to early 2000s)	IBM PC “clone” connected to company intranet.	Windows XP	Microsoft Office, Internet Explorer
Web 2.0 (mid-2000s to Early 2010s)	Laptop connected to company Wi-Fi. Apple iPhone, iPod, IPad	Windows XP-7 IOS	Microsoft Office, Firefox Google chrome
Post-PC (Early 2010s-Present)	IoT Devices, Cloud Computing, Virtual Reality	Windows 7-11 Windows Server	Visual Studio

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1.1.4: Competitive Advantage

Can Information Systems Bring Competitive Advantage?

It has always been the assumption that the implementation of information systems will, in and of itself, bring a business competitive advantage. After all, if installing one computer to manage inventory can make a company more efficient, won't installing several computers to handle even more of the business continue to improve it?

In 2003, Nicholas Carr wrote an article in the *Harvard Business Review* that questioned this assumption. The article, entitled "IT Doesn't Matter," raised the idea that information technology has become just a commodity. Instead of viewing technology as an investment that will make a company stand out, it should be seen as something like electricity: It should be managed to reduce costs, ensure that it is always running, and be as risk-free as possible.

As you might imagine, this article was both hailed and scorned. Can IT bring a competitive advantage? It sure did for Walmart (see sidebar). We will discuss this topic further in chapter 7.

Sidebar: Walmart Uses Information Systems to Become the World's Leading Retailer

File:Walmart_exteriorcropped.jpg)

Registered trademark of Wal-Mart Stores, Inc.

Walmart is the world's largest retailer, earning $15.2 billion on sales of $443.9 billion in the fiscal year that ended on January 31, 2012. Walmart currently serves over 200 million customers every week, worldwide.[5] Walmart's rise to prominence is due in no small part to their use of information systems.

One of the keys to this success was the implementation of Retail Link, a supply-chain management system. This system, unique when initially implemented in the mid-1980s, allowed Walmart's suppliers to directly access the inventory levels and sales information of their products at any of Walmart's more than ten thousand stores. Using Retail Link, suppliers can analyze how well their products are selling at one or more Walmart stores, with a range of reporting options. Further, Walmart requires the suppliers to use Retail Link to manage their own inventory levels. If a supplier feels that their products are selling out too quickly, they can use Retail Link to petition Walmart to raise the levels of inventory for their products. This has essentially allowed Walmart to "hire" thousands of product managers, all of whom have a vested interest in the products they are managing. This revolutionary approach to managing inventory has allowed Walmart to continue to drive prices down and respond to market forces quickly.

Today, Walmart continues to innovate with information technology. Using its tremendous market presence, any technology that Walmart requires its suppliers to implement immediately becomes a business standard.

Depending on which products and services a business offers, just as Nicholas mentioned, Information systems could be a utility as water and electricity that is required in order for you to succeed as a business in general. Walmart's growth had emerged in a time slot that business techniques and information technology had been still evolving, but it can be assumed that a vast majority of competing businesses achieved the same results as Walmart that may be unreported.

Just as at one point, having an Iphone or a Tesla was a huge sign of someone with wealth and or luck. Having those items is as common as drinking a water bottle. Businesses will need to get into the habit of managing their information systems for the ever changing demands of society and its clientele in order to maintain success. Putting a huge level of pressure on the technology used or types of practices that are implemented may introduce a certain level of growth or increase in sales, But it can not compare to a business that succeeds based on reputation or quality of service.

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1.1.5: Section 1 Summary

Summary

In this section, you have been introduced to the concept of information systems. We have reviewed several definitions, with a focus on the components of information systems: technology, people, data, and process. We have reviewed how the business use of information systems has evolved over the years, from the use of large mainframe computers for number crunching, through the introduction of the PC and networks, all the way to the era of mobile computing. During each of these phases, new innovations in software and technology allowed businesses to integrate technology more deeply.

As a Project Manager or System Analyst, you will have to have a great understanding of current technology trends and newer resources that will allow the organization you work for, or if you become a business owner, and stand a chance in the competitive world we live in. There are many resources freely available on the Internet and many resources that are available for purchase for you to understand how Information Technology has advanced and what skills you will need to have an understanding of.

Do not think that just because you already have experience building your own computer server, or have created some advanced software programs for your lab environments, you will succeed in a business environment. Businesses deal with many moving parts that require strong will and careful planning, As long as you are an individual who is open towards learning and is willing to take on the challenges that come with being a Project Manager or Systems Analyst, you will succeed.

Study Questions

1. What are the four components that make up an information system?
2. What are three examples of information system hardware?
3. What is application software?
4. What roles do people play in information systems?
5. What is the definition of a process?
6. In what year were restrictions on commercial use of the Internet first lifted? When were eBay and Amazon founded?
7. What does it mean to say we are in a “post-PC world”?
8. What is Carr’s main argument about information technology?

Exercises

1. Suppose that you had to explain to a member of your family or one of your closest friends the concept of an information system. How would you define it? Write a one-paragraph description *in your own words* that you feel would best describe an information system to your friends or family.
2. Of the five primary components of an information system (hardware, software, data, people, process), which do you think is the most important to the success of a business organization? Write a one-paragraph answer to this question that includes an example from your personal experience to support your answer.
3. We all interact with various information systems every day: at the grocery store, at work, at school, even in our cars (at least some of us). Make a list of the different information systems you interact with every day. See if you can identify the technologies, people, and processes involved in making these systems work.
4. Do you agree that we are in a post-PC stage in the evolution of information systems? Some people argue that we will always need the personal computer, but that it will not be the primary device used for manipulating information. Others think that a whole new era of mobile and biological computing is coming. Do some original research and make your prediction about what business computing will look like in the next generation.
5. The Walmart case study introduced you to how that company used information systems to become the world’s leading retailer. Walmart has continued to innovate and is still looked to as a leader in the use of technology. Do some original research and write a one-page report detailing a new technology that Walmart has recently implemented or is pioneering.

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1. Wikipedia entry on "Information Systems," as displayed on August 19, 2012. *Wikipedia: The Free Encyclopedia*. San Francisco: Wikimedia Foundation. http://en.Wikipedia.org/wiki/Informa...s_(discipline).↵
2. Excerpted from *Information Systems Today - Managing in the Digital World*, fourth edition. Prentice-Hall, 2010.↵
3. Excerpted from *Management Information Systems*, twelfth edition, Prentice-Hall, 2012.↵

4. CERN's "The Birth of the Web." http://public.web.cern.ch/public/en/about/web-en.html↵
5. Walmart 2012 Annual Report.↵

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SECTION OVERVIEW

1.2: Business Processes

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- define the term *business process*;
- identify the different systems needed to support business processes in an organization;
- explain the value of an enterprise resource planning (ERP) system;
- explain how business process management and business process reengineering work; and
- understand how information technology combined with business processes can bring an organization competitive advantage.

Introduction

In the previous section, we discussed some of the four major components of information systems. In this section, we will dive deeper into the inner workings of a business by discussing the fourth major component of an Information System: ***Process.*** A ***business process*** is *a series of steps that an organization performs.* Businesses are always performing numerous processes as they are juggling meeting the demands of customers and employees. Business owners need to be able to understand the needs of both parties involved if they want to have a successful organization. Being able to work with people can be very difficult because some employees will not comprehend the tasks that they are being asked to perform or they will misunderstand customers and cause potential problems for both the company and the client.

As the Project Manager or System Analyst, you must ensure that all of the steps being taken to complete a request for a brand new software, computer system, or new process must be organized and clear enough for you to be able to ensure success. If you fail to explicitly explain to your team what will be the proceeding steps or tasks that will need to be completed, you will risk losing your job, credibility, and money. Fear not! In this section, you will be introduced to tactics and some additional methodologies that businesses have followed to maintain order and structure.

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1.2.1: SWOT Analysis

Learning Objectives

1. Understand what SWOT analysis is.
2. Learn how SWOT analysis can help organizations and individuals, and its limitations.

Table 4.12 SWOT

Chess master Bruce Pandolfini has noted the similarities between business and chess. In both arenas, you must understand your own abilities as well as your flaws. You must also know your opponents, try to anticipate their moves, and deal with considerable uncertainty. A very popular management tool that incorporates the idea of understanding the elements internal and external to the firm is SWOT (strengths, weaknesses, opportunities, and threats) analysis. Strengths and weaknesses are assessed by examining the firm, while opportunities and threats refer to external events and trends. These ideas can be applied to individuals too. Below we offer examples of each element of SWOT analysis for organizations and for individuals who are seeking employment.

SWOT point	Organizational Examples	Individual Examples
Strenths	describes what an organization excels at and separates it from the competition: things like a strong brand, loyal customer base, strong balance sheet, unique technology, and so on. (Internal Influence)	Strong technical and language skills, as well as previous work experience, can help individuals rise above the competition.
Weaknesses	what stops an organization from performing at its optimum level? They are areas where the business needs to improve to remain competitive: things like higher-than-industry average turnover, high levels of debt, or no social media presence. (Internal Influence)	Poor communication skills keep many job seekers from being hired into sales and supervisory positions.
Opportunities	refers to favorable outside factors that an organization can use to give it a competitive advantage. For example, a car manufacturer may be able to export its cars into a new market, increasing sales and reaching untapped consumers. (External Influence)	The U.S. economy is increasingly services based, suggesting that individuals can enjoy more opportunities in service firms.
Threats	refers to factors that have the potential to harm an organization. Common threats include things like rising costs, increasing competition, tight labor supply, and so on. Weather could also be a threat for agricultural businesses (External Influence)	A tight job market poses challenges to new graduates.

Five forces analysis examines the situation faced by the competitors in an industry. Strategic groups analysis narrows the focus by centering on subsets of these competitors whose strategies are similar. SWOT analysis takes an even narrower focus by centering on an individual firm. Specifically, SWOT analysis is a tool that considers a firm’s **s**trengths and **w**eaknesses along with the **o**pportunities and **t**hreats that exist in the firm’s environment (Table 4.12).

Executives using SWOT analysis compare these internal and external factors to generate ideas about how their firm might become more successful. In general, it is wise to focus on ideas that allow a firm to leverage its strengths, steer clear of or resolve its weaknesses, capitalize on opportunities, and protect itself against threats. For example, untapped overseas markets have presented potentially lucrative opportunities to Subway and other restaurant chains such as McDonald's and Kentucky Fried Chicken. Meanwhile, Subway's strengths include a well-established brand name and a simple business format that can easily be adapted to other cultures. In considering the opportunities offered by overseas markets and Subway's strengths, it is not surprising that entering and expanding in different countries has been a key element of Subway's strategy in recent years. Indeed, Subway currently has operations in nearly 100 nations.

SWOT analysis is helpful to executives, and it is used within most organizations. Important cautions need to be offered about SWOT analysis, however. First, in laying out each of the four elements of SWOT, internal and external factors should not be confused with each other. It is important not to list strengths as opportunities, for example, if executives are to succeed at matching internal and external concerns during the idea generation process. Second, opportunities should not be confused with strategic moves designed to capitalize on these opportunities. In the case of Subway, it would be a mistake to list "entering new countries" as an opportunity. Instead, untapped markets are the opportunity presented to Subway, and entering those markets is a way for Subway to exploit the opportunity. Finally, and perhaps most important, the results of SWOT analysis should not be overemphasized. SWOT analysis is a relatively simple tool for understanding a firm's situation. As a result, SWOT is best viewed as a brainstorming technique for generating creative ideas, not as a rigorous method for selecting strategies. Thus the ideas produced by SWOT analysis offer a starting point for executives' efforts to craft strategies for their organization, not an ending point.

In addition to organizations, individuals can benefit from applying SWOT analysis to their personal situation. A college student who is approaching graduation, for example, could lay out her main strengths and weaknesses and the opportunities and threats presented by the environment. Suppose, for instance, that this person enjoys and is good at helping others (a strength) but also has a rather short attention span (a weakness). Meanwhile, opportunities to work at a rehabilitation center or to pursue an advanced degree are available. Our hypothetical student might be wise to pursue a job at the rehabilitation center (where her strength at helping others would be a powerful asset) rather than entering graduate school (where a lot of reading is required and her short attention span could undermine her studies).

Key Takeaway

- Executives using SWOT analysis compare internal strengths and weaknesses with external opportunities and threats to generate ideas about how their firm might become more successful. Ideas that allow a firm to leverage its strengths, steer clear of or resolve its weaknesses, capitalize on opportunities, and protect itself against threats are particularly helpful.

Exercises

1. What do each of the letters in SWOT represent?
2. What are your key strengths, and how might you build your own personal strategies for success around them?
3. Conduct a SWOT analysis of an organization of your choice.

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1.2.2: Documenting a Process

Documenting a Process

Every day, each of us will conduct many processes without even thinking about them: getting ready for work, using an ATM, reading our e-mail, etc. But as processes grow more complex, they need to be documented. For businesses, it is essential to do this, because it allows them to ensure control over how activities are undertaken in their organization. It also allows for standardization: McDonald’s has the same process for building a Big Mac in all of its restaurants.

The simplest way to document a process is to simply create a list. The list shows each step in the process; each step can be checked off upon completion. For example, a simple process, such as how to create an account on eBay, might look like this:

1. Go to ebay.com.
2. Click on “register.”
3. Enter your contact information in the “Tell us about you” box.
4. Choose your user ID and password.
5. Agree to User Agreement and Privacy Policy by clicking on “Submit.”

Documenting a process in list format may be beneficial for minor uses or quick fixes; however, if the process is more extensive, listing every detail will cause disorganization. It is best to invest in resources that help manage all of the activities and resources that are required. The ability of a business to effectively document processes and activities can determine the overall efficiency of the business.

There are a great number of office applications (both free and paid) that can help efficiently document processes and business activities. ***Microsoft*** offers many resources that are designed for businesses to manage their business as efficiently as possible, inclusive towards developing efficient information systems. There are too many to list in this section, however; you can do research to see what other resources will be beneficial for your company and its needs.

For processes that are not so straightforward, documenting the process as a checklist may not be sufficient. For example, here is the process for determining if an article for a term needs to be added to Wikipedia:

1. Search Wikipedia to determine if the term already exists.
2. If the term is found, then an article is already written, so you must think of another term. Go to 1.
3. If the term is not found, then look to see if there is a related term.
4. If there is a related term, then create a redirect.
5. If there is not a related term, then create a new article.

This procedure is relatively simple – in fact, it has the same number of steps as the previous example – but because it has some decision points, it is more difficult to track with as a simple list. In these cases, it may make more sense to use a diagram to document the process:

Process diagram for determining if a new term should be added to Wikipedia (click to enlarge). (Public Domain)

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1.2.2.1: Managing Documentation

Managing Business Process Documentation

As organizations begin to document their processes, it becomes an administrative task to keep track of them. As processes change and improve, it is important to know which processes are the most recent. It is also important to manage the process so that it can be easily updated! The requirement to manage process documentation has been one of the driving forces behind the creation of the *document management system*. A document management system stores and tracks documents and supports the following functions:

- Versions and timestamps. The document management system will keep multiple versions of documents. The most recent version of a document is easy to identify and will be served up by default.
- Approvals and workflows. When a process needs to be changed, the system will manage both access to the documents for editing and the routing of the document for approvals.
- Communication. When a process changes, those who implement the process need to be made aware of the changes. A document management system will notify the appropriate people when a change to a document is approved.

Of course, document management systems are not only used for managing business process documentation. Many other types of documents are managed in these systems, such as legal documents or design documents.

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1.2.3: ERP Systems

ERP Systems

An enterprise resource planning (ERP) system is a software application with a centralized database that can be used to run an entire company. Let's take a closer look at the definition of each of these components:

Software application: The system is a software application, which means that it has been developed with specific logic and rules behind it. It has to be installed and configured to work specifically for an individual organization.

Centralized database: All data in an ERP system is stored in a single, central database. This centralization is key to the success of an ERP **–** data entered in one part of the company can be immediately available to other parts of the company.

ERP Systems can be used to run an entire company: companies can purchase modules for an ERP that represent different functions within the organization, such as finance, manufacturing, and sales. Some companies choose to purchase many modules, others choose a subset of the modules.

An ERP system not only centralizes an organization's data, but the processes it enforces are the processes the organization adopts. When an ERP vendor designs a module, it has to implement the rules for the associated business processes. A selling point of an ERP system is that it has best practices built right into it. In other words, when an organization implements an ERP, it also gets improved best practices as part of the deal!

For many organizations, the implementation of an ERP system is an excellent opportunity to improve their business practices and upgrade their software at the same time. But for others, an ERP brings them a challenge: Is the process embedded in the ERP really better than the process they are currently utilizing? And if they implement this ERP, and it happens to be the same one that all of their competitors have, will they simply become more like them, making it much more difficult to differentiate themselves?

Registered trademark of SAP

This has been one of the criticisms of ERP systems: that they commoditize business processes, driving all businesses to use the same processes and thereby lose their uniqueness. The good news is that ERP systems also have the capability to be configured with custom processes. For organizations that want to continue using their own processes or even design new ones, ERP systems offer ways to support this through the use of customizations.

But there is a drawback to customizing an ERP system: organizations have to maintain the changes themselves. Whenever an update to the ERP system comes out, any organization that has created a custom process will be required to add that change to their ERP. This will require someone to maintain a listing of these changes and will also require retesting the system every time an upgrade is made. Organizations will have to wrestle with this decision: When should they go ahead and accept the best-practice processes built into the ERP system and when should they spend the resources to develop their own processes? It makes the most sense to only customize those processes that are critical to the competitive advantage of the company.

Some of the best-known ERP vendors are SAP, Microsoft, and Oracle.

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1.2.4: Process Management

Business Process Management

Organizations that are serious about improving their business processes will also create structures to manage those processes. Business process management (BPM) can be thought of as an intentional effort to plan, document, implement, and distribute an organization's business processes with the support of information technology.

BPM is more than just automating some simple steps. While automation can make a business more efficient, it cannot be used to provide a competitive advantage. BPM, on the other hand, can be an integral part of creating that advantage.

Not all of an organization's processes should be managed this way. An organization should look for processes that are essential to the functioning of the business and those that may be used to bring a competitive advantage. The best processes to look at are those that include employees from multiple departments, those that require decision-making that cannot be easily automated, and processes that change based on circumstances.

To make this clear, let's take a look at an example.

Suppose a large clothing retailer is looking to gain a competitive advantage through superior customer service. As part of this, they create a task force to develop a state-of-the-art returns policy that allows customers to return any article of clothing, no questions asked. The organization also decides that, in order to protect the competitive advantage that this returns policy will bring, they will develop their own customization to their ERP system to implement this returns policy. As they prepare to roll out the system, they invest in training for all of their customer-service employees, showing them how to use the new system and specifically how to process returns. Once the updated returns process is implemented, the organization will be able to measure several key indicators about returns that will allow them to adjust the policy as needed. For example, if they find that many women are returning their high-end dresses after wearing them once, they could implement a change to the process that limits – to, say, fourteen days – the time after the original purchase that an item can be returned. As changes to the returns policy are made, the changes are rolled out via internal communications, and updates to the returns processing on the system are made. In our example, the system would no longer allow a dress to be returned after fourteen days without an approved reason.

If done properly, business process management will provide several key benefits to an organization, which can be used to contribute to competitive advantage. These benefits include:

- Empowering employees. When a business process is designed correctly and supported with information technology, employees will be able to implement it on their own authority. In our returns-policy example, an employee would be able to accept returns made before fourteen days or use the system to make determinations on what returns would be allowed after fourteen days.
- Built-in reporting. By building measurement into the programming, the organization can keep up to date on key metrics regarding their processes. In our example, these can be used to improve the returns process and also, ideally, to reduce returns.
- Enforcing best practices. As an organization implements processes supported by information systems, it can work to implement the best practices for that class of business process. In our example, the organization may want to require that all customers returning a product without a receipt show a legal ID. This requirement can be built into the system so that the return will not be processed unless a valid ID number is entered.
- Enforcing consistency. By creating a process and enforcing it with information technology, it is possible to create a consistency across the entire organization. In our example, all stores in the retail chain can enforce the same returns policy. And if the returns policy changes, the change can be instantly enforced across the entire chain.

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1.2.4.1: Process Re-engineering

Business Process Re-engineering

As organizations look to manage their processes to gain a competitive advantage, they also need to understand that their existing ways of doing things may not be the most effective or efficient. A process developed in the 1950s is not going to be better just because it is now supported by technology.

In 1990, Michael Hammer published an article in the *Harvard Business Review* entitled “Reengineering Work: Don’t Automate, Obliterate.” This article put forward the thought that simply automating a bad process does not make it better. Instead, companies should “blow up” their existing processes and develop new processes that take advantage of the new technologies and concepts. He states in the introduction to the article:[1]

Many of our job designs, work flows, control mechanisms, and organizational structures came of age in a different competitive environment and before the advent of the computer. They are geared towards greater efficiency and control. Yet the watchwords of the new decade are innovation and speed, service, and quality.

It is time to stop paving the cow paths. Instead of embedding outdated processes in silicon and software, we should obliterate them and start over. We should “reengineer” our businesses: use the power of modern information technology to radically redesign our business processes in order to achieve dramatic improvements in their performance.

Business process reengineering is not just taking an existing process and automating it. BPR is fully understanding the goals of a process and then dramatically redesigning it from the ground up to achieve dramatic improvements in productivity and quality. But this is easier said than done. Most of us think in terms of how to do small, local improvements to a process; complete redesign requires thinking on a larger scale. Hammer provides some guidelines for how to go about doing business process reengineering:

- Organize around outcomes, not tasks. This simply means to design the process so that, if possible, one person performs all the steps. Instead of repeating one step in the process over and over, the person stays involved in the process from start to finish.
- Have those who use the outcomes of the process perform the process. Using information technology, many simple tasks are now automated, so we can empower the person who needs the outcome of the process to perform it. The example Hammer gives here is purchasing: instead of having every department in the company use a purchasing department to order supplies, have the supplies ordered directly by those who need the supplies using an information system.
- Subsume information-processing work into the real work that produces the information. When one part of the company creates information (like sales information, or payment information), it should be processed by that same department. There is no need for one part of the company to process information created in another part of the company.
- Treat geographically dispersed resources as though they were centralized. With the communications technologies in place today, it becomes easier than ever to not worry about physical location. A multinational organization does not need separate support departments (such as IT, purchasing, etc.) for each location anymore.
- Link parallel activities instead of integrating their results. Departments that work in parallel should be sharing data and communicating with each other during their activities instead of waiting until each group is done and then comparing notes.
- Put the decision points where the work is performed, and build controls into the process. The people who do the work should have decision-making authority and the process itself should have built-in controls using information technology.
- Capture information once, at the source. Requiring information to be entered more than once causes delays and errors. With information technology, an organization can capture it once and then make it available whenever needed.

These principles may seem like common sense today, but in 1990 they took the business world by storm. Hammer gives example after example of how organizations improved their business processes by many orders of magnitude without adding any new employees, simply by changing how they did things (see sidebar).

Unfortunately, business process reengineering got a bad name in many organizations. This was because it was used as an excuse for cost cutting that really had nothing to do with BPR. For example, many companies simply used it as an excuse for laying off part of their workforce. Today, however, many of the principles of BPR have been integrated into businesses and are considered part of good business-process management.

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1.2.4.2: Sample of Re-engineering

Reengineering the College Bookstore

The process of purchasing the correct textbooks in a timely manner for college classes has always been problematic. And now, with online bookstores such as Amazon competing directly with the college bookstore for students' purchases, the college bookstore is under pressure to justify its existence.

But college bookstores have one big advantage over their competitors: they have access to students' data. In other words, once a student has registered for classes, the bookstore knows exactly what books that student will need for the upcoming term. To leverage this advantage and take advantage of new technologies, the bookstore wants to implement a new process that will make purchasing books through the bookstore advantageous to students. Though they may not be able to compete on price, they can provide other advantages, such as reducing the time it takes to find the books and the ability to guarantee that the book is the correct one for the class. In order to do this, the bookstore will need to undertake a process redesign.

The goal of the process redesign is simple: capture a higher percentage of students as customers of the bookstore. After diagramming the existing process and meeting with student focus groups, the bookstore comes up with a new process. In the new process, the bookstore utilizes information technology to reduce the amount of work the students need to do in order to get their books. In this new process, the bookstore sends the students an e-mail with a list of all the books required for their upcoming classes. By clicking a link in this e-mail, the students can log into the bookstore, confirm their books, and purchase the books. The bookstore will then deliver the books to the students.

College bookstore process redesign (click to enlarge)

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1.2.5: Section 2 Summary

Summary

The advent of information technologies has had a huge impact on how organizations design, implement, and support business processes. From document management systems to ERP systems, information systems are tied into organizational processes. Using business process management, organizations can empower employees and leverage their processes for competitive advantage. Using business process reengineering, organizations can vastly improve their effectiveness and the quality of their products and services. Integrating information technology with business processes is one way that information systems can bring an organization lasting competitive advantage.

Study Questions

1. What does the term *business process* mean?
2. What are three examples of business process from a job you have had or an organization you have observed?
3. What is the value in documenting a business process?
4. What is an ERP system? How does an ERP system enforce best practices for an organization?
5. What is one of the criticisms of ERP systems?
6. What is business process reengineering? How is it different from incrementally improving a process?
7. Why did BPR get a bad name?
8. List the guidelines for redesigning a business process.
9. What is business process management? What role does it play in allowing a company to differentiate itself?

Exercises

1. Think of a business process that you have had to perform in the past. How would you document this process? Would a diagram make more sense than a checklist? Document the process both as a checklist and as a diagram.
2. Review the return policies at your favorite retailer, then answer this question: What information systems do you think would need to be in place to support their return policy.
3. If you were implementing an ERP system, in which cases would you be more inclined to modify the ERP to match your business processes? What are the drawbacks of doing this?
4. Which ERP is the best? Do some original research and compare three leading ERP systems to each other. Write a two- to three-page paper that compares their features.

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1. Hammer, Michael. "Reengineering work: don't automate, obliterate." *Harvard Business Review* 68.4 (1990): 104–112.↵

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CHAPTER OVERVIEW

2: Information Systems Development & RFPs

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- explain the overall process of developing a new software application
- explain the differences between software development methodologies
- understand the different types of programming languages used to develop software
- understand some of the issues surrounding the development of websites and mobile applications
- identify the four primary implementation policies

2.1: Introduction

When someone has an idea for a new function to be performed by a computer, how does that idea become reality? If a company wants to implement a new business process and needs new hardware or software to support it, how do they go about making it happen? When someone goes to buy a house, a car, or make any kind of purchase, there is always a process that the individual or team undergoes before making their final selection. Throughout this chapter, you will learn the concept of ***Information Systems Development***. Depending on where you search out on the internet, there are many methodologies and resources to help organizations properly implement new technology, software, networks, and business processes. As a Project Manager or System Analyst, you will need to familiarize yourself with the way the company you work for develops or implement new ideas. It may also be your responsibility to have your own way of executing a project.

Before you begin the process of developing the information systems, you must be able to understand the fundamentals of a proposal. A **proposal is a written request or suggestion for a new product, service, or idea to be implemented.** You will receive all projects to be completed and business ideas in the form of a written proposal; in which, you will be required to read the entire form to understand its constraints and guidelines.

Software development will require detailed and timely steps before full implementation. If you as the Project Manager or Systems Analyst, be sure to take careful and purposeful steps before proceeding to the next stage in the development process. In most projects, you will have teams of people involved that sponsor the project, responsible for blueprinting, & adjusting to any last-minute changes.

The ***Systems Development Life Cycle*** is a methodology designed to give detailed steps to take for project managers or system analysts to take for the completion of a project to develop a system.

We will dive deeper into each of these terms in the proceeding sections...

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2.1: SDLC

2.1.1: Systems-Development Life Cycle

The first development methodology we are going to review is the ***Systems Development Life Cycle (SDLC)***. This methodology was first developed in the 1960s to manage the large software projects associated with corporate systems running on mainframes. It is a very structured and risk-averse methodology designed to manage large projects that included multiple programmers and systems that would have a large impact on the organization.

SDLC waterfall (click to enlarge)

Various definitions of the SDLC methodology exist, but most contain the following phases.

1. **Preliminary Analysis**. In this phase, a review is done of the request. Is creating a solution possible? What alternatives exist? What is currently being done about it? Is this project a good fit for our organization? A key part of this step is a feasibility analysis, which includes an analysis of the technical feasibility (is it possible to create this?), the economic feasibility (can we afford to do this?), and the legal feasibility (are we allowed to do this?). This step is important in determining if the project should even get started.
2. **System Analysis.** In this phase, one or more system analysts work with different stakeholder groups to determine the specific requirements for the new system. No programming is done in this step. Instead, procedures are documented, key players are interviewed, and data requirements are developed in order to get an overall picture of exactly what the system is supposed to do. The result of this phase is a system-requirements document.
3. **System Design.** In this phase, a designer takes the system-requirements document created in the previous phase and develops the specific technical details required for the system. It is in this phase that the business requirements are translated into specific technical requirements. The design for the user interface, database, data inputs and outputs, and reporting are developed here. The result of this phase is a system-design document. This document will have everything a programmer will need to actually create the system.
4. **Development.** The system becomes further established in the development phase. Using the system-design document as a guide, a programmer (or team of programmers) develops the program. The result of this phase is an initial working program that meets the requirements laid out in the system-analysis phase and the design developed in the system-design phase.
5. **Testing**. In the testing phase, the software program or system developed in the previous phase is put through a series of structured tests. The first is a unit test, which tests individual parts of the code or system for errors or bugs. Next is a system test, where the different components of the system are tested to ensure that they work together properly. Finally, the user-acceptance test allows those that will be using the software to test the system to ensure that it meets their standards. Any bugs, errors, or problems found during testing are addressed and then tested again.
6. **Implementation.** Once the new system is developed and tested, it has to be implemented in the organization. This phase includes training the users, providing documentation, and converting from any previous system to the new system. Implementation can take many forms, depending on the type of system, the number and type of users, and how urgent it is that the system becomes operational. These different forms of implementation are covered later in the chapter.
7. **Maintenance.** This final phase takes place once the implementation phase is complete. In this phase, the system has a structured support process in place: reported bugs are fixed and requests for new features are evaluated and implemented; system updates and backups are performed on a regular basis.

The SDLC methodology is sometimes referred to as the waterfall methodology to represent how each step is a separate part of the process; only when one step is completed can another step begin. After each step, an organization must decide whether to move to the next step or not. This methodology has been criticized for being quite rigid. For example, changes to the requirements are not allowed once the process has begun. No software is available until after the programming phase.

Again, SDLC was developed for large, structured projects. Projects using SDLC can sometimes take months or years to complete. Because of its inflexibility and the availability of new programming techniques and tools, many other software-development methodologies have been developed. Many of these retain some of the underlying concepts of SDLC but are not as rigid.

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2.1.1: Agile and Lean Methods

2.1.1.1: Agile Methodologies

Agile methodologies are a group of methodologies that utilize incremental changes with a focus on quality and attention to detail. Each increment is released in a specified period of time (called a time box), creating a regular release schedule with very specific objectives. While considered a separate methodology from RAD, they share some of the same principles: iterative development, user interaction, ability to change. The agile methodologies are based on the "Agile Manifesto," first released in 2001.

The characteristics of agile methods include:

- small cross-functional teams that include development-team members and users;
- daily status meetings to discuss the current state of the project;
- short time-frame increments (from days to one or two weeks) for each change to be completed; and
- at the end of each iteration, a working project is completed to demonstrate to the stakeholders.

The goal of the agile methodologies is to provide the flexibility of an iterative approach while ensuring a quality product.

2.1.1.2: Lean Methodology

The lean methodology (click to enlarge)

One last methodology we will discuss is a relatively new concept taken from the business bestseller *The Lean Startup*, by Eric Reis. In this methodology, the focus is on taking an initial idea and developing a minimum viable product (MVP). The MVP is a working software application with just enough functionality to demonstrate the idea behind the project. Once the MVP is developed, it is given to potential users for review. Feedback on the MVP is generated in two forms: (1) direct observation and discussion with the users, and (2) usage statistics gathered from the software itself. Using these two forms of feedback, the team determines whether they should continue in the same direction or rethink the core idea behind the project, change the functions, and create a new MVP. This change in strategy is called a pivot. Several iterations of the MVP are developed, with new functions added each time based on the feedback, until a final product is completed.

The biggest difference between the lean methodology and the other methodologies is that the full set of requirements for the system are not known when the project is launched. As each iteration of the project is released, the statistics and feedback gathered are used to determine the requirements. The lean methodology works best in an entrepreneurial environment where a company is interested in determining if their idea for a software application is worth developing.

Sidebar: The Quality Triangle

The quality triangle

When developing software, or any sort of product or service, there exists a tension between the developers and the different stakeholder groups, such as management, users, and investors. This tension relates to how quickly the software can be developed (time), how much money will be spent (cost), and how well it will be built (quality). The quality triangle is a simple concept. It states that for any product or service being developed, you can only address two of the following: time, cost, and quality.

So what does it mean that you can only address two of the three? It means that you cannot complete a low-cost, high-quality project in a small amount of time. However, if you are willing or able to spend a lot of money, then a project can be completed quickly with high-quality results (through hiring more good programmers). If a project's completion date is not a priority, then it can be completed at a lower cost with higher-quality results. Of course, these are just generalizations, and different projects may not fit this model perfectly. But overall, this model helps us understand the tradeoffs that we must make when we are developing new products and services.

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2.1.2: Rapid App Dev

2.1.2.1: Rapid Application Development

The RAD methodology (Public Domain)

Rapid application development (RAD) is a software-development (or systems-development) methodology that focuses on quickly building a working model of the software, getting feedback from users, and then using that feedback to update the working model. After several iterations of development, a final version is developed and implemented.

The RAD methodology consists of four phases:

1. Requirements Planning. This phase is similar to the preliminary-analysis, system-analysis, and design phases of the SDLC. In this phase, the overall requirements for the system are defined, a team is identified, and feasibility is determined.
2. User Design. In this phase, representatives of the users work with the system analysts, designers, and programmers to interactively create the design of the system. One technique for working with all of these various stakeholders is the so-called JAD session. JAD is an acronym for joint application development. A JAD session gets all of the stakeholders together to have a structured discussion about the design of the system. Application developers also sit in on this meeting and observe, trying to understand the essence of the requirements.
3. Construction. In the construction phase, the application developers, working with the users, build the next version of the system.This is an interactive process, and changes can be made as developers are working on the program. This step is executed in parallel with the User Design step in an iterative fashion, until an acceptable version of the product is developed.
4. Cutover. In this step, which is similar to the implementation step of the SDLC, the system goes live. All steps required to move from the previous state to the use of the new system are completed here.

As you can see, the RAD methodology is much more compressed than SDLC. Many of the SDLC steps are combined and the focus is on user participation and iteration. This methodology is much better suited for smaller projects than SDLC and has the added advantage of giving users the ability to provide feedback throughout the process. SDLC requires more documentation and attention to detail and is well suited to large, resource-intensive projects. RAD makes more sense for smaller projects that are less resource-intensive and need to be developed quickly.

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2.2: IDE / CASE

2.2.1: Programming Tools

To write a program, a programmer needs little more than a text editor and a good idea. However, to be productive, he or she must be able to check the syntax of the code, and, in some cases, compile the code. To be more efficient at programming, additional tools, such as an integrated development environment (IDE) or computer-aided software-engineering (CASE) tools, can be used.

2.2.1.1: Integrated Development Environment

For most programming languages, an IDE can be used. An IDE provides a variety of tools for the programmer, and usually includes:

- an editor for writing the program that will color-code or highlight keywords from the programming language;
- a help system that gives detailed documentation regarding the programming language;
- a compiler/interpreter, which will allow the programmer to run the program;
- a debugging tool, which will provide the programmer details about the execution of the program in order to resolve problems in the code; and
- a check-in/check-out mechanism, which allows for a team of programmers to work together on a project and not write over each other's code changes.

Probably the most popular IDE software package right now is Microsoft's Visual Studio. Visual Studio is the IDE for all of Microsoft's programming languages, including Visual Basic, Visual C++, and Visual C#.

2.2.1.2: CASE Tools

While an IDE provides several tools to assist the programmer in writing the program, the code still must be written. Computer-aided software-engineering (CASE) tools allow a designer to develop software with little or no programming. Instead, the CASE tool writes the code for the designer. CASE tools come in many varieties, but their goal is to generate quality code based on input created by the designer.

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2.3: Build, Buy, or Rent?

Build vs. Buy

When an organization decides that a new software program needs to be developed, they must determine if it makes more sense to build it themselves or to purchase it from an outside company. This is the “build vs. buy” decision.

There are many advantages to purchasing software from an outside company. First, it is generally less expensive to purchase a software package than to build it. Second, when a software package is purchased, it is available much more quickly than if the package is built in-house. Software applications can take months or years to build; a purchased package can be up and running within a month. A purchased package has already been tested and many of the bugs have already been worked out. It is the role of a systems integrator to make various purchased systems and the existing systems at the organization work together.

There are also disadvantages to purchasing software. First, the same software you are using can be used by your competitors. If a company is trying to differentiate itself based on a business process that is in that purchased software, it will have a hard time doing so if its competitors use the same software. Another disadvantage to purchasing software is the process of customization. If you purchase a software package from a vendor and then customize it, you will have to manage those customizations every time the vendor provides an upgrade. This can become an administrative headache, to say the least!

Even if an organization determines to buy software, it still makes sense to go through many of the same analyses that they would do if they were going to build it themselves. This is an important decision that could have a long-term strategic impact on the organization.

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2.4: Cloud Computing- Hype or Hope?

Learning Objectives

After studying this section you should be able to do the following:

1. Understand the concept of cloud computing.
2. Identify the two major categories of cloud computing.

Oracle Chairman Larry Ellison, lamenting the buzzword-chasing character of the tech sector, once complained that the computer industry is more fashion-focused than even the women's clothing business (Farber, 2008). Ellison has a point: when a technology term becomes fashionable, the industry hype machine shifts into overdrive. The technology attracts press attention, customer interest, and vendor marketing teams scramble to label their products and services as part of that innovation. Recently, few tech trends have been more fashionable than *cloud computing*.

Like Web 2.0, trying to nail down an exact definition for cloud computing is tough. In fact, it's been quite a spectacle watching industry execs struggle to clarify the concept. HP's Chief Strategy Office "politely refused" when asked by *BusinessWeek* to define the term cloud computing (Hamm, 2008). Richard Stallman, founder of the Free Software Foundation said about cloud computing, "It's worse than stupidity. It's a marketing hype campaign" (McKay, 2009). And Larry Ellison, always ready with a sound bite, offered up this priceless quip, "Maybe I'm an idiot, but I have no idea what anyone is talking about. What is it? It's complete gibberish. It's insane" (Lyons, 2008). Insane, maybe, but also big bucks. By year-end 2008, the various businesses that fall under the rubric of cloud computing had already accounted for an estimated thirty-six-billion-dollar market. That represents a whopping 13 percent of global software sales (Liedtke, 2008)!

When folks talk about cloud computing they're really talking about replacing computing resources—either an organization's or an individual's hardware or software—with *services* provided over the Internet. The name actually comes from the popular industry convention of drawing the Internet or other computer network as a big cloud.

Cloud computing encompasses a bunch of different efforts. We'll concentrate on describing, providing examples, and analyzing the managerial implications of two separate categories of cloud computing: (1) *software as a service* (*SaaS*), where a firm subscribes to a third-party software-replacing service that is delivered online, and (2) models often referred to as utility computing, *platform as a service, or infrastructure as a service*. Using these latter techniques, an organization develops its own systems, but runs them over the Internet on someone else's hardware. A later section on virtualization will discuss how some organizations are developing their own private clouds, pools of computing resources that reside inside an organization and that can be served up for specific tasks as need arrives.

The benefits and risks of SaaS and the utility computing-style efforts are very similar, but understanding the nuances of each effort can help you figure out if and when the cloud makes sense for your organization. The evolution of cloud computing also has huge implications across the industry: from the financial future of hardware and software firms, to cost structure and innovativeness of adopting organizations, to the skill sets likely to be most valued by employers.

Key Takeaways

- Cloud computing is difficult to define. Managers and techies use the term cloud computing to describe computing services provided over a network, most often commercial services provided over the Internet by a third party that can replace or offload tasks that would otherwise run on a user or organization's existing hardware or software.
- Software as a service (SaaS) refers to a third-party software-replacing service that is delivered online.
- Hardware cloud computing services replace hardware that a firm might otherwise purchase.
- Estimated to be a thirty-six-billion-dollar industry, cloud computing is reshaping software, hardware, and service markets, and is impacting competitive dynamics across industries.

Questions and Exercises

1. Identify and contrast the two categories of cloud computing.
2. Define cloud computing.

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2.4.1: Clouds and Tech Industry Impact

Learning Objectives

After studying this section you should be able to do the following:

1. Understand how cloud computing's impact across industries is proving to be broad and significant.
2. Know the effects of cloud computing on high-end server sales and the influence on the trend shifting from hardware sales to service.
3. Know the effects of cloud computing on innovation and the influence on the changes in the desired skills mix and job outlook for IS workers.
4. Know that by lowering the cost to access powerful systems and software, cloud computing can decrease barriers to entry.
5. Understand the importance, size, and metrics of server farms.

Although still a relatively recent phenomenon, cloud computing's impact across industries is already proving to be broad and significant.

Cloud computing is affecting the competitive dynamics of the hardware, software, and consulting industries. In the past, firms seeking to increase computing capacity invested heavily in expensive, high margin server hardware, creating a huge market for computer manufacturers. But now hardware firms find these markets may be threatened by the cloud. The trend shifting from hardware to services is evident in IBM's quarterly numbers. The firm recently reported its overall earnings were up 12 percent, even though hardware sales were off by 20 percent (Fortt, 2009). What made up the difference? The growth of Big Blue's services business. IBM is particularly well positioned to take advantage of the shift to services because it employs more technology consultants than any other firm in the world, while most of its competitors are forced to partner to offer something comparable. Consulting firm Capgemini's partnership to offer cloud services through Amazon is one such example.

The shift to cloud computing also alters the margin structure for many in the computing industry. While Moore's Law has made servers cheap, deploying SaaS and operating a commercial cloud is still very expensive—much more so than simply making additional copies of conventional, packaged software. Microsoft surprised Wall Street when it announced it would need to pour at least $2 billion more than analysts expected into the year's server farm capital spending. The firm's stock—among the world's most widely held—sank 11 percent in a day (Mehta, 2006). As a result, many portfolio managers started paying closer attention to the business implications of the cloud.

Cloud computing can accelerate innovation and therefore changes the desired skills mix and job outlook for IS workers. If cloud computing customers spend less on expensive infrastructure investments, they potentially have more money to reinvest in strategic efforts and innovation. IT careers may change, too. Demand for nonstrategic skills like hardware operations and maintenance are likely to decrease. Organizations will need more business-focused technologists who intimately understand a firm's competitive environment, and can create systems that add value and differentiate the firm from its competition (Fortt, 2009). While these tech jobs require more business training, they're also likely to be more durable and less likely to be outsourced to a third party with a limited understanding of the firm.

By lowering the cost to access powerful systems and software, barriers to entry also decrease. Firms need to think about the strategic advantages they can create, even as technology is easily duplicated. This trend means the potential for more new entrants across industries, and since start-ups can do more with less, it's also influencing entrepreneurship and venture capital. The CTO of SlideShare, a start-up that launched using Amazon's S3 storage cloud, offers a presentation on his firm's site labeled "Using S3 to Avoid VC." Similarly, the CEO of online payments start-up Zuora claims to have saved between half a million and $1 million by using cloud computing: "We have no servers, we run the entire business in the cloud" (Ackerman, 2008). And the sophistication of these tools lowers development time. Enterprise firm Apttus claims it was able to perform the equivalent of six months of development in a couple of weekends by using cloud services. The firm scored its first million-dollar deal in three months, and was break-even in nine months, a ramp-up time that would have been unheard of, had they needed to plan, purchase, and deploy their own data center, and create from scratch the Web services that were provided by its cloud vendor (Rapyort, 2008).

So What's It Take to Run This Thing?

In the countryside surrounding the Columbia River in the Pacific Northwest, potato farms are yielding to server farms. Turns out the area is tailor made for creating the kinds of massive data installations that form the building blocks of cloud computing. The land is cheap, the region's hydroelectric power costs a fraction of Silicon Valley rates, and the area is served by ultrafast fiber-optic connections. Even the area's mild temperatures cut cooling costs.

Most major players in cloud computing have server farms in the region, each with thousands of processors humming away simultaneously. Microsoft's Quincy, Washington, facility is as big as ten American football fields and has nearly six hundred miles of wiring, 1.5 metric tons of battery backup, and three miles of chiller piping to keep things cool. Storage is big enough to store 6.75 trillion photos. Just a short drive away, Yahoo has two facilities on fifty acres, including one that runs at a zero carbon footprint. Google has a thirty-acre site sprawled across former farmland in The Dalles, Oregon. The Google site includes two massive buildings, with a third on the way. And in Boardman, Oregon, Amazon has a three building petabyte palace that sports its own ten-megawatt electrical substation (Katz, 2009).

While U.S. activity has been particularly intense in the Pacific Northwest, server farms that support cloud computing are popping up from Shanghai to São Paulo. Not only does a diverse infrastructure offer a degree of fault tolerance and disaster recovery (Oregon down? Shift to North Carolina), the myriad of national laws and industry-specific regulatory environments may require some firms to keep data within a specific country or region. To meet the challenge, cloud vendors are racing to deploy infrastructure worldwide and allowing customers to select regional availability zones for their cloud computing needs.

The build-out race has become so intense that many firms have developed rapid-deployment server farm modules that are preconfigured and packed inside shipping containers. Some of these units contain as many as three thousand servers each. Just drop the containers on-site, link to power, water, and telecom, and presto—you've got yourself a data center. More than two hundred containers can be used on a single site. One Microsoft VP claimed the configuration has cut the time to open a data center to just a few days, claiming Microsoft's San Antonio facility was operational in less time than it took a local western wear firm to deliver her custom-made cowboy boots (Burrows, 2008)! Microsoft's Dublin-based fourth generation data center will be built entirely of containers—no walls or roof—using the outside air for much of the cooling (Vanderbilt, 2009).

While firms are buying less hardware, cloud vendors have turned out to be the computing industry's best customers. Amazon has spent well over $2 billion on its cloud infrastructure. Google reportedly has 1.4 million servers operating across three dozen data centers (Katz, 2009). Demonstrating it won't be outdone, Microsoft plans to build as many as twenty server farms, at costs of up to $1 billion each (Burrows, 2008). Look for the clouds to pop up in unexpected places. Microsoft has scouted locations in Siberia, while Google has applied to patent a method for floating data centers on an offshore platform powered by wave motions (Katz, 2009).

Key Takeaways

- Cloud computing's impact across industries is proving to be broad and significant.
- Clouds can lower barriers to entry in an industry, making it easier for start-ups to launch and smaller firms to leverage the backing of powerful technology.
- Clouds may also lower the amount of capital a firm needs to launch a business, shifting power away from venture firms in those industries that had previously needed more VC money.
- Clouds can shift resources out of capital spending and into profitability and innovation.
- Hardware and software sales may drop as cloud use increases, while service revenues will increase.
- Cloud computing can accelerate innovation and therefore changes the desired skills mix and job outlook for IS workers. Tech skills in data center operations, support, and maintenance may shrink as a smaller number of vendors consolidate these functions.
- Demand continues to spike for business-savvy technologists. Tech managers will need even stronger business skills and will focus an increasing percentage of their time on strategic efforts. These latter jobs are tougher to outsource, since they involve an intimate knowledge of the firm, its industry, and its operations.
- The market for expensive, high margin, sever hardware is threatened by companies moving applications to the cloud instead of investing in hardware.
- Server farms require plenty of cheap land, low cost power, ultrafast fiber-optic connections, and benefit from mild climates.

- Sun, Microsoft, IBM, and HP have all developed rapid-deployment server farm modules that are pre configured and packed inside shipping containers.

Questions and Exercises

1. Describe the change in IBM's revenue stream resulting from the shift to the cloud.
2. Why is IBM particularly well positioned to take advantage of the shift to services?
3. Describe the shift in skill sets required for IT workers that is likely to result from the widespread adoption of cloud computing.
4. Why do certain entry barriers decrease as a result of cloud computing? What is the effect of lower entry barriers on new entrants, entrepreneurship, and venture capital? On existing competitors?
5. What factors make the Columbia River region of the Pacific Northwest an ideal location for server farms?
6. What is the estimated number of computers operated by Google?
7. Why did Microsoft's shift to cloud computing create an unexpected shock among stock analysts who cover the firm? What does this tell you about the importance of technology understanding among finance and investment professionals?
8. Why do cloud computing vendors build regional server farms instead of one mega site?
9. Why would a firm build a container-based data center?

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2.4.2: The Hardware Cloud- Utility Computing and Its Cousins

Learning Objectives

After studying this section you should be able to do the following:

1. Distinguish between SaaS and hardware clouds.
2. Provide examples of firms and uses of hardware clouds.
3. Understand the concepts of cloud computing, cloudbursting, and black swan events.
4. Understand the challenges and economics involved in shifting computing hardware to the cloud.

While SaaS provides the software *and* hardware to replace an internal information system, sometimes a firm develops its own custom software but wants to pay someone else to run it for them. That's where hardware clouds, utility computing, and related technologies come in. In this model, a firm replaces computing hardware that it might otherwise run on-site with a service provided by a third party online. While the term utility computing was fashionable a few years back (and old timers claim it shares a lineage with terms like hosted computing or even time sharing), now most in the industry have begun referring to this as an aspect of cloud computing, often referred to as hardware clouds. Computing hardware used in this scenario exists "in the cloud," meaning somewhere on the Internet. The costs of systems operated in this manner look more like a utility bill—you only pay for the amount of processing, storage, and telecommunications used. Tech research firm Gartner has estimated that 80 percent of corporate tech spending goes toward data center maintenance (Rayport, 2008). Hardware-focused cloud computing provides a way for firms to chip away at these costs.

Major players are spending billions building out huge data centers to take all kinds of computing out of the corporate data center and place it in the cloud. Efforts include Sun's Network.com grid, IBM's Cloud Labs, Amazon's EC2 (Elastic Computing Cloud), Google's App Engine, Microsoft's Azure, and Salesforce.com's Force.com. While cloud vendors typically host your software on their systems, many of these vendors also offer additional tools to help in creating and hosting apps in the cloud. Salesforce.com offers Force.com, which includes not only a hardware cloud but also several cloud-supporting tools, including a programming environment (IDE) to write applications specifically tailored for Web-based delivery. Google's App Engine offers developers a database product called Big Table, while Amazon offers one called Amazon DB. Traditional software firms like Oracle are also making their products available to developers through various cloud initiatives.

Still other cloud computing efforts focus on providing a virtual replacement for operational hardware like storage and backup solutions. These include the cloud-based backup efforts like EMC's Mozy, and corporate storage services like Amazon's Simple Storage Solution (S3). Even efforts like Apple's MobileMe and Microsoft's Live Mesh that sync user data across devices (phone, multiple desktops) are considered part of the cloud craze. The common theme in all of this is leveraging computing delivered over the Internet to satisfy the computing needs of both users and organizations.

Clouds in Action: A Snapshot of Diverse Efforts

Large, established organizations, small firms and start-ups are all embracing the cloud. The examples below illustrate the wide range of these efforts.

Journalists refer to the *New York Times* as, "The Old Gray Lady," but it turns out that the venerable paper is a cloud-pioneering whippersnapper. When the *Times* decided to make roughly one hundred fifty years of newspaper archives (over fifteen million articles) available over the Internet, it realized that the process of converting scans into searchable PDFs would require more computing power than the firm had available (Rayport, 2008). To solve the challenge, a *Times* IT staffer simply broke out a credit card and signed up for Amazon's EC2 cloud computing and S3 cloud storage services. The *Times* then started uploading terabytes of information to Amazon, along with a chunk of code to execute the conversion. While anyone can sign up for services online without speaking to a rep, someone from Amazon eventually contacted the *Times* to check in after noticing the massive volume of data coming into its systems. Using one hundred of Amazon's Linux servers, the *Times* job took just twenty-four hours to complete. In fact, a coding error in the initial batch forced the paper to rerun the job. Even the blunder was cheap—just two hundred forty dollars in extra processing costs. Says a member of the *Times* IT group: "It would have taken a month at our facilities, since we only had a few spare PCs.…It was cheap experimentation, and the learning curve isn't steep" (Gruman, 2008).

NASDAQ also uses Amazon's cloud as part of its Market Replay system. The exchange uses Amazon to make terabytes of data available on demand, and uploads an additional thirty to eighty gigabytes every day. Market Reply allows access through an Adobe AIR interface to pull together historical market conditions in the ten-minute period surrounding a trade's execution. This allows NASDAQ to produce a snapshot of information for regulators or customers who question a trade. Says the exchange's VP of Product Development, "The fact that we're able to keep so much data online indefinitely means the brokers can quickly answer a question without having to pull data out of old tapes and CD backups" (Grossman, 2009). NASDAQ isn't the only major financial organization leveraging someone else's cloud. Others include Merrill Lynch, which uses IBM's Blue Cloud servers to build and evaluate risk analysis programs; and Morgan Stanley, which relies on Force.com for recruiting applications.

The Network.com offering from Sun Microsystems is essentially a grid computer in the clouds (see Chapter 5 "Moore's Law: Fast, Cheap Computing and What It Means for the Manager"). Since grid computers break a task up to spread across multiple processors, the Sun service is best for problems that can be easily divided into smaller mini jobs that can be processed simultaneously by the army of processors in Sun's grid. The firm's cloud is particularly useful for performing large-scale image and data tasks. Infosolve, a data management firm, uses the Sun cloud to scrub massive data sets, at times harnessing thousands of processors to comb through client records and correct inconsistent entries.

IBM Cloud Labs, which counts Elizabeth Arden and the U.S. Golf Association among its customers, offers several services, including so-called cloudbursting. In a cloudbursting scenario a firm's data center running at maximum capacity can seamlessly shift part of the workload to IBM's cloud, with any spikes in system use metered, utility style. Cloudbursting is appealing because forecasting demand is difficult and can't account for the ultrarare, high-impact events, sometimes called black swans. Planning to account for usage spikes explains why the servers at many conventional corporate IS shops run at only 10 to 20 percent capacity (Parkinson, 2007). While Cloud Labs cloudbursting service is particularly appealing for firms that already have a heavy reliance on IBM hardware in-house, it is possible to build these systems using the hardware clouds of other vendors, too.

Salesforce.com's Force.com cloud is especially tuned to help firms create and deploy custom Web applications. The firm makes it possible to piece together projects using premade Web services that provide software building blocks for features like calendaring and scheduling. The integration with the firm's SaaS CRM effort, and with third-party products like Google Maps allows enterprise mash-ups that can combine services from different vendors into a single application that's run on Force.com hardware. The platform even includes tools to help deploy Facebook applications. Intuitive Surgical used Force.com to create and host a custom application to gather clinical trial data for the firm's surgical robots. An IS manager at Intuitive noted, "We could build it using just their tools, so in essence, there was no programming" (Gruman, 2008). Other users include Jobscience, which used Force.com to launch its online recruiting site; and Harrah's Entertainment, which uses Force.com applications to manage room reservations, air travel programs, and player relations.

These efforts compete with a host of other initiatives, including Google's App Engine and Microsoft's Azure Services Platform, hosting firms like Rackspace, and cloud-specific upstarts like GoGrid.

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Challenges Remain

Hardware clouds and SaaS share similar benefits and risk, and as our discussion of SaaS showed, cloud efforts aren't for everyone. Some additional examples illustrate the challenges in shifting computing hardware to the cloud.

For all the hype about cloud computing, it doesn't work in all situations. From an architectural standpoint, most large organizations run a hodgepodge of systems that include both package applications and custom code written in-house. Installing a complex set of systems on someone else's hardware can be a brutal challenge and in many cases is just about impossible. For that reason we can expect most cloud computing efforts to focus on new software development projects rather than options for old software. Even for efforts that can be custom-built and cloud-deployed, other roadblocks remain. For example, some firms face stringent regulatory compliance issues. To quote one tech industry executive, "How do you demonstrate what you are doing is in compliance when it is done outside?" (Gruman, 2008)

Firms considering cloud computing need to do a thorough financial analysis, comparing the capital and other costs of owning and operating their own systems over time against the variable costs over the same period for moving portions to the cloud. For high-volume, low-maintenance systems, the numbers may show that it makes sense to buy rather than rent. Cloud costs can seem super cheap at first. Sun's early cloud effort offered a flat fee of one dollar per CPU per hour. Amazon's cloud storage rates were twenty-five cents per gigabyte per month. But users often also pay for the number of accesses and the number of data transfers (Preimesberger, 2008). A quarter a gigabyte a month may seem like a small amount, but system maintenance costs often include the need to clean up old files or put them on tape. If unlimited data is stored in the cloud, these costs can add up.

Firms should enter the cloud cautiously, particularly where mission-critical systems are concerned. When one of the three centers supporting Amazon's cloud briefly went dark in 2008, start-ups relying on the service, including Twitter and SmugMug, reported outages. Apple's MobileMe cloud-based product for synchronizing data across computers and mobile devices, struggled for months after its introduction when the cloud repeatedly went down. Vendors with multiple data centers that are able to operate with fault-tolerant provisioning, keeping a firm's efforts at more than one location to account for any operating interruptions, will appeal to firms with stricter uptime requirements.

Key Takeaways

- It's estimated that 80 percent of corporate tech spending goes toward data center maintenance. Hardware-focused cloud computing initiatives from third party firms help tackle this cost by allowing firms to run their own software on the hardware of the provider.
- Amazon, EMC, Google, IBM, Microsoft, Oracle/Sun, Rackspace, and Salesforce.com are among firms offering platforms to run custom software projects. Some offer additional tools and services, including additional support for cloud-based software development, hosting, application integration, and backup.
- Users of cloud computing run the gamut of industries, including publishing (the *New York Times*), finance (NASDAQ), and cosmetics and skin care (Elizabeth Arden).
- Benefits and risks are similar to those discussed in SaaS efforts. Benefits include the use of the cloud for handling large batch jobs or limited-time tasks, offloading expensive computing tasks, and cloudbursting efforts that handle system overflow when an organization needs more capacity.
- Most legacy systems can't be easily migrated to the cloud, meaning most efforts will be new efforts or those launched by younger firms.
- Cloud (utility) computing doesn't work in situations where complex legacy systems have to be ported, or where there may be regulatory compliance issues.
- Some firms may still find TCO and pricing economics favor buying over renting—scale sometimes suggests an organization is better off keeping efforts in-house.

Questions and Exercises

1. What are hardware clouds? What kinds of services are described by this terms? What are other names for this phenomenon? How does this differ from SaaS?
2. Which firms are the leading providers of hardware clouds? How are clients using these efforts?
3. List the circumstances where hardware clouds work best and where it works poorly.
4. Research cloud-based alternatives for backing up your hard drive. Which are among the best reviewed product or services? Why? Do you or would you use such a service? Why or why not?
5. Can you think of "black swan" events that have caused computing services to become less reliable? Describe the events and its consequences for computing services. Suggest a method and vendor for helping firms overcome the sorts of events that you encountered.

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2.4.3: The Software Cloud- Why Buy When You Can Rent?

Learning Objectives

After studying this section you should be able to do the following:

1. Know how firms using SaaS products can dramatically lower several costs associated with their information systems.
2. Know how SaaS vendors earn their money.
3. Be able to list the benefits to users that accrue from using SaaS.
4. Be able to list the benefits to vendors from deploying SaaS.

If open source isn't enough of a threat to firms that sell packaged software, a new generation of products, collectively known as SaaS, claims that you can now get the bulk of your computing done through your Web browser. Don't install software—let someone else run it for you and deliver the results over the Internet.

Software as a service (SaaS) refers to software that is made available by a third party online. You might also see the terms ASP (application service provider) or HSV (hosted software vendor) used to identify this type of offering. SaaS is potentially a very big deal. Firms using SaaS products can dramatically lower several costs associated with the care and feeding of their information systems, including software licenses, server hardware, system maintenance, and IT staff. Most SaaS firms earn money via a usage-based pricing model akin to a monthly subscription. Others offer free services that are supported by advertising, while others promote the sale of upgraded or premium versions for additional fees.

Make no mistake, SaaS is yet another direct assault on traditional software firms. The most iconic SaaS firm is Salesforce.com, an enterprise customer relationship management (CRM) provider. This "un-software" company even sports a logo featuring the word "software" crossed out, *Ghostbusters*-style (Hempel, 2009).

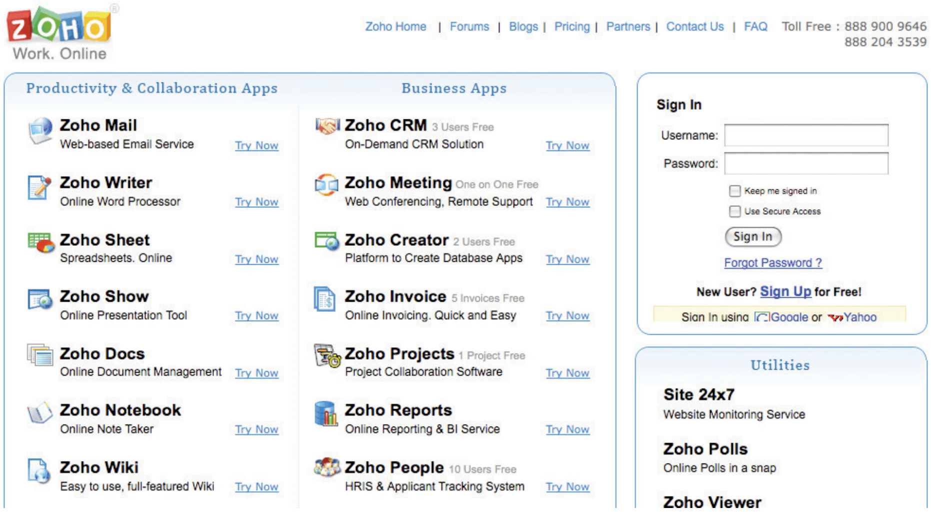
Figure 10.3

The antisoftware message is evident in the logo of SaaS leader Salesforce.com.

Other enterprise-focused SaaS firms compete directly with the biggest names in software. Some of these upstarts are even backed by leading enterprise software executives. Examples include NetSuite (funded in part by Oracle's Larry Ellison—the guy's all over this chapter), which offers a comprehensive SaaS ERP suite; and Workday (launched by founders of Peoplesoft), which has SaaS offerings for managing human resources. Several traditional software firms have countered start-ups by offering SaaS efforts of their own. IBM offers a SaaS version of its Cognos business intelligence products, Oracle offers CRM On Demand, and SAP's Business ByDesign includes a full suite of enterprise SaaS offerings. Even Microsoft has gone SaaS, with a variety of Web-based services that include CRM, Web meeting tools, collaboration, e-mail, and calendaring.

SaaS is also taking on desktop applications. Intuit has online versions of its QuickBooks, TurboTax, and Quicken finance software. Adobe has an online version of Photoshop. Google and Zoho offer office suites that compete with desktop alternatives, prompting Microsoft's own introduction of an online version of Office. And if you store photos on Flickr or Picassa instead of your PC's hard drive, then you're using SaaS, too.

Figure 10.4



A look at Zoho's home page shows the diversity of both desktop and enterprise offerings from this SaaS upstart. Note that the firm makes it services available through browsers, phones, and even Facebook.

-

The Benefits of SaaS

Firms can potentially save big using SaaS. Organizations that adopt SaaS forgo the large upfront costs of buying and installing software packages. For large enterprises, the cost to license, install, and configure products like ERP and CRM systems can easily run into the hundreds of thousands or even millions of dollars. And these costs are rarely a one time fee. Additional costs like annual maintenance contracts have also been rising as rivals fail or get bought up. Less competition among traditional firms recently allowed Oracle and SAP to raise maintenance fees to as much as 20 percent (Lacy, 2008).

Firms that adopt SaaS don't just save on software and hardware, either. There's also the added cost for the IT staff needed to run these systems. Forrester Research estimates that SaaS can bring cost savings of 25 to 60 percent if all these costs are factored in (Quittner, 2008).

There are also accounting and corporate finance implications for SaaS. Firms that adopt software as a service never actually buy a system's software and hardware, so these systems become a variable operating expense. This flexibility helps mitigate the financial risks associated with making a large capital investment in information systems. For example, if a firm pays Salesforce.com sixty-five dollars per month per user for its CRM software, it can reduce payments during a slow season with a smaller staff, or pay more during heavy months when a firm might employ temporary workers. At these rates, SaaS not only looks good to large firms, it makes very sophisticated technology available to smaller firms that otherwise wouldn't be able to afford expensive systems, let alone the IT staff and hardware required to run them.

In addition to cost benefits, SaaS offerings also provide the advantage of being highly scalable. This feature is important because many organizations operate in environments prone to wide variance in usage. Some firms might expect systems to be particularly busy during tax time or the period around quarterly financial reporting deadlines, while others might have their heaviest system loads around a holiday season. A music label might see spikes when an artist drops a new album. Using conventional software, an organization would have to buy enough computing capacity to ensure that it could handle its heaviest anticipated workload. But sometimes these loads are difficult to predict, and if the difference between high workloads and average use is great, a lot of that expensive computer hardware will spend most of its time doing nothing. In SaaS, however, the vendor is responsible for ensuring that systems meet demand fluctuation. Vendors frequently sign a service level agreement (SLA) with their customers to ensure a guaranteed uptime and define their ability to meet demand spikes.

When looking at the benefits of SaaS, also consider the potential for higher quality and service levels. SaaS firms benefit from economies of scale that not only lower software and hardware costs, but also potentially boost quality. The volume of customers and diversity of their experiences means that an established SaaS vendor is most likely an expert in dealing with all sorts of critical computing issues. SaaS firms handle backups, instantly deploy upgrades and bug fixes, and deal with the continual burden of security maintenance—all costly tasks that must be performed regularly and with care, although each offers little strategic value to firms that perform these functions themselves in-house. The breadth of a SaaS vendor's customer base typically pushes the firm to evaluate and address new technologies as they emerge, like quickly offering accessibility from mobile platforms like the BlackBerry and iPhone. For all but the savviest of IT shops, an established SaaS vendor can likely leverage its scale and experience to provide better, cheaper, more reliable standard information systems than individual companies typically can.

Software developers who choose to operate as SaaS providers also realize benefits. While a packaged software company like SAP must support multiple versions of its software to accommodate operating systems like Windows, Linux, and various flavors of Unix, an SaaS provider develops, tests, deploys, and supports just one version of the software executing on its own servers.

An argument might also be made that SaaS vendors are more attuned to customer needs. Since SaaS firms run a customer's systems on their own hardware, they have a tighter feedback loop in understanding how products are used (and why they fail)—potentially accelerating their ability to enhance their offerings. And once made, enhancements or fixes are immediately available to customers the next time they log in.

SaaS applications also impact distribution costs and capacity. As much as 30 percent of the price of traditional desktop software is tied to the cost of distribution—pressing CD-ROMs, packaging them in boxes, and shipping them to retail outlets (Drummond, 2001). Going direct to consumers can cut out the middleman, so vendors can charge less or capture profits that they might otherwise share with a store or other distributor. Going direct also means that SaaS applications are available anywhere someone has an Internet connection, making them truly global applications. This feature has allowed many SaaS firms to address highly specialized markets (sometimes called vertical niches). For example, the Internet allows a company writing specialized legal software, for example, or a custom package for the pharmaceutical industry, to have a national deployment footprint from day one. Vendors of desktop applications that go SaaS benefit from this kind of distribution, too.

Finally, SaaS allows a vendor to counter the vexing and costly problem of software piracy. It's just about impossible to make an executable, illegal copy of a subscription service that runs on a SaaS provider's hardware.

Gaming in Flux: Is There a Future in Free?

PC game makers are in a particularly tough spot. Development costs are growing as games become more sophisticated. But profits are plummeting as firms face rampant piracy, a growing market for used game sales, and lower sales from rental options from firms like Blockbuster and GameFly. To combat these trends, Electronic Arts (EA) has begun to experiment with a radical alternative to PC game sales—give the base version of the product away for free and make money by selling additional features.

The firm started with the Korean version of its popular FIFA soccer game. Koreans are crazy for the world's most popular sport; their nation even cohosted the World Cup in 2002. But piracy was killing EA's sales in Korea. To combat the problem, EA created a free, online version of FIFA that let fans pay for additional features and upgrades, such as new uniforms for their virtual teams, or performance-enhancing add-ons. Each enhancement only costs about one dollar and fifty cents, but the move to a model based on these so-called microtransactions has brought in big earnings. During the first two years that the microtransaction-based Korean FIFA game was available, EA raked in roughly $1 million a month. The two-year, twenty-four-million-dollar take was twice the sales record for EA's original FIFA game.

Asian markets have been particularly receptive to microtransactions—this revenue model makes up a whopping 50 percent of the region's gaming revenues. But whether this model can spread to other parts of the world remains to be seen. The firm's first free, microtransaction offering outside of Korea leverages EA's popular Battlefield franchise. Battlefield Heroes sports lower quality, more cartoon-like graphics than EA's conventional Battlefield offerings, but it will be offered free online. Lest someone think they can rise to the top of player rankings by buying the best military hardware for their virtual armies, EA offers a sophisticated matching engine, pitting players with similar abilities and add-ons against one another (Schenker, 2008).

Players of the first versions of Battlefield Heroes and FIFA Online needed to download software to their PC. But the start-up World Golf Tour shows how increasingly sophisticated games can execute within a browser, SaaS-style. WGT doesn't have quite the graphics sophistication of the dominant desktop golf game (EA's Tiger Woods PGA Golf), but the free, ad-supported offering is surprisingly detailed. Buddies can meet up online for a virtual foursome, played on high-resolution representations of the world's elite courses stitched together from fly-over photographs taken as part of game development. World Golf Tour is ad-supported. The firm hopes that advertisers will covet access to the high-income office workers likely to favor a quick virtual golf game to break up their workday. Zynga's FarmVille, an app game for Facebook, combines both models. Free online, but offering added features purchased in micropayment-sized chunks, FarmVille made half a million dollars in three days, just by selling five-dollar virtual sweet potatoes (MacMillan, et. al., 2009). FIFA Online, Battlefield Heroes, World Golf Tour, and FarmVille all show that the conventional models of gaming software are just as much in flux as those facing business and productivity packages.

Key Takeaways

- SaaS firms may offer their clients several benefits including the following:
  - *lower costs* by eliminating or reducing software, hardware, maintenance, and staff expenses
  - *financial risk mitigation* since start-up costs are so low
  - potentially *faster deployment times* compared with installed packaged software or systems developed in-house
  - costs that are a *variable operating expense* rather than a large, fixed capital expense
  - *scalable systems* that make it easier for firms to ramp up during periods of unexpectedly high system use
  - *higher quality and service levels* through instantly available upgrades, vendor scale economies, and expertise gained across its entire client base
  - *remote access and availability*—most SaaS offerings are accessed through any Web browser, and often even by phone or other mobile device
- Vendors of SaaS products benefit from the following:
  - *limiting development to a single platform*, instead of having to create versions for different operating systems
  - *tighter feedback loop* with clients, helping fuel innovation and responsiveness
  - ability to *instantly deploy bug fixes and product enhancements* to all users
  - *lower distribution costs*
  - *accessibility* to anyone with an Internet connection
  - greatly *reduced risk of software piracy*
- Microtransactions and ad-supported gaming present alternatives to conventional purchased video games. Firms leveraging these models potentially benefit from a host of SaaS advantages, including direct-to-consumer distribution, instant upgrades, continued revenue streams rather than one-time purchase payments, and a method for combating piracy.

Questions and Exercises

1. Firms that buy conventional enterprise software spend money buying software and hardware. What additional and ongoing expenses are required as part of the "care and feeding" of enterprise applications?
2. In what ways can firms using SaaS products dramatically lower costs associated with their information systems?
3. How do SaaS vendors earn their money?
4. Give examples of enterprise-focused SaaS vendors and their products. Visit the Web sites of the firms that offer these services. Which firms are listed as clients? Does there appear to be a particular type of firm that uses its services, or are client firms broadly represented?
5. Give examples of desktop-focused SaaS vendors and their products. If some of these are free, try them out and compare them to desktop alternatives you may have used. Be prepared to share your experiences with your class.
6. List the cost-related benefits to users that accrue from using SaaS.
7. List the benefits other than cost-related that accrue to users from using SaaS.
8. List the benefits realized by vendors that offer SaaS services instead of conventional software.
9. Microtransactions have been tried in many contexts, but have often failed. Can you think of contexts where microtransactions don't work well? Are there contexts where you have paid (or would be wiling to pay) for products and services via microtransactions? What do you suppose are the major barriers to the broader acceptance of microtransactions? Do struggles have more to do with technology, consumer attitudes, or both?
10. Search online to find free and microtransaction-based games. What do you think of these efforts? What kind of gamers do these efforts appeal to? See if you can investigate whether there are examples of particularly successful offerings, or efforts that have failed. What's the reason behind the success or failure of the efforts that you've investigated?

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2.5: End User Dev

2.5.1: End-User Computing

In many organizations, application development is not limited to the programmers and analysts in the information-technology department. Especially in larger organizations, other departments develop their own department-specific applications. The people who build these are not necessarily trained in programming or application development, but they tend to be adept with computers. A person, for example, who is skilled in a particular software package, such as a spreadsheet or database package, may be called upon to build smaller applications for use by his or her own department. This phenomenon is referred to as end-user development or end-user computing.

End-user computing can have many advantages for an organization. First, it brings the development of applications closer to those who will use them. Because IT departments are sometimes quite backlogged, it also provides a means to have software created more quickly. Many organizations encourage end-user computing to reduce the strain on the IT department.

End-user computing does have its disadvantages as well. If departments within an organization are developing their own applications, the organization may end up with several applications that perform similar functions, which is inefficient, since it is a duplication of effort. Sometimes, these different versions of the same application end up providing different results, bringing confusion when departments interact. These applications are often developed by someone with little or no formal training in programming. In these cases, the software developed can have problems that then have to be resolved by the IT department.

End-user computing can be beneficial to an organization, but it should be managed. The IT department should set guidelines and provide tools for the departments that want to create their own solutions. Communication between departments will go a long way towards the successful use of end-user computing.

References

End-user development. (2021, April 30). Retrieved from https://en.Wikipedia.org/wiki/End-user_development

2.5.2: Sidebar: Building a Mobile App

In many ways, building an application for a mobile device is exactly the same as building an application for a traditional computer. Understanding the requirements for the application, designing the interface, working with users – all of these steps still need to be carried out.

So what's different about building an application for a mobile device? In some ways, mobile applications are more limited. An application running on a mobile device must be designed to be functional on a smaller screen. Mobile applications should be designed to use fingers as the primary pointing device. Mobile devices generally have less available memory, storage space, and processing power.

Mobile applications also have many advantages over applications built for traditional computers. Mobile applications have access to the functionality of the mobile device, which usually includes features such as geolocation data, messaging, the camera, and even a gyroscope.

One of the most important questions regarding development for mobile devices is this: Do we want to develop an app at all? A mobile app is an expensive proposition, and it will only run on one type of mobile device at a time. For example, if you create an iPhone app, users with Android phones are out of luck. Each app takes several thousand dollars to create, so this may not be the best use of your funds.

Many organizations are moving away from developing a specific app for a mobile device and are instead making their websites more functional on mobile devices. Using a web-design framework called responsive design, a website can be made highly functional no matter what type of device is browsing it. With a responsive website, images resize themselves based on the size of the device's screen, and text flows and sizes itself properly for optimal viewing. You can find out more about responsive design here.

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SECTION OVERVIEW

2.6: Systems Testing

2.6.0.1: Software Testing

Software testing is an investigation conducted to provide stakeholders with information about the quality of the software product or service under test.[1] Software testing can also provide an objective, independent view of the software to allow the business to appreciate and understand the risks of software implementation. Test techniques include the process of executing a program or application with the intent of finding software bugs (errors or other defects), and verifying that the software product is fit for use.

Software testing involves the execution of a software component or system component to evaluate one or more properties of interest. In general, these properties indicate the extent to which the component or system under test:

- meets the requirements that guided its design and development,
- responds correctly to all kinds of inputs,
- performs its functions within an acceptable time,
- is sufficiently usable,
- can be installed and run in its intended environments, and
- achieves the general result its stakeholders desire.

As the number of possible tests for even simple software components is practically infinite, all software testing uses some strategy to select tests that are feasible for the available time and resources. As a result, software testing typically (but not exclusively) attempts to execute a program or application with the intent of finding software bugs (errors or other defects). The job of testing is an iterative process as when one bug is fixed, it can illuminate other, deeper bugs, or can even create new ones.

Software testing can provide objective, independent information about the quality of software and risk of its failure to users or sponsors.[1]

Software testing can be conducted as soon as executable software (even if partially complete) exists. The overall approach to software development often determines when and how testing is conducted. For example, in a phased process, most testing occurs after system requirements have been defined and then implemented in testable programs. In contrast, under an agile approach, requirements, programming, and testing are often done concurrently.

2.6.1: Test plans

A test plan documents the strategy that will be used to verify and ensure that a product or system meets its design specifications and other requirements. A test plan is usually prepared by or with significant input from test engineers.

Depending on the product and the responsibility of the organization to which the test plan applies, a test plan may include a strategy for one or more of the following:

- *Design Verification or Compliance test* – to be performed during the development or approval stages of the product, typically on a small sample of units.
- *Manufacturing or Production test* – to be performed during preparation or assembly of the product in an ongoing manner for purposes of performance verification and quality control.
- *Acceptance or Commissioning test* – to be performed at the time of delivery or installation of the product.
- *Service and Repair test* – to be performed as required over the service life of the product.
- *Regression test* – to be performed on an existing operational product, to verify that existing functionality was not negatively affected when other aspects of the environment were changed (e.g., upgrading the platform on which an existing application runs).

A complex system may have a high level test plan to address the overall requirements and supporting test plans to address the design details of subsystems and components.

Test plan document formats can be as varied as the products and organizations to which they apply. There are three major elements that should be described in the test plan: Test Coverage, Test Methods, and Test Responsibilities. These are also used in a formal test strategy.

System testing is testing conducted on a complete integrated system to evaluate the system's compliance with its specified requirements.

System testing takes, as its input, all of the integrated components that have passed integration testing. The purpose of integration testing is to detect any inconsistencies between the units that are integrated together (called *assemblages*). System testing seeks to detect defects both within the "inter-assemblages" and also within the system as a whole. The actual result is the behavior produced or observed when a component or system is tested.[1]

System testing is performed on the entire system in the context of either functional requirement specifications (FRS) or system requirement specification (SRS), or both. System testing tests not only the design, but also the behaviour and even the believed expectations of the customer. It is also intended to test up to and beyond the bounds defined in the software or hardware requirements specification(s).

2.6.1.1: Integration Testing

Integration testing (sometimes called **integration and testing**, abbreviated **I&T**) is the phase in software testing in which individual software modules are combined and tested as a group. Integration testing is conducted to evaluate the compliance of a system or component with specified functional requirements.[1] It occurs after unit testing and before validation testing. Integration testing takes as its input modules that have been unit tested, groups them in larger aggregates, applies tests defined in an integration test plan to those aggregates, and delivers as its output the integrated system ready for system testing.[2]

2.6.1.2: Unit Testing

In computer programming, **unit testing** is a software testing method by which individual units of source code—sets of one or more computer program modules together with associated control data, usage procedures, and operating procedures—are tested to determine whether they are fit for use.[1]

2.6.1.3: User Acceptance Testing

User acceptance testing (UAT) consists of a process of verifying that a solution works for the user.[8] It is not system testing (ensuring software does not crash and meets documented requirements) but rather ensures that the solution will work for the user (i.e. tests that the user accepts the solution); software vendors often refer to this as "Beta testing".

This testing should be undertaken by a subject-matter expert (SME), preferably the owner or client of the solution under test, and provide a summary of the findings for confirmation to proceed after trial or review. In software development, UAT as one of the final stages of a project often occurs before a client or customer accepts the new system. Users of the system perform tests in line with what would occur in real-life scenarios.[9]

It is important that the materials given to the tester be similar to the materials that the end user will have. Testers should be given real-life scenarios such as the three most common or difficult tasks that the users they represent will undertake.

The UAT acts as a final verification of the required business functionality and proper functioning of the system, emulating real-world conditions on behalf of the paying client or a specific large customer. If the software works as required and without issues during normal use, one can reasonably extrapolate the same level of stability in production.[10]

User tests, usually performed by clients or by end-users, do not normally focus on identifying simple cosmetic problems such as spelling errors, nor on showstopper defects, such as software crashes; testers and developers identify and fix these issues during earlier unit testing, integration testing, and system testing phases.

UAT should be executed against test scenarios.Test scenarios usually differ from System or Functional test cases in that they represent a "player" or "user" journey. The broad nature of the test scenario ensures that the focus is on the journey and not on technical or system-specific details, staying away from "click-by-click" test steps to allow for a variance in users' behaviour. Test scenarios can be broken down into logical "days", which are usually where the actor (player/customer/operator) or system (backoffice, front end) changes.

In industry, a common UAT is a factory acceptance test (FAT). This test takes place before installation of the equipment. Most of the time testers not only check that the equipment meets the specification, but also that it is fully functional. A FAT usually includes a check of completeness, a verification against contractual requirements, a proof of functionality (either by simulation or a conventional function test) and a final inspection.

The results of these tests give clients confidence in how the system will perform in production. There may also be legal or contractual requirements for acceptance of the system.

To View Supplemental Materials

2.6.1: Supplmental - Decision Tables/Trees

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2.6.1: Supplmental - Decision Tables/Trees

2.6.1.1: Decision Tables

Decision tables are a concise visual representation for specifying which actions to perform depending on given conditions. They are algorithms whose output is a set of actions. The information expressed in decision tables could also be represented as decision trees or in a programming language as a series of if-then-else and switch-case statements.

The limited-entry decision table is the simplest to describe. The condition alternatives are simple Boolean values, and the action entries are check-marks, representing which of the actions in a given column are to be performed.

Example: A person seeking admission to PGCC is required to:

· Possess a high school diploma or GED

· Fill out an admission form

· Pay admission fee

	Requirements							
	R1	R2	R3	R4	R5	R6	R7	R8
Conditions								
High School Diplomat	N	N	N	N	Y	Y	Y	Y
GED	N	N	N	Y	Y	N	Y	Y
Fill Out Admission Form	N	N	Y	Y	Y	N	N	Y
Admission fee	N	Y	Y	Y	Y	N	N	N
Actions								
Accepted				X	X			
Rejected	X	X	X			X	X	X

Of course, this is just a simple example, but even so, it demonstrates how decision tables can scale to several conditions with many possibilities.

2.6.1.2: Decision Tree

A **decision tree** is a decision support tool that uses a tree-like model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. It is one way to display an algorithm that only contains conditional control statements.

Decision trees are commonly used in operations research, specifically in decision analysis, to help identify a strategy most likely to reach a goal, but are also a popular tool in machine learning.

2.6.1.3: **Decision tree elements**

Decision-Tree-Elements.png

Drawn from left to right, a decision tree has only burst nodes (splitting paths) but no sink nodes (converging paths). Therefore, used manually, they can grow very big and are then often hard to draw fully by hand. Traditionally, decision trees have been created manually – as the aside example shows – although increasingly, specialized software is employed.

2.6.1.4: **Decision rules[edit]**

The decision tree can be linearized into **decision rules**,[2] where the outcome is the contents of the leaf node, and the conditions along the path form a conjunction in the if clause. In general, the rules have the form:

> *if* condition1 *and* condition2 *and* condition3 *then* outcome.

Decision rules can be generated by constructing association rules with the target variable on the right. They can also denote temporal or causal relations.[3]

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2.7: Project Implementation

2.7.1: Implementation Methodologies

Once a new system is developed (or purchased), the organization must determine the best method for implementing it. Convincing a group of people to learn and use a new system can be a very difficult process. Using new software, and the business processes it gives rise to, can have far-reaching effects within the organization.

There are several different methodologies an organization can adopt to implement a new system. Four of the most popular are listed below.

- Direct cutover. In the direct-cutover implementation methodology, the organization selects a particular date that the old system is not going to be used anymore. On that date, the users begin using the new system and the old system is unavailable. The advantages to using this methodology are that it is very fast and the least expensive. However, this method is the riskiest as well. If the new system has an operational problem or if the users are not properly prepared, it could prove disastrous for the organization.
- Pilot implementation. In this methodology, a subset of the organization (called a pilot group) starts using the new system before the rest of the organization. This has a smaller impact on the company and allows the support team to focus on a smaller group of individuals.
- Parallel operation. With parallel operation, the old and new systems are used simultaneously for a limited period of time. This method is the least risky because the old system is still being used while the new system is essentially being tested. However, this is by far the most expensive methodology since work is duplicated and support is needed for both systems in full.
- Phased implementation. In phased implementation, different functions of the new application are used as functions from the old system are turned off. This approach allows an organization to slowly move from one system to another.

Which of these implementation methodologies to use depends on the complexity and importance of the old and new systems.

2.7.2: Change Management

As new systems are brought online and old systems are phased out, it becomes important to manage the way change is implemented in the organization. Change should never be introduced in a vacuum. The organization should be sure to communicate proposed changes before they happen and plan to minimize the impact of the change that will occur after implementation. Change management is a critical component of IT oversight.

2.7.3: Maintenance

Once a new system has been introduced, it enters the maintenance phase. In this phase, the system is in production and is being used by the organization. While the system is no longer actively being developed, changes need to be made when bugs are found or new features are requested. During the maintenance phase, IT management must ensure that the system continues to stay aligned with business priorities and continues to run well.

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2.8: Summary

Summary

Software development is about so much more than programming. Developing new software applications requires several steps, from the formal SDLC process to more informal processes such as agile programming or lean methodologies. Programming languages have evolved from very low-level machine-specific languages to higher-level languages that allow a programmer to write software for a wide variety of machines. Most programmers work with software development tools that provide them with integrated components to make the software development process more efficient. For some organizations, building their own software applications does not make the most sense; instead, they choose to purchase software built by a third party to save development costs and speed implementation. In end-user computing, software development happens outside the information technology department. When implementing new software applications, there are several different types of implementation methodologies that must be considered.

Study Questions

1. What are the steps in the SDLC methodology?
2. What is RAD software development?
3. What makes the lean methodology unique?
4. What are three differences between second-generation and third-generation languages?
5. Why would an organization consider building its own software application if it is cheaper to buy one?
6. What is responsive design?
7. What is the relationship between HTML and CSS in website design?
8. What is the difference between the pilot implementation methodology and the parallel implementation methodology?
9. What is change management?
10. What are the four different implementation methodologies?

Exercises

1. Which software-development methodology would be best if an organization needed to develop a software tool for a small group of users in the marketing department? Why? Which implementation methodology should they use? Why?
2. Doing your own research, find three programming languages and categorize them in these areas: generation, compiled vs. interpreted, procedural vs. object-oriented.
3. Some argue that HTML is not a programming language. Doing your own research, find three arguments for why it is not a programming language and three arguments for why it is.
4. Read more about responsive design using the link given in the text. Provide the links to three websites that use responsive design and explain how they demonstrate responsive-design behavior.

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SECTION OVERVIEW

2.9: Proposals

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2.9.1: Some preliminaries

In a technical writing course, the proposal assignment is an opportunity for you to present an idea to a specific, named audience about an idea you have to improve a certain aspect of that company, organization, center, or other business. Whatever topic you choose, you must be able to conduct thorough research that you will integrate into your final report.

To begin planning a proposal, remember the basic definition: a proposal is an offer or bid to complete a project for someone. Proposals may contain other elements—technical background, recommendations, results of surveys, information about feasibility, and so on. But what makes a proposal a proposal is that it asks the audience to approve, fund, or grant permission to do the proposed project.

A proposal should contain information that would enable the audience of that proposal to decide whether to approve the project, to approve or hire you to do the work, or both. To write a successful proposal, put yourself in the place of your audience—the recipient of the proposal—and think about what sorts of information that person would need in order to feel confident having you complete the project.

It is easy to confuse proposals with other kinds of documents in technical writing. Imagine that you have a terrific idea for installing some new technology where you work, and you write up a document explaining how it work, showing the benefits, and then urging management to install it. Is that a proposal? All by itself, this would not be a complete proposal. It would be more like a feasibility report, which studies the merits of a project and then recommends for or against it. However, all it would take to make this document a proposal would be to add elements that ask management for approval for you to go ahead with the project. Additionally, for some technical writing classes offered in college, one of those elements may be scholarly research. Check with your instructor to see if this is the case. Certainly, some writers of proposals must sell the projects they propose, but in all cases, proposals must sell the writer (or the writer's organization) as the one to complete the project.

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2.9.2: Types of proposals

Consider the situations in which proposals occur. A company may send out a public announcement requesting proposals for a specific project. This public announcement—called a request for proposals (RFP)—could be issued through websites, emails, social media, newspapers, or trade journals. Firms or individuals interested in the project would then write proposals in which they summarize their qualifications, project schedules and costs, and discuss their approach to the project. The recipient of all these proposals would then evaluate them, select the best candidate, and then work up a contract.

But proposals also come about much less formally. Imagine that you are interested in doing a project at work (for example, investigating the merits of bringing in some new technology to increase productivity). Imagine that you met with your supervisor and tried to convince her of this. She might respond by saying, “Write me a proposal and I’ll present it to upper management.” This is more like the kind of proposal you will write in a technical writing course.

Most proposals can be divided into several categories:

- Internal, external: A proposal to someone within your organization (a business, a government agency, etc.) is an internal proposal. With internal proposals, you may not have to include certain sections (such as qualifications) or as much information in them. An external proposal is one written from one separate, independent organization or individual to another such entity. The typical example is the independent consultant proposing to do a project for another firm. This kind of proposal may be solicited or unsolicited, as explained below.
- Solicited, unsolicited: A solicited proposal is one in which the recipient has requested the proposal. Typically, a company will send out requests for proposals (RFPs) through the mail or publish them in some news source. But proposals can be solicited on a very local level: for example, you could be explaining to your boss what a great thing it would be to install a new technology in the office; your boss might get interested and ask you to write up a proposal that offered to do a formal study of the idea. Unsolicited proposals are those in which the recipient has not requested proposals. With unsolicited proposals, you sometimes must convince the recipient that a problem or need exists before you can begin the main part of the proposal.

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2.9.3: Typical scenarios for the proposal

Many of you may have never given much thought to producing a technical report based on a viable proposal. Here are some sample proposal ideas to ponder:

- Imagine that a company has a problem or wants to make some sort of improvement. The company sends out a request for proposals; you receive one and respond with a proposal. You offer to come in, investigate, interview, make recommendations—and present it all in the form of a report.
- An organization wants a seminar in your expertise. You write a proposal to give the seminar—included in the package deal is a guide or handbook that the people attending the seminar will receive.
- An agency has just started using a new online data system, but the user's manual is technically complex and difficult to read. You receive a request for proposals from this agency to write a simplified guide or startup guide.
- Imagine that a nonprofit organization focused on a particular issue wants an consultant to write a handbook or guide for its membership. This document will present information on the issue in a way that the members can understand.

Not all research topics are appropriate for technical writing. Topics that are based on values and beliefs do not fall into the category of technical. Historical and literary topics do not qualify.

If your technical writing course requires that you integrate scholarly research into your final report, choose a topic for which you can readily find such material. While interviews and other first-hand sources are often valuable to a report, one that relies heavily on these sources may not meet the outcomes of your particular course.

Always check with your instructor about any topic ideas you have before starting on your project.

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2.9.4: Common sections in proposals

The following provides a review of the sections you will commonly find in proposals. Do not assume that each one of them has to be in the actual proposal you write, nor that they have to be in the order they are presented here. Refer to the assignment sheet provided by your instructor and consider other kinds of information unique to your topic that should be included in your particular proposal.

Introduction. Plan the introduction to your proposal carefully. Make sure it does all of the following things (but not necessarily in this order) that apply to your particular proposal:

- Indicate that the content of the memo is a proposal for a specific project.
- Develop at least one brief motivating statement that will encourage the recipient to read on and to consider approving the project (especially if it is an unsolicited or competitive proposal).
- Give an overview of the contents of the proposal.

Background on the problem, opportunity, or situation. Often occurring just after the introduction, the background section discusses what has brought about the need for the project—what problem, what opportunity exists for improving things, what the basic situation is. For example, management of a chain of day care centers may need to ensure that all employees know CPR because of new state mandates requiring it, or an owner of pine timber land in eastern Oregon may want to get the land producing saleable timber without destroying the environment.

While the named audience of the proposal may know the problem very well, writing the background section is useful in demonstrating your particular view of the problem. Also, if the the proposal is unsolicited, a background section is almost a requirement—you will probably need to convince the audience that the problem or opportunity exists and that it should be addressed.

Benefits and feasibility of the proposed project. Most proposals briefly discuss the advantages or benefits of completing the proposed project. This acts as a type of argument in favor of approving the project. Also, some proposals discuss the likelihood of the project's success. In an unsolicited proposal, this section is especially important—you are trying to "sell" the audience on the project.

Description of the proposed work (results of the project). Most proposals must describe the finished product of the proposed project. In a technical writing course, that means describing the written document you propose to write, its audience and purpose; providing an outline; and discussing such things as its length, graphics, binding, and so forth. In the scenario you define, there may be other work such as conducting training seminars or providing an ongoing service. At this early stage, you might not know all that it will take to complete your project, but you should at least have an idea of some of the steps required.

Method, procedure, theory. In some proposals, you will need to explain how you will go about completing the proposed work. This acts as an additional persuasive element; it shows the audience you have a sound, thoughtful approach to the project. Also, it serves to demonstrate that you have the knowledge of the field to complete the project.

Schedule. Most proposals contain a section that shows not only the projected completion date but also key milestones for the project. If you are doing a large project spreading over many months, the timeline would also show dates on which you would deliver progress reports. If you cannot cite specific dates, cite amounts of time for each phase of the project.

Costs, resources required. Most proposals also contain a section detailing the costs of the project, whether internal or external. With external projects, you may need to list your hourly rates, projected hours, costs of equipment and supplies, and so forth, and then calculate the total cost of the complete project. Internal projects, of course, are not free, so you should still list the project costs: hours you will need to complete the project, equipment and supplies you will be using, assistance from other people in the organization, and so on.

Conclusions. The final paragraph or section of the proposal should bring readers back to a focus on the positive aspects of the project. In the final section, you can urge them to contact you to work out the details of the project, remind them of the benefits of doing the project, and maybe make one last argument for you or your organization as the right choice for the project.

Special project-specific sections. Remember that the preceding sections are typical or common in written proposals, not absolute requirements. Always ask yourself what else might your audience need to understand the project, the need for it, the benefits arising from it, your role in it, and your qualifications to do it. What else do they need to see in order to approve the project and to approve you to do it?

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2.9.5: Special assignment requirements

Depending on the writing situation, your proposal may need to include other specialized elements as well. Your supervisor might ask you to include in your proposal any of the following:

Audience: Describe the audience of the final report (which may be different than the audience for the proposal). You may need to discuss for whom the report is designed, their titles and jobs, their technical background, and their ability to understand the report.

Information sources: List information sources; make sure you know that there is adequate information for your topic; list citations for specific books, articles, reference works, other kinds of sources that you think will contribute to your report.

Graphics: List the graphics you think your report will need according to their type and their content. (If you cannot think of any your report would need, you may not have a good topic—do some brainstorming with your instructor.)

Outline: Include an outline of the topics and subtopics you think you will cover in your report.

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2.9.6: Proposals and audience

Remember that, in a technical writing course, the proposal assignment serves several purposes: (1) it gives you some experience in writing a proposal; (2) it gets you started planning your major assignment; (3) it gives your instructor a chance to work with you on your project, to make sure you have a viable topic. For the second and third reasons, you need to include specific elements in your proposal (as noted in your assignment sheet) some of which may not seem appropriate in a real-world proposal.

The proposal is often the beginning of a weeks-long research and writing process that goes through many stages until it gets to the end point: the technical report. In this case, you only submit the proposal once during this process. After that, you may write and submit different types of documents: a progress report, an outline, an annotated bibliography, a graphics draft, a report draft, and a final report. Be careful to use the term "proposal" only if you are specifically referring to the proposal stage of your project.

Another point to keep in mind relates to the audience for different kinds of documents that may be produced for the same project. Consider the example of a proposal written to a supervisor at a solar power company suggesting the creation of a policy manual for residential solar panel installers. The proposal's audience may be an executive, whose knowledge of the technicalities may be very broad. Let's imagine the executive approves the proposal and requests completion of the manual, which will be produced well after the proposal. The manual's audience is the technicians, who may have more specialized knowledge than the executive. The content and language used for these two different audiences will need to be adjusted to fit the writing situation. (For more on this, review the chapter on Audience Analysis.)

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2.9.7: Revision checklist for proposals

As you review and revise your proposal, keep the following in mind:

- Use the right format. Check with your instructor to insure you are using the format requested and look at any samples provided.
- Write a clear summary of (or introduction to) your proposal topic.
- Identify exactly what you are proposing to do.
- Ensure that a report—a written document—is somehow involved in the project you are proposing to do if that is what your instructor has assigned.
- Ensure that the sections of your proposal are in a logical, natural order and that you use sub-headers and bullets (and any other formatting styles) correctly.
- Address the proposal to your named audience—not your instructor.

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CHAPTER OVERVIEW

3: Software

Installing Windows... Installing Google Chrome... Many of you in this course have had to deal with installing these software onto a computer. Others have had the opportunity to create their very own software. As you pursue your studies and continue to familiarize yourself with the many practices of how to develop information systems, people will depend on you to provide concise and logical information on what software to buy and implement. In this chapter, you will learn about the different types of software that exist and how software has impacted the world as a whole. Now, it is not rocket science to understand how software has allowed companies to be erected and brought billions of dollars into the pockets of genius innovators. Nowadays, software is able to effectively communicate through the internet which brings a lot of favor towards the companies that developed these software and allows flexibility for the common consumer.

Software can be broadly divided into two categories: **System Software** and **Application software**. Operating systems manage the hardware and create the interface between the hardware and the user. Application software is the category of programs that do something useful for the user. As a Systems Analyst or Project Manager, you will need to look into software that either be a financial assistance application software to be installed an already existing operating system of a company-owned computer or find an inexpensive, if not free, an operating system for a new line of servers to be installed for a new website.

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3.1: Open Source

What is Open Source Software (OSS)?

Open-source software is computer software that has a source code available to the general public for use as is or with modifications. This software typically does not require a license fee. There are open-source software applications for a variety of different uses such as office automation, web design, content management, operating systems, and communications. The key fact that makes open-source software (OSS) different from proprietary software is its license. As copyright material, software is almost always licensed.

The license indicates how the software may be used. OSS is unique in that it is always released under a license that has been certified to meet the criteria of the Open Source Definition. These criteria include the right to:

- Redistribute the software without restriction;
- Access the source code;
- Modify the source code; and
- Distribute the modified version of the software.

In contrast, creators of **proprietary software** usually do not make their source code available to others to modify. When considering the advantages of open source software you should consider the open-source product itself. Open source products vary in quality. OSS software does not come with phone support or personalized e-mail support. However, there are commercial service providers who will provide support. If you need a lot of support, consider whether the overall costs of using an open-source product will be higher than that of a proprietary product.

Keep in mind that while OSS is usually free there are some exceptions. You will usually be able to determine what these exceptions are by considering the total cost of ownership (TCO) involved in adopting and managing open-source software. While the software itself may be free, make sure you consider the need for additional services or products, as these may have costs attached (e.g. access to software updates, support services). You also have to take into account possible switching costs. These costs would include moving data from an old system to new systems, training costs, and costs involved when switching from one platform to another one (e.g. the costs of switching from Microsoft Windows to a Linux operating system). If your business does not have enough information technology expertise, you may have to outsource outside technical services to provide open source support or to manage its implementation and delivery.

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3.1.1: Why Open Source?

Learning Objectives

After studying this section you should be able to do the following:

1. Know the primary reasons firms choose to use OSS.
2. Understand how OSS can beneficially impact industry and government.

There are many reasons why firms choose open source products over commercial alternatives:

Cost—Free alternatives to costly commercial code can be a tremendous motivator, particularly since conventional software often requires customers to pay for every copy used and to pay more for software that runs on increasingly powerful hardware. Big Lots stores lowered costs by as much as $10 million by finding viable OSS (Castelluccio, 2008) to serve their system needs. Online broker E*TRADE estimates that its switch to open source helped save over $13 million a year (King, 2008). And Amazon claimed in SEC filings that the switch to open source was a key contributor to nearly $20 million in tech savings (Shankland, et. al., 2001). Firms like TiVo, which use OSS in their own products, eliminate a cost spent either developing their own operating system or licensing similar software from a vendor like Microsoft.

Reliability—There's a saying in the open source community, "Given enough eyeballs, all bugs are shallow" (Raymond, 1999). What this means is that the more people who look at a program's code, the greater the likelihood that an error will be caught and corrected. The open source community harnesses the power of legions of geeks who are constantly trawling OSS products, looking to squash bugs and improve product quality. And studies have shown that the quality of popular OSS products outperforms proprietary commercial competitors (Ljungberg, 2000). In one study, Carnegie Mellon University's Cylab estimated the quality of Linux code to be less buggy than commercial alternatives by a factor of two hundred (Castelluccio, 2008)!

Security—OSS advocates also argue that by allowing "many eyes" to examine the code, the security vulnerabilities of open source products come to light more quickly and can be addressed with greater speed and reliability (Wheeler, 2003). High profile hacking contests have frequently demonstrated the strength of OSS products. In one well-publicized 2008 event, laptops running Windows and Macintosh were both hacked (the latter in just two minutes), while a laptop running Linux remained uncompromised (McMillan, 2008). Government agencies and the military often appreciate the opportunity to scrutinize open source efforts to verify system integrity (a particularly sensitive issue among foreign governments leery of legislation like the USA PATRIOT Act of 2001) (Lohr, 2003). Many OSS vendors offer security focused (sometimes called *hardened*) versions of their products. These can include systems that monitor the integrity of an OSS distribution, checking file size and other indicators to be sure that code has not been modified and redistributed by bad guys who've added a back door, malicious routines, or other vulnerabilities.

Scalability—Many major OSS efforts can run on everything from cheap commodity hardware to high-end supercomputing. Scalability allows a firm to scale from start-up to blue chip without having to significantly rewrite their code, potentially saving big on software development costs. Not only can many forms of OSS be migrated to more powerful hardware, packages like Linux have also been optimized to balance a server's workload among a large number of machines working in tandem. Brokerage firm E*TRADE claims that usage spikes following 2008 U.S. Federal Reserve moves flooded the firm's systems, creating the highest utilization levels in five years. But E*TRADE credits its scalable open source systems for maintaining performance while competitors' systems struggled (King, 2008).

Agility and Time to Market—Vendors who use OSS as part of product offerings may be able to skip whole segments of the software development process, allowing new products to reach the market faster than if the entire software system had to be developed from scratch, in-house. Motorola has claimed that customizing products built on OSS has helped speed time-to-market for the firm's mobile phones, while the team behind the Zimbra e-mail and calendar effort built their first product in just a few months by using some forty blocks of free code (Guth, 2006).

Key Takeaways

- The most widely cited benefits of using OSS include low cost; increased reliability; improved security and auditing; system scalability; and helping a firm improve its time to market.
- Free OSS has resulted in cost savings for many large companies in several industries.

- OSS often has fewer bugs than its commercial counterparts due to the large number of persons who have looked at the code.
- The huge exposure to scrutiny by developers and other people helps to strengthen the security of OSS.
- “Hardened” versions of OSS products often include systems that monitor the integrity of an OSS distribution, checking file size and other indicators to be sure that code has not been modified and redistributed by bad guys who have added a back door, malicious routines, or other vulnerabilities.
- OSS can be easily migrated to more powerful computers as circumstances dictate, and also can balance workload by distributing work over a number of machines.
- Vendors who use OSS as part of product offerings may be able to skip whole segments of the software development process, allowing new products to reach the market faster.

Questions and Exercises

1. What advantages does OSS offer TiVo? What alternatives to OSS might the firm consider and why do you suppose the firm decided on OSS?
2. What’s meant by the phrase, “Given enough eyeballs, all bugs are shallow”? Provide evidence that the insight behind this phrase is an accurate one.
3. How has OSS benefited E*TRADE? Amazon? Motorola? Zimbra? What benefits were achieved in each of these examples?
4. Describe how OSS provides a firm with scalability. What does this mean, and why does this appeal to a firm? What issues might a firm face if chosen systems aren’t scalable?
5. The Web site NetCraft (http://www.netcraft.com) is one of many that provide a tool to see the kind of operating system and Web server software that a given site is running. Visit NetCraft or a similar site and enter the address of some of your favorite Web sites. How many run open source products (e.g., the Linux OS or Apache Web server)? Do some sites show their software as “unknown”? Why might a site be reluctant to broadcast the kind of software that it uses?

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3.1.2: Why Give It Away? The Business of Open Source

Learning Objectives

After studying this section you should be able to do the following:

1. Understand the disproportional impact OSS has on the IT market.
2. Understand how vendors make money on open source.
3. Know what SQL and MySQL are.

Open source is a sixty-billion-dollar industry (Asay, 2008), but it has a disproportionate impact on the trillion-dollar IT market. By lowering the cost of computing, open source efforts make more computing options accessible to smaller firms. More reliable, secure computing also lowers costs for all users. OSS also diverts funds that firms would otherwise spend on fixed costs, like operating systems and databases, so that these funds can be spent on innovation or other more competitive initiatives. Think about Google, a firm that some estimate has over 1.4 million servers. Imagine the costs if it had to license software for each of those boxes!

Commercial interest in OSS has sparked an acquisition binge. Red Hat bought open source application server firm JBoss for $350 million. Novell snapped up SUSE Linux for $210 million. And Sun plunked down over $1 billion for open source database provider MySQL (Greenberg, 2008). And with Oracle's acquisition of Sun, one of the world's largest commercial software firms has zeroed in on one of the deepest portfolios of open source products.

But how do *vendors* make money on open source? One way is by selling support and consulting services. While not exactly Microsoft money, Red Hat, the largest purely OSS firm, reported half a billion dollars in revenue in 2008. The firm had two and a half million *paid* subscriptions offering access to software updates and support services (Greenberg, 2008). Oracle, a firm that sells commercial ERP and database products, provides Linux for free, selling high-margin Linux support contracts for as much as five hundred thousand dollars (Fortt, 2007). The added benefit for Oracle? Weaning customers away from Microsoft—a firm that sells many products that compete head-to-head with Oracle's offerings. Service also represents the most important part of IBM's business. The firm now makes more from services than from selling hardware and software (Robertson, 2009). And every dollar saved on buying someone else's software product means more money IBM customers can spend on IBM computers and services. Sun Microsystems was a leader in OSS, even before the Oracle acquisition bid. The firm has used OSS to drive advanced hardware sales, but the firm also sells proprietary products that augment its open source efforts. These products include special optimization, configuration management, and performance tools that can tweak OSS code to work its best (Preimesberger, 2008).

Here's where we also can relate the industry's evolution to what we've learned about standards competition in our earlier chapters. In the pre-Linux days, nearly every major hardware manufacturer made its own, incompatible version of the Unix operating system. These fractured, incompatible markets were each so small that they had difficulty attracting third-party vendors to write application software. Now, much to Microsoft's dismay, all major hardware firms run Linux. That means there's a large, unified market that attracts software developers who might otherwise write for Windows.

To keep standards unified, several Linux-supporting hardware and software firms also back the Linux Foundation, the nonprofit effort where Linus Torvalds serves as a fellow, helping to oversee Linux's evolution. Sharing development expenses in OSS has been likened to going in on a pizza together. Everyone wants a pizza with the same ingredients. The pizza doesn't make you smarter or better. So why not share the cost of a bigger pie instead of buying by the slice (Cohen, 2008)? With OSS, hardware firms spend less money than they would in the brutal, head-to-head competition where each once offered a "me too" operating system that was incompatible with rivals but offered little differentiation. Hardware firms now find their technical talent can be deployed in other value-added services mentioned above: developing commercial software add-ons, offering consulting services, and enhancing hardware offerings.

Linux on the Desktop?

While Linux is a major player in enterprise software, mobile phones, and consumer electronics, the Linux OS can only be found on a tiny fraction of desktop computers. There are several reasons for this. Some suggest Linux simply isn't as easy to install and use as Windows or the Mac OS. This complexity can raise the total cost of ownership (TCO) of Linux desktops, with additional end-user support offsetting any gains from free software. The small number of desktop users also dissuades third party firms from porting popular desktop applications over to Linux. For consumers in most industrialized nations, the added complexity and limited desktop application availability of desktop Linux just it isn't worth the one to two hundred dollars saved by giving up Windows.

But in developing nations where incomes are lower, the cost of Windows can be daunting. Consider the OLPC, Nicholas Negroponte's "one-hundred-dollar" laptop. An additional one hundred dollars for Windows would double the target cost for the nonprofit's machines. It is not surprising that the first OLPC laptops ran Linux. Microsoft recognizes that if a whole generation of first-time computer users grows up without Windows, they may favor open source alternatives years later when starting their own businesses. As a result, Microsoft has begun offering low-cost versions of Windows (in some cases for as little as seven dollars) in nations where populations have much lower incomes. Microsoft has even offered a version of Windows to the backers of the OLPC. While Microsoft won't make much money on these efforts, the low cost versions will serve to entrench Microsoft products as standards in emerging markets, staving off open source rivals and positioning the firm to raise prices years later when income levels rise.

MySQL: Turning a Ten-Billion-Dollars-a-Year Business into a One-Billion-Dollar One

Finland is not the only Scandinavian country to spawn an open source powerhouse. Uppsala Sweden's MySQL (pronounced "my sequel") is the "M" in the LAMP stack, and is used by organizations as diverse as FedEx, Lufthansa, NASA, Sony, UPS, and YouTube.

The "SQL" in name stands for the structured query language, a standard method for organizing and accessing data. SQL is also employed by commercial database products from Oracle, Microsoft, and Sybase. Even Linux-loving IBM uses SQL in its own lucrative DB2 commercial database product. Since all of these databases are based on the same standard, switching costs are lower, so migrating from a commercial product to MySQL's open source alternative is relatively easy. And that spells trouble for commercial firms. Granted, the commercial efforts offer some bells and whistles that MySQL doesn't yet have, but those extras aren't necessary in a lot of standard database use. Some organizations, impressed with MySQL's capabilities, are mandating its use on all new development efforts, attempting to cordon off proprietary products in legacy code that is maintained but not expanded.

Savings from using MySQL can be huge. The Web site PriceGrabber pays less than ten thousand dollars in support for MySQL compared to one hundred thousand to two hundred thousand dollars for a comparable Oracle effort. Lycos Europe switched from Oracle to MySQL and slashed costs from one hundred twenty thousand dollars a year to seven thousand dollars. And the travel reservation firm Sabre used open source products such as MySQL to slash ticket purchase processing costs by 80 percent (Lyons, 2004).

MySQL does make money, just not as much as its commercial rivals. While you can download a version of MySQL over the Net, the flagship product also sells for four hundred ninety-five dollars per server computer compared to a list price for Oracle that can climb as high as one hundred sixty thousand dollars. Of the roughly eleven million copies of MySQL in use, the company only gets paid for about one in a thousand (Ricadela, 2007). Firms pay for what's free for one of two reasons: (1) for MySQL service, and (2) for the right to incorporate MySQL's code into their own products (Kirkpatrick, 2004). Amazon, Facebook, Gap, NBC, and Sabre pay MySQL for support; Cisco, Ericsson, HP, and Symantec pay for the rights to the code (Ricadela, 2007). Top-level round-the-clock support for MySQL for up to fifty servers is fifty thousand dollars a year, still a fraction of the cost for commercial alternatives. Founder Marten Mickos has stated an explicit goal of the firm is "turning the $10-billion-a-year database business into a $1 billion one" (Kirkpatrick, 2004).

When Sun Microsystems spent over $1 billion to buy Mickos' MySQL in 2008, Sun CEO Jonathan Schwartz called the purchase the "most important acquisition in the company's history" (Shankland, 2008). Sun hoped the cheap database software could make the firm's hardware offerings seem more attractive. And it looked like Sun was good for MySQL, with the product's revenues growing 55 percent in the year after the acquisition (Asay, 2009).

But here's where it gets complicated. Sun also had a lucrative business selling hardware to support commercial ERP and database software from Oracle. That put Sun and partner Oracle in a relationship where they were both competitors and collaborators (the "coopetition" or "frenemies" phenomenon mentioned in Chapter 6 "Understanding Network Effects"). Then in spring 2009, Oracle announced it was buying Sun. Oracle CEO Larry Ellison mentioned acquiring the Java language was the crown jewel of the purchase, but industry watchers have raised several questions. Will the firm continue to nurture MySQL and other open source products, even as this software poses a threat to its bread-and-butter database products? Will the development community continue to back MySQL as the de facto standard for open source SQL databases, or will they migrate to an alternative? Or will Oracle find the right mix of free and fee-based products and services that allow MySQL to thrive while Oracle continues to grow? The implications are serious for investors, as well as firms that have made commitments to Sun, Oracle, and MySQL products. The complexity of this environment further demonstrates why technologists need business savvy and market monitoring skills and why business folks need to understand the implications of technology and tech-industry developments.

Legal Risks and Open Source Software: A Hidden and Complex Challenge

Open source software isn't without its risks. Competing reports cite certain open source products as being difficult to install and maintain (suggesting potentially higher total cost of ownership, or TCO). Adopters of OSS without support contracts may lament having to rely on an uncertain community of volunteers to support their problems and provide innovative upgrades. Another major concern is legal exposure. Firms adopting OSS may be at risk if they distribute code and aren't aware of the licensing implications. Some commercial software firms have pressed legal action against the users of open source products when there is a perceived violation of software patents or other unauthorized use of their proprietary code.

For example, in 2007 Microsoft suggested that Linux and other open source software efforts violated some two hundred thirty-five of its patents (Ricadela, 2007). The firm then began collecting payments and gaining access to the patent portfolios of companies that use the open source Linux operating system in their products, including Fuji, Samsung, and Xerox. Microsoft also cut a deal with Linux vendor Novell in which both firms pledged not to sue each other's customers for potential patent infringements.

Also complicating issues are the varying open source license agreements (these go by various names, such as GPL and the Apache License), each with slightly different legal provisions—many of which have evolved over time. Keeping legal with so many licensing standards can be a challenge, especially for firms that want to bundle open source code into their own products (Lacy, 2006). An entire industry has sprouted up to help firms navigate the minefield of open source legal licenses. Chief among these are products, such as those offered by the firm Black Duck, which analyze the composition of software source code and report on any areas of concern so that firms can honor any legal obligations associated with their offerings. Keeping legal requires effort and attention, even in an environment where products are allegedly "free." This also shows that even corporate lawyers had best geek-up if they want to prove they're capable of navigating a twenty-first-century legal environment.

Key Takeaways

- Business models for firms in the open source industry are varied, and can include selling services, licensing OSS for incorporation into commercial products, and using OSS to fuel hardware sales.
- Many firms are trying to use OSS markets to drive a wedge between competitors and their customers.
- Linux has been very successful on mobile devices and consumer electronics, as well as on high-end server class and above computers. But it has not been as successful on the desktop. The small user base for desktop Linux makes the platform less attractive for desktop software developers. Incompatibility with Windows applications, switching costs, and other network effects-related issues all suggest that Desktop Linux has an uphill climb in more mature markets.
- MySQL is the dominant open source database software product. Adoption of the SQL standard eases some issues with migrating from commercial products to MySQL.
- OSS also has several drawbacks and challenges that limit its appeal. These include complexity of some products and a higher total cost of ownership for some products, concern about the ability of a product's development community to provide support or product improvement, and legal and licensing concerns.

Questions and Exercises

1. Describe the impact of OSS on the IT market.
2. Show your understanding of the commercial OSS market. How do Red Hat, Oracle, Oracle's Sun division, and IBM make money via open source?

3. Visit Mozilla.org. Which open source products does this organization develop? Investigate how development of these efforts is financed. How does this organization differ from the ones mentioned above?
4. What is the Linux Foundation? Why is it necessary? Which firms are members, underwriting foundation efforts?
5. List the reasons why Linux is installed on only a very small fraction of desktop computers. Are there particular categories of products or users who might see Linux as more appealing than conventional operating systems? Do you think Linux's share of the desktop market will increase? Why or why not?
6. How is Microsoft combating the threat of open source software and other free tools that compete with its commercial products?
7. What is the dominant open source database software product? Which firms use this product? Why?
8. Which firm developed the leading OSS database product? Do you think it's more or less likely that a firm would switch to an OSS database instead of an OSS office suite or desktop alternative? Why or why not?
9. How has stewardship of the leading OSS database effort changed in recent years? Who oversees the effort today? What questions does this raise for the product's future? Although this book is updated regularly, current events continue to change after publication of this chapter. Investigate the current status of this effort—reaction of the developer community, continued reception of the product—and be prepared to share your findings with class.
10. List some of the risks associated with using OSS. Give examples of firms that might pass on OSS software, and explain why.

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3.1.3: Examples of Open Source Software

Learning Objectives

After studying this section you should be able to do the following:

1. Recognize that just about every type of commercial product has an open source equivalent.
2. Be able to list commercial products and their open source competitors.

Just about every type of commercial product has an open source equivalent. SourceForge.net lists over two hundred and thirty thousand such products[1]! Many of these products come with the installation tools, support utilities, and full documentation that make them difficult to distinguish from traditional commercial efforts (Woods, 2008). In addition to the LAMP products, some major examples include the following:

- Firefox—a Web browser that competes with Internet Explorer
- OpenOffice—a competitor to Microsoft Office
- Gimp—a graphic tool with features found in Photoshop
- Alfresco—collaboration software that competes with Microsoft Sharepoint and EMC's Documentum
- Marketcetera—an enterprise trading platform for hedge fund managers that competes with FlexTrade and Portware
- Zimbra—open source e-mail software that competes with Outlook server
- MySQL, Ingres, and EnterpriseDB—open source database software packages that each go head-to-head with commercial products from Oracle, Microsoft, Sybase, and IBM
- SugarCRM—customer relationship management software that competes with Salesforce.com and Siebel
- Asterix—an open source implementation for running a PBX corporate telephony system that competes with offerings from Nortel and Cisco, among others
- Free BSD and Sun's OpenSolaris—open source versions of the Unix operating system

Key Takeaways

- There are thousands of open source products available, covering nearly every software category. Many have a sophistication that rivals commercial software products.
- Not all open source products are contenders. Less popular open source products are not likely to attract the community of users and contributors necessary to help these products improve over time (again we see network effects are a key to success—this time in determining the quality of an OSS effort).
- Just about every type of commercial product has an open source equivalent.

Questions and Exercises

1. Visit http://www.SourceForge.net. Make a brief list of commercial product categories that an individual or enterprise might use. Are there open source alternatives for these categories? Are well-known firms leveraging these OSS offerings? Which commercial firms do they compete with?
2. Are the OSS efforts you identified above provided by commercial firms, nonprofit organizations, or private individuals? Does this make a difference in your willingness to adopt a particular product? Why or why not? What other factors influence your adoption decision?
3. Download a popular, end-user version of an OSS tool that competes with a desktop application that you own, or that you've used (hint: choose something that's a smaller file or easy to install). What do you think of the OSS offering compared to the commercial product? Will you continue to use the OSS product? Why or why not?

[1]See http://sourceforge.net.

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3.2: Commercial Software

Commercial Software

Commercial software, or seldom payware, is computer software that is produced for sale or that serves commercial purposes. Commercial software can be proprietary software or free and open-source software.

When software is sold in binary form only **("closed source")** on the market, exclusive control over software derivatives and further development is additionally achieved. The reverse engineering reconstruction process of complex software from its binary form to its source code form, required for unauthorized third-party adaption and development, is a burdensome and often impossible process. This creates another commercialization opportunity of software in source code form for a higher price, e.g. by licensing a game engine's source code to another game developer for flexible use and adaption.

This business model also called "research and development model", "IP-rent model" or "proprietary software business model", was described by Craig Mundie of Microsoft in 2001 as follows: "Companies and investors need to focus on business models that can be sustainable over the long term in the real world economy…. We emphatically remain committed to a model that protects the intellectual property rights in software and ensures the continued vitality of an independent software sector that generates revenue and will sustain ongoing research and development. This research and development model … based on the importance of intellectual property rights [was the] foundation in law that made it possible for companies to raise capital, take risks, focus on the long term, and create sustainable business models…. An economic model that protects intellectual property and a business model that recoups research and development costs have shown repeatedly that they can create impressive economic benefits and distribute them very broadly.

While less common than commercial proprietary software, free and open-source software may also be commercial software in the **free and open-source software (FOSS) domain**. But unlike the proprietary model, commercialization is achieved in the FOSS commercialization model without limiting the users in their capability to share, reuse and duplicate software freely. This is a fact that the Free Software Foundation emphasizes, and is the basis of the Open Source Initiative.[citation needed]

Under a FOSS business model, software vendors may charge a fee for distribution and offer pay support and software customization services. Proprietary software uses a different business model, where a customer of the proprietary software pays a fee for a license to use the software. This license may grant the customer the ability to configure some or no parts of the software themselves. Often some level of support is included in the purchase of proprietary software[citation needed], but additional support services (especially for enterprise applications) are usually available for an additional fee. Some proprietary software vendors will also customize software for a fee. Free software is often available at no cost and can result in permanently lower costs compared to proprietary software. With free software, businesses can fit software to their specific needs by changing the software themselves or by hiring programmers to modify it for them. Free software often has no warranty, and more importantly, generally does not assign legal liability to anyone. However, warranties are permitted between any two parties upon the condition of the software and its usage. Such an agreement is made separately from the free software license.

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3.3: Virtualization- Software That Makes One Computer Act Like Many

Learning Objectives

After studying this section you should be able to do the following:

1. Know what virtualization software is and its impact on cloud computing.
2. Be able to list the benefits to a firm from using virtualization.

The reduced costs and increased power of commodity hardware are not the only contributors to the explosion of cloud computing. The availability of increasingly sophisticated software tools has also had an impact. Perhaps the most important software tool in the cloud computing toolbox is virtualization. Think of virtualization as being a kind of operating system for operating systems. A server running virtualization software can create smaller compartments in memory that each behave as a separate computer with its own operating system and resources. The most sophisticated of these tools also allow firms to combine servers into a huge pool of computing resources that can be allocated as needed (Lyons, 2008).

Virtualization can generate huge savings. Some studies have shown that on average, conventional data centers run at 15 percent or less of their maximum capacity. Data centers using virtualization software have increased utilization to 80 percent or more (Katz, 2009).This increased efficiency means cost savings in hardware, staff, and real estate. Plus it reduces a firm's IT-based energy consumption, cutting costs, lowering its carbon footprint, and boosting "green cred" (Castro, 2007). Using virtualization, firms can buy and maintain fewer servers, each running at a greater capacity. It can also power down servers until demand increases require them to come online.

While virtualization is a key software building block that makes public cloud computing happen, it can also be used in-house to reduce an organization's hardware needs, and even to create a firm's own private cloud of scalable assets. Bechtel, BT, Merrill Lynch, and Morgan Stanley are among the firms with large private clouds enabled by virtualization (Brodkin, 2008). Another kind of virtualization, virtual desktops allow a server to run what amounts to a copy of a PC—OS, applications, and all—and simply deliver an image of what's executing to a PC or other connected device. This allows firms to scale, back up, secure, and upgrade systems far more easily than if they had to maintain each individual PC. One game start-up hopes to remove the high-powered game console hardware attached to your television and instead put the console in the cloud, delivering games to your TV as they execute remotely on superfast server hardware. Virtualization can even live on your desktop. Anyone who's ever run Windows in a window on Mac OS X is using virtualization software; these tools inhabit a chunk of your Mac's memory for running Windows and actually fool this foreign OS into thinking that it's on a PC.

Interest in virtualization has exploded in recent years. VMware, the virtualization software division of storage firm EMC, was the biggest IPO of 2007. But its niche is getting crowded. Microsoft has entered the market, building virtualization into its server offerings. Dell bought a virtualization software firm for $1.54 billion. And there's even an open source virtualization product called Xen (Castro, 2007).

Key Takeaways

- Virtualization software allows one computing device to function as many. The most sophisticated products also make it easy for organizations to scale computing requirements across several servers.
- Virtualization software can lower a firm's hardware needs, save energy, and boost scalability.
- Data center virtualization software is at the heart of many so-called private clouds and scalable corporate data centers, as well as the sorts of public efforts described earlier.
- Virtualization also works on the desktop, allowing multiple operating systems (Mac OS X, Linux, Windows) to run simultaneously on the same platform.
- Virtualization software can increase data center utilization to 80 percent or more.
- While virtualization is used to make public cloud computing happen, it can also be used in-house to create a firm's own private cloud.
- A number of companies, including Microsoft and Dell, have entered the growing virtualization market.

Questions and Exercises

1. List the benefits to a firm from using virtualization.
2. What is the average utilization rate for conventional data centers?
3. List companies that have virtualization-enabled private clouds.
4. Give an example of desktop virtualization.
5. Name three companies that are players in the virtualization software industry.

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3.4: Build, Buy, or Rent

Learning Objectives

After studying this section you should be able to do the following:

1. Know the options managers have when determining how to satisfy the software needs of their companies.
2. Know the factors that must be considered when making the make, buy, or rent decision.

So now you realize managers have a whole host of options when seeking to fulfill the software needs of their firms. An organization can purchase packaged software from a vendor, use open source offerings, leverage SaaS or other type of cloud computing, outsource development or other IT functions to another firm either domestically or abroad, or a firm can develop all or part of the effort themselves. When presented with all of these options, making decisions about technologies and systems can seem pretty daunting.

First, realize that that for most firms, technology decisions are not binary options for the whole organization in all situations. Few businesses will opt for an IT configuration that is 100 percent in-house, packaged, or SaaS. Being aware of the parameters to consider can help a firm make better, more informed decisions. It's also important to keep in mind that these decisions need to be continuously reevaluated as markets and business needs change. What follows is a summary of some of the key variables to consider.

Competitive Advantage—*Do we rely on unique processes, procedures, or technologies that create vital, differentiating competitive advantage?* If so, then these functions aren't a good candidate to outsource or replace with a package software offering. Amazon.com had originally used recommendation software provided by a third party, and Netflix and Dell both considered third-party software to manage inventory fulfillment. But in all three cases, these firms felt that mastery of these functions was too critical to competitive advantage, so each firm developed proprietary systems unique to the circumstances of each firm.

Security—*Are there unacceptable risks associated with using the packaged software, OSS, cloud solution, or an outsourcing vendor? Are we convinced that the prospective solution is sufficiently secure and reliable? Can we trust the prospective vendor with our code, our data, our procedures and our way of doing business? Are there noncompete provisions for vendor staff that may be privy to our secrets? For off-site work, are there sufficient policies in place for on-site auditing?* If the answers to any of these questions is no, outsourcing might not be a viable option.

Legal and Compliance—*Is our firm prohibited outright from using technologies? Are there specific legal and compliance requirements related to deploying our products or services?* Even a technology as innocuous as instant messaging may need to be deployed in such a way that it complies with laws requiring firms to record and reproduce the electronic equivalent of a paper trail. For example, SEC Rule 17a-4 requires broker dealers to retain client communications for a minimum of three years. HIPAA laws governing health care providers state that electronic communications must also be captured and stored (Shapiro, 2004). While tech has gained a seat in the board room, legal also deserves a seat in systems planning meetings.

Skill, Expertise, and Available Labor—*Can we build it?* The firm may have skilled technologists, but they may not be sufficiently experienced with a new technology. Even if they are skilled, managers much consider the costs of allocating staff away from existing projects for this effort.

Cost—*Is this a cost-effective choice for our firm?* A host of factors must be considered when evaluating the cost of an IT decision. The costs to build, host, maintain, and support an ongoing effort involve labor (software development, quality assurance, ongoing support, training, and maintenance), consulting, security, operations, licensing, energy, and real estate. Any analysis of costs should consider not only the aggregate spending required over the lifetime of the effort but also whether these factors might vary over time.

Time—*Do we have time to build, test, and deploy the system?*

Vendor Issues—*Is the vendor reputable and in a sound financial position? Can the vendor guarantee the service levels and reliability we need? What provisions are in place in case the vendor fails or is acquired? Is the vendor certified via the Carnegie Mellon Software Institute or other standards organizations in a way that conveys quality, trust, and reliability?*

The list above is a starter. It should also be clear that these metrics are sometimes quite tough to estimate. Welcome to the challenges of being a manager! At times an environment in flux can make an executive feel like he or she is working on a surfboard, constantly being buffeted about by unexpected currents and waves. Hopefully the issues outlined in this chapter will give you the surfing skills you need for a safe ride that avoids the organizational equivalent of a wipeout.

Key Takeaways

- The make, buy, or rent decision may apply on a case-by-case basis that might be evaluated by firm, division, project or project component. Firm and industry dynamics may change in a way that causes firms to reassess earlier decisions, or to alter the direction of new initiatives.
- Factors that managers should consider when making a make, buy, or rent decision include the following: competitive advantage, security, legal and compliance issues, the organization's skill and available labor, cost, time, and vendor issues.
- Factors must be evaluated over the lifetime of a project, not at a single point in time.
- Managers have numerous options available when determining how to satisfy the software needs of their companies: purchase packaged software from a vendor, use OSS, use SaaS or utility computing, outsourcing development, or developing all or part of the effort themselves.
- If a company relies on unique processes, procedures, or technologies that create vital, differentiating, competitive advantages, the functions probably aren't a good candidate to outsource.

Questions and Exercises

1. What are the options available to managers when seeking to meet the software needs of their companies?
2. What are the factors that must be considered when making the make, buy, or rent decision?
3. What are some security-related questions that must be asked when making the make, buy, or rent decision?
4. What are some vendor-related questions that must be asked when making the make, buy, or rent decision?
5. What are some of the factors that must be considered when evaluating the cost of an IT decision?
6. Why must factors be evaluated over the lifetime of a project, not at a single point in time?

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3.5: SaaS- Not without Risks

Learning Objective

After studying this section you should be able to do the following:

1. Be able to list and appreciate the risks associated with SaaS.

Like any technology, we also recognize there is rarely a silver bullet that solves all problems. A successful manager is able to see through industry hype and weigh the benefits of a technology against its weaknesses and limitations. And there are still several major concerns surrounding SaaS.

The largest concerns involve the tremendous dependence a firm develops with its SaaS vendor. Having all of your eggs in one basket can leave a firm particularly vulnerable. If a traditional software company goes out of business, in most cases its customers can still go on using its products. But if your SaaS vendor goes under, you're hosed. They've got all your data, and even if firms could get their data out, most organizations don't have the hardware, software, staff, or expertise to quickly absorb an abandoned function.

Beware with whom you partner. Any hot technology is likely to attract a lot of start-ups, and most of these start-ups are unlikely to survive. In just a single year, the leading trade association found the number of SaaS vendors dropped from seven hundred members to four hundred fifty (Drummond, 2001). One of the early efforts to collapse was Pandesic, a joint venture between SAP and Intel—two large firms that might have otherwise instilled confidence among prospective customers. In another example, Danish SaaS firm "IT Factory" was declared "Denmark's Best IT Company 2008" by *Computerworld*, only to follow the award one week later with a bankruptcy declaration (Wauters, 2008). Indeed, despite the benefits, the costs of operating as a SaaS vendor can be daunting. NetSuite's founder claimed it "takes ten years and $100 million to do right" (Lacy, 2008) —maybe that's why the firm still wasn't profitable, even a year and a half after going public.

Firms that buy and install packaged software usually have the option of sticking with the old stuff as long as it works, but organizations adopting SaaS may find they are forced into adopting new versions. This fact is important because any radical changes in a SaaS system's user interface or system functionality might result in unforeseen training costs, or increase the chance that a user might make an error.

Keep in mind that SaaS systems are also reliant on a network connection. If a firm's link to the Internet goes down, its link to its SaaS vendor is also severed. Relying on an Internet connection also means that data is transferred to and from a SaaS firm at Internet speeds, rather the potentially higher speeds of a firm's internal network. Solutions to many of these issues are evolving as Internet speeds become faster and Internet service providers become more reliable. There are also several programs that allow for offline use of data that is typically stored in SaaS systems, including Google Gears and Adobe AIR. With these products a user can download a subset of data to be offline (say on a plane flight or other inaccessible location), and then sync the data when the connection is restored. Ultimately, though, SaaS users have a much higher level of dependence on their Internet connections.

And although a SaaS firm may have more security expertise than your organization, that doesn't mean that security issues can be ignored. Any time a firm allows employees to access a corporation's systems and data assets from a remote location, a firm is potentially vulnerable to abuse and infiltration. Some firms may simply be unacceptably uncomfortable with critical data assets existing outside their own network. There may also be contractual or legal issues preventing data from being housed remotely, especially if a SaaS vendor's systems are in another country operating under different laws and regulations. "We're very bound by regulators in terms of client data and country-of-origin issues, so it's very difficult to use the cloud," says Rupert Brown, a chief architect at Merrill Lynch (Gruman, 2008).

SaaS systems are often accused of being less flexible than their installed software counterparts—mostly due to the more robust configuration and programming options available in traditional software packages. It is true that many SaaS vendors have improved system customization options and integration with standard software packages. And at times a lack of complexity can be a blessing —fewer choices can mean less training, faster start-up time, and lower costs associated with system use. But firms with unique needs may find SaaS restrictive.

SaaS offerings usually work well when the bulk of computing happens at the server end of a distributed system because the kind of user interface you can create in a browser isn't as sophisticated as what you can do with a separate, custom-developed desktop program. A comparison of the first few iterations of the Web-based Google office suite, which offers word processing, presentation software, and a spreadsheet, reveals a much more limited feature set than Microsoft's Office desktop software. The bonus, of course, is that an online office suite is accessible anywhere and makes sharing documents a snap. Again, an understanding of trade-offs is key.

Here's another challenge for a firm and its IT staff: SaaS means a greater *consumerization* of technology. Employees, at their own initiative, can go to Socialtext or Google Sites and set up a wiki, WordPress to start blogging, or subscribe to a SaaS offering like Salesforce.com, all without corporate oversight and approval. This work can result in employees operating outside established firm guidelines and procedures, potentially introducing operational inconsistencies or even legal and security concerns.

The consumerization of corporate technology isn't all bad. Employee creativity can blossom with increased access to new technologies, costs might be lower than home grown solutions, and staff could introduce the firm to new tools that might not otherwise be on the radar of the firm's IS Department. But all this creates an environment that requires a level of engagement between a firm's technical staff and the groups that it serves that is deeper than that employed by any prior generation of technology workers. Those working in an organization's information systems group must be sure to conduct regular meetings with representative groups of employees across the firm to understand their pain points and assess their changing technology needs. Non-IT managers should regularly reach out to IT to ensure that their needs are on the tech staff's agenda. Organizations with internal IT-staff R&D functions that scan new technologies and critically examine their relevance and potential impact on the firm can help guide an organization through the promise and peril of new technologies. Now more than ever, IT managers must be deeply knowledgeable about business areas, broadly aware of new technologies, and able to bridge the tech and business worlds. Similarly, any manager looking to advance his or her organization has to regularly consider the impact of new technologies.

Key Takeaways

The risks associated with SaaS include the following:

- *dependence on a single vendor*.
- concern about the long-term *viability of partner firms*.
- users *may be forced to migrate to new versions*—possibly incurring unforeseen training costs and shifts in operating procedures.
- *reliance on a network connection*—which may be slower, less stable, and less secure.
- *data asset stored off-site*—with the potential for security and legal concerns.
- *limited configuration, customization, and system integration options* compared to packaged software or alternatives developed in-house.
- *the user interface of Web-based software is often less sophisticated and lacks the richness of most desktop alternatives*.
- ease of adoption *may lead to pockets of unauthorized IT* being used throughout an organization.

Questions and Exercises

1. Consider the following two firms: a consulting start-up, and a defense contractor. Leverage what you know about SaaS and advise whether each might consider SaaS efforts for CRM or other enterprise functions? Why or why not?
2. Think of firms you've worked for, or firms you would like to work for. Do SaaS offerings make sense for these firms? Make a case for or against using certain categories of SaaS.
3. What factors would you consider when evaluating a SaaS vendor? Which firms are more appealing to you and why?
4. Discuss problems that may arise because SaaS solutions rely on Internet connections. Discuss the advantages of through-the-browser access.
5. Evaluate trial versions of desktop SaaS offerings (offered by Adobe, Google, Microsoft, Zoho, or others). Do you agree that the interfaces of Web-based versions are not as robust as desktop rivals? Are they good enough for you? For most users?

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4: Project Scheduling Tools

In order to develop our schedule, we first need to define the activities, sequence them in the right order, estimate the resources needed, and estimate the time it will take to complete the tasks.

Defining Activities

The activity definition process is a further breakdown of the work package elements of the WBS. It documents the specific activities needed to fulfill the deliverables detailed in the WBS. These activities are not the deliverables themselves but the individual units of work that must be completed to fulfill the deliverables. Activity definition uses everything we already know about the project to divide the work into activities that can be estimated. You might want to look at all the lessons learned from similar projects your company has done to get a good idea of what you need to do on the current one.

Expert judgment in the form of project team members with prior experience developing project scope statements and WBS can help you define activities. If you are asked to manage a project in a new domain, you might also use experts in that particular field to help define tasks so you can understand what activities are going to be involved. You may want to create an activity list and then have the expert review it and suggest changes. Alternatively, you could involve the expert from the very beginning and ask to have an activity definition conversation with him or her before even making your first draft of the list.

Sometimes you start a project without knowing a lot about the work that you'll be doing later. Rolling-wave planning lets you plan and schedule only the portion that you know enough about to plan well. When you don't know enough about a project, you can use placeholders for the unknown portions until you know more. These are extra items that are put at high levels in the WBS to allow you to plan for the unknown.

A Case Study

Susan and Steve have decided to tie the knot, but they don't have much time to plan their wedding. They want the big day to be unforgettable. They want to invite many people and provide a great time. They've always dreamed of a June wedding, but it's already January. Just thinking about all of the details involved is overwhelming. Susan has been dreaming of the big day since she was 12, but it seems that there's so little time for all the tasks to be completed. When they were choosing the paper for the invitations, the couple realized that they needed help.

Susan: Steve, we need some help.
Steve: Don't worry. My sister's wedding planner was great. Let me give her a call. [Steve calls the wedding planner Sally.]
Wedding Planner: Hello, Susan and Steve.
Steve: We want everything to be perfect.
Susan: There is so much to do! Invitations, food, guests, and music.
Steve: Oh no, we haven't even booked a place!
Susan: And it has to be done right. We can't print the invitations until we have the menu planned. We can't do the seating arrangements until we have the RSVPs. We aren't sure what kind of band to get for the reception, or should it be a DJ? We're just overwhelmed.
Steve: My sister said you really saved her wedding. I know she gave you over a year to plan. But I've always dreamed of a June wedding, and I'm not willing to give that up. I know it's late, but Sally, can you help us?
Wedding Planner: Take it easy. I've got it under control. We've a lot of people and activities to get under control. You really should have called six months ago, but we'll still make this wedding happen on time.

Much work has to be done before June. First, Sally figures out what work needs to be done. She starts to put together a to-do list:

- Invitations
- Flowers
- Wedding cake
- Dinner menu
- Band

Since many different people are involved in the making of the wedding, it takes much planning to coordinate all the work in the right order by the right people at the right time. Initially, Sally was worried that she didn't have enough time to make sure that everything would be done properly. However, she knew that she had some powerful time management tools on her side when she took the job, and these tools would help her to synchronize all the required tasks.

To get started, Sally arranged all the activities in a work breakdown structure. The next exercise presents part of the WBS Sally made for the wedding.

WBS Exercise

Arrange the following activities into the WBS (Figure 10.1) to show how the work items decompose into activities.

- Shop for shoes
- Create guest list
- Have the tailoring and fitting done
- Shop for dress
- Find caterer
- Cater the wedding
- Wait for RSVPs
- Mail the invitations
- Finalize the menu
- Print the invitations
- Choose the bouquet

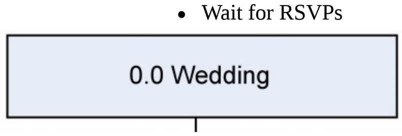

Figure 10.1 Work breakdown structure (WBS) based on the project phase.

Solution to Exercise:

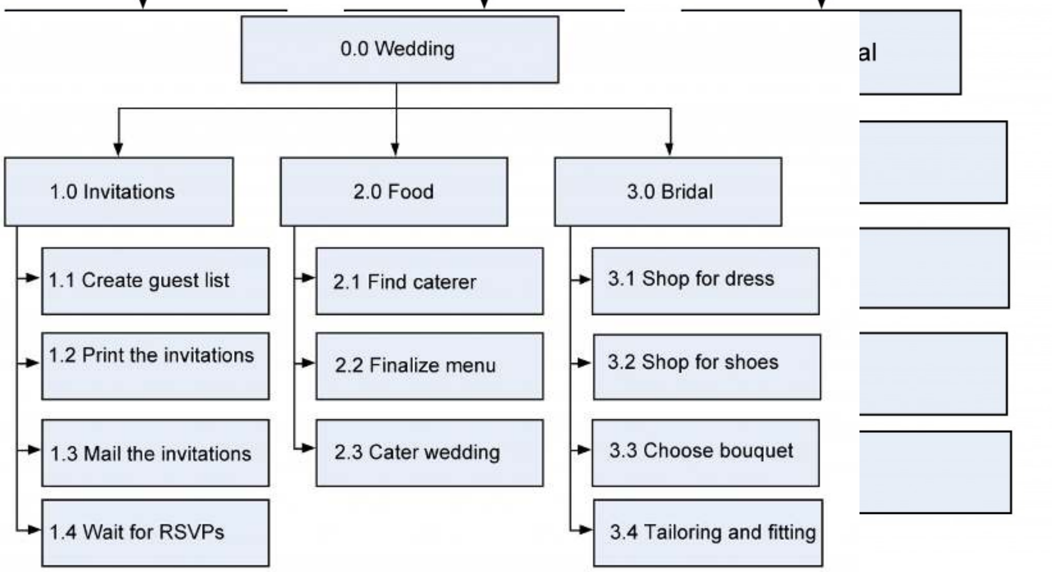

Figure 10.2 WSB Wedding Exercises Solution. [Image description]

Activity List

Now that the activity definitions for the work packages have been completed, the next task is to complete the activity list. The project activity list is a list of everything that needs to be done to complete your project, including all the activities that must be accomplished to deliver each work package. Next you want to define the activity attributes. Here's where the description of each activity is kept. It includes all the information you need to figure out plus the order of the work. Any predecessor activities, successor activities, or constraints should be listed in the attributes along with descriptions and any other information about resources or time that you need for planning. The three main kinds of predecessors are finish-to-start (FS), start-to-start (SS), and finish-to-finish (FF). The most common kind of predecessor is the finish-to-start. It means that one task needs to be completed before another one can start. When you think of predecessors, this is what you usually think of; one thing needs to end before the next can begin. It's called finish-to-start because the first activity's finish leads into the second activity's start (Figure 10.3).

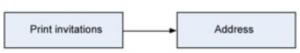

Figure 10.3: An example of a finish-to-start (FS) predecessor.

The start-to-start predecessor is a little less common, but sometimes you need to coordinate activities so they begin at the same time (Figure 10.4).

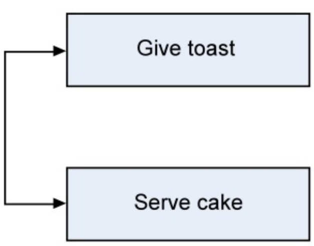

Figure 10.4: An example of a start-to-start (SS) predecessor.

The finish-to-finish predecessor shows activities that finish at the same time (Figure 10.5).

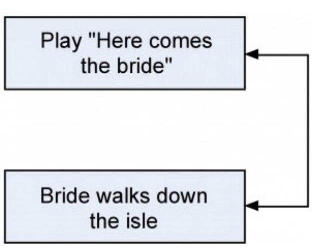

Figure 10.5: An example of a finish-to-finish (FF) predecessor.

It is possible to have start-to-finish (SF) predecessors. This happens when activities require that another task be started before the successor task can finish. An example might be that the musicians cannot finish playing until the guests have started leaving the ceremony. In addition, there are some particular types of predecessors that must be considered.

External Predecessors

Sometimes your project will depend on things outside the work you're doing. For the wedding, we are depending on the wedding party before us to be out of the reception hall in time for us to decorate. The decoration of the reception hall then depends on that as an external predecessor.

Discretionary Predecessors

These are usually process- or procedure-driven or best-practice techniques based on past experience. In the wedding example, Steve and Susan want the bridesmaids to arrive at the reception before the couple arrives. There's no necessity; it is just a matter of preference.

Mandatory Predecessors

You can't address an invitation that hasn't been printed yet. So printing invitations is a mandatory predecessor for addressing them. Mandatory predecessors are the kinds that have to exist just because of the nature of the work.

Leads and Lags

Sometimes you need to give some extra time between activities. Lag time is when you purposefully put a delay between the predecessor task and the successor. For example, when the bride and her father dance, the others wait awhile before they join them (Figure 10.6).

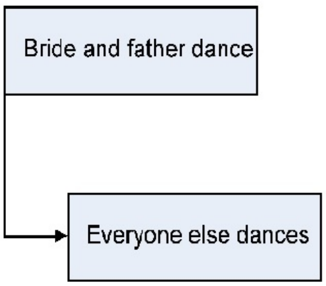

Figure 10.6 A lag means making sure that one task waits a while before it gets started.

Lead time is when you give a successor task some time to get started before the predecessor finishes (Figure 10.7). So you might want the caterer preparing dessert an hour before everybody is eating dinner.

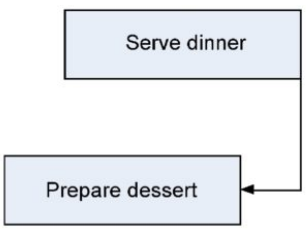

Figure 10.7: A lead is when you let a task get started before its predecessor is done.

Milestones

All of the important checkpoints of your project are tracked as milestones. Some of them could be listed in your contract as requirements of successful completion; some could just be significant points in the project that you want to keep track of. The milestone list needs to let everyone know which milestones are required and which are not.

Some milestones for Susan and Steve's wedding might be:

- Invitations sent
- Menu finalized
- Location booked
- Bridesmaids' dresses fitted

As you figure out which activities will need to be done, you may realize that the scope needs to change. When that happens, you need to create a change request and send it through the change control system.

Some things that could go wrong:

Wedding Planner: We just got the programs back from the printer and they're all wrong.
Steve: The quartet cancelled. They had another wedding that day.
Susan: Aunt Jane is supposed to sing at the service, but after what happened at her uncle's funeral, I think I want someone else to do it.
Steve: Should we really have a pan flute player? I'm beginning to think it might be overkill.
Susan: Apparently! Maybe we should hold off on printing the invitations until these things are worked out.
Wedding Planner: OK, let's think about exactly how we want to do this. I think we need to be sure about how we want the service to go before we do any more printing.

The Activity Sequencing Process

Now that we know what we have to do to make the wedding a success, we need to focus on the order of the work. Sally sat down with all of the activities she had defined for the wedding and decided to figure out exactly how they needed to happen. That's where she used the activity sequencing process.

The activity attribute list Sally created had most of the predecessors and successors necessary written in it. This is where she thought of what comes first, second, third, etc. Sally's milestone list had major pieces of work written down, and there were a couple of changes to the scope she had discovered along the way that were approved and ready to go.

Example milestone list: Steve and Susan had asked that the invitations be printed at least three months in advance to be sure that everyone had time to RSVP. That's a milestone on Sally's list.
Example change request: When Sally realized that Steve and Susan were going to need another limo to take the bridesmaids to the reception hall, she put that change through change control, including running everything by Susan's mother, and it was approved.

Creating the Gantt Chart

A Gantt chart is a type of bar chart, developed by Henry Gantt, that illustrates a project schedule. Gantt charts are easy to read and are commonly used to display schedule activities. These charts display the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project. Some Gantt charts also show the dependency relationships (i.e., precedence network) between activities.

Gantt charts show all the key stages of a project and their duration as a bar chart, with the time scale across the top. The key stages are placed on the bar chart in sequence, starting in the top left corner and ending in the bottom right corner (Figure 10.8). A Gantt chart can be drawn quickly and easily and is often the first tool a project manager uses to provide a rough estimate of the time that it will take to complete the key tasks. Sometimes it is useful to start with the target deadline for completion of the whole project, because it is soon apparent if the time scale is too short or unnecessarily long. The detailed Gantt chart is usually constructed after the main objectives have been determined.

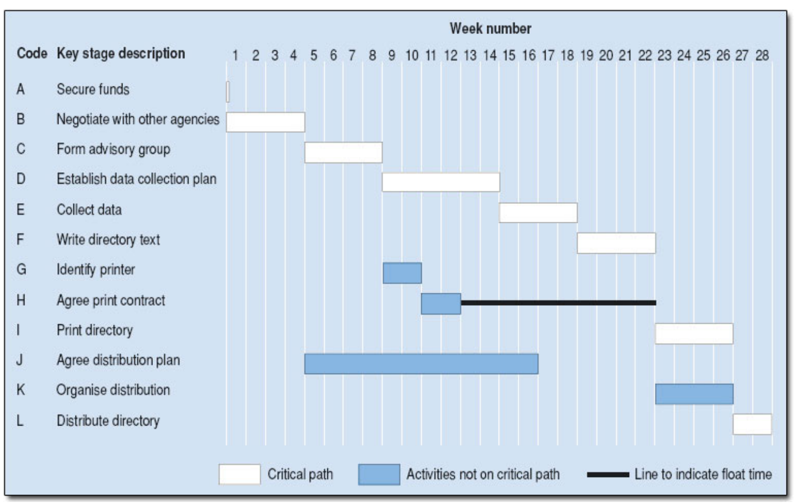

Figure 10.8 Gantt chart for directory production

In this example in Figure 10.8, key stage K (Organize distribution) starts at week 23 so that its end point coincides with key stage L (Distribute directory). However, K could begin as early as week 17, as soon as key stage J is completed. Key stage K is therefore said to have "slack." Key stage H (Agree print contract) has been placed to end at week 12. However, it could end as late as week 22, because key stage I (Print directory) does not begin until week 23. Key stage H is therefore said to have "float." Float time can be indicated on the chart by adding a line ahead of the bar to the latest possible end point. Slack and float show you where there is flexibility in the schedule, and this can be useful when you need to gain time once the project is up and running.

You can add other information to a Gantt chart, for example:

- Milestones could be indicated by using a symbol such as a diamond or triangle.
- Project meetings could be indicated by another symbol such as a circle.

- Reviews of progress could be indicated by a square.

For a complex project, you may decide to produce a separate Gantt chart for each of the key stages. If you do this shortly before each key stage begins, you will be able to take any last-minute eventualities into account. These charts provide a useful tool for monitoring and control as the project progresses.

Gantt charts are relatively easy to draw by hand, but this doesn't offer the same level of flexibility during monitoring that you would get from a software package. Various programs are available to assist project managers in scheduling and control. Once the data have been entered, a program helps you to work on "what if" scenarios, showing what might happen if a key stage is delayed or speeded up. This is more difficult if you are working manually.

Creating the Network Diagram

Many project managers use network diagrams when scheduling a project. The network diagram is a way to visualize the interrelationships of project activities. Network diagrams provide a graphical view of the tasks and how they relate to one another. The tasks in the network are the work packages of the WBS. All of the WBS tasks must be included in the network because they have to be accounted for in the schedule. Leaving even one task out of the network could change the overall schedule duration, estimated costs, and resource allocation commitments.

The first step is to arrange the tasks from your WBS into a sequence. Some tasks can be accomplished at any time throughout the project where other tasks depend on input from another task or are constrained by time or resources.

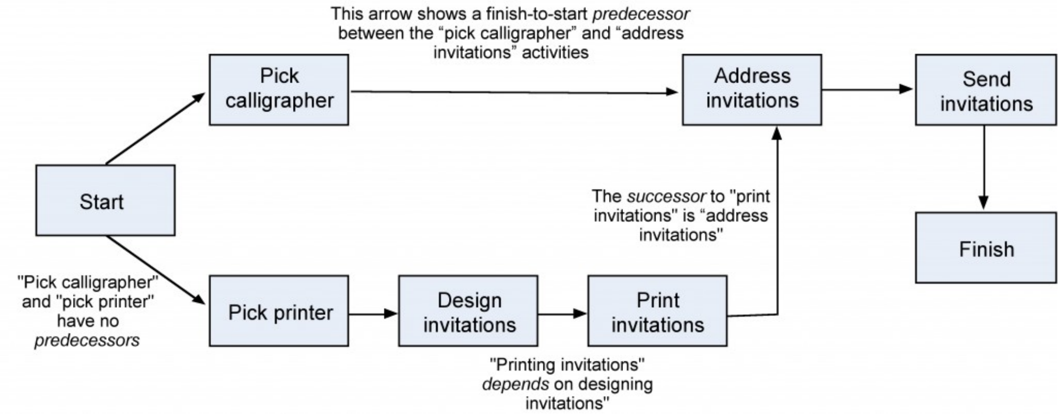

Figure 10.9: The relationship between the work breakdown structure (WBS) and the network diagram.

The WBS is *not* a schedule, but it is the basis for it. The network diagram *is* a schedule but is used primarily to identify key scheduling information that ultimately goes into user-friendly schedule formats, such as milestone and Gantt charts.

The network diagram provides important information to the project team. It provides information about how the tasks are related (Figure 10.9), where the risk points are in the schedule, how long it will take as currently planned to finish the project, and when each task needs to begin and end.

In our wedding planner example, Sally would look for relationships between tasks and determine what can be done in parallel and what activities need to wait for others to complete. As an example, Figure 10.10 shows how the activities involved in producing the invitations depend on one another. Showing the activities in rectangles and their relationships as arrows is called a precedence diagramming method (PDM). This kind of diagram is also called an activity-on-node (AON) diagram.

Another way to show how tasks relate is with the activity-on-arrow (AOA) diagram. Although AON is more commonly used and is supported by all project management programs, PERT is the best-known AOA-type diagram and is the historical basis of all network diagramming. The main difference is the AOA diagram is traditionally drawn using circles as the nodes, with nodes representing the beginning and ending points of the arrows or tasks. In the AOA network, the arrows represent the activities or tasks (Figure 10.11).

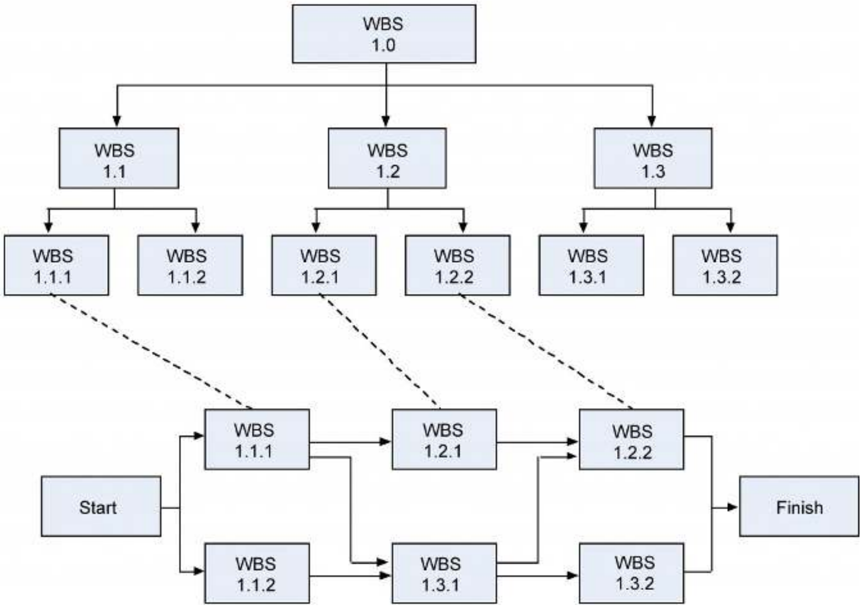

Figure 10.10: An example of an activity on node (AON) diagram.

All network diagrams have the advantages of showing task interdependencies, start and end times, and the critical path (the longest path through the network) but the AOA network diagram has some disadvantages that limit the use of the method.

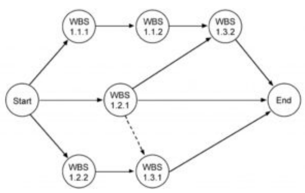

Figure 10.11: An example of an activity arrow (AOA) network diagram.

The three major disadvantages of the AOA method are:

- The AOA network can only show finish-to-start relationships. It is not possible to show lead and lag except by adding or subtracting time, which makes project tracking difficult.
- There are instances when dummy activities can occur in an AOA network. Dummy activities are activities that show the dependency of one task on other tasks but for other than technical reasons. For example, one task may depend on another because it would be more cost effective to use the same resources for the two; otherwise the two tasks could be accomplished in parallel. Dummy activities do not have durations associated with them. They simply show that a task has some kind of dependence on another task.
- AOA diagrams are not as widely used as AON diagrams simply because the latter are somewhat simpler to use, and all project management software programs can accommodate AON networks, whereas not all can accommodate AOA networks.

The Critical Path

The critical path describes the sequence of tasks that would enable the project to be completed in the shortest possible time. It is based on the idea that some tasks must be completed before others can begin. A critical path diagram is a useful tool for scheduling dependencies and controlling a project. In order to identify the critical path, the length of time that each task will take must be calculated.

Let’s take a look at an example. The length of time in weeks for each key stage is estimated:

Table 10.1 Stages of the Critical Path

Key stage	Estimated time in weeks
A. Secure funds	0
B. Negotiate with other agencies	4
C. Form advisory group	4
D. Establish data collection plan	6
E. Collect data	4
F. Write directory text	4
G. Identify printer	2
H. Agree print contract	2
I. Print directory	4
J. Agree distribution plan	12
K. Organize distribution	4
L. Distribute directory	2

We have given the key stage "Secure funds" an estimated time of zero weeks because the project cannot start without the availability of some funding, although estimates would provide detail at a later stage. The stages can now be lined up to produce a network diagram that shows that there are three paths from start to finish and that the lines making up each path have a minimum duration (Figure 10.12).

If we now trace each of the possible paths to "Distribute directory" (the finishing point), taking dependencies into account, the route that has the longest duration is known as the critical path. This is the minimum time in which it will be possible to complete the project.

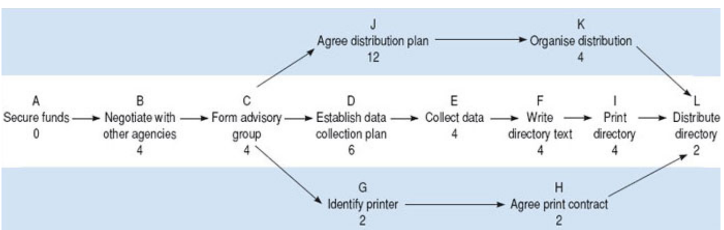

Figure 10.12: Critical Path Diagram

In this example, the critical path is A–B–C–D–E–F–I–L, and the earliest completion date for the project is the sum of the estimated times for all the stages on the critical path – 28 weeks – from the point of securing the funding. All the key stages on the critical path must be completed on time if the project is to be finished on schedule.

If the projected total time is much longer than the project sponsor's expectations, you will need to renegotiate the time scale. Mapping the critical path helps to identify the activities that need to be monitored most closely.

PERT

Like CPM, the **program evaluation and review technique (PERT)** helps managers identify critical tasks and assess how delays in certain activities will affect operations or production. In both methods, managers use diagrams to see how operations and production will flow. PERT differs from CPM in one important respect. CPM assumes that the amount of time needed to finish a task is known with certainty; therefore, the CPM diagram shows only one number for the time needed to complete each activity. In contrast, PERT assigns three time estimates for each activity: an optimistic time for completion, the most probable time, and a pessimistic time. These estimates allow managers to anticipate delays and potential problems and schedule accordingly.

Image Descriptions

Figure 10.2 image description:

0.0 Wedding

- 1.0 Invitations
  - 1.1 Create guest list
  - 1.2 Wait for RSVPs
  - 1.3 Mail the invitations
  - 1.4 Print the invitations
- 2.0 Food

- 2.1 Find caterer
  - 2.2 Cater the wedding
  - 2.3 Finalize the menu
- 3.0 Bridal
  - 3.1 Shop for shoes
  - 3.2 Tailoring and fitting
  - 3.3 Shop for dress
  - 3.4 Choose the bouquet

[Return to Figure 10.2]

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CHAPTER OVERVIEW

5: Project Management

People have been undertaking projects since the earliest days of organized human activity. The hunting parties of our prehistoric ancestors were projects. Large complex projects such as the pyramids and the Great Wall of China were also projects. Even something as simple as creating a dinner is considered a project. We use the term “project” frequently in our daily conversations. This book covers the basics of project management. This includes the process of initiation, planning, execution, control, and closeout that all projects share.

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5.1: Project Management - Past and Present

Careers Using Project Management Skills

Skills learned by your exposure to studying project management can be used in most careers as well as in your daily life. Strong planning skills, good communication, ability to implement a project to deliver the product or service while also monitoring for risks and managing the resources will provide an edge toward your success. Project managers can be seen in many industry sectors including agriculture and natural resources; arts, media, and entertainment; building trades and construction; energy and utilities; engineering and design; fashion and interiors; finance and business; health and human services; hospitality, tourism, and recreation; manufacturing and product development; public and private education services; public services; retail and wholesale trade; transportation; and information technology.

Below we explore various careers and some of the ways in which project management knowledge can be leveraged.

Business Owners

Business owners definitely need to have some project management skills. With all successful businesses, the product or service being delivered to the customer meets their needs in many ways. The product or service is of the quality desired, the costs are aligned with what the consumer expected, and the timeliness of the product or service meets the deadline for the buyer of that item.

The pillars of project management are delivering a product/service within schedule, cost, scope, and quality requirements. Business owners need planning, organizing, and scoping skills and the ability to analyze, communicate, budget, staff, equip, implement, and deliver.

Understanding the finances, operations, and expenses of the business are among the skills that project managers learn and practice. Some businesses may focus more on accounting, providing financial advice, sales, training, public relations, and actuary or logistician roles. Business owners may own a travel agency or provide hospitality. Business owners could be managing a storefront or a location in their town's marketplace.

Example: Restaurant Owner/Manager

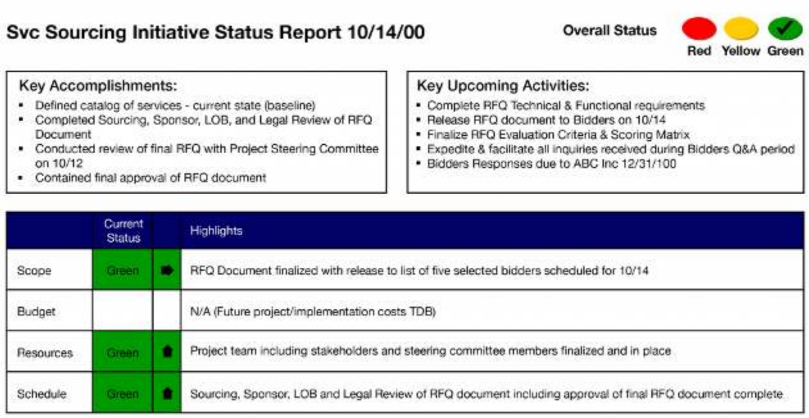
Restaurant managers are responsible for the daily operations of a restaurant that prepares and serves meals and beverages to customers. Strong planning skills, especially coordinating with the various departments (kitchen, dining room, banquet operations, food service managers, vendors providing the supplies) ensure that customers are satisfied with their dining experience. Managers' abilities to recruit and retain employees, and monitor employee performance and training ensure quality with cost containment. Scheduling in many aspects, not only the staff but also the timing of the food service deliveries, is critical in meeting customer expectations.

Risk management is essential to ensure food safety and quality. Managers monitor orders in the kitchen to determine where delays may occur, and they work with the chef to prevent these delays. Legal compliance is essential in order for the restaurant to stay open, so restaurant managers direct the cleaning of the dining areas and the washing of tableware, kitchen utensils, and equipment. They ensure the safety standards and legality, especially in serving alcohol. Sensitivity and strong communication skills are needed when customers have complaints or employees feel pressured because more customers arrive than predicted.

Financial knowledge is needed for the soundness of running the restaurant, especially tracking special projects, events, and costs for the various menu selections. Catering events smoothly can be an outcome of using project plans and the philosophy of project management. The restaurant manager or the executive chef analyzes the recipes to determine food, labour, and overhead costs; determines the portion size and nutritional content of each serving; and assigns prices to various menu items, so that supplies can be ordered and received in time.

Planning is the key for successful implementation. Managers or executive chefs need to estimate food needs, place orders with distributors, and schedule the delivery of fresh food and supplies. They also plan for routine services (equipment maintenance, pest control, waste removal) and deliveries, including linen services or the heavy cleaning of dining rooms or kitchen equipment, to occur during slow times or when the dining room is closed. A successful restaurant relies on many skills that the project management profession emphasizes.

Outsourcing Services


Svc Sourcing Initiative Status Report 10/14/00

Overall Status: Red Yellow Green

Key Accomplishments:
- Defined catalog of services - current state (baseline)
- Completed Sourcing, Sponsor, LOB, and Legal Review of RFQ Document
- Conducted review of final RFQ with Project Steering Committee on 10/12
- Contained final approval of RFQ document

Key Upcoming Activities:
- Complete RFQ Technical & Functional requirements
- Release RFQ document to Bidders on 10/14
- Finalize RFQ Evaluation Criteria & Scoring Matrix
- Expedite & facilitate all inquiries received during Bidders Q&A period
- Bidders Responses due to ABC Inc 12/31/100

	Current Status		Highlights
Scope	Green		RFQ Document finalized with release to list of five selected bidders scheduled for 10/14
Budget			N/A (Future project/implementation costs TDB)
Resources	Green		Project team including stakeholders and steering committee members finalized and in place
Schedule	Green		Sourcing, Sponsor, LOB and Legal Review of RFQ document including approval of final RFQ document complete

Figure 1.1: Sample status chart, which is typical with the use of a red-yellow-green

Many businesses explore outsourcing for certain services. Below is a sample status and project plan that reflects the various tasks needed for a project. A review of finances, the importance of communicating to stakeholders, and the importance of time, cost, schedule, scope, and quality are reflected. Many companies may use these steps in their business. These plans show the need for the entire team to review the various proposals to choose the best plan. Figure 1.1 represents a sample project status report.

Example: Construction Managers

Construction managers plan, direct, coordinate, and budget a wide variety of residential, commercial, and industrial construction projects including homes, stores, offices, roads, bridges, wastewater treatment plants, schools, and hospitals. Strong scheduling skills are essential for this role. Communication skills are often used in coordinating design and construction processes, teams executing the work, and governance of special trades (carpentry, plumbing, electrical wiring) as well as government representatives for the permit processes.

A construction manager may be called a project manager or project engineer. The construction manager ensures that the project is completed on time and within budget while meeting quality specifications and codes and maintaining a safe work environment. These managers create project plans in which they divide all required construction site activities into logical steps, estimating and budgeting the time required to meet established deadlines, usually utilizing sophisticated scheduling and cost-estimating software. Many use software packages such as Microsoft Project® or Procure® or online tools like BaseCamp®. Most construction projects rely on spreadsheets for project management. Procurement skills used in this field include acquiring the bills for material, lumber for the house being built, and more. Construction managers also coordinate labor, determining the needs and overseeing their performance, ensuring that all work is completed on schedule.

Values including sustainability, reuse, LEED-certified building, use of green energy, and various energy efficiencies are being incorporated into today's projects with an eye to the future. Jennifer Russell, spoke about project management and global sustainability" at the 2011 Silicon Valley Project Management Institute (PMI) conference. She informed the attendees of the financial, environmental, and social areas in expanding the vision of project management with the slide in Figure 1.2. These values are part of the PMI's code of ethics and professionalism. By adhering to this code, project managers include in their decisions the best interests of society, the safety of the public, and enhancement of the environment.

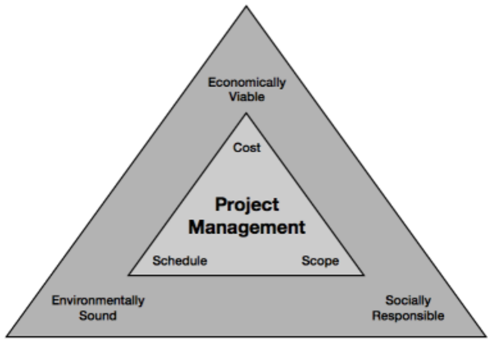


Figure 1.2: In addition to considering the cost, scope, and schedule of a project, a project manager should work to ensure the project is socially responsible, environmentally sound, and economically viable.

Creative Services

Creative service careers include graphic artists, curators, video editors, gaming managers, multimedia artists, media producers, technical writers, interpreters, and translators. These positions use project management skills, especially in handling the delivery channel and meeting clients' requirements.

Let us look at one example, graphic artists, to understand and identify some of the project management skills that aid in this career.

Example: Graphic Artists

Graphic artists plan, analyze, and create visual solutions to communication problems. They use many skills found in project management, especially communications. They work to achieve the most effective way to get messages across in print and electronic media. They emphasize their messages using colour, type, illustration, photography, animation, and various print and layout techniques. Results can be seen in magazines, newspapers, journals, corporate reports, and other publications. Other deliverables from graphic artists using project management skills include promotional displays, packaging, and marketing brochures supporting products and services, logos, and signage. In addition to print media, graphic artists create materials for the web, TV, movies, and mobile device apps.

Initiation in project management can be seen in developing a new design: determining the needs of the client, the message the design should portray, and its appeal to customers or users. Graphic designers consider cognitive, cultural, physical, and social factors in planning and executing designs for the target audience, very similar to some of the dynamics a project manager considers in communicating with various project stakeholders. Designers may gather relevant information by meeting with clients, creative staff, or art directors; brainstorming with others within their firm or professional association; and performing their own research to ensure that their results have high quality and they can manage risks.

Graphic designers may supervise assistants who follow instructions to complete parts of the design process. Therefore scheduling, resource planning, and cost monitoring are pillars of project management seen in this industry. These artists use computer and communications equipment to meet their clients' needs and business requirements in a timely and cost-efficient manner.

Educators

"Educator" is a broad term that can describe a career in teaching, maybe being a lecturer, a professor, a tutor, or a home-schooler. Other educators include gurus, mullahs, pastors, rabbis, and priests. Instructors also provide vocational training or teach skills like learning how to drive a car or use a computer. Educators provide motivation to learn a new language or showcase new products and services. Educators use project management skills including planning and communication.

Let us look at teachers, since we all have had teachers, and see if we can recognize the project management skills that are demonstrated in this profession.

Example: Teachers

Some teachers foster the intellectual and social development of children during their formative years; other teachers provide knowledge, career skill sets, and guidance to adults. Project management skills that teachers exhibit include acting as facilitators or coaches and communicating in the classroom and in individual instruction. Project managers plan and evaluate various aspects of a project; teachers plan, evaluate, and assign lessons; implement these plans; and monitor each student's progress similar to the way a project manager monitors and delivers goods or services. Teachers use their people skills to manage students, parents, and administrators. The soft skills that project managers exercise can be seen in teachers who encourage collaboration in solving problems by having students work in groups to discuss and solve problems as a team.

Project managers may work in a variety of fields with a broad assortment of people, similar to teachers who work with students from varied ethnic, racial, and religious backgrounds. These teachers must have awareness and understanding of different cultures.

Teachers in some schools may be involved in making decisions regarding the budget, personnel, textbooks, curriculum design, and teaching methods, demonstrating skills that a project manager would possess such as financial management and decision making.

Engineers

Engineers apply the principles of science and mathematics to develop economical solutions to technical problems. As a project cycles from an idea in the project charter to the implementation and delivery of a product or service, engineers link scientific discoveries to commercial applications that meet societal and consumer needs.

Engineers use many project management skills, especially when they must specify functional requirements. They demonstrate attention to quality as they evaluate a design's overall effectiveness, cost, reliability, and safety similar to the project manager reviewing the criteria for the customer's acceptance of delivery of the product or service.

Estimation skills in project management are used in engineering. Engineers are asked many times to provide an estimate of time and cost required to complete projects.

Health Care

There are many jobs and careers in health care that use project management skills. Occupations in the field of health care vary widely, such as athletic trainer, dental hygienist, massage therapist, occupational therapist, optometrist, nurse, physician, physician assistant, and X-ray technician. These individuals actively apply risk management in providing health care delivery of service to their clients, ensuring that they do not injure the person they are caring for. *Note: There is a section on nursing later in this chapter.*

Many of you may have had a fall while you were growing up, and needed an X-ray to determine if you had a fracture or merely a sprain. Let us look at this career as an example of a health care professional using project management skills.

Example: Radiology Technologists

Radiology technologists and technicians perform diagnostic imaging examinations like X-rays, computed tomography (CT), magnetic resonance imaging (MRI), and mammography. They could also be called radiographers, because they produce X-ray films (radiographs) of parts of the human body for use in diagnosing medical problems.

Project management skills, especially people skills and strong communication, are demonstrated when they prepare patients for radiologic examinations by explaining the procedure and what position the patient needs to be in, so that the parts of the body can be appropriately radiographed. Risk management is demonstrated when these professionals work to prevent unnecessary exposure to radiation by surrounding the exposed area with radiation protection devices, such as lead shields, or limiting the size of the X-ray beam. To ensure quality results, the health technician monitors the radiograph and sets controls on the X-ray machine to produce radiographs of the appropriate density, detail, and contrast.

Safety and regulations concerning the use of radiation to protect themselves, their patients, and their coworkers from unnecessary exposure is tracked in an efficient manner and reported as a control to ensure compliance. Project management skills are also used in preparing work schedules, evaluating equipment for purchase, or managing a radiology department.

Some radiological technologists specialize in CT scans; as CT technologists they too use project management skills. CT uses ionizing radiation to produce a substantial number of cross-sectional X-rays of an area of the body. Therefore, it requires the same precautionary measures that are used with X-rays, hence the need for risk management and monitoring for exposure.

Teamwork, not only with the patient that the radiological technologist supports and the doctor who ordered the request, but also with other health care providers, relies on strong communication, quality, work done in a timely manner, and wise use of hospital resources. This all boils down to ensuring that the three elements of the project management triangle of cost, schedule, and scope with quality delivered remain the essentials that provide a cornerstone to project management and the skills needed to obtain the objective.

Example: Nurses

Nurses treat and educate patients and their families and the public about various medical conditions and provide advice and emotional support. Nurses establish a care plan for their patients that include activities like scheduling the administration and discontinuation of medications (e.g., intravenous (IV) lines for fluid, medication, blood, and blood products) and application of therapies and treatments. Communication with the patient, their family, physicians and other health care clinicians may be done in person or via technology. Telehealth allows nurses to provide care and advice through electronic communications media including videoconferencing, the Internet, or telephone.

Risk management is very important for a nurse, with some cases having a life or death consequence. Nurses monitor pain management and vital signs and provide status reports to physicians to help in responding to the health care needs of the patient.

The nursing field varies. Some nurses work in infection control. They identify, track, and control infectious outbreaks in health care facilities and create programs for outbreak prevention and response to biological terrorism. Others are educators who plan, develop, execute, and evaluate educational programs and curricula for the professional development of students and graduate nurses. Nurses may use project management skills while conducting health care consultations, advising on public policy, researching in the field, or providing sales support of a product or service.

Paralegal

Attorneys assume the ultimate responsibility for legal work but they often obtain assistance. Paralegals assume this role in law firms and perform many tasks to aid the legal profession. However, they are explicitly prohibited from carrying out duties considered to be the practice of law (e.g., giving legal advice, setting legal fees, presenting court cases).

Project management skills such as planning are used in helping lawyers prepare for closings, hearings, trials, and corporate meetings. Communication skills are used in preparing written reports that help attorneys determine how cases should be handled or drafts for actions such as pleading, filing motions, and obtaining affidavits.

Monitoring skills aid paralegals who may track files of important case documents, working on risk containment related to filing dates and responses to the court. Procurement skills, which a project manager uses, can also be seen from a paralegal perspective in negotiating terms of hiring expert witnesses as well as other services such as acquiring services from process servers.

Financial skills may be used as well, such as assisting in preparing tax returns, establishing trust funds, and planning estates or maintaining financial office records at the law firm.

Government, litigation, personal injury, corporate law, criminal law, employee benefits, intellectual property, labour law, bankruptcy, immigration, family law, and real estate are some of the many different law practices where a paralegal professional may use project management skills.

Software developer

Computer software developers and computer programmers design and develop software. They apply the principles of computer science and mathematics to create, test, and evaluate software applications and systems that make computers come alive. Software is developed in many kinds of projects: computer games, business applications, operating systems, network control systems, and more. Software developers us project management skills to develop the requirements for the software, identify and track the product development tasks, communicate within the development team and with clients, test cases, and manage quality, the schedule, and resources (staff, equipment, labs, and more).

Science Technicians

Science technicians use principles and theories of science and mathematics to assist in research and development and help invent and improve products and processes. In their jobs, they are more practically oriented than scientists. Planning skills project managers use can be seen as science technicians set up, operate, and maintain labouratory instruments; monitor experiments; and observe, calculate, and record results. Quality is a factor here as it is in project management; science technicians must ensure that processes are performed correctly, with proper proportions of ingredients, for purity or for strength and durability.

There are different fields in which science technicians can apply project management skills. Agricultural and food science technicians test food and other agricultural products and are involved in food, fibre, and animal research, production, and processing. Control and risk management are important here in executing the tests and experiments, for example, to improve the yield and quality of crops, or the resistance of plants and animals to disease, insects, or other hazards. Quality factors are paramount when food science technicians conduct tests on food additives and preservatives to ensure compliance with government regulations regarding colour, texture, and nutrients.

Biological technicians work with biologists studying living organisms. Many assist scientists who conduct medical research or who work in pharmaceutical companies to help develop and manufacture medicines. Skills in scheduling, especially in incubation periods for the study of the impact on cells, could impact projects, such as exploring and isolating variables for research in living organisms and infectious agents. Biotechnology technicians apply knowledge and execution skills and techniques gained from basic research, including gene splicing and recombinant DNA, to product development. Project management skills are used in collaboration and communication among team members to record and understand the results and progress toward a cure or product.

Other kinds of technicians are chemical technicians who may work in labouratories or factories, using monitoring and control skills in the way they collect and analyze samples. Again, quality assurance is an important factor for most process technicians' work in manufacturing, testing packaging for design, ensuring integrity of materials, and verifying environmental acceptability.

Technicians use a project management skill set to assist in their initiation, planning, and executing tasks, while managing risks with some measure of reporting to determine if their objectives satisfy the constraints of cost, schedule, resource, and quality standards set.

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5.2: Project Management Overview

The starting point in discussing how projects should be properly managed is to first understand what a project is and, just as importantly, what it is not.

People have been undertaking projects since the earliest days of organized human activity. The hunting parties of our prehistoric ancestors were projects, for example; they were temporary undertakings directed at the goal of obtaining meat for the community. Large complex projects have also been with us for a long time. The pyramids and the Great Wall of China were in their day of roughly the same dimensions as the Apollo project to send men to the moon. We use the term "project" frequently in our daily conversations. A husband, for example may tell his wife, "My main project for this weekend is to straighten out the garage." Going hunting, building pyramids, and fixing faucets all share certain features that make them projects.

Project Attributes

A project has distinctive attributes that distinguish it from ongoing work or business operations. Projects are temporary in nature. They are not an everyday business process and have definitive start dates and end dates. This characteristic is important because a large part of the project effort is dedicated to ensuring that the project is completed at the appointed time. To do this, schedules are created showing when tasks should begin and end. Projects can last minutes, hours, days, weeks, months, or years.

Projects exist to bring about a product or service that hasn't existed before. In this sense, a project is unique. Unique means that this is new; this has never been done before. Maybe it's been done in a very similar fashion before but never exactly in this way. For example, Ford Motor Company is in the business of designing and assembling cars. Each model that Ford designs and produces can be considered a project. The models differ from each other in their features and are marketed to people with various needs. An SUV serves a different purpose and clientele than a luxury car. The design and marketing of these two models are unique projects. However, the actual assembly of the cars is considered an operation (i.e., a repetitive process that is followed for most makes and models).

In contrast with projects, operations are ongoing and repetitive. They involve work that is continuous without an ending date and with the same processes repeated to produce the same results. The purpose of operations is to keep the organization functioning while the purpose of a project is to meet its goals and conclude. Therefore, operations are ongoing while projects are unique and temporary.

A project is completed when its goals and objectives are accomplished. It is these goals that drive the project, and all the planning and implementation efforts undertaken to achieve them. Sometimes projects end when it is determined that the goals and objectives cannot be accomplished or when the product or service of the project is no longer needed and the project is cancelled.

Definition of a Project

There are many written definitions of a project. All of them contain the key elements described above. For those looking for a formal definition of a project, the Project Management Institute (PMI) defines a project as a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists.

Project Characteristics

When considering whether or not you have a project on your hands, there are some things to keep in mind. First, is it a project or an ongoing operation? Second, if it is a project, who are the stakeholders? And third, what characteristics distinguish this endeavor as a project?

Projects have several characteristics:

- Projects are unique.
- Projects are temporary in nature and have a definite beginning and ending date.
- Projects are completed when the project goals are achieved or it's determined the project is no longer viable.

A successful project is one that meets or exceeds the expectations of the stakeholders.

Consider the following scenario: The vice-president (VP) of marketing approaches you with a fabulous idea. (Obviously it must be "fabulous" because he thought of it.) He wants to set up kiosks in local grocery stores as mini-offices. These offices will offer customers the ability to sign up for car and home insurance services as well as make their bill payments. He believes that the exposure in grocery stores will increase awareness of the company's offerings. He told you that senior management has already cleared the project, and he'll dedicate as many resources to this as he can. He wants the new kiosks in place in 12 selected stores in a major city by the end of the year. Finally, he has assigned you to head up this project.

Your first question should be, "Is it a project?" This may seem elementary, but confusing projects with ongoing operations happens often. Projects are temporary in nature, have definite start and end dates, result in the creation of a unique product or service, and are completed when their goals and objectives have been met and signed off by the stakeholders.

Using these criteria, let's examine the assignment from the VP of marketing to determine if it is a project:

- Is it unique? Yes, because the kiosks don't exist in the local grocery stores. This is a new way of offering the company's services to its customer base. While the service the company is offering isn't new, the way it is presenting its services is.
- Does the product have a limited timeframe? Yes, the start date of this project is today, and the end date is the end of next year. It is a temporary endeavor.
- Is there a way to determine when the project is completed? Yes, the kiosks will be installed and the services will be offered from them. Once all the kiosks are installed and operating, the project will come to a close.
- Is there a way to determine stakeholder satisfaction? Yes, the expectations of the stakeholders will be documented in the form of requirements during the planning processes. These requirements will be compared to the finished product to determine if it meets the expectations of the stakeholder.

If the answer is yes to all these questions, then we have a project.

The Process of Project Management

You've determined that you have a project. What now? The notes you scribbled down on the back of the napkin at lunch are a start, but not exactly good project management practice. Too often, organizations follow Nike's advice when it comes to managing projects when they "just do it." An assignment is made, and the project team members jump directly into the development of the product or service requested. In the end, the delivered product doesn't meet the expectations of the customer. Unfortunately, many projects follow this poorly constructed path, and that is a primary contributor to a large percentage of projects not meeting their original objectives, as defined by performance, schedule, and budget.

In the United States, more than $250 billion is spent each year on information technology (IT) application development in approximately 175,000 projects. The Standish Group (a Boston-based leader in project and value performance research) released the summary version of their 2009 CHAOS Report that tracks project failure rates across a broad range of companies and industries (Figure 2.1).

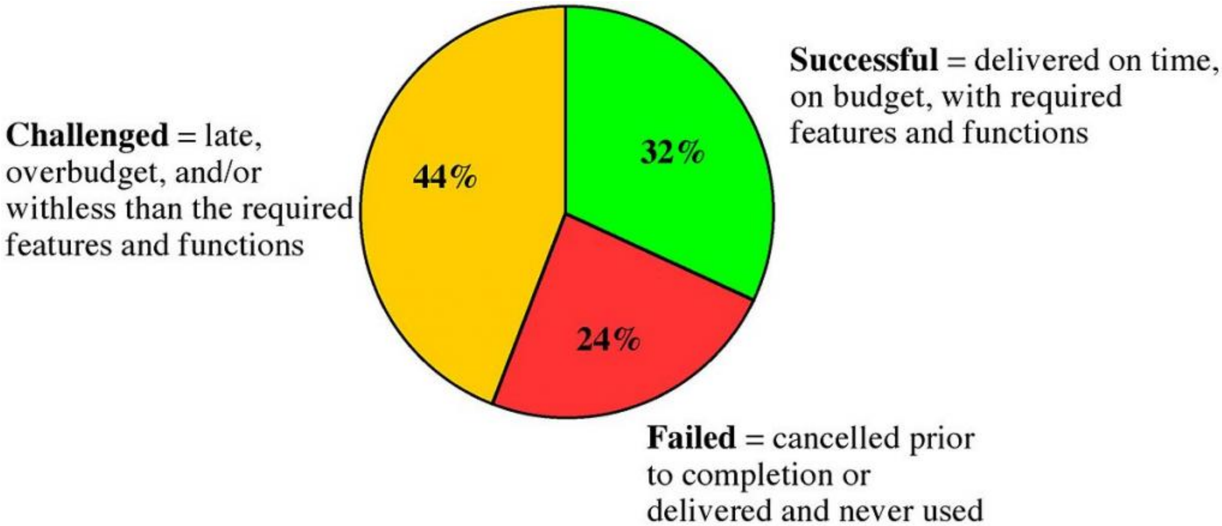

Figure 2.1: Summary of 2009 Standish Group CHAOS report.

Jim Johnson, chairman of the Standish Group, has stated that “this year’s results show a marked decrease in project success rates, with 32% of all projects succeeding which are delivered on time, on budget, with required features and functions, 44% were challenged-which are late, over budget, and/or with less than the required features and functions and 24% failed which are cancelled prior to completion or delivered and never used.”

When are companies going to stop wasting billions of dollars on failed projects? The vast majority of this waste is completely avoidable: simply get the right business needs (requirements) understood early in the process and ensure that project management techniques are applied and followed, and the project activities are monitored.

Applying good project management discipline is the way to help reduce the risks. Having good project management skills does not completely eliminate problems, risks, or surprises. The value of good project management is that you have standard processes in place to deal with all contingencies.

Project management is the application of knowledge, skills, tools, and techniques applied to project activities in order to meet the project requirements. Project management is a process that includes planning, putting the project plan into action, and measuring progress and performance.

Managing a project includes identifying your project’s requirements and writing down what everyone needs from the project. What are the objectives for your project? When everyone understands the goal, it’s much easier to keep them all on the right path. Make sure you set goals that everyone agrees on to avoid team conflicts later on. Understanding and addressing the needs of everyone affected by the project means the end result of your project is far more likely to satisfy your stakeholders. Last but not least, as project manager, you will also be balancing the many competing project constraints.

On any project, you will have a number of project constraints that are competing for your attention. They are cost, scope, quality, risk, resources, and time.

- **Cost** is the budget approved for the project including all necessary expenses needed to deliver the project. Within organizations, project managers have to balance between not running out of money and not underspending because many projects receive funds or grants that have contract clauses with a “use it or lose it” approach to project funds. Poorly executed budget plans can result in a last-minute rush to spend the allocated funds. For virtually all projects, cost is ultimately a limiting constraint; few projects can go over budget without eventually requiring a corrective action.
- **Scope** is what the project is trying to achieve. It entails all the work involved in delivering the project outcomes and the processes used to produce them. It is the reason and the purpose of the project.
- **Quality** is a combination of the standards and criteria to which the project’s products must be delivered for them to perform effectively. The product must perform to provide the functionality expected, solve the identified problem, and deliver the benefit and value expected. It must also meet other performance requirements, or service levels, such as availability, reliability, and maintainability, and have acceptable finish and polish. Quality on a project is controlled through quality assurance (QA),

which is the process of evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards.

- **Risk** is defined by potential external events that will have a negative impact on your project if they occur. Risk refers to the combination of the probability the event will occur and the impact on the project if the event occurs. If the combination of the probability of the occurrence and the impact on the project is too high, you should identify the potential event as a risk and put a proactive plan in place to manage the risk.
- **Resources** are required to carry out the project tasks. They can be people, equipment, facilities, funding, or anything else capable of definition (usually other than labour) required for the completion of a project activity.
- **Time** is defined as the time to complete the project. Time is often the most frequent project oversight in developing projects. This is reflected in missed deadlines and incomplete deliverables. Proper control of the schedule requires the careful identification of tasks to be performed and accurate estimations of their durations, the sequence in which they are going to be done, and how people and other resources are to be allocated. Any schedule should take into account vacations and holidays.

You may have heard of the term "triple constraint," which traditionally consisted of only time, cost, and scope. These are the primary competing project constraints that you have to be most aware of. The triple constraint is illustrated in the form of a triangle to visualize the project work and see the relationship between the scope/quality, schedule/time, and cost/resource (Figure 2.2). In this triangle, each side represents one of the constraints (or related constraints) wherein any changes to any one side cause a change in the other sides. The best projects have a perfectly balanced triangle. Maintaining this balance is difficult because projects are prone to change. For example, if scope increases, cost and time may increase disproportionately. Alternatively, if the amount of money you have for your project decreases, you may be able to do as much, but your time may increase.

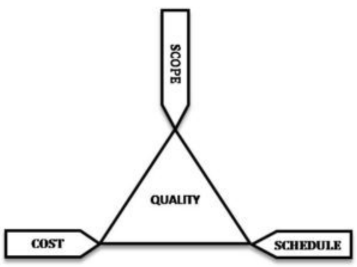

Figure 2.2: A schematic of the triple constraint triangle.

Your project may have additional constraints that you must face, and as the project manager, you have to balance the needs of these constraints against the needs of the stakeholders and your project goals. For instance, if your sponsor wants to add functionality to the original scope, you will very likely need more money to finish the project, or if they cut the budget, you will have to reduce the quality of your scope, and if you don't get the appropriate resources to work on your project tasks, you will have to extend your schedule because the resources you have take much longer to finish the work.

You get the idea; the constraints are all dependent on each other. Think of all of these constraints as the classic carnival game of Whac-a-mole (Figure 2.3). Each time you try to push one mole back in the hole, another one pops out. The best advice is to rely on your project team to keep these moles in place.


Figure 2.3: Whac-a-mole.

Here is an example of a project that cut quality because the project costs were fixed. The P-36 oil platform (Figure 2.4) was the largest footing production platform in the world capable of processing 180,000 barrels of oil per day and 5.2 million cubic metres of gas per day. Located in the Roncador Field, Campos Basin, Brazil, the P-36 was operated by Petrobras.

https://eng.libretexts.org/@go/page/75163


Figure 2.4.: The Petrobras P-36 oil platform sinking.

In March 2001, the P-36 was producing around 84,000 barrels of oil and 1.3 million cubic metres of gas per day when it became destabilized by two explosions and subsequently sank in 3,900 feet of water with 1,650 short tons of crude oil remaining on board, killing 11 people. The sinking is attributed to a complete failure in quality assurance, and pressure for increased production led to corners being cut on safety procedures. It is listed as one of the most expensive accidents with a price tag of $515,000,000.

The following quotes are from a Petrobras executive, citing the benefits of cutting quality assurance and inspection costs on the project.

“Petrobras has established new global benchmarks for the generation of exceptional shareholder wealth through an aggressive and innovative program of cost cutting on its P36 production facility.”

“Conventional constraints have been successfully challenged and replaced with new paradigms appropriate to the globalized corporate market place.”

“Elimination of these unnecessary straitjackets has empowered the project’s suppliers and contractors to propose highly economical solutions, with the win-win bonus of enhanced profitability margins for themselves.”

“The P36 platform shows the shape of things to come in the unregulated global market economy of the 21st century.”

The dynamic trade-offs between the project constraint values have been humorously and accurately described in Figure 2.5.

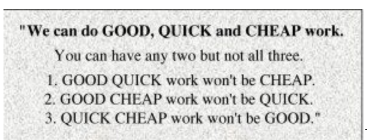

Figure 2.5: Good, Quick, Cheap: Choose two. A sign seen at an automotive repair shop. [Image Description]

Project Management Expertise

In order for you, as the project manager, to manage the competing project constraints and the project as a whole, there are some areas of expertise you should bring to the project team (Figure 2.11). They are knowledge of the application area and the standards and regulations in your industry, understanding of the project environment, general management knowledge and skills, and interpersonal skills. It should be noted that industry expertise is not in a certain field but the expertise to run the project. So while knowledge of the type of industry is important, you will have a project team supporting you in this endeavor. For example, if you are managing a project that is building an oil platform, you would not be expected to have a detailed understanding of the engineering since your team will have mechanical and civil engineers who will provide the appropriate expertise; however, it would definitely help if you understood this type of work.

Let’s take a look at each of these areas in more detail.

Application knowledge

By standards, we mean guidelines or preferred approaches that are not necessarily mandatory. In contrast, when referring to regulations we mean mandatory rules that must be followed, such as government-imposed requirements through laws. It should go without saying that as a professional, you’re required to follow all applicable laws and rules that apply to your industry, organization, or project. Every industry has standards and regulations. Knowing which ones affect your project before you begin work will not only help the project to unfold smoothly, but will also allow for effective risk analysis.

Areas of Expertise
Application knowledge, standards & regulations
Understanding the project environment
Management knowledge & skills
Interpersonal skills

Figure 2.6: Areas of expertise that a project manager should bring to the project team.

Some projects require specific skills in certain application areas. Application areas are made up of categories of projects that have common elements. They can be defined by industry group (pharmaceutical, financial, etc.), department (accounting, marketing, legal, etc.), technology (software development, engineering, etc), or management specialties (procurement, research and development, etc.). These application areas are usually concerned with disciplines, regulations, and the specific needs of the project, the customer, or the industry. For example, most government agencies have specific procurement rules that apply to their projects that wouldn't be applicable in the construction industry. The pharmaceutical industry is interested in regulations set forth by government regulators, whereas the automotive industry has little or no concern for either of these types of regulations. You need to stay up-to-date regarding your industry so that you can apply your knowledge effectively. Today's fast-paced advances can leave you behind fairly quickly if you don't stay abreast of current trends.

Having some level of experience in the application area you're working in will give you an advantage when it comes to project management. While you can call in experts who have the application area knowledge, it doesn't hurt for you to understand the specific aspects of the application areas of your project.

Understanding the Project Environment

There are many factors that need to be understood within your project environment (Figure 2.7). At one level, you need to think in terms of the cultural and social environments (i.e., people, demographics, and education). The international and political environment is where you need to understand about different countries' cultural influences. Then we move to the physical environment; here we think about time zones. Think about different countries and how differently your project will be executed whether it is just in your country or if it involves an international project team that is distributed throughout the world in five different countries.

Project Environment	
Cultural	Social
International	Political
Physical	

Figure 2.7: The important factors to consider within the project environment.

Of all the factors, the physical ones are the easiest to understand, and it is the cultural and international factors that are often misunderstood or ignored. How we deal with clients, customers, or project members from other countries can be critical to the success of the project. For example, the culture of the United States values accomplishments and individualism. Americans tend to be informal and call each other by first names, even if having just met. Europeans tend to be more formal, using surnames instead of first names in a business setting, even if they know each other well. In addition, their communication style is more formal than in the United States, and while they tend to value individualism, they also value history, hierarchy, and loyalty. The Japanese, on the other hand, tend to communicate indirectly and consider themselves part of a group, not as individuals. The Japanese value hard work and success, as most of us do.

How a product is received can be very dependent on the international cultural differences. For example, in the 1990s, when many large American and European telecommunications companies were cultivating new markets in Asia, their customer's cultural differences often produced unexpected situations. Western companies planned their telephone systems to work the same way in

Asia as they did in Europe and the United States. But the protocol of conversation was different. Call-waiting, a popular feature in the West, is considered impolite in some parts of Asia. This cultural blunder could have been avoided had the team captured the project environment requirements and involved the customer.

It is often the simplest things that can cause trouble since, unsurprisingly, in different countries, people do things differently. One of the most notorious examples of this is also one of the most simple: date formats. What day and month is 2/8/2009? Of course it depends where you come from; in North America it is February 8th while in Europe (and much of the rest of the world) it is 2nd August. Clearly, when schedules and deadlines are being defined it is important that everyone is clear on the format used.

The diversity of practices and cultures and its impact on products in general and on software in particular goes well beyond the date issue. You may be managing a project to create a new website for a company that sells products worldwide. There are language and presentation style issues to take into consideration; converting the site into different languages isn't enough. It is obvious that you need to ensure the translation is correct; however, the presentation layer will have its own set of requirements for different cultures. The left side of a website may be the first focus of attention for a Canadian; the right side would be the initial focus for anyone from the Middle East, as both Arabic and Hebrew are written from right to left. Colors also have different meanings in different cultures. White, which is a sign of purity in North America (e.g., a bride's wedding dress), and thus would be a favoured background colour in North America, signifies death in Japan (e.g., a burial shroud). Table 2.1 summarizes different meanings of common colours.

Table 2.1: The meaning of colours in various cultures.

Colour	United States	China	Japan	Egypt	France
Red	Danger, stop	Happiness	Anger, danger	Death	Aristocracy
Blue	Sadness, melancholy	Heavens, clouds	Villainy	Virtue, faith, truth	Freedom, peace
Green	Novice, apprentice	Ming dynasty, heavens	Future, youth, energy	Fertility, strength	Criminality
Yellow	Cowardice	Birth, wealth	Grace, nobility	Happiness, prosperity	Temporary
White	Purity	Death, purity	Death	Joy	Naturality

Project managers in multicultural projects must appreciate the culture dimensions and try to learn relevant customs, courtesies, and business protocols before taking responsibility for managing an international project. A project manager must take into consideration these various cultural influences and how they may affect the project's completion, schedule, scope, and cost.

Management Knowledge and Skills

As the project manager, you have to rely on your project management knowledge and your general management skills. Here, we are thinking of items like your ability to plan the project, execute it properly, and of course control it and bring it to a successful conclusion, along with your ability to guide the project team to achieve project objectives and balance project constraints.

There is more to project management than just getting the work done. Inherent in the process of project management are the general management skills that allow the project manager to complete the project with some level of efficiency and control. In some respects, managing a project is similar to running a business: there are risk and rewards, finance and accounting activities, human resource issues, time management, stress management, and a purpose for the project to exist. General management skills are needed in every project.

Interpersonal Skills

Last but not least you also have to bring the ability into the project to manage personal relationships and deal with personnel issues as they arise. Here were talking about your interpersonal skills as shown in Figure 2.8.

Communication

Project managers spend 90% of their time communicating. Therefore they must be good communicators, promoting clear, unambiguous exchange of information. As a project manager, it is your job to keep a number of people well informed. It is essential that your project staff know what is expected of them: what they have to do, when they have to do it, and what budget and time constraints and quality specifications they are working toward. If project staff members do not know what their tasks are, or how to accomplish them, then the entire project will grind to a halt. If you do not know what the project staff is (or often is not) doing, then you will be unable to monitor project progress. Finally, if you are uncertain of what the customer expects of you, then the project will not even get off the ground. Project communication can thus be summed up as knowing "who needs what information and when" and making sure they have it.

Interpersonal Skills	
Communication	Influence
Leadership	Motivation
Negotiation	Problem solving

Figure 2.8: Interpersonal skills required of a project manager.

All projects require sound communication plans, but not all projects will have the same types of communication or the same methods for distributing the information. For example, will information be distributed via mail or email, is there a shared website, or are face-to-face meetings required? The communication management plan documents how the communication needs of the stakeholders will be met, including the types of information that will be communicated, who will communicate them, and who will receive them; the methods used to communicate; the timing and frequency of communication; the method for updating the plan as the project progresses, including the escalation process; and a glossary of common terms.

Influence

Project management is about getting things done. Every organization is different in its policies, modes of operations, and underlying culture. There are political alliances, differing motivations, conflicting interests, and power struggles. A project manager must understand all of the unspoken influences at work within an organization.

Leadership

Leadership is the ability to motivate and inspire individuals to work toward expected results. Leaders inspire vision and rally people around common goals. A good project manager can motivate and inspire the project team to see the vision and value of the project. The project manager as a leader can inspire the project team to find a solution to overcome perceived obstacles to get the work done.

Motivation

Motivation helps people work more efficiently and produce better results. Motivation is a constant process that the project manager must guide to help the team move toward completion with passion and a profound reason to complete the work. Motivating the team is accomplished by using a variety of team-building techniques and exercises. Team building is simply getting a diverse group of people to work together in the most efficient and effective manner possible. This may involve management events as well as individual actions designed to improve team performance.

Recognition and rewards are an important part of team motivations. They are formal ways of recognizing and promoting desirable behaviour and are most effective when carried out by the management team and the project manager. Consider individual preferences and cultural differences when using rewards and recognition. Some people don't like to be recognized in front of a group; others thrive on it.

Negotiation

Project managers must negotiate for the good of the project. In any project, the project manager, the project sponsor, and the project team will have to negotiate with stakeholders, vendors, and customers to reach a level of agreement acceptable to all parties involved in the negotiation process.

Problem Solving

Problem solving is the ability to understand the heart of a problem, look for a viable solution, and then make a decision to implement that solution. The starting point for problem solving is problem definition. Problem definition is the ability to understand the cause and effect of the problem; this centres on root-cause analysis. If a project manager treats only the symptoms of a problem rather than its cause, the symptoms will perpetuate and continue through the project life. Even worse, treating a symptom may result in a greater problem. For example, increasing the ampere rating of a fuse in your car because the old one keeps blowing does not solve the problem of an electrical short that could result in a fire. Root-cause analysis looks beyond the immediate symptoms to the cause of the symptoms, which then affords opportunities for solutions. Once the root of a problem has been identified, a decision must be made to effectively address the problem.

Solutions can be presented from vendors, the project team, the project manager, or various stakeholders. A viable solution focuses on more than just the problem; it looks at the cause and effect of the solution itself. In addition, a timely decision is needed or the window of opportunity may pass and then a new decision will be needed to address the problem. As in most cases, the worst thing you can do is nothing.

All of these interpersonal skills will be used in all areas of project management. Start practicing now because it's guaranteed that you'll need these skills on your next project.

Image Descriptions

Figure 2.5 image description: The sign says, "We can do good, quick, and cheap work. You can have any two but not all three. 1. Good, quick work won't be cheap. 2. Good, cheap work won't be quick. 3. Quick, cheap work won't be good." [Return to Figure 2.5]

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5.3: The Project Life Cycle (Phases)

The project manager and project team have one shared goal: to carry out the work of the project for the purpose of meeting the project's objectives. Every project has a beginning, a middle period during which activities move the project toward completion, and an ending (either successful or unsuccessful). A standard project typically has the following four major phases (each with its own agenda of tasks and issues): initiation, planning, implementation, and closure. Taken together, these phases represent the path a project takes from the beginning to its end and are generally referred to as the project "life cycle."

Initiation Phase

During the first of these phases, the initiation phase, the project objective or need is identified; this can be a business problem or opportunity. An appropriate response to the need is documented in a business case with recommended solution options. A feasibility study is conducted to investigate whether each option addresses the project objective and a final recommended solution is determined. Issues of feasibility ("can we do the project?") and justification ("should we do the project?") are addressed.

Once the recommended solution is approved, a project is initiated to deliver the approved solution and a project manager is appointed. The major deliverables and the participating work groups are identified, and the project team begins to take shape. Approval is then sought by the project manager to move onto the detailed planning phase.

Comparing Options Using a Weighted Decision Matrix

Sometimes we have multiple options to choose from when determining requirements and deciding which project to work on. To select the best option, we can use tools such as a weighted decision matrix.

A basic decision matrix consists of establishing a set of criteria for options that are scored and summed to gain a total score that can then be ranked. Importantly, it is not weighted to allow a quick selection process.

A weighted decision matrix operates in the same way as the basic decision matrix but introduces the concept of weighting the criteria in order of importance. The resultant scores better reflect the importance to the decision maker of the criteria involved. The more important a criterion, the higher the weighting it should be given. Each of the potential options is scored and then multiplied by the weighting given to each of the criteria to produce a result.

The advantage of the weighted decision matrix is that subjective opinions about one alternative versus another can be made more objective. Another advantage of this method is that sensitivity studies can be performed. An example of this might be to see how much your opinion would have to change in order for a lower-ranked alternative to outrank a competing alternative.

A **weighted decision matrix** therefore allows decision makers to structure and solve their problem by:

1. **Specifying** and **prioritizing** their needs with a list a criteria; then
2. **Evaluating**, **rating**, and **comparing** the different solutions; and
3. **Selecting** the best matching solution.

A weighted decision matrix is a decision tool used by decision makers.

A *decision matrix* is basically an array presenting on one axis a list of **alternatives**, also called *options* or *solutions*, that are evaluated regarding, on the other axis, a list of **criteria**, which are *weighted* depending on their respective importance in the final decision to be taken.

Weighted Decision Matrix Sample

The example in Figure 7.4 shows a weighted decision matrix that compared three options for a web development project (SJS Enterprises). This method is especially useful when choosing purchase alternatives and comparing them against specific desirable system requirements.

Weighted Decision Matrix for Game Delivery System

Criteria	Weight	SJS Enterprises	Game Access	DVD Link
Educational	15%	90	0	0
Sports-related	15%	90	90	90
Secure payment area with the ability to use Paypal, bank payments, cheque, school payment systems as a payment source	10%	90	50	50
Live Support	15%	90	0	0
Search Option	5%	50	50	30
Games available for all platforms currently on the market including school learning systems	10%	60	30	30
Longer Rental Periods (1 to 2 weeks)	5%	40	20	40
Sidebar with categories such as most popular, multiplayer and just released	5%	50	50	20
Registered customers must be able to order the videos, track delivery, return of videos and be able to provide reviews of views	10%	50	30	30
Age/grade appropriate section (can isolate certain games to certain ages or grade levels)	10%	70	5	0
Weighted Project Scores	**100%**	**74.5**	**31**	**29**

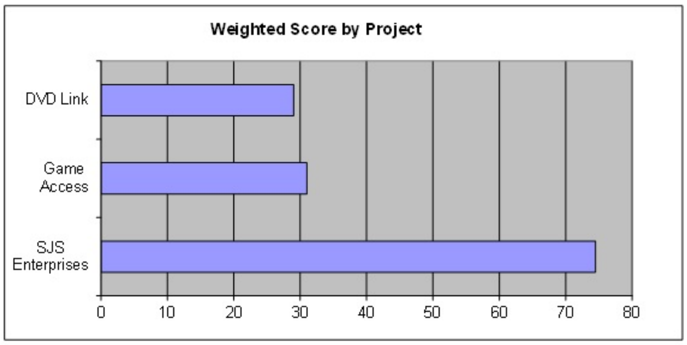

Figure 7.4: Weighted Decision Matrix for Game Delivery Project.

Planning Phase

The next phase, the planning phase, is where the project solution is further developed in as much detail as possible and the steps necessary to meet the project's objective are planned. In this step, the team identifies all of the work to be done. The project's tasks and resource requirements are identified, along with the strategy for producing them. This is also referred to as "scope management." A project plan is created outlining the activities, tasks, dependencies, and timeframes. The project manager coordinates the preparation of a project budget by providing cost estimates for the labour, equipment, and materials costs. The budget is used to monitor and control cost expenditures during project implementation.

Once the project team has identified the work, prepared the schedule, and estimated the costs, the three fundamental components of the planning process are complete. This is an excellent time to identify and try to deal with anything that might pose a threat to the successful completion of the project. This is called risk management. In risk management, "high-threat" potential problems are identified along with the action that is to be taken on each high-threat potential problem, either to reduce the probability that the problem will occur or to reduce the impact on the project if it does occur. This is also a good time to identify all project stakeholders and establish a communication plan describing the information needed and the delivery method to be used to keep the stakeholders informed.

Finally, you will want to document a quality plan, providing quality targets, assurance, and control measures, along with an acceptance plan, listing the criteria to be met to gain customer acceptance. At this point, the project would have been planned in detail and is ready to be executed.

Implementation (Execution) Phase

During the third phase, the implementation phase, the project plan is put into motion and the work of the project is performed. It is important to maintain control and communicate as needed during implementation. Progress is continuously monitored and appropriate adjustments are made and recorded as variances from the original plan. In any project, a project manager spends most of the time in this step. During project implementation, people are carrying out the tasks, and progress information is being reported through regular team meetings. The project manager uses this information to maintain control over the direction of the project by comparing the progress reports with the project plan to measure the performance of the project activities and take corrective action as needed. The first course of action should always be to bring the project back on course (i.e., to return it to the original plan). If that cannot happen, the team should record variations from the original plan and record and publish modifications to the plan. Throughout this step, project sponsors and other key stakeholders should be kept informed of the project's status according to the agreed-on frequency and format of communication. The plan should be updated and published on a regular basis.

Change Control

When you find a problem, you can't just make a change, because it may be too expensive or take too long to do. You will need to look at how it affects the triple constraint (time, cost, scope) and how it impacts project quality. You will then have to figure out if it is worth making the change. If you evaluate the impact of the change and find that it won't have an impact on the project triple constraint, then you can make the change without going through change control. Change control is a set of procedures that lets you make changes in an organized way.

Any time you need to make a change to your plan, you must start with a change request. This is a document that either you or the person making the request must complete. Any change to your project must be documented so you can figure out what needs to be done, by when, and by whom.

Once the change request is documented, it is submitted to a change control board. A change control board is a group of people who consider changes for approval. Not every change control system has a board but most do. The change request could also be submitted to the project sponsor or management for review and approval. Putting the recommended changes through change control will help you evaluate the impact and update all the necessary documents. Not all changes are approved, but if the changes are approved, you send them back to the team to put them in place.

The implementation phase uses the most project time and resources, and as a result, costs are usually the highest during this phase. Project managers also experience the greatest conflicts over schedules in this phase. You may find as you are monitoring your project that the actual time it is taking to do the scheduled work is longer than the amount of time planned.

When you absolutely have to meet the date and you are running behind, you can sometimes find ways to do activities more quickly by adding more resources to critical path tasks. That's called *crashing*. Crashing the schedule means adding resources or moving them around to to bring the project back into line with the schedule. Crashing **always** costs more and doesn't always work. There's no way to crash a schedule without raising the overall cost of the project. So, if the budget is fixed and you don't have any extra money to spend, you can't use this technique.

Sometimes you've got two activities planned to occur in sequence, but you can actually do them at the same time. This is called *fast tracking* the project. On a software project, you might do both your user acceptance testing (UAT) and your functional testing at the same time, for example. This is pretty risky. There's a good chance you might need to redo some of the work you have done concurrently. Crashing and fast tracking are schedule compression tools. Managing a schedule change means keeping all of your schedule documents up to date. That way, you will always be comparing your results to the correct plan.

Status reports should always emphasize the anticipated end point in terms of cost, schedule, and quality of deliverables. Each project deliverable produced should be reviewed for quality and measured against the acceptance criteria. Once all of the deliverables have been produced and the customer has accepted the final solution, the project is ready for closure.

Closing Phase

During the final closure, or completion phase, the emphasis is on releasing the final deliverables to the customer, handing over project documentation to the business, terminating supplier contracts, releasing project resources, and communicating the closure of the project to all stakeholders. The last remaining step is to conduct lessons-learned studies to examine what went well and what didn't. Through this type of analysis, the wisdom of experience is transferred back to the project organization, which will help future project teams.

Archiving of Document:

The documents associated with the project must be stored in a safe location where they can be retrieved for future reference. Signed contracts or other documents that might be used in tax reviews or lawsuits must be stored. Organizations will have legal document storage and retrieval policies that apply to project documents and must be followed. Some project documents can be stored electronically.

Care should be taken to store documents in a form that can be recovered easily. If the documents are stored electronically, standard naming conventions should be used so documents can be sorted and grouped by name. If documents are stored in paper form, the expiration date of the documents should be determined so they can be destroyed at some point in the future. The following are documents that are typically archived:

- Charter documents
- Scope statement
- Original budget
- Change documents
- DPCI ratings
- Manager's summary—lessons learned
- Final DPCI rating

Example: Project Phases on a Large Multinational Project

A U.S. construction company won a contract to design and build the first copper mine in northern Argentina. There was no existing infrastructure for either the mining industry or large construction projects in this part of South America. During the initiation phase of the project, the project manager focused on defining and finding a project leadership team with the knowledge, skills, and experience to manage a large complex project in a remote area of the globe. The project team set up three offices. One was in Chile, where large mining construction project infrastructure existed. The other two were in Argentina. One was in Buenos Aries to establish relationships and Argentinian expertise, and the second was in Catamarca—the largest town close to the mine site. With offices in place, the project start-up team began developing procedures for getting work done, acquiring the appropriate permits, and developing relationships with Chilean and Argentine partners.

During the planning phase, the project team developed an integrated project schedule that coordinated the activities of the design, procurement, and construction teams. The project controls team also developed a detailed budget that enabled the project team to track project expenditures against the expected expenses. The project design team built on the conceptual design and developed detailed drawings for use by the procurement team. The procurement team used the drawings to begin ordering equipment and materials for the construction team; develop labour projections; refine the construction schedule; and set up the construction site. Although planning is a never-ending process on a project, the planning phase focused on developing sufficient details to allow various parts of the project team to coordinate their work and allow the project management team to make priority decisions.

The implementation phase represents the work done to meet the requirements of the scope of work and fulfill the charter. During the implementation phase, the project team accomplished the work defined in the plan and made adjustments when the project factors changed. Equipment and materials were delivered to the work site, labour was hired and trained, a construction site was built, and all the construction activities, from the arrival of the first dozer to the installation of the final light switch, were accomplished.

The closeout phase included turning over the newly constructed plant to the operations team of the client. A punch list of a few remaining construction items was developed and those items completed. The office in Catamarca was closed, the office in Buenos Aries archived all the project documents, and the Chilean office was already working on the next project. The accounting books were reconciled and closed, final reports written and distributed, and the project manager started on a new project.

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5.4: Framework for Project Management

Many different professions contribute to the theory and practice of project management. Engineers and architects have been managing major projects since pre-history. Since approximately the 1960s, there have been efforts to professionalize the practice of project management as a specialization of its own. There are many active debates around this: Should project management be a profession in the same way as engineering, accounting, and medicine? These have professional associations that certify who is legally allowed to use the job title, and who can legally practice the profession. They also provide a level of assurance of quality and discipline members who behave inappropriately. Another ongoing debate is: How much industry knowledge is required of a seasoned project manager? How easily can a project manager from one industry, say, IT, transition to another industry such as hospitality?

There are two major organizations with worldwide impact on the practice of project management: the Project Management Institute (PMI), with world headquarters in the United States, and the International Project Management Association (IPMA), with world headquarters in Switzerland. This textbook takes an approach that is closer to the PMI approach. More details are included in this chapter, along with a section on the project management office.

Project Management Institute Overview

Five volunteers founded the Project Management Institute (PMI) in 1969. Their initial goal was to establish an organization where members could share their experiences in project management and discuss issues. Today, PMI is a non-profit project management professional association and the most widely recognized organization in terms of promoting project management best practices. PMI was formed to serve the interests of the project management industry. The premise of PMI is that the tools and techniques of project management are common even among the widespread application of projects from the software to the construction industry. PMI first began offering the Project Management Professional (PMP) certification exam in 1984. Although it took a while for people to take notice, now more than 590,000 individuals around the world hold the PMP designation.

To help keep project management terms and concepts clear and consistent, PMI introduced the book *A Guide to the Project Management Body of Knowledge (PMBOK Guide)* in 1987. It was updated it in 1996, 2000, 2004, 2009, and most recently in 2013 as the fifth edition. At present, there are more than one million copies of the *PMBOK Guide* in circulation. The highly regarded Institute of Electrical and Electronics Engineers (IEEE) has adopted it as their project management standard. In 1999 PMI was accredited as an American National Standards Institute (ANSI) standards developer and also has the distinction of being the first organization to have its certification program attain International Organization for Standardization (ISO) 9001 recognition. In 2008, the organization reported more than 260,000 members in over 171 countries. PMI has its headquarters in Pennsylvania, United States, and also has offices in Washington, DC, and in Canada, Mexico, and China, as well as having regional service centres in Singapore, Brussels (Belgium), and New Delhi (India). Recently, an office was opened in Mumbai (India).

Because of the importance of projects, the discipline of project management has evolved into a working body of knowledge known as PMBOK – Project Management Body of Knowledge. The PMI is responsible for developing and promoting PMBOK. PMI also administers a professional certification program for project managers, the PMP. So if you want to get grounded in project management, PMBOK is the place to start, and if you want to make project management your profession, then you should consider becoming a PMP.

So what is PMBOK?

PMBOK is the fundamental knowledge you need for managing a project, categorized into 10 knowledge areas:

1. **Managing integration:** Projects have all types of activities going on and there is a need to keep the "whole" thing moving collectively – integrating all of the dynamics that take place. Managing integration is about developing the project charter, scope statement, and plan to direct, manage, monitor, and control project change.
2. **Managing scope:** Projects need to have a defined parameter or scope, and this must be broken down and managed through a work breakdown structure or WBS. Managing scope is about planning, definition, WBS creation, verification, and control.
3. **Managing time/schedule:** Projects have a definite beginning and a definite ending date. Therefore, there is a need to manage the budgeted time according to a project schedule. Managing time/schedule is about definition, sequencing, resource and duration estimating, schedule development, and schedule control.

4. **Managing costs:** Projects consume resources, and therefore, there is a need to manage the investment with the realization of creating value (i.e., the benefits derived exceed the amount spent). Managing costs is about resource planning, cost estimating, budgeting, and control.
5. **Managing quality:** Projects involve specific deliverables or work products. These deliverables need to meet project objectives and performance standards. Managing quality is about quality planning, quality assurance, and quality control.
6. **Managing human resources:** Projects consist of teams and you need to manage project team(s) during the life cycle of the project. Finding the right people, managing their outputs, and keeping them on schedule is a big part of managing a project. Managing human resources is about human resources planning, hiring, and developing and managing a project team.
7. **Managing communication:** Projects invariably touch lots of people, not just the end users (customers) who benefit directly from the project outcomes. This can include project participants, managers who oversee the project, and external stakeholders who have an interest in the success of the project. Managing communication is about communications planning, information distribution, performance reporting, and stakeholder management.
8. **Managing risk:** Projects are a discovery-driven process, often uncovering new customer needs and identifying critical issues not previously disclosed. Projects also encounter unexpected events, such as project team members resigning, budgeted resources suddenly changing, the organization becoming unstable, and newer technologies being introduced. There is a real need to properly identify various risks and manage these risks. Managing risk is about risk planning and identification, risk analysis (qualitative and quantitative), risk response (action) planning, and risk monitoring and control.
9. **Managing procurement:** Projects procure the services of outside vendors and contractors, including the purchase of equipment. There is a need to manage how vendors are selected and managed within the project life cycle. Managing procurement is about acquisition and contracting plans, sellers' responses and selections, contract administration, and contract closure.
10. **Managing stakeholders:** Every project impacts people and organizations and is impacted by people and organizations. Identifying these stakeholders early, and as they arise and change throughout the project, is a key success factor. Managing stakeholders is about identifying stakeholders, their interest level, and their potential to influence the project; and managing and controlling the relationships and communications between stakeholders and the project.

This is the big framework for managing projects and if you want to be effective in managing projects, then you need to be effective in managing each of the 10 knowledge areas that make up PMBOK (see Figure 4.1)

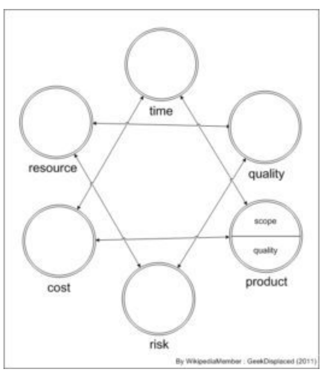

Figure 4.1: PM Star Model suggested by GeekDisplaced

Certification in project management is available from the PMI, PRINCE2, ITIL, Critical Chain, and others. Agile project management methodologies (Scrum, extreme programming, Lean Six Sigma, others) also have certifications.

Introduction to the Project Management Knowledge Areas

As discussed above, projects are divided into components, and a project manager must be knowledgeable in each area. Each of these areas of knowledge will be explored in more depth in subsequent chapters. For now, lets look at them in a little more detail to prepare you for the chapters that follow.

Project Start-Up and Integration

The start-up of a project is similar to the start-up of a new organization. The project leader develops the project infrastructure used to design and execute the project. The project management team must develop alignment among the major stakeholders—those who have a share or interest—on the project during the early phases or definition phases of the project. The project manager will conduct one or more kickoff meetings or alignment sessions to bring the various parties of the project together and begin the project team building required to operate efficiently during the project.

During project start-up, the project management team refines the scope of work and develops a preliminary schedule and conceptual budget. The project team builds a plan for executing the project based on the project profile. The plan for developing and tracking the detailed schedule, the procurement plan, and the plan for building the budget and estimating and tracking costs are developed during the start-up. The plans for information technology, communication, and tracking client satisfaction are also all developed during the start-up phase of the project.

Flowcharts, diagrams, and responsibility matrices are tools to capture the work processes associated with executing the project plan. The first draft of the project procedures manual captures the historic and intuitional knowledge that team members bring to the project. The development and review of these procedures and work processes contribute to the development of the organizational structure of the project.

This is typically an exciting time on a project where all things are possible. The project management team is working many hours developing the initial plan, staffing the project, and building relationships with the client. The project manager sets the tone of the project and sets expectations for each of the project team members. The project start-up phase on complex projects can be chaotic, and until plans are developed, the project manager becomes the source of information and direction. The project manager creates an environment that encourages team members to fully engage in the project and encourages innovative approaches to developing the project plan.

Project Scope

The project scope is a document that defines the parameters—factors that define a system and determine its behaviour—of the project, what work is done within the boundaries of the project, and the work that is outside the project boundaries. The scope of work (SOW) is typically a written document that defines what work will be accomplished by the end of the project—the deliverables of the project. The project scope defines what will be done, and the project execution plan defines how the work will be accomplished.

No template works for all projects. Some projects have a very detailed scope of work, and some have a short summary document. The quality of the scope is measured by the ability of the project manager and project stakeholders to develop and maintain a common understanding of what products or services the project will deliver. The size and detail of the project scope is related to the complexity profile of the project. A more complex project often requires a more detailed and comprehensive scope document.

According to the PMI, the scope statement should include the following:

- Description of the scope
- Product acceptance criteria
- Project deliverables
- Project exclusions
- Project constraints
- Project assumptions

The scope document is the basis for agreement by all parties. A clear project scope document is also critical to managing change on a project. Since the project scope reflects what work will be accomplished on the project, any change in expectations that is not captured and documented creates the opportunity for confusion. One of the most common trends on projects is the incremental expansion in the project scope. This trend is labeled “scope creep.” Scope creep threatens the success of a project because the small increases in scope require additional resources that were not in the plan. Increasing the scope of the project is a common occurrence, and adjustments are made to the project budget and schedule to account for these changes. Scope *creep* occurs when these changes are not recognized or not managed. The ability of a project manager to identify potential changes is often related to the quality of the scope documents.

Events do occur that require the scope of the project to change. Changes in the marketplace may require change in a product design or the timing of the product delivery. Changes in the client's management team or the financial health of the client may also result in changes in the project scope. Changes in the project schedule, budget, or product quality will have an effect on the project plan. Generally, the later in the project the change occurs, the greater the increase to the project costs. Establishing a change management system for the project that captures changes to the project scope and assures that these changes are authorized by the appropriate level of management in the client's organization is the responsibility of the project manager. The project manager also analyzes the cost and schedule impact of these changes and adjusts the project plan to reflect the changes authorized by the client. Changes to the scope can cause costs to increase or decrease.

Project Schedule and Time Management

The definition of project success often includes completing the project on time. The development and management of a project schedule that will complete the project on time is a primary responsibility of the project manager, and completing the project on time requires the development of a realistic plan and the effective management of the plan. On smaller projects, project managers may lead the development of the project plan and build a schedule to meet that plan. On larger and more complex projects, a project controls team that focuses on both costs and schedule planning and controlling functions will assist the project management team in developing the plan and tracking progress against the plan.

To develop the project schedule, the project team does an analysis of the project scope, contract, and other information that helps the team define the project deliverables. Based on this information, the project team develops a milestone schedule. The milestone schedule establishes key dates throughout the life of a project that must be met for the project to finish on time. The key dates are often established to meet contractual obligations or established intervals that will reflect appropriate progress for the project. For less complex projects, a milestone schedule may be sufficient for tracking the progress of the project. For more complex projects, a more detailed schedule is required.

To develop a more detailed schedule, the project team first develops a work breakdown structure (WBS)—a description of tasks arranged in layers of detail. Although the project scope is the primary document for developing the WBS, the WBS incorporates all project deliverables and reflects any documents or information that clarifies the project deliverables. From the WBS, a project plan is developed. The project plan lists the activities that are needed to accomplish the work identified in the WBS. The more detailed the WBS, the more activities that are identified to accomplish the work.

After the project team identifies the activities, the team sequences the activities according to the order in which the activities are to be accomplished. An outcome from the work process is the project logic diagram. The logic diagram represents the logical sequence of the activities needed to complete the project. The next step in the planning process is to develop an estimation of the time it will take to accomplish each activity or the activity duration. Some activities must be done sequentially, and some activities can be done concurrently. The planning process creates a project schedule by scheduling activities in a way that effectively and efficiently uses project resources and completes the project in the shortest time.

On larger projects, several paths are created that represent a sequence of activities from the beginning to the end of the project. The longest path to the completion of the project is the critical path. If the critical path takes less time than is allowed by the client to complete the project, the project has a positive total float or project slack. If the client's project completion date precedes the calculated critical path end date, the project has a negative float. Understanding and managing activities on the critical path is an important project management skill.

To successfully manage a project, the project manager must also know how to accelerate a schedule to compensate for unanticipated events that delay critical activities. Compressing—crashing—the schedule is a term used to describe the techniques used to shorten the project schedule. During the life of the project, scheduling conflicts often occur, and the project manager is responsible for reducing these conflicts while maintaining project quality and meeting cost goals.

Project Costs

The definition of project success often includes completing the project within budget. Developing and controlling a project budget that will accomplish the project objectives is a critical project management skill. Although clients expect the project to be executed efficiently, cost pressures vary on projects. On some projects, the project completion or end date is the largest contributor to the project complexity. The development of a new drug to address a critical health issue, the production of a new product that will generate critical cash flow for a company, and the competitive advantage for a company to be first in the marketplace with a new technology are examples of projects with schedule pressures that override project costs.

The accuracy of the project budget is related to the amount of information known by the project team. In the early stages of the project, the amount of information needed to develop a detailed budget is often missing. To address the lack of information, the project team develops different levels of project budget estimates. The conceptual estimate (or "ballpark estimate") is developed with the least amount of knowledge. The major input into the conceptual estimate is expert knowledge or past experience. A project manager who has executed a similar project in the past can use those costs to estimate the costs of the current project.

When more information is known, the project team can develop a rough order of magnitude (ROM) estimate. Additional information such as the approximate square feet of a building, the production capacity of a plant, and the approximate number of hours needed to develop a software program can provide a basis for providing a ROM estimate. After a project design is more complete, a project detailed estimate can be developed. For example, when the project team knows the number of rooms, the type of materials, and the building location of a home, they can provide a detailed estimate. A detailed estimate is not a bid.

The cost of the project is tracked relative to the progress of the work and the estimate for accomplishing that work. Based on the cost estimate, the cost of the work performed is compared against the cost budgeted for that work. If the cost is significantly higher or lower, the project team explores reasons for the difference between expected costs and actual costs.

Project costs may deviate from the budget because the prices in the marketplace were different from what was expected. For example, the estimated costs for lumber on a housing project may be higher than budgeted or the hourly cost for labour may be lower than budgeted. Project costs may also deviate based on project performance. For example, a project team estimated that the steel design for a bridge over a river would take 800 labour hours, but 846 hours were actually expended. The project team captures the deviation between costs budgeted for work and the actual cost for work, revises the estimate as needed, and takes corrective action if the deviation appears to reflect a trend.

The project manager is responsible for assuring that the project team develops cost estimates based on the best information available and revises those estimates as new or better information becomes available. The project manager is also responsible for tracking costs against the budget and conducting an analysis when project costs deviate significantly from the project estimate. The project manager then takes appropriate corrective action to ensure that project performance matches the revised project plan.

Project Quality

Project quality focuses on the end product or service deliverables that reflect the purpose of the project. The project manager is responsible for developing a project execution approach that provides for a clear understanding of the expected project deliverables and the quality specifications. The project manager of a housing construction project not only needs to understand which rooms in the house will be carpeted but also what grade of carpet is needed. A room with a high volume of traffic will need a high-grade carpet.

The project manager is responsible for developing a project quality plan that defines the quality expectations and ensures that the specifications and expectations are met. Developing a good understanding of the project deliverables through documenting specifications and expectations is critical to a good quality plan. The processes for ensuring that the specifications and expectations are met are integrated into the project execution plan. Just as the project budget and completion dates may change over the life of a project, the project specifications may also change. Changes in quality specifications are typically managed in the same process as cost or schedule changes. The impact of the changes is analyzed for impact on cost and schedule, and with appropriate approvals, changes are made to the project execution plan.

The PMI's *A Guide to the Project Management Body of Knowledge (PMBOK Guide)* has an extensive chapter on project quality management. The material found in this chapter would be similar to material found in a good operational management text.

Although any of the quality management techniques designed to make incremental improvement to work processes can be applied to a project work process, the character of a project (unique and relatively short in duration) makes small improvements less attractive on projects. Rework on projects, as with manufacturing operations, increases the cost of the product or service and often increases the time needed to complete the reworked activities. Because of the duration constraints of a project, the development of the appropriate skills, materials, and work processes early in the project is critical to project success. On more complex projects, time is allocated to developing a plan to understand and develop the appropriate levels of skills and work processes.

Project management organizations that execute several similar types of projects may find process improvement tools useful in identifying and improving the baseline processes used on their projects. Process improvement tools may also be helpful in identifying cost and schedule improvement opportunities. Opportunities for improvement must be found quickly to influence project performance. The investment in time and resources to find improvements is greatest during the early stages of the project, when the project is in the planning stages. During later project stages, as pressures to meet project schedule goals increase, the culture of the project is less conducive to making changes in work processes.

Another opportunity for applying process improvement tools is on projects that have repetitive processes. A housing contractor that is building several identical houses may benefit from evaluating work processes in the first few houses to explore the opportunities available to improve the work processes. The investment of $1,000 in a work process that saves $200 per house is a good investment as long as the contractor is building more than five houses.

Project Team: Human Resources and Communications

Staffing the project with the right skills, at the right place, and at the right time is an important responsibility of the project management team. The project usually has two types of team members: functional managers and process managers. The functional managers and team focus on the technology of the project. On a construction project, the functional managers would include the engineering manager and construction superintendents. On a training project, the functional manager would include the professional trainers; on an information technology project, the software development managers would be functional managers. The project management team also includes project process managers. The project controls team would include process managers who have expertise in estimating, cost tracking, planning, and scheduling. The project manager needs functional and process expertise to plan and execute a successful project.

Because projects are temporary, the staffing plan for a project typically reflects both the long-term goals of skilled team members needed for the project and short-term commitment that reflects the nature of the project. Exact start and end dates for team members are often negotiated to best meet the needs of individuals and the project. The staffing plan is also determined by the different phases of the project. Team members needed in the early or conceptual phases of the project are often not needed during the later phases or project closeout phases. Team members needed during the implementation phase are often not needed during the conceptual or closeout phases. Each phase has staffing requirements, and the staffing of a complex project requires detailed planning to have the right skills, at the right place, at the right time.

Typically a core project management team is dedicated to the project from start-up to closeout. This core team would include members of the project management team: project manager, project controls, project procurement, and key members of the function management or experts in the technology of the project. Although longer projects may experience more team turnover than shorter projects, it is important on all projects to have team members who can provide continuity through the project phases.

For example, on a large commercial building project, the civil engineering team that designs the site work where the building will be constructed would make their largest contribution during the early phases of the design. The civil engineering lead would bring on different civil engineering specialties as they were needed. As the civil engineering work is completed and the structural engineering is well underway, a large portion of the civil engineers would be released from the project. The functional managers, the engineering manager, and civil engineering lead would provide expertise during the entire length of the project, addressing technical questions that may arise and addressing change requests.

Project team members can be assigned to the project from a number of different sources. The organization that charters the project can assign talented managers and staff from functional units within the organization, contract with individuals or agencies to staff positions on the project, temporarily hire staff for the project, or use any combination of these staffing options. This staffing approach allows the project manager to create the project organizational culture. Some project cultures are more structured and detail oriented, and some are less structured with less formal roles and communication requirements. The type of culture the project manager creates depends greatly on the type of project.

Project Risk

Risk exists on all projects. The role of the project management team is to understand the kinds and levels of risks on the project and then to develop and implement plans to mitigate these risks. Risk represents the likelihood that an event will happen during the life of the project that will negatively affect the achievement of project goals. The type and amount of risk varies by industry type, complexity, and phase of the project. The project risk plan will also reflect the risk profile of the project manager and key stakeholders. People have different comfort levels with risk, and some members of the project team will be more risk averse than others.

The first step in developing a risk management plan involves identifying potential project risks. Some risks are easy to identify, such as the potential for a damaging storm in the Caribbean, and some are less obvious. Many industries or companies have risk checklists developed from past experience. The Construction Industry Institute published a 100-item risk checklist that provides examples and areas of project risks. No risk checklist will include all potential risks. The value of a checklist is the stimulation of discussion and thought about the potential risks on a project.

The project team analyzes the identified risks and estimates the likelihood of the risks occurring. The team then estimates the potential impact on project goals if the event does occur. The outcome from this process is a prioritized list of estimated project risks with a value that represents the likelihood of occurrence and the potential impact on the project.

The project team then develops a risk mitigation plan that reduces the likelihood of an event occurring or reduces the impact on the project if the event does occur. The risk management plan is integrated into the project execution plan, and mitigation activities are assigned to the appropriate project team member. The likelihood that all the potential events identified in the risk analysis would occur is extremely rare. The likelihood that one or more events will happen is high.

The project risk plan reflects the risk profile of the project and balances the investment of the mitigation against the benefit for the project. One of the more common risk mitigation approaches is the use of contingency. Contingency is funds set aside by the project team to address unforeseen events. Projects with a high-risk profile will typically have a large contingency budget. If the team knows which activities have the highest risk, contingency can be allocated to activities with the highest risk. When risks are less identifiable to specific activities, contingency is identified in a separate line item. The plan includes periodic risk-plan reviews during the life of the project. The risk review evaluates the effectiveness of the current plan and explores possible risks not identified in earlier sessions.

Project Procurement

The procurement effort on projects varies widely and depends on the type of project. Often the client organization will provide procurement services on less complex projects. In this case, the project team identifies the materials, equipment, and supplies needed by the project and provides product specifications and a detailed delivery schedule. When the procurement department of the parent organization provides procurement services, a liaison from the project can help the procurement team better understand the unique requirements of the project and the time-sensitive or critical items of the project schedule.

On larger, more complex projects, personnel are dedicated to procuring and managing the equipment, supplies, and materials needed by the project. Because of the temporary nature of projects, equipment, supplies, and materials are procured as part of the product of the project or for the execution of the project. For example, the bricks procured for a construction project would be procured for the product of the project, and the mortar mixer would be equipment procured for the execution of the project work. At the end of the project, equipment bought or rented for the execution of the work of the project are sold, returned to rental organizations, or disposed of some other way.

More complex projects will typically procure through different procurement and management methods. Commodities are common products that are purchased based on the lowest bid. Commodities include items like concrete for building projects, office supplies, or even lab equipment for a research project. The second type of procurement includes products that are specified for the project. Vendors who can produce these products bid for a contract. The awarding of a contract can include price, ability to meet the project schedule, the fit for purpose of the product, and other considerations important to the project. Manufacturing a furnace for a new steel mill would be provided by a project vendor. Equipment especially designed and built for a research project is another example. These vendors' performances become important parts of the project, and the project manager assigns resources to coordinate the work and schedule of the vendor. The third procurement approach is the development of one or more partners. A design firm that is awarded the design contract for a major part of the steel mill and a research firm that is conducting critical subparts of the research are examples of potential project partners. A partner contributes to and is integrated into the execution plan. Partners perform best when they share the project vision of success and are emotionally invested in the project. The project management team builds and implements a project procurement plan that recognizes the most efficient and effective procurement approach to support the project schedule and goals.

Project Stakeholder Management

People and organizations can have many different relationships to the project. Most commonly, these relationships can be grouped into those who will be impacted by the project and those who can impact the project.

A successful project manager will identify stakeholders early in the project. For each stakeholder, it is important to identify what they want or need and what influence or power they have over the project. Based on this information, the need to communicate with the stakeholder or stakeholder group can be identified, followed by the creation of a stakeholder management plan. A stakeholder register is used to identify and track the interactions between the project and each stakeholder. This register must be updated on a regular basis, as new stakeholders can arise at any time, and the needs and interest levels of a particular stakeholder may change through the course of the project.

Table 4.1 Stakeholder Register

Knowledge Area	Initiating	Planning	Executing	Monitoring and Controlling	Closing
Project Integration Management	Develop Project Charter	Develop Project Management Plan		• Monitor and control project work • Perform integrated change control	Close project or phase
Project Scope Management		• Plan scope management • Collect requirements • Define scope • Create WBS		• Validate scope • Control scope	
Project Time Management		• Plan schedule management • Define activities • Sequence activities • Estimate activity resources • Estimate activity durations • Develop schedule		Control schedule	
Project Cost Management		• Plan cost management • Estimate costs • Determine budget		Control costs	
Project Quality Management		Plan quality management	Perform quality assurance	Control quality	

Scrum Development Overview

"Scrum" is another formal project management/product development methodology and part of agile project management. Scrum is a term from rugby (scrimmage) that means a way of restarting a game. It's like restarting the project efforts every X weeks. It's based on the idea that you do not really know how to plan the whole project up front, so you start and build empirical data, and then re-plan and iterate from there.

Scrum uses sequential sprints for development. Sprints are like small project phases (ideally two to four weeks). The idea is to take one day to plan for what can be done now, then develop what was planned for, and demonstrate it at the end of the sprint. Scrum uses a short daily meeting of the development team to check what was done yesterday, what is planned for the next day, and what if anything is impeding the team members from accomplishing what they have committed to. At the end of the sprint, what has been demonstrated can then be tested, and the next sprint cycle starts.

Scrum methodology defines several major roles. They are:

- Product owners: essentially the business owner of the project who knows the industry, the market, the customers, and the business goals of the project. The product owner **must** be intimately involved with the Scrum process, especially the planning and the demonstration parts of the sprint.
- Scrum Master: somewhat like a project manager, but not exactly. The Scrum Master's duties are essentially to remove barriers that impede the progress of the development team, teach the product owner how to maximize return on investment (ROI) in terms of development effort, facilitate creativity and empowerment of the team, improve the productivity of the team, improve engineering practices and tools, run daily standup meetings, track progress, and ensure the health of the team.
- Development team: self-organizing (light-touch leadership), empowered group; they participate in planning and estimating for each sprint, do the development, and demonstrate the results at the end of the sprint. It has been shown that the ideal size for a development team is 7 +/- 2. The development team can be broken into "teamlets" that "swarm" on user stories, which are created in the sprint planning session.

Typically, the way a product is developed is that there is a "front burner" (which has stories/tasks for the current sprint), a "back burner" (which has stories for the next sprint), and a "fridge" (which has stories for later, as well as process changes). One can look at a product as having been broken down like this: product -> features -> stories -> tasks.

Often effort estimations are done using "story points" (tiny = 1 SP, small = 2 SP, medium = 4 SP, large = 8 SP, big = 16+ SP, unknown = ? SP) Stories can be of various types. User stories are very common and are descriptions of what the user can do and what happens as a result of different actions from a given starting point. Other types of stories are from these areas: analysis, development, QA, documentation, installation, localization, and training.

Planning meetings for each sprint require participation by the product owner, the Scrum Master, and the development team. In the planning meeting, they set the goals for the upcoming sprint and select a subset of the product backlog (proposed stories) to work on. The development team decomposes stories to tasks and estimates them. The development team and product owner do final negotiations to determine the backlog for the following sprint.

The Scrum methodology uses metrics to help with future planning and tracking of progress; for example, "burn down" – the number of hours remaining in the sprint versus the time in days; "velocity" – essentially, the amount of effort the team expends. (After approximately three sprints with the same team, one can get a feel for what the team can do going forward.)

Some caveats about using Scrum methodology: 1) You need committed, mature developers; 2) You still need to do major requirements definition, some analysis, architecture definition, and definition of roles and terms up front or early; 3) You need commitment from the company and the product owner; and 4) It is best for products that require frequent new releases or updates, and less effective for large, totally new products that will not allow for frequent upgrades once they are released.

The Project Management Office

Many large and even medium-sized organizations have created a department to oversee and support projects throughout the organization. This is an attempt to reduce the high numbers of failed projects (see the Project Management Overview chapter.) These offices are usually called the project management office or PMO.

The PMO may be the home of all the project managers in an organization, or it may simply be a resource for all project managers, who report to their line areas.

Typical objectives of a PMO are:

- Help ensure that projects are aligned with organizational objectives
- Provide templates and procedures for use by project managers
- Provide training and mentorship
- Provide facilitation
- Stay abreast of the latest trends in project management
- Serve as a repository for project reports and lessons learned

The existence and role of PMOs tends to be somewhat fluid. If a PMO is created, and greater success is not experienced in organizational projects, the PMO is at risk of being disbanded as a cost-saving measure. If an organization in which you are a project manager or a project team member has a PMO, try to make good use of the resources available. If you are employed as a resource person in a PMO, remember that your role is not to get in the way and create red tape, but to enable and enhance the success of project managers and projects within the organization.

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CHAPTER OVERVIEW

6: Teamwork and Leadership

Learning Objectives

1. Define teamwork and explain how to overcome various challenges to group success
2. Describe the process of leader development
3. Describe several different leadership styles and their likely influence on followers

Two important aspects of group communication, especially in the business environment, are ***teamwork and leadership***. You will work in a team and at some point may be called on to lead. You may emerge to that role as the group recognizes your specific skill set in relation to the task, or you may be appointed to a position of responsibility for yourself and others. Your communication skills will be your foundation for success as a member, and as a leader. Listen and seek to understand both the task and your group members as you become involved with the new effort. Have confidence in yourself and inspire the trust of others. Know that leading and following are both integral aspects of effective teamwork.

Teamwork

Teamwork is a compound word, combining team and work. Teams are a form of group normally dedicated to production or problem-solving. That leaves us with the work. This is where our previous example of problem-solving can serve us well. Each member of the team has skills, talents, experience, and education. Each is expected to contribute. Work is the activity, and while it may be fun or engaging, it also requires effort and commitment, as there is a schedule for production with individual and group responsibilities. Each member must fulfill his or her own obligations for the team to succeed, and the team, like a chain, is only as strong as its weakest member. In this context, we don’t measure strength or weakness at the gym, but in terms of productivity.

Teams can often achieve higher levels of performance than individuals because of the combined energies and talents of the members. Collaboration can produce motivation and creativity that may not be present in single-contractor projects. Individuals also have a sense of belonging to the group, and the range of views and diversity can energize the process, helping address creative blocks and stalemates. By involving members of the team in decision-making, and calling upon each member's area of contribution, teams can produce positive results.

Teamwork is not without its challenges. The work itself may prove a challenge as members juggle competing assignments and personal commitments. The work may also be compromised if team members are expected to conform, and pressured to go along with a procedure, plan, or product that they themselves have not developed. Groupthink, or the tendency to accept the group's ideas and actions in spite of individual concerns, can also compromise the process and reduce efficiency. Personalities and competition can play a role in a team's failure to produce.

We can recognize that people want to belong to a successful team, and celebrating incremental gain can focus the attention on the project and its goals. Members will be more willing to express thoughts and opinions, and follow through with actions, when they perceive that they are an important part of the team. By failing to include all of the team members, valuable insights may be lost in the rush to judgment or production. Making time for planning, and giving each member time to study, reflect, and contribute can allow them to gain valuable insights from each other, and may make them more likely to contribute information that challenges the status quo. Unconventional or "devil's advocate" thinking may prove insightful and serve to challenge the process in a positive way, improving the production of the team. Respect for divergent views can encourage open discussion.

Thill and Bovee, Thill, J. V., & Bovee, C. L. (2002). *Essentials of business communication*. Upper Saddle River, NJ: Prentice Hall. provide a valuable list to consider when setting up a team, which we have adapted here for our discussion:

- Select team members wisely
- Select a responsible leader
- Promote cooperation
- Clarify goals
- Elicit commitment
- Clarify responsibilities
- Instill prompt action
- Apply technology
- Ensure technological compatibility
- Provide prompt feedback

Group dynamics involve the interactions and processes of a team, and influence the degree to which members feel a part of the goal and mission. A team with a strong identity can prove to be a powerful force, but requires time and commitment. A team that exerts too much control over individual members can run the risk or reducing creative interactions and encourage tunnel vision. A team that exerts too little control, with attention to process and areas of specific responsibility, may not be productive. The balance between motivation and encouragement, and control and influence, is challenging as team members represent diverse viewpoints and approaches to the problem. A skilled business communicator creates a positive team by first selecting members based on their areas of skill and expertise, but attention to their style of communication is also warranted. Individuals that typically work alone, or tend to be introverted, may need additional encouragement to participate. Extroverts may need to be encouraged to listen to others and not dominate the conversation. Teamwork involves teams and work, and group dynamics play an integral role in their function and production.

Types of Leaders

We can see types of leaders in action and draw on common experience for examples. The heart surgeon does not involve everyone democratically, is typically appointed to the role through earned degrees and experience, and resembles a military sergeant more than a politician. The autocratic leader is self-directed and often establishes norms and conduct for the group. In some settings, we can see that this is quite advantageous, such as open-heart surgery or during a military exercise, but it does not apply equally to all leadership opportunities.

Contrasting the autocrat is the laissez-faire leader, or "live and let live" leader. In a professional setting, such as a university, professors may bristle at the thought of an autocratic leader telling them what to do. They have earned their role through time, effort, and experience and know their job. A wise laissez-faire leader recognizes this aspect of working with professionals and may choose to focus efforts on providing the professors with the tools they need to make a positive impact. Imagine that you are in the role of a television director, and you have a vision or idea of what the successful pilot program should look like. The script is set, the lighting correct, and the cameras are in the correct position. You may tell people what to do and where to stand, but you remember that your job is to facilitate the overall process. You work with talent, and creative people are interesting on camera. If you micromanage your actors, they may perform in ways that are not creative, and that will not draw audiences. If you let them run wild through improvisation, the program may not go well at all. Balancing the need for control with the need for space is the challenge of the laissez-faire leader.

Not all leaders are autocrats or laissez-faire leaders. Harris and Sherblom, Harris, T., & Sherblom, J. (1999). *Small group and team communication*. Boston, MA: Allyn & Bacon. specifically, note three leadership styles that characterize the modern business or organization, and reflect our modern economy. We are not born leaders but may become them if the context or environment requires our skill set. A leader-as-technician role often occurs when we have skills that others do not. If you can fix the copy machine at the office, your leadership and ability to get it running again are prized and sought-after skills. You may instruct others on how to load the paper, or how to change the toner, and even though your pay grade may not reflect this leadership role, you are looked to by the group as a leader within that context. Technical skills, from Internet technology to facilities maintenance, may experience moments where their particular area of knowledge is required to solve a problem. Their leadership will be in demand.

The leader-as-conductor involves a central role of bringing people together for a common goal. In the common analogy, a conductor leads an orchestra and integrates the specialized skills, and sounds, of the various components the musical group comprises. In the same way, a leader who conducts may set a vision, create benchmarks, and creative collaborate with group as they interpret a set script. Whether it is a beautiful movement in music, or a group of teams that comes together to address a common challenge, the leader-as-conductor keeps the time and tempo of the group.

Coaches are often discussed in business-related books as models of leadership for good reason. A leader-as-coach combines many of the talents and skills we've discussed here, serving as a teacher, motivator, and keeper of the goals of the group. A coach may be autocratic at times and give pointed direction without input from the group, and they may stand on the sidelines while the players do what they've been trained to do and make the points. The coach may look out for the group and defend it against bad calls, and may motivate players with words of encouragement. We can recognize some of the behaviors of coaches, but what specific traits have a positive influence on the group? Peters and Austin, Peters, T., & Austin, N. (1985). *A passion for excellence: the leadership difference*. New York: Random House. identify five important traits that produce results:

- Orientation and education
- Nurturing and encouragement
- Assessment and correction
- Listening and counseling
- Establishing group emphasis

Coaches are teachers, motivators, and keepers of the goals of the group. There are times when members of the team forget that there is no "I" in the word "team." At such times coaches serve to redirect the attention and energy of the individuals to the overall goals of the group. They conduct the group with a sense of timing and tempo, and at times relax and let the members demonstrate their talents. Through their listening skills and counseling, they come to know each member as an individual, but keep the team focus for all to see. They set an example. Coaches, however, are human and by definition are not perfect. They can and do prefer some players over others, and can display less than professional sideline behavior when they don't agree with the referee, but the style of leadership is worthy of your consideration in its multidisciplinary approach. Coaches use more than one style of leadership and adapt to the context and environment. A skilled business communicator will recognize that this approach has its merits

Key Takeaway

Teamwork allows individuals to share their talents and energy to accomplish goals, and an effective leader facilitates this teamwork process.

Exercise 6.1

1. Do you prefer working in a group or team environment, or working individually? What are the advantages and disadvantages of each? Discuss your thoughts with your classmates.

2. Imagine that you could choose anyone you wanted to be on a team with you. Who would you choose, and why? Write a 2–3 paragraph description and share it with a classmate.
3. Think of a leader you admire and respect. What leadership traits to they display or possess? How would you characterize this leader's style—is the leader autocratic or laissez-faire; a technician or a coach?

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SECTION OVERVIEW

6.1: Listening in Groups

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6.1.1: Chapter Introduction

Introductory Exercises

1. In order to communicate with others, you need to know yourself. Please complete a personal inventory, a simple list of what comes to mind in these five areas:
    1. Your knowledge. What is your favorite subject?
    2. Your skills. What can you do?
    3. Your experience. What has been your experience writing to date?
    4. Your interests. What do you enjoy?
    5. Your relationships. Who is important to you?
2. To be a successful communicator, it is helpful to be conscious of how you view yourself and others. Please consider what groups you belong to, particularly in terms of race, ethnicity or culture. Imagine that you had to communicate your perception of just one of these groups. Please choose five terms from the list below, and indicate the degree to which you agree or disagree that the term describes the group accurately.

    Term Describes the Group Accurately = 1

    Strongly Disagree = 2

    Somewhat Disagree = 3

    Neither Agree nor Disagree = 4

    Somewhat Agree = 5

    Strongly Agree = 6

Independent	Dependent
Hard working	Lazy
Progressive	Traditional
Sophisticated	Simple
Creative	Practical

3. Now consider how you know someone is listening to you. Make a list of the behaviors you observe that indicate they are listening, and understand you. Share and compare the results with classmates.

Your mind is like a parachute. It works best when it's open.

Anonymous

If speaking is silver then listening is gold.

Turkish Proverb

Getting Started

Communicating involves the translation of your thoughts and ideas to words. Speaking or writing involves sharing your perspective with others. Listening, therefore, involves making sense of what is shared with us, and can require all of our attention. A Cuban saying captures it best: "Listening looks easy, but it's not simple. In every head is a world." For us to understand each other we have to listen, and make sense of each other's perspectives. In order for us to work effectively as a group or team, we need to listen to each other, not just hear each other or wait for our turn to deliver a monologue, make our point, or convince others that we are right. Each group member brings a valuable perspective, indeed a world, to contribute to the team.

When group members interact, do you find yourself getting lost in your own thoughts. While text messages and other distractions can be powerful, the most distracting voice by far is our own internal monologue. If you silently talk to yourself, the action is a reflection of the communication process, but you play the role of audience. In your own head, you may make sense of your words and their meaning. You may have rehearsed your "lines" or what you want to say, and completing miss the turns and contributions in the conversation. Then, when I hear what you said, what you meant may escape me. I might not "get it" because I don't know you, your references, your perspectives, your word choices, your underlying meaning and motivation for speaking in the first place.

In this chapter we'll discuss perspectives, and how people perceive information, as we learn how communication is an imperfect bridge to understanding each other. It requires our constant attention, maintenance, and effort. Listening is anything but simple or easy.

Sometimes people mistake hearing for listening. Hearing involves the physiological process of recognizing sounds. Your ears receive and transmit the information to your brain. Once your brain receives the signals, then it starts to make sense to you. This is the listening stage, where you create meaning based on previous experiences and contextual cues to make sense of the sounds.

Knowing your team involves understanding others, and their perspectives, to see if they understand your words, examples, or the frames of reference you use to communicate your experiences, points and conclusions. Ask yourself when was the last time you had a miscommunication with someone. No doubt it was fairly recently, as it is for most people. It's not people's fault that language, both verbal and nonverbal, is an imperfect system. We can, however, take responsibility for the utility and limitations of language to try to gain a better understanding of how we can communicate more effectively. We can choose to actively listen to each other, and ask clarifying questions instead of rushing to judgment or making statement.

As a communicator, consider both the role of the speaker and the group, and not only what and how you want to communicate but what and how your team needs you to communicate with them in order to present an effective message.

Take, for example, the word "love." Yes, we recognize those four little letters all in a row, but what does it really mean? You can use it to describe the feelings and emotions associated with your mother, a partner, or perhaps your dog. Or you might say you love chocolate cake. Does your use of the word in any given context allow the audience to get any closer to what you mean by this word, "love?" The key here is context, which provides clues to how you mean the word, and what its use means to you. The context allows you to close the gap between your meaning of "love" and what the receiver, or group member, has in their range of understanding of the same word. Your experiences are certainly different, but through clues, contexts, and attempts to understand each other's perspectives, we can often communicate more effectively.

Let's first follow the advice given by the character Polonius in Shakespeare's *Hamlet*: "to thine own self be true." This relates to the notion that you need to know yourself, or your perspective, before you can explore ways to know others and communicate more effectively. You will examine how you perceive stimuli, choosing some information over others, organizing the information according to your frame of reference, and interpreting it, deciding what it means to you and whether you should remember it or just ignore it and move on. We can recognize that not everyone tunes into the same music, trends in clothing, or even classes, so experiences or stimuli can have different meanings. Still, we can find common ground and communicate effectively, if we only choose to listen to each other.

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6.1.2: Listening to Understand

Learning Objectives

1. Explain the importance of becoming an active listener and reader

As the popular author and Hollywood entrepreneur Wilson Mizner said, "A good listener is not only popular everywhere, but after a while, he knows something." Learning to listen to your conversational partner, customer, supplier, or supervisor is an important part of business communication. Too often, instead of listening we mentally rehearse what we want to say. Similarly, when we read, we are often trying to multitask and therefore cannot read with full attention. Inattentive listening can cause us to miss much of what the speaker is sharing with us.

Communication involves the sharing and understanding of meaning, To fully share and understand, practice active listening so that you are fully attentive, fully present in the moment of interaction. Pay attention to both the actual words and for other clues to meaning, such as tone of voice or writing style. Look for opportunities for clarification and feedback when the time comes for you to respond, not before. Remember we hear with our ears, but listen with our brain, and sometimes it is all too easy to tune out the messenger or their message.

Active Listening

You've probably experienced the odd sensation of driving somewhere and, having arrived, have realized you don't remember driving. Your mind may have been filled with other issues and you drove on autopilot. It's dangerous when you drive, and it is dangerous in communication. Choosing to listen or read attentively takes effort. People communicate with words, expressions, and even in silence, and your attention to them will make you a better communicator. From discussions on improving customer service to retaining customers in challenging economic times, the importance of listening comes up frequently as a success strategy.

Here are some tips to facilitate active listening:

- Maintain eye contact with the speaker
- Don't interrupt
- Focus your attention on the message, not your own internal monologue
- Restate the message in your own words and ask if you understood correctly
- Ask clarifying questions to communicate interest and gain insight

When the Going Gets Tough

Our previous tips will serve you well in daily interactions, but suppose you have an especially difficult subject to discuss. In a difficult situation like this, it is worth taking extra effort to create an environment and context that will facilitate positive communication.

Here are some tips that may be helpful:

- Special time. To have the difficult conversation, set aside a special time when you will not be disturbed. Close the door and turn off the TV, music player, and instant messaging client.
- Don't interrupt. Keep silence while you let the other person "speak their piece." Make an effort to understand and digest the news without mental interruptions.
- Non-judgmental. Receive the message without judgment or criticism. Set aside your opinions, attitudes, and beliefs.
- Acceptance. Be open to the message being communicated, realizing that acceptance does not necessarily mean you agree with what is being said.
- Take turns. Wait until it is your turn to respond, then measure your response in proportion to the message that was delivered to you. Reciprocal turn-taking allows each person have their say.
- Acknowledge. Let the other person know that you have listened to the message or read it attentively.
- Understanding. Be certain that you understand what your partner is saying. If you don't understand, ask for clarification. Restate the message in your own words.

- Keep your cool. Speak your truth without blaming. Use “I” statements (e.g., “I felt concerned when I learned that my department is going to have a layoff”) rather than “you” statements (e.g., “You want to get rid of some of our best people”).

Finally, recognize that mutual respect and understanding are built one conversation at a time. Trust is difficult to gain and easy to lose. Be patient and keep the channels of communication open, as a solution may develop slowly over the course of many small interactions. Recognize that it is more valuable to maintain the relationship over the long term than to “win” in an individual transaction.

Key Takeaway

Part of being an effective communicator is learning to practice active listening.

Exercise 6.1.2.1

1. Pair up with a classmate and do a role-play exercise in which one person tries to deliver a message while the other person multitasks and interrupts. Then try it again while the listener practices active listening. How do the two communication experiences compare? Discuss your findings.
2. Select a news article and practice “active reading” by reading the article and summarizing each of its main points in your own words. Write a letter to the editor commenting on the article—you don’t have to send it, but you may if you wish.
3. In a half-hour period of time, see if you can count how many times you are interrupted. Share and compare with your classmates.

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6.1.3: Types of Listening

Learning Objectives

1. Identify four preferences and four purposes of listening
2. Distinguish among the components of the "HURIER model" of listening
3. Identify foundations for good learning, including the features of "dialogic listening"
4. Identify several kinds of negative listening

I'd invited my wife to accompany me to a professional conference in Portland. Since I was going to be making a presentation there, my colleague and co-presenter Sally was with us for the trip down and back.

Driving along the Interstate, Sally and I talked shop. What about our supervisor? Yak yak yak. What about our faculty union? Yak yak yak. And our plans for next year? Yak yak yak.

After 20 minutes of chatter with Sally, I realized that what we were discussing might not mean much to my wife. Being the considerate guy that I am, I paused and looked over at her.

"Sorry we've been talking so much about work. Thanks for listening."

"I'm not listening," she replied.

—Phil Venditti

Preferences, Purposes, and Types of Listening

People speak for various reasons and with various goals in mind. Likewise, the ways we listen vary according to our preferences and purposes. Several theorists have identified types of listening which can help us understand our own behavior and that of others.

Galanes and Adams, Galanes, G., & Adams, K. (2013). *Effective group discussion: Theory and practice*. New York: McGraw-Hill. wrote that people fall into four possible orientation categories as they listen to one another in groups. People-oriented listeners, also known as "relational listeners," direct themselves toward detecting and preserving positive emotional features of a relationship. For instance, best friends are probably people who practice nonjudgmental listening in an effort to understand and support each other. In a group, people-oriented listeners may share their feelings openly and strive to defuse anger or frustration on the part of other members.

Action-oriented listeners, by comparison, prefer to focus on tasks that they and their fellow communicators have set for themselves. (Think back to chapter 1, where we differentiated between the "task" and "relationship" sides of group interaction). Action-oriented listeners will generally retain and share details and information which they believe will keep a group moving.

Content-oriented listeners are those who care particularly about the specifics of a group's discussions. They tend to seek, provide, and analyze information that has been gathered through research. What they primarily choose to hear and to share with others, thus, is material that they consider to be factual.

Time-oriented listeners concern themselves above all with how a group's activities fit into a calendar or schedule. They may listen and watch especially for signs that other group members want to accelerate the pace of the group's activities. Their preference is usually for short, concise messages rather than extended ones.

In the real world, few people fit neatly and completely into a single category within Galanes and Adams's typology of listeners. Instead, each of us embodies a mixture of the four preferences depending on the topic a group is dealing with, the developmental stage of the group, and other factors.

Like Galanes and Adams, Waldeck, Kearney, and PlaxWaldeck, J. H., Kearney, P., & Plax, T. (2013). *Business & professional communication in a digital age*. Boston: Wadsworth. proposed four purposes which they believe people have in mind as they listen to others. First, we may want to acquire information. Students listening to class lectures are pursuing this purpose. Second, we may listen in order to screen and evaluate what we hear. For instance, we may have the radio on continuously but listen especially for and to stories and comments which are relevant to our work or study. Third, we may listen recreationally, to relax and enjoy ourselves. Perhaps we listen to music or watch and listen to video images on a mobile device, or we might attend a concert of music we enjoy. Finally, just as Galanes and Adams indicated, we may listen because it helps other people or ourselves from the standpoint of our relationships. When we listen attentively to friends, classmates, or work colleagues, we demonstrate our interest in them and thereby develop positive feelings in them about us.

Beebe and Masterson, Beebe, S.A., & Masterson, J.T. (2006). *Communicating in small groups; Principles and practices* (8th ed.). Boston: Pearson. cited Allan Glatthorn and Herbert Adams, Glatthorn, A.A., & Adams, H.R. (1984). *Listening your way to management success*. (Glenview, IL: Scott, Foresman). as identifying the following three types of listening:

Type one: hearing. This is the simple physical act of having sound waves enter our ears and be transmitted into neural impulses sent to our brain. In 1965, Paul Simon and Art Garfunkel sang in "The Sound of Silence" about "people hearing but not listening," and this is really what Glatthorn and Adams were referring to.

Type two: analyzing. Beyond simply receiving sound waves, listeners may employ critical judgment to ascertain the purpose behind a speaker's message(s). In so doing, they may consider not only the content of the message, but also its stated and unstated intent, its context, and what kind of persuasive strategy the speaker may be using it as part of.

Kelly, Kelly, M.S. (2006). *Communication @ work: Ethical, effective, and expressive communication in the workplace*. Boston: Pearson. offered a helpful elaboration on this type of listening. She suggested that "analyzing" may also involve discriminating—that is, distinguishing—between information and propaganda, research and personal experience, official business and small talk, and simple information and material which requires a listener to take action.

Type three: empathizing. Empathizing requires that a listener not only discern a speaker's intention, but also withhold judgment about that person and see things from his or her perspective. Once this is accomplished, it may be possible to respond to the speaker with acceptance.

The Listening Process

Even though listening is a natural human process, and one in which we spend most of our communication time, it may not occur to us how complex the activity really is. Many authorities have proposed models that comprise what they consider to be steps in the process. We'll consider one such model.

Engleberg & Wynn, Engleberg, I.N., & Wynn, D. R. (2013). *Working in groups* (6th ed.). Boston: Pearson. described the HURIER model, an acronym developed by Judi Brownell. Brownell, J. (2010). *Listening: Attitudes, principles, and skills* (4th ed.). Boston: Pearson Allyn & Bacon. That model proposed that, in listening, people first hear; then understand; next interpret (including the emotional grounds/status of the speaker); evaluate (including whether the message is meant to persuade, and if so whether it should do so); remember; and finally respond. Among the strengths of this model for application to group settings are that its steps take a group's goals into account and that it recognizes both the task and relationship elements of communication.

Foundations for Good Listening

Each of us can probably think of a few people whom we consider to be outstanding listeners. What makes them that way, and what attitudes and behaviors do they display in their listening that we most appreciate? Let's consider some answers that various theorists have offered concerning the strengths of good listeners.

First, the famous educator and philosopher John Dewey, Dewey, J. (1944). *Democracy and education*. New York: Macmillan. exhorted people to show what he called "intellectual hospitality." By this, he meant "an active disposition to welcome points of view hitherto alien." If a person is willing to entertain perspectives outside his or her previous experience, listening can proceed on favorable ground.

Objectivity represents a related initial ingredient in good listening. As Rohlander, Rohlander, D.G. (2000, February). The well-rounded IE. *IIE Solutions*, 32 (2), 22. wrote, people should be prepared to weigh facts and emotional elements in their listening "on imaginary balanced scales."

Stewart and Thomas, Stewart, J., & Thomas, M. (1990). Dialogic listening: Sculpting mutual meanings. In J. Stewart (Ed.), *Bridges not walls* (5th ed.) (pp. 192–210). New York: McGraw-Hill. coined the term "dialogic listening" to identify what they considered to be ideal listening behavior. They characterized dialogic listeners in these ways:

1. They are "deeply in" the transaction with those with whom they communicate.

2. They deal with present topics and concerns.
3. They consider the speaking and listening process to be a shared enterprise—“ours” rather than “yours” or “mine.”
4. They see speaking and listening as being open-ended and playful.

Whatever models they propose, and whatever vocabulary they use, all the authorities who write about listening share the belief that listening needs to be active rather than passive. We’ll provide specific steps later in this chapter for how to engage in active, positive listening.

Negative Kinds of Listening

Figure 6.1.3.1

Now for some unfortunate news. There is a rich array of ways to be a bad listener.

Adler and Towne, Adler, R.B., & Towne, N. (2002). *Looking out/looking in* (10th ed.). Fort Worth, TX: Harcourt Brace College Publishers. named and described several of these ways. The first is pseudo-listening. You’ve seen this many times in your own life, and probably you’ve even done it. It’s the act of seeming to be listening while your mind is actually somewhere else. When you’re pseudo-listening, you may nod your head and emit periodic sounds of approval, just as you would if you were really paying attention, but those actions are for show.

Figure 6.1.3.2

Then there's "stage-hogging," also known as "disruptive listening." This is an active behavior—but the action isn't good, since the listener attends only minimally to what the other person is saying and butts in persistently and repeatedly to insert views or express needs of his or her own.

The first panel of a "Far Side" cartoon by Gary Larson shows a man scolding his dog. He starts out by saying, "Okay, Ginger" and then goes on at length. Once or twice more in the harangue the man says Ginger's name. In the second panel, the "speech balloon" of the master is altered to show what the dog hears: "Blah blah Ginger. Blah blah blah blah blah blah blah GINGER blah blah blah blah…" In this case, the fact that Ginger is a dog means that she can only detect the sound of her own name in her master's speech. Selective listening among human beings, on the other hand, consists of listening only to the parts of someone else's communication that are personally important to us—even though we could certainly understand and respond to the rest of it if we chose to.

Figure 6.1.3.3

Insulated listening is, in a way, the reverse of selective listening. In this self-protective behavior, the listener takes in and responds actively to everything the speaker says *except* what's unpleasant to him or her.

Defensive listening is performed by a person when he or she interprets much or most of another person's statements as being personal attacks. A defensive listener is apt to ignore, exclude, or fail to accurately interpret parts of a speaker's comments.

Face-value listening can be described as aural nitpicking. That is to say, the face-value listener pays a great deal of attention to the terminology of someone else's message and very little to the person's intentions or feelings.

https://eng.libretexts.org/@go/page/75169

Davis, Paleg, & Fanning, Davis, M., Paleg, K., & Fanning, P. (2004). *How to communicate workbook; Powerful strategies for effective communication at work and home*. New York: MJF Books. identified three further ways to be a bad listener: rehearsing, identifying, and sparring. Rehearsing is the practice of planning a response to another person's message while the message is still being delivered. Identifying takes place when a large portion of a speaker's message triggers memories of the listener's own experiences and makes the listener want to dive into a story of his or her own. Finally, a listener who engages in sparring attends to messages only long enough to find something to disagree with and then jabs back and forth with the speaker argumentatively.

Key Takeaway

To function well in a group, people should become familiar with both positive and negative purposes and types of listening.

Exercise 6.1.3.1

1. Do you consider yourself to be primarily a people-oriented, action-oriented, or content-oriented listener? Describe a time when you found yourself listening with an orientation other than your primary one. What caused you to use that orientation? What was the result?
2. Think about a time when you tried unsuccessfully to share an important message with someone. How did the other person respond? What "bad kind(s)" of listening behaviors did the person display?
3. Stewart and Thomas believe that listening should be "open-ended and playful." What does this mean to you? Describe a time when you listened "playfully" and how others around you reacted.
4. Imagine that you're in a group that is assessing its members' performance and that you expect to be criticized because of a mistake you've made. What will you do to avoid defensive listening, sparring, or other bad kinds of listening?

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6.1.4: Group Members and Listening

Learning Objectives

1. Identify seven challenges of listening in a group as opposed to listening to one person
2. Identify two advantages of group listening as opposed to listening to one person
3. Identify pros and cons of listening in digital groups

In the beginning, God made an individual—and then He made a pair. The pair formed a group, and together they begot others and thus the group grew. Unfortunately, working in a group led to friction, and the group disintegrated in conflict. And Cain settled in the land of Nod. There has been trouble with groups ever since. Sharp, D. (2004, February 24). Workgroups that actually work. Business Times, p. 10.

Davis Sharp

I remind myself every morning: Nothing I say this day will teach me anything. So if I'm going to learn, I must do it by listening.

Larry King

All listening takes energy, concentration, and fortitude. To a degree that will depend on the topic and the listener's individual personality, it also requires self-sacrifice, since at least part of the time that we're listening we may need to stifle the urge to question, correct, interrupt, or even silence a speaker.

Listening in a group is especially portentous. If you do it well, you can learn a great deal, present yourself in a favorable light, and contribute to a positive atmosphere and high level of productivity on the part of the group.

Poor listening in a group, on the other hand, can lead to serious negative consequences. Take the case of a group numbering six members. For every time it has to retrace its ground for five minutes and repeat things because of poor listening, that's 30 minutes of time wasted. Furthermore, misunderstandings among group members can be spread and magnified outside the group to the point that its image and effectiveness are weakened. When we get to chapter 12 we'll examine this danger and some of the other things that can go wrong when groups of people take part in formal meetings.

Challenges of Listening in a Group

Although all of us get practice at it for years as students and eventually as employees, listening in a group isn't easy. It presents more of a challenge to each member, in fact, than does listening to one other person at a time. Why? We'll consider seven reasons, all of which stem from the inherent differences between groups and pairs of people.

First, in a typical one-on-one conversation you're probably going to listen about 50% of the time, right? Compare that to your participation in a group, in which you're likely to spend between 65% and 90% of your time listening. Steil, L.K. (1997). Listening training: The key to success in today's organizations. In M. Purdy & D. Borisoff (Eds.), *Listening in everyday life* (pp. 213–237). Landham, MD: University Press of America. If you listen with the same depth of energy and concentration in the group that you do with a single conversation partner, you're going to get tired out a lot more quickly.

Second, unless you know each of the other members of a group very well, you may not adequately gauge their knowledge and perspectives on a given topic before it's discussed. This may make you less likely to be receptive and responsive to their views on a topic, especially a contentious one. You may also have to work harder to understand their viewpoints.

Third, it may be difficult to keep up with changing levels of engagement on the part of other members of your group. People's attention and involvement may fluctuate because they're anxious about the circumstances of a discussion, about a particular message that's being sent, or even about extraneous factors in their lives that come to mind. At some moments in a group's activities, everyone may be attentive and actively involved; at others, they come and go both mentally and physically. Because all the members are rarely simultaneously "firing on all cylinders," you'll need to work particularly hard to distinguish between vital messages and routine, mundane, or irrelevant ones.

Fourth, in a group, you have less of an opportunity to influence others' thoughts and actions than you do in one-on-one communication. Deciding when to cease listening and interject your viewpoints so that they'll be most likely to be received positively by the largest possible proportion of group members is hard, especially if conversation is fast and free-wheeling.

Fifth, listening for long periods prevents you from releasing some of your own energy. Because you speak less in a group than in a one-on-one conversation, this build-up of energy may frustrate you and interfere with your ability to process what other people are saying.

Sixth, in a group, you have lots of time to daydream. People talk at about 100–150 words per minute, but your mind can process information at up to 600 words a minute. Wolvin, A., & Coakley, C.G. *Listening* (3rd ed.). Dubuque, IA: 1988. You may not be compelled or feel a need to listen actively all the time that a group is interacting, nor do you have to worry about other people's assessment of your behavior if you're not the one speaking at a particular time. Thus, you'll be able to fill in the gap between other people's talking speed and your own thinking speed with thoughts of your choice…or with thoughts that just float into and out of your consciousness. You may even be tempted to surreptitiously glance at reading material unrelated to the group's activities, or to send or receive text messages.

Seventh, it may be harder to listen in a group because of the existence of social loafing. This is the tendency for each member to devote less energy to a task than she or he would alone because it's possible to let others take responsibility for getting things done.

Advantages to Listening in a Group

Now that we've reviewed some of its challenges and pitfalls, we should note that listening in a group offers potential benefits as well. Let's consider two major kinds.

The first big advantage to listening in a group is that it embodies the possibility of taking one of the characteristics that we earlier said could be used negatively—i.e., that you have time and opportunity to think about and react to what you hear—and using it in a positive way. Rather than using that surplus time to daydream or plan a rebuttal to other group members' messages, you can try in your mind to empathetically interpret the messages and decide whether and how to respond in ways that promote the well-being of the speakers and the whole group. Here's an illustration with a cross-cultural dimension (and with the person's name changed):

Yukio Sakai was a young Japanese man enrolled in a college public speaking class. Whatever went on in class, Yukio watched and listened raptly…and silently. Often the instructor posed open-ended questions to the group as a whole, such as, "What do you think John did well in his persuasive speech?" When such questions were posed, almost anyone in class except Yukio would pipe up with an opinion. To a casual observer, Yukio would seem to be "just sitting there."

If the instructor directly asked Yukio one of the questions, however, what usually happened was that he replied without the slightest hesitation. Furthermore, his answers conveyed insight, sound reasoning, and common sense. It would have been a mistake to take his apparent lack of activity at any given moment as a sign of incapacity.

As we discovered earlier in our chapter on intercultural and international group communication, someone from a high power distance culture such as Japan's may not outwardly react to messages from an authority figure such as a college instructor. What appears to be the person's inert passivity, however, could actually be thoughtful analysis and reflection. (Of course, you don't have to be Japanese to practice those good habits).

The second advantage of listening in groups is a product of the fact that there will always be more diverse perspectives and more interaction in a group than in a dyad. People can be fascinating, can't they? And many times the product of discussion among different people, with their different backgrounds and values, is something entirely unexpected. What this means, if you're a curious person at all, is that you should find lots to keep you entertained and educated as you listen to people in a group setting.

Listening in Digital Groups

As we mentioned earlier, digital groups can communicate either synchronously or asynchronously; that is, in real-time or with delays between messages. If you use synchronous tools, such as Skype or some other form of audio or video conferencing, the same challenges and advantages apply to digital groups that we've already presented. The only difference may be that you and the other group participants aren't physically in the same place.

On the other hand, group members who exchange oral messages asynchronously may confront more intense pros and cons. Davis, M., Paleg, K., & Fanning, P. (2004). *How to communicate workbook; Powerful strategies for effective communication at work and home*. New York: MJF Books. The good news is that you'll have even more time than in a face-to-face group discussion to review and think about messages before reacting to them, which may yield wiser and calmer responses. The bad news is that the freshness and spontaneity of listening to each other's comments in real-time will be lost, which could tend to homogenize people's attitudes and make it less likely for "aha moments" to take place.

Furthermore, if other group members can't actually see you when you're communicating, you may feign attentiveness or behave in unorthodox ways. One of the authors remembers being part of a group that was conducting a phone interview with a candidate for a job at a university many years ago. When the person in charge of the interview started the exchange by saying, "We know it may be uncomfortable for you to have to do an interview without being able to see us," one of the candidates said, "That's all right. I'm sitting here on my couch naked, anyway."

Key Takeaway

Listening in a group presents significant challenges but can also pay important dividends.

Exercise $6.1.4.1$

1. If you're enrolled in college courses, do a little measuring in one of your next class sessions. Use a stopwatch to measure exactly how long you and one or two other students actually spend speaking during the class period. Ask a classmate to do the same for the instructor. Afterward, compare the measurements. What did you learn from the results?
2. Pick two groups of which you're a member. How would you compare the level of participation of their members in group discussions? How do their members' listening practices compare? In which group do you find it harder to function as a listener? Why?
3. The next time a group you're part of meets, watch and listen for the person who says the least. Does the person appear to be listening? If you feel comfortable doing so, ask the person afterward how much of the time he or she was attending closely to the discussion. Does the person's answer fit with how you'd assessed his or her behavior?
4. "To become a leader, you need to talk; to stay a leader, you need to listen." Do you agree, or not? What examples can you give to support your viewpoint?

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6.1.5: Strategies to Improve Listening in Groups

Learning Objectives

1. Identify physical actions that contribute to good listening
2. Identify effective pre-listening behaviors
3. Identify what to do and what to avoid doing when listening in a group

Figure 6.1.5.1

The greatest compliment that was ever paid me was when one asked me what I thought, and attended to my answer.

Henry David Thoreau

Listening to people keeps them entertained.

Mason Cooley

First Things First

In the last few sections, we've established that listening is a vital skill in groups. Now let's review two fundamental points before we discuss specific steps for doing it well.

The first point is that before you can listen, you have to stop talking. This might seem self-evident, but in a culture like that of the United States, in which talking is highly valued, we may tend to overlook it.

The second point, though less obvious, is just as important. It is that both senders and receivers—both speakers and listeners—are responsible for effective listening. Listening actually transcends the mere reception of messages by listeners and imposes obligations on both senders and receivers in what Waldeck, Kearney, and Plax, Waldeck, J. H., Kearney, P., & Plax, T. (2013). *Business & professional communication in a digital age*. Boston: Wadsworth. called "sender-receiver reciprocity."

Senders should choose their messages according to the context or occasion. Furthermore, they should consider what media they will use to communicate them—for instance, face-to-face interaction or synchronous or asynchronous transmissions—and be mindful of the implications of their selection.

Figure 6.1.5.2: *Image from* http://www.public-domain-image.com

For their part, receivers must make an effort to listen, be prepared to provide feedback, and manage their responses to ensure relevance and civility. They should also practice what Beebe, Beebe, and IvyBeebe, S.A., Beebe, S.J., & Ivy, D.K. (2007). *Communication: Principles for a lifetime* (3rd ed.). Boston: Pearson. labeled "social decentering"—i.e., "stepping away from your own thoughts and attempting to experience the thoughts of others."

The Physical Side of Listening

As we've already pointed out, good listening is an active process. As such, it requires energy. In fact, listening is work—and not just mental work, either. To do the work of listening, which generally consumes the majority of your time whenever you interact with a group, you should be sure you're physically primed and ready to go. To confirm that your body is really prepared for high-quality listening, you should first check your posture. Assuming that you're seated, sit up straight and lean slightly forward. Not only does good posture allow you to remain relaxed and alert, but it makes it more likely that other people will see you as competent and confident. Burgoon, J.K., & Saine, T.J. (1978). *The unspoken dialogue: An introduction to nonverbal communication*. Boston: Houghton Mifflin.

Next, notice your breathing. Be sure you're inhaling and exhaling deeply. Also, identify any aches or pains that may interfere with your ability to take in other people's messages. See if you can shift into a position that will allow you to remain comfortable and attentive throughout the communication process.

Pre-listening

How much time and effort you put into getting ready to listen will depend among other things on what kind of group you're in, how well you and the other members know each other, and what topics you're dealing with. Sometimes you're talking about light or superficial matters—like "Where shall we get together after we complete our project?"—and you can just dive into a conversation without any particular thought to getting ready to listen.

There will be occasions, however, when you ought to stop, consider, and plan your listening carefully. Let's say you're in a student government group considering requests for activity fee money, for instance, or a screening committee involved in hiring a new person to join your business. In cases like these, when careful, accurate listening will be at a premium, you should probably take some or all of these preparatory steps:

Assign listening tasks to people. Because social loafing is more likely when members aren't held accountable for their behavior, Thompson, L. (2008). *Organizational behavior today*. Upper Saddle River, NJ: Pearson Education. you may want to ask individuals to listen for different kinds of information or divide a long period of listening into segments, each of which has a designated "major listener."

Confirm (or reconfirm) your group's norms with respect to listening. Remind yourselves about how you plan to take turns speaking.

Identify any potential contextual barriers to listening. Kelly, M.S. (2006). *Communication @ work: Ethical, effective, and expressive communication in the workplace*. Boston: Pearson. Such barriers may include the location in which you're communicating, the cultural identity of group members, and the mixture of genders represented in the group.

Remind the members of the group that they should recognize their own biases, including their tendency to interpret information in the light of their beliefs. Hybels, S., & Weaver, R.L. (1998). *Communicating effectively* (5th ed.). Boston: McGraw-Hill. Perhaps note that each group members is tuned in to a special mental radio station, "WII-FM," which stands for "What's in it for me?"

Decide whether it's all right for group members to take notes or make audio recordings during the upcoming communication. If it is, decide whether you'd like to name one or more members "primary note-takers" or recorders.

Determine how often and when you plan to take breaks. Remember that "the mind can absorb only what the seat can endure." Even though parts of a lengthy discussion may be engrossing, when the time for a scheduled break comes your listening ability will probably be rejuvenated if you pause at least long enough for people to stand and stretch for 30–60 seconds before proceeding.

Listening Itself

All right. Let's say the members of your group have physically and mentally readied themselves to listen, and you've begun a discussion. What do you need to do as the process unfolds? Here are some important dos and don'ts:

In listening, do…

1. Determine your purpose in listening, and keep it in mind. Thinking back to earlier in this chapter, are you listening to acquire information, to evaluate messages, to relax and enjoy ourselves, or to demonstrate empathy?
2. Identify the levels at which group members are communicating their messages—e.g., emotional, political, or intellectual.
3. Assess the relative significance of people's comments and listen for main ideas rather than trying to take in everything on an equal plane. To help you do this, you may want from time to time to mentally summarize the message(s) you're listening to.
4. When possible and appropriate, urge other members of the group to speak, especially those who are less dominant. Say things like "Please go on"; "Tell me more"; "Care to expand on that?" Remember that each person has a unique perspective that can add to the group's ability to consider ideas and make decisions.
5. "Listen with your eyes." Observe people's body language and other nonverbal cues carefully, since those physical manifestations may add to or sometimes contradict their spoken words.
6. Show interest in others' messages through your own nonverbal actions. Establish and maintain eye contact. Smile. Adopt an open posture. Avoid fidgeting or slouching.
7. Use "interactive questioning".Lumsden, G., & Lumsden, D. (2004). *Communicating in groups and teams; Sharing leadership* (4th ed.). Belmont, CA: Thomson. Ask open-minded and open-ended questions to clarify ideas & information; to probe a speaker's reasoning and evidence; and to expand incomplete information. Use and ask for examples so that the speaker can connect your questions with his or her own world of experiences.
8. Use tentative clarifying/confirming statements: e.g., "It sounds like…"; "You seem to think that…"; "As I get it, you…"
9. Make polite, "targeted" interruptionsLumsden, G., & Lumsden, D. (2004). *Communicating in groups and teams; Sharing leadership* (4th ed.). Belmont, CA: Thomson. to get answers to pressing questions, or if you'd like establish your place in line to speak next. Be judicious and infrequent with interruptions, however.
10. Paraphrase. Don't just see if you can accurately reflect what a person is saying; see if you can determine if your understanding of the person's "inner world" is accurate and whether you see things as the other person is experiencing them at the moment.
11. Respond after listening, sincerely and constructively. Focus on content, ideas, & analysis rather than on personal matters.

12. Allow for, and be careful how you interpret, silence. Keep in mind that people may have many reasons, positive or otherwise, for not speaking at a particular time.

In listening, don't…

1. Let listening be a dead end, in which you receive messages and don't react at all.
2. Allow the listening behavior of others to sway your own. If they're inattentive, don't lose your own focus; if they're especially positive or negative, don't lose your objectivity or critical ability.
3. Cut off or put down a speaker.
4. Interrupt excessively.
5. Pose "counterfeit questions"—belligerent statements masquerading as questions simply because they end with question marks.
6. Allow the tone of someone's message, or how agreeable you find the person to be, to color your interpretation or reactions to it.
7. Express your interpretations of other people's messages excessively. Why not? First of all, your interpretation may be wrong. Second, even if you're right, you may arouse a defensive reaction that in turn leads to unproductive argumentation.

Figure 6.1.5.3

No matter how often you listen to people, and no matter how many groups you may be part of, each new listening situation will be unique. It's your responsibility, shared with your fellow group members, to see that in each new conversation or discussion you exercise proper practices and skills in your listening.

Key Takeaway

To listen well in a group, it's important to prepare properly and heed several dos and don'ts.

Exercise 6.1.5.1

1. Observe a televised, recorded, or live group discussion. Identify the listening processes which furthered understanding and those which impeded it. What suggestions would you make to the members of the group to improve their listening? Which person in the discussion listened most effectively, and how did she or he accomplish that?

2. Visit the website of the International Listening Association (http://www.listen.org) and read an article in one of the Association's online publications. What discoveries did you make in your reading? How will you apply the discoveries to your future group interactions?
3. Who's the best listener you know? What does the person do (or not do) that makes him/her so effective? Give an example of how the person has listened well.

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6.1.6: Summary

We discussed many ways to gain a better understanding of your group members. To begin, it is important to understand yourself: your attitudes, beliefs, and values. It is also helpful to understand the processes that influence perception and listening. There are many individual differences in the ways people perceive things. Demographic traits such as age, gender, and employment can determine people's interests, needs, and goals. Effective communication involves recognizing these differences in perception and practicing fairness in delivering your message to your group or team. Finally, an important dimension of group communication is the ability to receive messages from others through active listening.

Chapter Review Questions

1. Interpretive Questions
    1. How does listening limit or expand our view?
    2. How does our internal monologue influence our listening?
    3. In what ways, if any, are all group members the same?
2. Application Questions
    1. What are some of the ways people demonstrate listening among people you know? Identify a target sample size (20 is a good number), and ask members of your family, friends, and peers about they know someone is listening to them. Compare your results with those of your classmates.
    2. What impact does technology and specifically the cell phone have on listening? Investigate the issue and share your findings.
    3. Investigate two ways to learn more about your group members and share them with your classmates.

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6.2: Effective Conflict Management Strategies

Learning Objectives

1. List four preventive steps that a group and its members may take to lessen the likelihood of experiencing damaging conflict
2. Identify measures related to space and time that a group may employ to mediate against potentially destructive conflict
3. Describe steps which members of a group may take to manage conflict when it arises
4. Explain the "SLACK" method of managing conflict

I've led a school whose faculty and students examine and discuss and debate every aspect of our law and legal system. And what I've learned most is that no one has a monopoly on truth or wisdom. I've learned that we make progress by listening to each other, across every apparent political or ideological divide.

Elena Kagan

In calm water, every ship has a good captain.

Swedish Proverb

To be peaceable is, by definition, to be peaceable in time of conflict.

Progressive magazine

If group members communicate effectively and show sensitivity to each other's needs and styles, they can often prevent unproductive and destructive conflict from developing. Nevertheless, they should also be prepared to respond in situations when conflict does crop up.

Before considering some strategies for dealing with conflicts, it's worth pointing out that the title of this section refers to "management" of conflict rather than to "resolution." The reason for this choice of terminology is that not all conflict needs to be—or can be—resolved. Still, most conflict needs to be managed to keep it from side-tracking, slowing down, weakening, or eventually destroying a group.

First Things First

We've all heard that an ounce of prevention is worth a pound of cure. Managing conflict is easiest if we've acquired some tools to prevent it from getting out of hand. One way to gain such tools is to undergo some actual formal training in conflict management. A Google search of educational sites related to "conflict management courses" yields several thousand results from around the United States and elsewhere, including numerous certificate and degree programs at the undergraduate and graduate level. Commercial entities offer hundreds more opportunities for professional development in this realm.

A second, more specific preventive measure is for members of a group to periodically review and reaffirm their commitment to the norms, policies, and procedures they've set for themselves. In more formal groups, it's a good idea to assign one member to look over the bylaws or constitution every year to see if anything needs to be changed, clarified, or removed in light of altered circumstances. The danger in not paying attention to such details is represented in the story, told by Robert Townsend, Townsend, Robert (1970). *Up the organization*. New York: Alfred A. Knopf., of a British civil service job created in 1803 which called for a man to stand on the Cliffs of Dover with a spyglass. The man's role was to ring a bell if he saw Napoleon coming. The job was not abolished until 1945.

A third measure which groups can take to lessen the possibility that damaging conflict will take place within them is to discuss and distinguish between detrimental and beneficial conflict—between that which promotes improvement and that which obstructs progress. The initial "forming" stage of a group, when people are apt to act tentative and be on their best behavior, is probably the best time to set aside some group time to let members share their views, experiences, and expectations with regard to "bad" and "good" conflict. It may be a good idea to ask members of the group to cite specific examples of conflict which they would accept or endorse, and also examples of conflict which they would hope to avoid.

A fourth preventive measure is for the group to explicitly remind its members that "deviates" are to be appreciated and respected for the diverse perspectives they can share and the unconventional opinions they may hold. This kind of statement may give creative members the impression that they have intellectual "free space" for generating and sharing ideas later in the evolution of the group.

Logistical Measures

Proponents of feng shui believe that configurations of furniture affect people's moods and behavior. Employees at the National Observatory in Washington, DC, maintain an atomic clock that keeps precise universal time. You don't need to belong to either of these groups to believe that how a group uses space and time can affect the level and nature of conflict it will experience.

With respect to proxemics, for instance, research has demonstrated that conflict between people who disagree with each other is more likely to flare up if they sit directly across from each other than if they are seated side by side. Gordon, J., Mondy, R. W., Sharplin, A., & Premeaux, S. R. (1990). *Management and organizational behavior*. New York: Simon & Schuster, p. 540. Why not, then, purposefully plan where people are going to sit and the angles from which they'll see each other?

Decisions about when and for how long groups will gather can also affect their level of conflict. Research into human beings' circadian rhythm—the 24-hour cycle of energy highs and lows-shows that 3 a.m. and 3 p.m. are the two lowest-energy times. www.thedailybeast.com/newsweek/2004/10/17/night-shift.html Depending on whether group members clash more or less when their energy level is low, it, therefore, may or may not be wise to meet at three o'clock in the afternoon.

Whenever people in a group get together, it's natural that the mood and outlook they bring with them will be influenced in part by what's happened to them earlier that day. For any individual, a touchy discussion, a disappointment, or an embarrassing episode might precede the group's interactions. Unfortunate events like these—as well as other powerful experiences, whether positive or not—may consciously or unconsciously color the demeanor of group members at the start of their interaction.

Another time-related conflict management strategy, thus, is to begin a discussion with a "time out" for people to rest and loosen up. We know of college instructors who initiate each of their class sessions with two minutes of silence for this same purpose.

Once Conflict Occurs…

Numerous authorities have offered suggestions on how to manage conflict once it reaches a level where it should not or cannot be allowed to dissipate on its own. Hartley & Dawson, first of all, Hartley, P., & Dawson, M. (2010). *Success in groupwork.* New York: St. Martin's Press. suggested taking the following steps:

1. Make sure the lines of communication are open. If they aren't, open them.
2. Define the issues. Don't allow a nebulous sense of overpowering disagreement to develop. Be specific about what the conflict pertains to.
3. Focus on the task, rather than on personalities. Discourage or deflect comments that question a group member's motives or personal qualities.
4. Proceed according to your established ground rules, policies, procedures, and norms. After all, you established these components of your group's identity precisely to deal with difficult circumstances.

In addition to following rules and procedures peculiar to its own history, a group that's experiencing conflict should strive to maintain civilityMeyer, J.R. Effect of verbal aggressiveness on the perceived importance of secondary goals in messages. *Communication Studies, 55*, 168–184. and follow basic etiquette. As Georges Clemenceau wrote, "Etiquette is nothing but hot air, but that is what our automobiles ride on, and look how it smoothes out the bumps."

Malcolm Gladwell's popular book, *The Tipping Point*, describes how New York City's subway system was revitalized by David Gunn and William Bratton in the 1980s and 90s Gladwell, M. (2000). *The tipping point: How little things can make a big difference.* New York: Little, Brown and Company.. Together, Gunn and Bratton launched a campaign to eliminate vandalism, including graffiti on the sides of train cars, and to prosecute "fare-beaters." At the start of the campaign, doubters complained that more serious crime in the subways and streets needed to be attacked first. Gunn and Bratton insisted, however, that setting a broad example of civility would ultimately create an atmosphere in which potential criminals would be less likely to engage in serious criminal acts. After many years of relentlessly enforcing basic laws mandating public decency, not only did graffiti nearly disappear entirely from the subway system, but overall crime in the New York metropolitan area declined substantially.

Hopefully, you will never witness vandalism, much less felonious behavior, in a small group. Malicious verbal interchanges, nevertheless, can poison the atmosphere among people and should be prevented if at all possible. As an old Japanese saying puts it, "The one who raises his voice first loses the argument." It doesn't hurt to calmly and quietly ask that discussion of particularly contentious topics be postponed if comments seem to be in danger of overwhelming the group with negativity.

Figure 6.2.1: Source: www.flickr.com/photos/joeshlabotnik/842977816/

In addition to reminding people that they should exercise basic politeness, it may be wise at times for someone in the group to ask for a recess in a discussion. Calvin Coolidge said, "I have never been hurt by anything I didn't say," and it may be a good idea in irate moments to silence people briefly to prevent what Adler and Rodman, Adler, R.B., & Rodman, G. (2009). *Understanding human communication* (10th ed.). New York: Oxford University Press. referred to as an "escalatory spiral" of hurtful conversation.

If the tone of a group discussion permits thoughtful reflection, it can be helpful to separate task and relationship goals and deal with conflict over each kind separately. Fisher, R., & Brown, S. (1988). *Getting Together: Building a relationship that gets to yes.* Boston: Houghton-Mifflin. Using indirect communication, rather than confronting another group member head-on, may also defuse extreme emotions and preserve other people's faces.

Here are further techniques for managing conflict in group interactions:

1. "Test the waters" for new ideas without making it seem that you're so attached to them that you'll fight to impose them on others.
2. If an ego clash erupts, see if you can identify something that the disagreeing individuals *can* agree on. Perhaps this will be a superordinate goal. It could also be a common opposing force, since the idea that "my enemy's enemy is my friend" can serve to bind people together.
3. Employ active listening. Strive to fully understand other people's viewpoints before stating your own.
4. If people's comments meander to topics that aren't germane, steer the discussion back to the key issues under discussion.
5. Frame the situation as a problem to be solved, rather than as a struggle which must be won.
6. Treat everyone as partners on a common quest. Invite continued frank interchanges and assure group members that they may speak out without fear of reprisal.
7. Consider carefully how important it is for you to prevail in a particular conflict or even just to express your views. Ask yourself whether the potential negative consequences of your action will be worth it.
8. Unless a disagreement is over an essential point, consider whether it might be best to "agree to disagree" and move on.

Figure 6.2.2: Source: www.flickr.com/photos/buddawiggi/5987710858/

"Going with the Flow"

As we've seen, there is no shortage of specific strategies and techniques for people to choose from when conflict occurs in a group. In fact, it may be overwhelming to try to decide which strategies and techniques to use, at which times and with which people, under which circumstances. Randy Fujishin, a therapist and writer from California, proposed an attitude that might help people deal both with conflict itself and with the feelings of stress it often engenders. He suggested that we regard conflict as neither a call to battle nor a warning to dissolve or disband a group. Instead, Fujishin proposed that people regard conflict as "an invitation to listen, learn, explore, and growFujishin, R. (1998). *Gifts from the heart: 10 communication skills for developing more loving relationships.* San Francisco: Acada Books.." His advice when conflict takes place is this: "Instead of tensing, relax. Instead of stiffening, bend. Instead of arguing, listen. Instead of pushing or running away, get closer. Flow with the disagreement, situation, or individual for a period to discover where it may lead."

Fujishin also developed what he called the "SLACK" method of managing conflict. Although he intended it to be brought to bear primarily on disputes in one-on-one relationships, its components may apply also in group situations. "SLACK" is an acronym standing for "sit, listen, ask, compromise, and kiss." Major emphasis in this method is placed on being receptive to what other parties in a conflict have to say, as well as to their emotional states. Fujishin really does suggest kissing or hugging as the final step in this method, but of course many groups will choose instead to celebrate the achievement of post-conflict reconciliation and progress through words.

Perhaps the central message we can derive from Fujishin's writings on this topic is that, although we should respond to conflict earnestly, we should take a long view and avoid losing our composure in the process of managing it. Even at moments of extreme tension, we can remind ourselves of an ancient saying attributed first to Persian mystics and later cited by such notable figures as Abraham Lincoln: "This too shall pass."Taylor, A. (1968). "This Too Will Pass (Jason 910Q)". In F. Harkort, K.C. Peeters, & R. Wildhaber. *Volksüberlieferung: Festschrift für Kurt Ranke* (pp. 345–350). Göttingen, German: Schwartz.

Key Takeaway

- Conflict can be managed by implementing a combination of preventive, logistical, and procedural actions, as well as by maintaining composure and perspective.

Exercise 6.2.1

1. What proportion of conflicts within small groups do you feel can actually be resolved rather than merely managed? Provide a rationale and example(s) for your answer.
2. Think about a conflict that you recently observed or took part in. What elements of its timing, location, or physical surroundings do you think contributed to its nature or severity? Which of those elements, if any, do you think someone might have been able to change to lessen the intensity of the conflict?
3. Labor negotiations sometimes include a mandated "cooling-off period." Describe a conflict situation you've witnessed which you believe might have turned out better had such a cooling-off period been incorporated into it. Describe areas of conflict in your life, at school or elsewhere, in which you feel it would be helpful to make use of such a technique?

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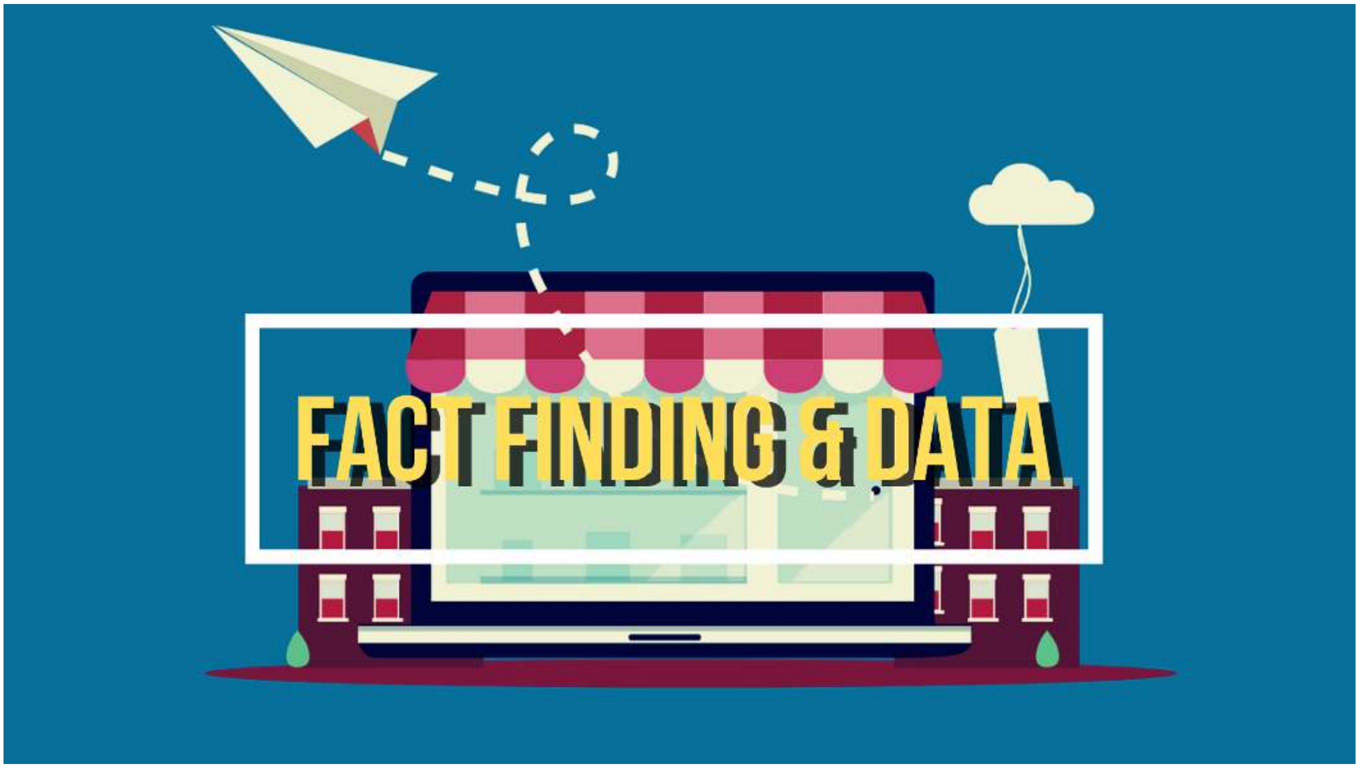
CHAPTER OVERVIEW

7: Fact-Finding Techniques and Data



Introduction

Information is everywhere, but where exactly do you look when you do not know enough information to accomplish your project? Do you accept the first thing that makes sense to you? Does it really matter where we collect our info from as long as it was found on the Internet? When completing a project of any nature it is very important to gather accurate information from all parties involve to meet the project requirement and satisfy the need of the clients and stakeholders.

In this chapter, we are going to discuss the various fact-finding techniques including interview, survey, document review, direct observation and research and data validation that will help collect accurate information and how we can use those statistics to meet to project requirement.

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7.1: Interview

An interview: is a structured conversation between multiple parties one that ask questions and others that gives responses. It is very important for the interviewer to prepare for the interview, plan the interview by Identifying people to interview, establishing the objectives for the interview, conduct Interview, Develop interview questions, document and evaluate the responses.

Identify people to interview: Identifying people to interview is the first step when planning for an interview because in order to get accurate information you must select the right people to interview. Your knowledge of a company formal structure is necessary when choosing the people to interview.

Establish Objectives for the interview: you should start by discussing general areas and ideas then get into specific topics. setting up specifics objectives for the interview will help you creates questions to ask and how to phrase the questions.

Develop Interview Questions: developing a list of questions will help keep the interviewer on track and avoid unnecessary deviation. In some cases, the answer of a specific question on the list may lead to an important topic that need to be discuss. Therefore the topic will need to be included in the list for future interview.

The interview should consist of different kind of questions:

- Closed-ended questions – Respondents' answers are limited to a fixed set of responses.
  - Yes/no questions – The respondent answers with a "yes" or a "no".
  - Multiple choice – The respondent has several options from which to choose.
  - Scaled questions – Responses are graded on a continuum (e.g.: rate the appearance of the product on a scale from 1 to 10, with 10 being the most preferred appearance). Examples of types of scales include the Likert scale, semantic differential scale, and rank-order scale. (See scale for further information)
  - Matrix questions – Identical response categories are assigned to multiple questions. The questions are placed one under the other, forming a matrix with response categories along the top and a list of questions down the side. This is an efficient use of page space and the respondents' time.
- Open-ended questions – No options or predefined categories are suggested. The respondent supplies their own answer without being constrained by a fixed set of possible responses. Examples include:
  - Completely unstructured – For example, "What is your opinion on questionnaires?"
  - Word association – Words are presented and the respondent mentions the first word that comes to mind.
  - Sentence completion – Respondents complete an incomplete sentence. For example, "The most important consideration in my decision to buy a new house is..."

Prepare For the interview: It is extremely important to prepare for the interview because it is a very important meeting not just a casual conversation. It is a good practice for the interviewer to set an interview day and to sent an email to the interviewee or to set a reminder. The interview questions that was created should be sent the interviewee several days before the meeting. Keep in mind an interview is the interruption of someone else routine therefore an interview should be less than an hour.

Conduct the Interview: conducting the interview is the main step of the planning. When conducting the interview, make sure you introduce yourself, describe the project, and explain the objectives of the interview and why it is important. Make sure you can see the interviewee either on camera or face to face so you can observe his or her body language. make the person been interview feel comfortable and at ease. Give him or her enough time to respond and listen carefully. After each response mark a very short break of three to five second then move on to the next question. Before finishing the interview summarize the session and seek the confirmation of the interviewee, by doing so that will give him or her the opportunity to correct you if there is any mistake.

Document the Interview: It is a good practice to take some note while conducting the interview so you can jog your memory after the interview. Keep the note taking to a minimum to avoid distracting the interviewee. Record the information gather immediately after the you finished the interview to remember all the information provided. Therefore, it is not a good idea to conduct back to back interviews. They use of devices as a recorder during the interview should be discuss and approve by the interviewee and make sure the content is deleted right after you finish to record the interview. Whether the interview is recorder or not, you should listen carefully to the interviewee in order to ask good follow up question. After the conversation send a memo to the interviewee express your appreciation, in the memo you should include the time, date, location, reason for the interview, and all the main points discuss during the meeting so that the interviewee can make correction or give more details if necessary.

Evaluate the Responses: while recording the interview it is very important to evaluate the interviewee responses to identify any biases. For instance, an interviewee who has a strong opinion about the current or future system might give incomplete answers or refrain the information. Also, an interviewee might provide answers to be helpful even though they do not have enough experience to give accurate information.

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7.2: Surveys

Survey: also known as questionnaire is a document that contain a standard list of questions that can be sent to many individual to measure a number of variables for a group of people at a certain point in time.

A typical survey form will have at the beginning the title, the name and the telephone number of the analyst, a short description of the purpose, how and where to submit the survey form, the due date to complete the survey, the survey questions and the end a statement to thanks the participants.

Should participants sign their name while complete the survey or not? The issue of anonymity depend on two things. First, does the evaluator need to know who the participants are in order to correlate the information? Second, does the questionnaire contain sensitive and controversial information? Individuals do not want to be identify when answering questions that might negatively impact them. For example, "how well did you instructors explain the course?" In this case anonymous responses might ensure accurate information.

Some ideas to keep in mind when creating a questionnaire that will help collect the right data:

- Give clear instructions that will answer and anticipate questions
- Simplify the language used on your questionnaires
- Organize your questionnaire in logical order from simple to complex questions
- Avoid using questions that will lead to expected answers
- Limit Open-ended questions
- Do not use questions that will negatively affect the participant career, or other issues, especially if the survey is not anonymous.
- Provide a space at the end for general statement and opinions.
- Test the questionnaire on a small group before distributing to a large group.

One point in time: the survey's "snapshot" of one particular moment. Because surveys measure things that vary, the results of any one survey are good only for that one point in time. We could ask you your opinion about a controversial issue today and you might tell us how you truly feel about it. But something could happen tomorrow in your personal world or the world at large that could utterly change your opinion about that same topic. For this reason, surveys cannot be used to predict anything – it is scientifically invalid for someone to use the results of any poll or survey to predict the outcome of any activity whatsoever. Despite the fact that you will run across reports all the time that appear to be predicting the outcome of an election or the likelihood of one thing or another based on survey results, there is absolutely no validity in those predictions.

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7.2.1: Interpreting Survey Data

Communicators are faced with a formidable task in evaluating and interpreting information generated from polls and surveys. In order to avoid some of the common pitfalls and mistakes that are possible when using survey data, you must ask important questions about how the survey was conducted, how the respondents were selected to participate, and how questions were worded and ordered.

Evaluating the results of a survey involves both statistical analysis and interpretive skill. The person who conducts and analyzes the survey data has great sway in determining how the data get interpreted. It is up to you to carefully critique any information based on a survey and apply stringent standards of evaluation. When you are considering using survey information, you should have the answers to the following questions:

1. **Who sponsored or paid for this survey,** and **who conducted it**? Serious bias can enter into a survey design if the sponsoring agency or the firm conducting the survey has a particular ax to grind.

2. **Who was interviewed**? What population was sampled?

3. **How were people selected for the interviews?** In other words, was it a probability or a non-probability sample? If a non-probability sample was used, the results cannot be generalized to a larger population.

4. **How many people were interviewed?** What was the size of the sample? Were the results categorized into specific sub-samples or subgroups and if so, what was the size of those smaller groups?

5. If a probability sample was used, **what was the range of sampling error** and the level of confidence for the total sample? What were those figures for any sub-samples?

6. **How were the interviews conducted?** Were they telephone, face-to-face or self-administered (mail or online) interviews? Were the interviewers trained personnel or volunteers? Were they supervised or working on their own?

7. **What were the actual questions that were asked?** What kind of response choices did respondents have (open-ended responses; pre-set choices). Experts know that when you ask questions about something that is potentially awkward or embarrassing, people over-report socially desirable behavior and under-report behavior that is considered antisocial. If the survey asks about topics such as sexuality or illegal behavior such as drug use, the results must be interpreted and reported upon with a great deal of caution.

8. **What was the wording of questions?** Were there biased, loaded, double-barreled, leading or ambiguous questions? Even individual words can influence results. Did the question ask about taxes or revenues? Welfare or assistance to the poor? Universal health insurance or managed health care?

9. **When were the interviews conducted?** The results of a survey are good only for the time at which the questions were asked. Surveys do not have any predictive value and cannot and should not be used to predict anything. For instance, a survey may ask respondents about their preferences for one candidate over another during a three-day polling window just before an election and the results may show that candidate A has a wide margin of support over candidate B. But some last-minute revelation about candidate A may change the atmospherics around the election, influencing the outcome and making the poll data irrelevant. Outside events always hold the potential to affect results of any survey. That is why surveys should never be used to predict anything. The results are good for just one point in time.

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7.2.2: Question Order in Surveys

The order in which questions appear in the questionnaire can also affect the reliability of the results. Questions should be grouped together by topic and within topic to avoid confusion. The first few questions in a questionnaire are crucial in preventing termination of the interview and in relaxing the respondent. Questions asking personal characteristics (age, education level, income level) should come in the last section. Topic questions that are likely to be objectionable (asking about touchy subjects such as sexuality, religious beliefs or illegal behavior) should be placed just before the personal items at the end of the questionnaire.

Furthermore, try to evaluate how the order of the questions might have affected respondents' tendency to answer. For instance, a poll might ask about how much trust respondents have in the federal government. If the question is asked as a stand-alone question without any preceding "set-up" questions, you are likely to get a response that reflects Americans' general dislike of big bureaucracies.

However, if the question about trust in government is preceded by questions asking about trust in a number of programs that Americans generally support (Social Security, Medicare, environmental protection, programs to support wounded military veterans), the question about trust in the government as a whole would reflect a very different response. Respondents would have been reminded about the things that the federal government does that are generally supported, and hence their answer about trust in the government would be different than it would be by asking that one question in isolation.

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7.3: Survey Sampling

Sample: is a small group selected to represent the larger group that the survey researcher wants to learn about. Unless the researchers are going to conduct a census (talk to every member of the group in question), they must draw a sample. The main goal of the sample is to ensure the accurate representation of the entire population. there are various type of sampling technique including systematic sampling, stratified sampling, and random sampling.

Systematic Sampling: is a sampling method where set of individuals or object are selected from a larger population at a random starting point, but with a fixed or periodic interval. In this approach, progression through the list is treated circularly, with a return to the top once the end of the list is passed. The sampling starts by selecting an element from the list at random and then every k^{th} element in the frame is selected, where *k*, is the sampling interval (sometimes known as the *skip*): this is calculated as:[1]

$$k = \frac{N}{n}$$

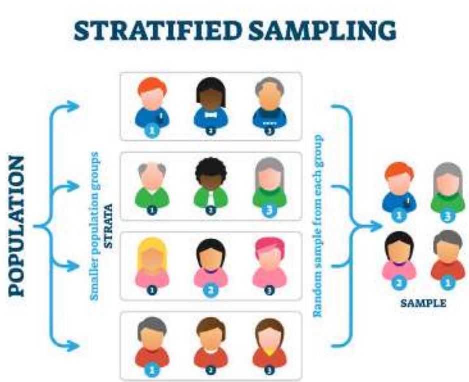
where *n* is the sample size, and *N* is the population size.

Example: Suppose a supermarket wants to study buying habits of their customers, then using systematic sampling they can choose every 10th or 15th customer entering the supermarket and conduct the study on this sample.

This is random sampling with a system. From the sampling frame, a starting point is chosen at random, and choices thereafter are at regular intervals. For example, suppose you want to sample 8 houses from a street of 120 houses. 120/8=15, so every 15th house is chosen after a random starting point between 1 and 15. If the random starting point is 11, then the houses selected are 11, 26, 41, 56, 71, 86, 101, and 116. As an aside, if every 15th house was a "corner house" then this corner pattern could destroy the randomness of the sample.

If, as more frequently, the population is not evenly divisible (suppose you want to sample 8 houses out of 125, where 125/8=15.625), should you take every 15th house or every 16th house? If you take every 16th house, 8*16=128, so there is a risk that the last house chosen does not exist. On the other hand, if you take every 15th house, 8*15=120, so the last five houses will never be selected. The random starting point should instead be selected as a non integer between 0 and 15.625 (inclusive on one endpoint only) to ensure that every house has equal chance of being selected; the interval should now be non integral (15.625); and each non integer selected should be rounded up to the next integer. If the random starting point is 3.6, then the houses selected are 4, 20, 35, 50, 66, 82, 98, and 113, where there are 3 cyclic intervals of 15 and 4 intervals of 16.

Stratified sampling: is a sampling method where the population is randomly divided into small group called strata before being



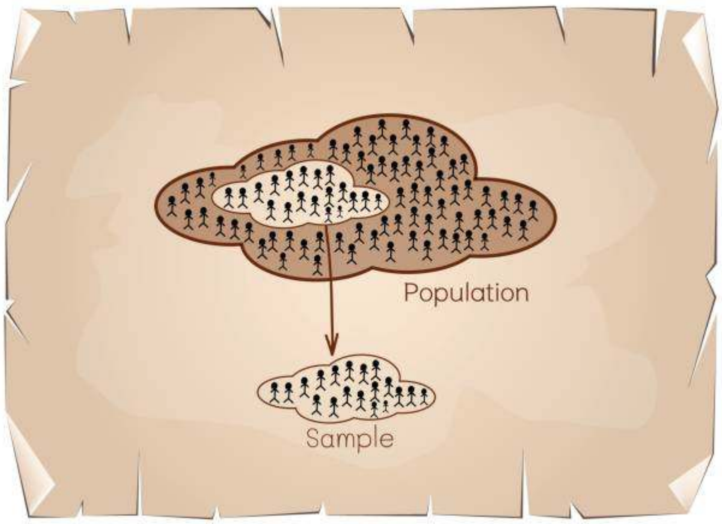
sample.

A simple example of a stratified sampling could be a researcher select five customers from each of the the four postal code or he could select six transactions from each of the four postal code. In this example we use stratified sampling to ensure that the sample is balance geographically.

Random Sampling: is a sampling method where each member of the population being sample has equal chance of been selected. Example: 20 students out of 200 being selected out the hat, without any criteria taking into consideration.

The term population has been mention repetitively during our discussion of sample, so what is a population? How is a population deferent from a sample?

Population: the broad group of people with something in common that the researchers want to learn something about. For example, a reporter investigating the popularity of Facebook may define the population for her survey as 18-24 year-olds who have an account on Facebook. For a study to inform the creators of an advertising campaign for Toyota, researchers may want to look at the population of everyone who purchased a new Toyota in the last year in the state of Colorado. In other words, the population can be defined in any way that makes sense given who the researchers want to study for a particular purpose.



The difference between the population and sample is that population is an entire group that a researcher study whereas a sample is a small group selected from a larger group where you will collect information from.

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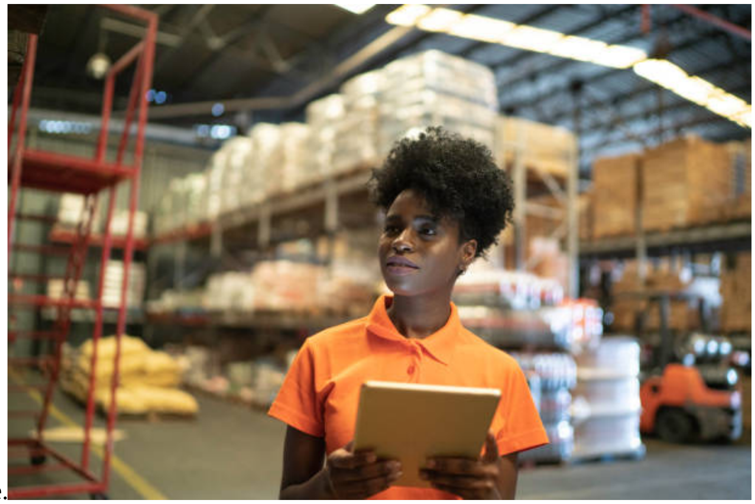
7.4: Other Fact-Finding Techniques and Misleading Data

In addition to interview, Questionnaires, and survey analysts use other fact-finding techniques including documents review, Observation, and research. These fact-finding techniques are used to help system analysts develop good interview questions.

Document review: the fact finding base on reviewing documents can help you understand how the system is supposed to work. It is very important to make sure that the documents are for the system currently in use and are up to date.

Direct Observation: observation is another fact-finding technique, witnessing how the system works will help you understand the system operation better. In addition, the technique can also help make sure that the system documentation and the interview answers are accurate or not. Direct observation can also be use as an additional means of verification that the data collected about a system from the interview are accurate and reliable.



Plan your observations by preparing a list of specific things you want to observe and ask many questions to the people working to ensure that you understand the current system and review and study all necessary document. Since, the goal of the observation is to see how the changes of the system can improve employees productivity, while observing the people at work consider the factor called the **Hawthorne Effect** (effect where the workers productivity improve when they know they are being observed). Always give advance notice to the supervisor and in some cases it might be helpful to explain the purpose of the your visit to the people being observed.

Research: research is another important fact-finding technique that uses public sources like the Internet, magazine, Newsletter and books. Research is conducted to collect accurate information, materials, and news about industry trends and development.

The internet is a very important resource for research. When using the internet you can access information from government, universities, publishers, and libraries all over the world at the blink of an eye. Also, with the internet you can access newsgroup and forum to exchange information with other professional form you field seeking answers to question and monitoring discussions that are of interest to you.

Data misleading: data misleading could be defined as the misrepresentation of a particular group, or data that will produce inaccurate results.

In statistics, a misleading graph, also known as a distorted graph, is a graph that misrepresents data, constitutes a misuse of statistics and with the result that an incorrect conclusion may be derived from it.

Graphs may be misleading by being excessively complex or poorly constructed. Even when constructed to display the characteristics of their data accurately, graphs can be subject to different interpretations, or unintended kinds of data can seemingly and ultimately erroneously be derived.[1]

Misleading graphs may be created intentionally to hinder the proper interpretation of data or accidentally due to unfamiliarity with graphing software, misinterpretation of data, or because data cannot be accurately conveyed. Misleading graphs are often used in false advertising.

Sampling bias: In statistics, **sampling bias** is a bias in which a sample is collected in such a way that some members of the intended population have a lower or higher sampling probability than others. It results in a **biased sample**[1] of a population (or non-human factors) in which all individuals, or instances, were not equally likely to have been selected.[2] If this is not accounted for, results can be erroneously attributed to the phenomenon under study rather than to the method of sampling.

Chapter Questions:

1. What are the pros and cons of the following fact-finding types:face-to-face interview. telephone interview and self-administered interviews?
2. Describe the different steps when planning for an interview.
3. What are three types of sampling? give a brief description of each.
4. List 3 guidelines for the wording of survey questions Can the order of questions affect survey results?
5. Please explain What are some factors that can affect survey results.
6. What is the difference between a sample and a population?
7. Explain what is an open-ended question and close-ended and range of respond question? Give an example for each.
8. What is the Hawthorne Effect? Have you ever experienced it? When and where?

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7.5: Data Validation

In computer science, **data validation** is the process of ensuring data has undergone data cleansing to ensure they have data quality, that is, that they are both correct and useful. It uses routines, often called "validation rules", "validation constraints", or "check routines", that check for correctness, meaningfulness, and security of data that are input to the system. The rules may be implemented through the automated facilities of a data dictionary, or by the inclusion of explicit application program validation logic of the computer and its application.

This is distinct from formal verification, which attempts to prove or disprove the correctness of algorithms for implementing a specification or property.

Overview

Data validation is intended to provide certain well-defined guarantees for fitness and consistency of data in an application or automated system. Data validation rules can be defined and designed using various methodologies, and be deployed in various contexts.[1] Their implementation can use declarative data integrity rules, or procedure-based business rules.[2]

Note that the guarantees of data validation do not necessarily include accuracy, and it is possible for data entry errors such as misspellings to be accepted as valid. Other clerical and/or computer controls may be applied to reduce inaccuracy within a system.

Different kinds

In evaluating the basics of data validation, generalizations can be made regarding the different kinds of validation according to their scope, complexity, and purpose.

For example:

- Data type validation;
- Range and constraint validation;
- Code and cross-reference validation;
- Structured validation; and
- Consistency validation

Data-type check

Data type validation is customarily carried out on one or more simple data fields.

The simplest kind of data type validation verifies that the individual characters provided through user input are consistent with the expected characters of one or more known primitive data types as defined in a programming language or data storage and retrieval mechanism.

For example, an integer field may require input to use only characters 0 through 9.

Simple range and constraint check

Simple range and constraint validation may examine input for consistency with a minimum/maximum range, or consistency with a test for evaluating a sequence of characters, such as one or more tests against regular expressions. For example, a counter value may be required to be a non-negative integer, and a password may be required to meet a minimum length and contain characters from multiple categories.

Code and cross-reference check

Code and cross-reference validation includes operations to verify that data is consistent with one or more possibly-external rules, requirements, or collections relevant to a particular organization, context or set of underlying assumptions. These additional validity constraints may involve cross-referencing supplied data with a known look-up table or directory information service such as LDAP.

For example, a user-provided country code might be required to identify a current geopolitical region.

Structured check

Structured validation allows for the combination of other kinds of validation, along with more complex processing. Such complex processing may include the testing of conditional constraints for an entire complex data object or set of process operations within a system.

Consistency check

Consistency validation ensures that data is logical. For example, the delivery date of an order can be prohibited from preceding its shipment date.

Example

Multiple kinds of data validation are relevant to 10-digit pre-2007 ISBNs (the 2005 edition of ISO 2108 required ISBNs to have 13 digits from 2007 onwards[3]).

- Size. A pre-2007 ISBN must consist of 10 digits, with optional hyphens or spaces separating its four parts.
- Format checks. Each of the first 9 digits must be 0 through 9, and the 10th must be either 0 through 9 or an *X*.
- Check digit. To detect transcription errors in which digits have been altered or transposed, the last digit of a pre-2007 ISBN must match the result of a mathematical formula incorporating the other 9 digits (ISBN-10 check digits).

Validation Types

Allowed character checks

Checks to ascertain that only expected characters are present in a field. For example a numeric field may only allow the digits 0–9, the decimal point and perhaps a minus sign or commas. A text field such as a personal name might disallow characters used for markup. An e-mail address might require at least one @ sign and various other structural details. Regular expressions can be effective ways to implement such checks.

Batch totals

Checks for missing records. Numerical fields may be added together for all records in a batch. The batch total is entered and the computer checks that the total is correct, e.g., add the 'Total Cost' field of a number of transactions together.

Cardinality check

Checks that record has a valid number of related records. For example, if a contact record is classified as "customer" then it must have at least one associated order (cardinality > 0). This type of rule can be complicated by additional conditions. For example, if a contact record in a payroll database is classified as "former employee" then it must not have any associated salary payments after the separation date (cardinality = 0).

Check digits

Used for numerical data. To support error detection, an extra digit is added to a number which is calculated from the other digits.

Consistency checks

Checks fields to ensure data in these fields correspond, e.g., if expiration date is in the past then status is not "active".

Cross-system consistency checks

Compares data in different systems to ensure it is consistent. Systems may represent the same data differently, in which case comparison requires transformation (e.g., one system may store customer name in a single Name field as 'Doe, John Q', while another uses First_Name 'John' and Last_Name 'Doe' and Middle_Name 'Quality').

Data type checks

Checks input conformance with typed data. For example, an input box accepting numeric data may reject the letter 'O'.

File existence check

Checks that a file with a specified name exists. This check is essential for programs that use file handling.

Format check

Checks that the data is in a specified format (template), e.g., dates have to be in the format YYYY-MM-DD. Regular expressions may be used for this kind of validation.

Presence check

Checks that data is present, e.g., customers may be required to have an email address.

Range check

Checks that the data is within a specified range of values, e.g., a probability must be between 0 and 1.

Referential integrity

Values in two relational database tables can be linked through foreign key and primary key. If values in the foreign key field are not constrained by internal mechanisms, then they should be validated to ensure that the referencing table always refers to a row in the referenced table.

Spelling and grammar check

Looks for spelling and grammatical errors.

Uniqueness check

Checks that each value is unique. This can be applied to several fields (i.e. Address, First Name, Last Name).

Table look up check

A table look up check compares data to a collection of allowed values.

Source - Wikipedia

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CHAPTER OVERVIEW

8: Information Systems Security

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- identify the information security triad;
- identify and understand the high-level concepts surrounding information security tools; and
- secure yourself digitally.

Introduction

As computers and other digital devices have become essential to business and commerce, they have also increasingly become a target for attacks. In order for a company or an individual to use a computing device with confidence, they must first be assured that the device is not compromised in any way and that all communications will be secure. In this chapter, we will review the fundamental concepts of information systems security and discuss some of the measures that can be taken to mitigate security threats. We will begin with an overview focusing on how organizations can stay secure. Several different measures that a company can take to improve security will be discussed. We will then follow up by reviewing security precautions that individuals can take in order to secure their personal computing environment.

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8.1: CIA

The security triad

The Information Security Triad: Confidentiality, Integrity, Availability (CIA)

Confidentiality

When protecting information, we want to be able to restrict access to those who are allowed to see it; everyone else should be disallowed from learning anything about its contents. This is the essence of confidentiality. For example, federal law requires that universities restrict access to private student information. The university must be sure that only those who are authorized have access to view the grade records.

Integrity

Integrity is the assurance that the information being accessed has not been altered and truly represents what is intended. Just as a person with integrity means what he or she says and can be trusted to consistently represent the truth, information integrity means information truly represents its intended meaning. Information can lose its integrity through malicious intent, such as when someone who is not authorized makes a change to intentionally misrepresent something. An example of this would be when a hacker is hired to go into the university's system and change a grade.

Integrity can also be lost unintentionally, such as when a computer power surge corrupts a file or someone authorized to make a change accidentally deletes a file or enters incorrect information.

Availability

Information availability is the third part of the CIA triad. *Availability* means that information can be accessed and modified by anyone authorized to do so in an appropriate timeframe. Depending on the type of information, *appropriate timeframe* can mean different things. For example, a stock trader needs information to be available immediately, while a sales person may be happy to get sales numbers for the day in a report the next morning. Companies such as Amazon.com will require their servers to be available twenty-four hours a day, seven days a week. Other companies may not suffer if their web servers are down for a few minutes once in a while.

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8.2: Tools to Use

Tools for Information Security

In order to ensure the confidentiality, integrity, and availability of information, organizations can choose from a variety of tools. Each of these tools can be utilized as part of an overall information-security policy, which will be discussed in the next section.

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8.2.1: Authentication

Authentication

The most common way to identify someone is through their physical appearance, but how do we identify someone sitting behind a computer screen or at the ATM? Tools for authentication are used to ensure that the person accessing the information is, indeed, who they present themselves to be.

Authentication can be accomplished by identifying someone through one or more of three factors: something they know, something they have, or something they are. For example, the most common form of authentication today is the user ID and password. In this case, the authentication is done by confirming something that the user knows (their ID and password). But this form of authentication is easy to compromise (see sidebar) and stronger forms of authentication are sometimes needed. Identifying someone only by something they have, such as a key or a card, can also be problematic. When that identifying token is lost or stolen, the identity can be easily stolen. The final factor, something you are, is much harder to compromise. This factor identifies a user through the use of a physical characteristic, such as an eye-scan or fingerprint. Identifying someone through their physical characteristics is called biometrics.

A more secure way to authenticate a user is to do multi-factor authentication. By combining two or more of the factors listed above, it becomes much more difficult for someone to misrepresent themselves. An example of this would be the use of an RSA SecurID token. The RSA device is something you have, and will generate a new access code every sixty seconds. To log in to an information resource using the RSA device, you combine something you know, a four-digit PIN, with the code generated by the device. The only way to properly authenticate is by both knowing the code *and* having the RSA device.

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8.2.2: Access Control

Access Control

Once a user has been authenticated, the next step is to ensure that they can only access the information resources that are appropriate. This is done through the use of access control. Access control determines which users are authorized to read, modify, add, and/or delete information. Several different access control models exist. Here we will discuss two: the access control list (ACL) and role-based access control (RBAC).

For each information resource that an organization wishes to manage, a list of users who have the ability to take specific actions can be created. This is an access control list, or ACL. For each user, specific capabilities are assigned, such as *read*, *write*, *delete*, or *add*. Only users with those capabilities are allowed to perform those functions. If a user is not on the list, they have no ability to even know that the information resource exists.

ACLs are simple to understand and maintain. However, they have several drawbacks. The primary drawback is that each information resource is managed separately, so if a security administrator wanted to add or remove a user to a large set of information resources, it would be quite difficult. And as the number of users and resources increase, ACLs become harder to maintain. This has led to an improved method of access control, called role-based access control, or RBAC. With RBAC, instead of giving specific users access rights to an information resource, users are assigned to roles and then those roles are assigned the access. This allows the administrators to manage users and roles separately, simplifying administration and, by extension, improving security.

Comparison of ACL and RBAC (click to enlarge)

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8.2.3: Encryption

Encryption

Many times, an organization needs to transmit information over the Internet or transfer it on external media such as a CD or flash drive. In these cases, even with proper authentication and access control, it is possible for an unauthorized person to get access to the data. Encryption is a process of encoding data upon its transmission or storage so that only authorized individuals can read it. This encoding is accomplished by a computer program, which encodes the plain text that needs to be transmitted; then the recipient receives the cipher text and decodes it (decryption). In order for this to work, the sender and receiver need to agree on the method of encoding so that both parties can communicate properly. Both parties share the encryption key, enabling them to encode and decode each other's messages. This is called symmetric key encryption. This type of encryption is problematic because the key is available in two different places.

An alternative to symmetric key encryption is public key encryption. In public key encryption, two keys are used: a public key and a private key. To send an encrypted message, you obtain the public key, encode the message, and send it. The recipient then uses the private key to decode it. The public key can be given to anyone who wishes to send the recipient a message. Each user simply needs one private key and one public key in order to secure messages. The private key is necessary in order to decrypt something sent with the public key.

Public key encryption (click for larger diagram)

Sidebar: Password Security

So why is using just a simple user ID/password not considered a secure method of authentication? It turns out that this single-factor authentication is extremely easy to compromise. Good password policies must be put in place in order to ensure that passwords cannot be compromised. Below are some of the more common policies that organizations should put in place.

- Require complex passwords. One reason passwords are compromised is that they can be easily guessed. A recent study found that the top three passwords people used in 2012 were *password*, *123456* and *12345678*.[1] A password should not be simple, or a word that can be found in a dictionary. One of the first things a hacker will do is try to crack a password by testing every term in the dictionary! Instead, a good password policy is one that requires the use of a minimum of eight characters, and at least one upper-case letter, one special character, and one number.
- Change passwords regularly. It is essential that users change their passwords on a regular basis. Users should change their passwords every sixty to ninety days, ensuring that any passwords that might have been stolen or guessed will not be able to be used against the company.
- Train employees not to give away passwords. One of the primary methods that is used to steal passwords is to simply figure them out by asking the users or administrators. *Pretexting* occurs when an attacker calls a helpdesk or security administrator and pretends to be a particular authorized user having trouble logging in. Then, by providing some personal information about the authorized user, the attacker convinces the security person to reset the password and tell him what it is. Another way that employees may be tricked into giving away passwords is through e-mail phishing. Phishing occurs when a user receives an e-mail that looks as if it is from a trusted source, such as their bank, or their employer. In the e-mail, the user is asked to click a link and log in to a website that mimics the genuine website and enter their ID and password, which are then captured by the attacker.

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8.2.4: Backups

Backups

Another essential tool for information security is a comprehensive backup plan for the entire organization. Not only should the data on the corporate servers be backed up, but individual computers used throughout the organization should also be backed up. A good backup plan should consist of several components.

- A full understanding of the organizational information resources. What information does the organization actually have? Where is it stored? Some data may be stored on the organization’s servers, other data on users’ hard drives, some in the cloud, and some on third-party sites. An organization should make a full inventory of all of the information that needs to be backed up and determine the best way back it up.
- Regular backups of all data. The frequency of backups should be based on how important the data is to the company, combined with the ability of the company to replace any data that is lost. Critical data should be backed up daily, while less critical data could be backed up weekly.
- Offsite storage of backup data sets. If all of the backup data is being stored in the same facility as the original copies of the data, then a single event, such as an earthquake, fire, or tornado, would take out both the original data and the backup! It is essential that part of the backup plan is to store the data in an offsite location.
- Test of data restoration. On a regular basis, the backups should be put to the test by having some of the data restored. This will ensure that the process is working and will give the organization confidence in the backup plan.

Besides these considerations, organizations should also examine their operations to determine what effect downtime would have on their business. If their information technology were to be unavailable for any sustained period of time, how would it impact the business?

Additional concepts related to backup include the following:

- Universal Power Supply (UPS). A UPS is a device that provides battery backup to critical components of the system, allowing them to stay online longer and/or allowing the IT staff to shut them down using proper procedures in order to prevent the data loss that might occur from a power failure.
- Alternate, or “hot” sites. Some organizations choose to have an alternate site where an exact replica of their critical data is always kept up to date. When the primary site goes down, the alternate site is immediately brought online so that little or no downtime is experienced.

As information has become a strategic asset, a whole industry has sprung up around the technologies necessary for implementing a proper backup strategy. A company can contract with a service provider to back up all of their data or they can purchase large amounts of online storage space and do it themselves. Technologies such as storage area networks and archival systems are now used by most large businesses.

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8.3: Firewalls

Firewalls

Network configuration with firewalls, IDS, and a DMZ. Click to enlarge.

Another method that an organization should use to increase security on its network is a firewall. A firewall can exist as hardware or software (or both). A hardware firewall is a device that is connected to the network and filters the packets based on a set of rules. A software firewall runs on the operating system and intercepts packets as they arrive to a computer. A firewall protects all company servers and computers by stopping packets from outside the organization's network that do not meet a strict set of criteria. A firewall may also be configured to restrict the flow of packets leaving the organization. This may be done to eliminate the possibility of employees watching YouTube videos or using Facebook from a company computer.

Some organizations may choose to implement multiple firewalls as part of their network security configuration, creating one or more sections of their network that are partially secured. This segment of the network is referred to as a DMZ, borrowing the term *demilitarized zone* from the military, and it is where an organization may place resources that need broader access but still need to be secured.

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8.4: IDS

Intrusion Detection Systems

Another device that can be placed on the network for security purposes is an intrusion detection system, or IDS. An IDS does not add any additional security; instead, it provides the functionality to identify if the network is being attacked. An IDS can be configured to watch for specific types of activities and then alert security personnel if that activity occurs. An IDS also can log various types of traffic on the network for analysis later. An IDS is an essential part of any good security setup.

Sidebar: Virtual Private Networks

Using firewalls and other security technologies, organizations can effectively protect many of their information resources by making them invisible to the outside world. But what if an employee working from home requires access to some of these resources? What if a consultant is hired who needs to do work on the internal corporate network from a remote location? In these cases, a virtual private network (VPN) is called for.

A VPN allows a user who is outside of a corporate network to take a detour around the firewall and access the internal network from the outside. Through a combination of software and security measures, this lets an organization allow limited access to its networks while at the same time ensuring overall security.

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8.5: Physical Security

Physical Security

An organization can implement the best authentication scheme in the world, develop the best access control, and install firewalls and intrusion prevention, but its security cannot be complete without implementation of physical security. Physical security is the protection of the actual hardware and networking components that store and transmit information resources. To implement physical security, an organization must identify all of the vulnerable resources and take measures to ensure that these resources cannot be physically tampered with or stolen. These measures include the following.

- Locked doors: It may seem obvious, but all the security in the world is useless if an intruder can simply walk in and physically remove a computing device. High-value information assets should be secured in a location with limited access.
- Physical intrusion detection: High-value information assets should be monitored through the use of security cameras and other means to detect unauthorized access to the physical locations where they exist.
- Secured equipment: Devices should be locked down to prevent them from being stolen. One employee's hard drive could contain all of your customer information, so it is essential that it be secured.
- Environmental monitoring: An organization's servers and other high-value equipment should always be kept in a room that is monitored for temperature, humidity, and airflow. The risk of a server failure rises when these factors go out of a specified range.
- Employee training: One of the most common ways thieves steal corporate information is to steal employee laptops while employees are traveling. Employees should be trained to secure their equipment whenever they are away from the office.

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8.6: Security Policies

Security Policies

Besides the technical controls listed above, organizations also need to implement security policies as a form of administrative control. In fact, these policies should really be a starting point in developing an overall security plan. A good information-security policy lays out the guidelines for employee use of the information resources of the company and provides the company recourse in the case that an employee violates a policy.

According to the SANS Institute, a good policy is “a formal, brief, and high-level statement or plan that embraces an organization’s general beliefs, goals, objectives, and acceptable procedures for a specified subject area.” Policies require compliance; failure to comply with a policy will result in disciplinary action. A policy does not lay out the specific technical details, instead it focuses on the desired results. A security policy should be based on the guiding principles of confidentiality, integrity, and availability.[2]

A good example of a security policy that many will be familiar with is a web use policy. A web use policy lays out the responsibilities of company employees as they use company resources to access the Internet. A good example of a web use policy is included in Harvard University’s “Computer Rules and Responsibilities” policy, which can be found here.

A security policy should also address any governmental or industry regulations that apply to the organization. For example, if the organization is a university, it must be aware of the Family Educational Rights and Privacy Act (FERPA), which restricts who has access to student information. Health care organizations are obligated to follow several regulations, such as the Health Insurance Portability and Accountability Act (HIPAA).

A good resource for learning more about security policies is the SANS Institute’s Information Security Policy Page.

Usability

When looking to secure information resources, organizations must balance the need for security with users’ need to effectively access and use these resources. If a system’s security measures make it difficult to use, then users will find ways around the security, which may make the system more vulnerable than it would have been without the security measures! Take, for example, password policies. If the organization requires an extremely long password with several special characters, an employee may resort to writing it down and putting it in a drawer since it will be impossible to memorize.

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8.6.1: Mobile Secuirty

Sidebar: Mobile Security

As the use of mobile devices such as smartphones and tablets proliferates, organizations must be ready to address the unique security concerns that the use of these devices bring. One of the first questions an organization must consider is whether to allow mobile devices in the workplace at all. Many employees already have these devices, so the question becomes: Should we allow employees to bring their own devices and use them as part of their employment activities? Or should we provide the devices to our employees? Creating a BYOD ("Bring Your Own Device") policy allows employees to integrate themselves more fully into their job and can bring higher employee satisfaction and productivity. In many cases, it may be virtually impossible to prevent employees from having their own smartphones or iPads in the workplace. If the organization provides the devices to its employees, it gains more control over use of the devices, but it also exposes itself to the possibility of an administrative (and costly) mess.

Mobile devices can pose many unique security challenges to an organization. Probably one of the biggest concerns is theft of intellectual property. For an employee with malicious intent, it would be a very simple process to connect a mobile device either to a computer via the USB port, or wirelessly to the corporate network, and download confidential data. It would also be easy to secretly take a high-quality picture using a built-in camera.

When an employee does have permission to access and save company data on his or her device, a different security threat emerges: that device now becomes a target for thieves. Theft of mobile devices (in this case, including laptops) is one of the primary methods that data thieves use.

So what can be done to secure mobile devices? It will start with a good policy regarding their use. According to a 2013 SANS study, organizations should consider developing a mobile device policy that addresses the following issues: use of the camera, use of voice recording, application purchases, encryption at rest, Wi-Fi autoconnect settings, bluetooth settings, VPN use, password settings, lost or stolen device reporting, and backup. [3]

Besides policies, there are several different tools that an organization can use to mitigate some of these risks. For example, if a device is stolen or lost, geolocation software can help the organization find it. In some cases, it may even make sense to install remote data-removal software, which will remove data from a device if it becomes a security risk.

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8.7: Personal info Sec

Personal Information Security

Poster from Stop. Think. Connect. Click to enlarge. (Copyright: Stop. Think. Connect. http://stopthinkconnect.org/resources)

We will end this chapter with a discussion of what measures each of us, as individual users, can take to secure our computing technologies. There is no way to have 100% security, but there are several simple steps we, as individuals, can take to make ourselves more secure.

- Keep your software up to date. Whenever a software vendor determines that a security flaw has been found in their software, they will release an update to the software that you can download to fix the problem. Turn on automatic updating on your computer to automate this process.
- Install antivirus software and keep it up to date. There are many good antivirus software packages on the market today, including free ones.
- Be smart about your connections. You should be aware of your surroundings. When connecting to a Wi-Fi network in a public place, be aware that you could be at risk of being spied on by others sharing that network. It is advisable not to access your financial or personal data while attached to a Wi-Fi hotspot. You should also be aware that connecting USB flash drives to your device could also put you at risk. Do not attach an unfamiliar flash drive to your device unless you can scan it first with your security software.
- Back up your data. Just as organizations need to back up their data, individuals need to as well. And the same rules apply: do it regularly and keep a copy of it in another location. One simple solution for this is to set up an account with an online backup service, such as Mozy or Carbonite, to automate your backups.
- Secure your accounts with two-factor authentication. Most e-mail and social media providers now have a two-factor authentication option. The way this works is simple: when you log in to your account from an unfamiliar computer for the first time, it sends you a text message with a code that you must enter to confirm that you are really you. This means that no one else can log in to your accounts without knowing your password *and* having your mobile phone with them.
- Make your passwords long, strong, and unique. For your personal passwords, you should follow the same rules that are recommended for organizations. Your passwords should be long (eight or more characters) and contain at least two of the following: upper-case letters, numbers, and special characters. You also should use different passwords for different accounts, so that if someone steals your password for one account, they still are locked out of your other accounts.
- Be suspicious of strange links and attachments. When you receive an e-mail, tweet, or Facebook post, be suspicious of any links or attachments included there. Do not click on the link directly if you are at all suspicious. Instead, if you want to access the website, find it yourself and navigate to it directly.

You can find more about these steps and many other ways to be secure with your computing by going to Stop. Think. Connect. This website is part of a campaign that was launched in October of 2010 by the STOP. THINK. CONNECT. Messaging Convention in partnership with the U.S. government, including the White House.

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SECTION OVERVIEW

8.8: Information Security- Barbarians at the Gateway (and Just About Everywhere Else)

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8.8.1: Introduction

Learning Objectives

After studying this section you should be able to do the following:

1. Recognize that information security breaches are on the rise.
2. Understand the potentially damaging impact of security breaches.
3. Recognize that information security must be made a top organizational priority.

Sitting in the parking lot of a Minneapolis Marshalls, a hacker armed with a laptop and a telescope-shaped antenna infiltrated the store's network via an insecure Wi-Fi base station[1]. The attack launched what would become a billion-dollar-plus nightmare scenario for TJX, the parent of retail chains that include Marshalls, Home Goods, and T. J. Maxx. Over a period of several months, the hacker and his gang stole at least 45.7 million credit and debit card numbers and pilfered driver's licenses and other private information from an additional 450,000 customers (King, 2009).

TJX, at the time a $17.5 billion *Fortune* 500 firm, was left reeling from the incident. The attack deeply damaged the firm's reputation. It burdened customers and banking partners with the time and cost of reissuing credit cards. And TJX suffered under settlement costs, payouts from court-imposed restitution, legal fees, and more. The firm estimated that it spent more than $150 million to correct security problems and settle with consumers affected by the breach, and that was just the tip of the iceberg. Estimates peg TJX's overall losses from this incident at between $1.35 billion and $4.5 billion (Matwyshyn, 2009).

A number of factors led to and amplified the severity of the TJX breach. There was a personnel betrayal: the mastermind was an alleged FBI informant who previously helped bring down a massive credit card theft scheme but then double-crossed the Feds and used insider information to help his gang outsmart the law and carry out subsequent hacks (Goldman, 2009). There was a technology lapse: TJX made itself an easy mark by using WEP, a wireless security technology less secure than the stuff many consumers use in their homes—one known for years to be trivially compromised by the kind of "drive-by" hacking initiated by the perpetrators. And there was a procedural gaffe: retailers were in the process of rolling out a security rubric known as the Payment Card Industry Data Security Standard. Despite an industry deadline, however, TJX had requested and received an extension, delaying the rollout of mechanisms that might have discovered and plugged the hole before the hackers got in (Anthes, 2008).

The massive impact of the TJX breach should make it clear that security must be a top organizational priority. Attacks are on the rise. In 2008, more electronic records were breached than in the previous four years *combined* (King, 2009). While the examples and scenarios presented here are shocking, the good news is that the vast majority of security breaches can be prevented. Let's be clear from the start: no text can provide an approach that will guarantee that you'll be 100 percent secure. And that's not the goal of this chapter. The issues raised in this brief introduction can, however, help make you aware of vulnerabilities; improve your critical thinking regarding current and future security issues; and help you consider whether a firm has technologies, training, policies, and procedures in place to assess risks, lessen the likelihood of damage, and respond in the event of a breach. A constant vigilance regarding security needs to be part of your individual skill set and a key component in your organization's culture. An awareness of the threats and approaches discussed in this chapter should help reduce your chance of becoming a victim.

As we examine security issues, we'll first need to understand what's happening, who's doing it, and what their motivation is. We'll then examine how these breaches are happening with a focus on technologies and procedures. Finally, we'll sum up with what can be done to minimize the risks of being victimized and quell potential damage of a breach for both the individual and the organization.

Key Takeaways

- Information security is everyone's business and needs to be made a top organizational priority.
- Firms suffering a security breach can experience direct financial loss, exposed proprietary information, fines, legal payouts, court costs, damaged reputations, plummeting stock prices, and more.
- Information security isn't just a technology problem; a host of personnel and procedural factors can create and amplify a firm's vulnerability.

Questions and Exercises

1. As individuals or in groups assigned by your instructor, search online for recent reports on information security breaches. Come to class prepared to discuss the breach, its potential impact, and how it might have been avoided. What should the key takeaways be for managers studying your example?
2. Think of firms that you've done business with online. Search to see if these firms have experienced security breaches in the past. What have you found out? Does this change your attitude about dealing with the firm? Why or why not?
3. What factors were responsible for the TJX breach? Who was responsible for the breach? How do you think the firm should have responded?

[1]Particular thanks goes to my Boston College colleague, Professor Sam Ransbotham, whose advice, guidance, and suggestions were invaluable in creating this chapter. Any errors or omissions are entirely my own.

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8.8.2: Why Is This Happening? Who Is Doing It? And What's Their Motivation?

Learning Objectives

After studying this section you should be able to do the following:

1. Understand the source and motivation of those initiating information security attacks.
2. Relate examples of various infiltrations in a way that helps raise organizational awareness of threats.

Thieves, vandals, and other bad guys have always existed, but the environment has changed. Today, nearly every organization is online, making any Internet-connected network a potential entry point for the growing worldwide community of computer criminals. Software and hardware solutions are also more complex than ever. Different vendors, each with their own potential weaknesses, provide technology components that may be compromised by misuse, misconfiguration, or mismanagement. Corporations have become data packrats, hoarding information in hopes of turning bits into bucks by licensing databases, targeting advertisements, or cross-selling products. And flatter organizations also mean that lower-level employees may be able to use technology to reach deep into corporate assets—amplifying threats from operator error, a renegade employee, or one compromised by external forces.

There are a lot of bad guys out there, and motivations vary widely, including the following:

- Account theft and illegal funds transfer
- Stealing personal or financial data
- Compromising computing assets for use in other crimes
- Extortion
- Espionage
- Cyberwarfare
- Terrorism
- Pranksters
- Protest hacking (hacktivism)
- Revenge (disgruntled employees)

Criminals have stolen more than $100 million from U.S. banks in the first three quarters of 2009, and they did it "without drawing a gun or passing a note to a teller" (Kroft, 2009). While some steal cash for their own use, other resell their hacking take to others. There is a thriving cybercrime underworld market in which data harvesters sell to cash-out fraudsters: criminals who might purchase data from the harvesters in order to buy (then resell) goods using stolen credit cards or create false accounts via identity theft. These collection and resale operations are efficient and sophisticated. Law enforcement has taken down sites like DarkMarket and ShadowCrew, in which card thieves and hacking tool peddlers received eBay-style seller ratings vouching for the "quality" of their wares (Singel, 2008).

Hackers might also infiltrate computer systems to enlist hardware for subsequent illegal acts. A cybercrook might deliberately hop through several systems to make his path difficult to follow, slowing cross-border legal pursuit or even thwarting prosecution if launched from nations without extradition agreements.

In fact, your computer may be up for rent by cyber thieves right now. Botnets of zombie computers (networks of infiltrated and compromised machines controlled by a central command) are used for all sorts of nefarious activity. This includes sending spam from thousands of difficult-to-shut-down accounts, launching tough-to-track click fraud efforts or staging what's known as distributed denial of service (DDoS) attacks (effectively shutting down Web sites by overwhelming them with a crushing load of seemingly legitimate requests sent simultaneously by thousands of machines). Botnets have been discovered that are capable of sending out 100 billion spam messages a day (Higgins, 2008), and botnets as large as 10 million zombies have been identified. Such systems theoretically control more computing power than the world's fastest supercomputers (Krebs, 2007).

Extortionists might leverage botnets or hacked data to demand payment to avoid retribution. Three eastern European gangsters used a botnet and threatened DDoS to extort $4 million from UK sports bookmakers[1], while an extortion plot against the state of Virginia threatened to reveal names, Social Security numbers, and prescription information stolen from a medical records database

(Kroft, 2009). Competition has also lowered the price to inflict such pain. *BusinessWeek* reports that the cost of renting out ten thousand machines, enough to cripple a site like Twitter, has tumbled to just $200 a day (Schectman, 2009).

Corporate espionage might be performed by insiders, rivals, or even foreign governments. Gary Min, a scientist working for DuPont, was busted when he tried to sell information valued at some $400 million, including R&D documents and secret data on proprietary products (Vijayan, 2007). Spies also breached the $300 billion U.S. Joint Strike Fighter project, siphoning off terabytes of data on navigation and other electronics systems (Gorman, et. al., 2009).

Cyberwarfare has become a legitimate threat, with several attacks demonstrating how devastating technology disruptions by terrorists or a foreign power might be. Brazil has seen hacks that cut off power to millions.

The *60 Minutes* news program showed a demonstration by “white hat” hackers that could compromise a key component in an oil refinery, force it to overheat, and cause an explosion. Taking out key components of the vulnerable U.S. power grid may be particularly devastating, as the equipment is expensive, much of it is no longer made in the United States, and some components may take three to four months to replace (Kroft, 2009).

“Hacker”: Good or Bad?

The terms hacker and hack are widely used, but their meaning is often based on context. When referring to security issues, the media widely refers to hackers as bad guys who try to break into (hack) computer systems. Some geezer geeks object to this use, as the term *hack* in computer circles originally referred to a clever (often technical) solution and the term *hacker* referred to a particularly skilled programmer. Expect to see the terms used both positively and negatively.

You might also encounter the terms white hat hackers and black hat hackers. The white hats are the good guys who probe for weaknesses, but don’t exploit them. Instead, they share their knowledge in hopes that the holes they’ve found will be plugged and security will be improved. Many firms hire consultants to conduct “white hat” hacking expeditions on their own assets as part of their auditing and security process. “Black hats” are the bad guys. Some call them “crackers.” There’s even a well-known series of hacker conventions known as the Black Hat conference.

Other threats come from malicious pranksters, like the group that posted seizure-inducing images on Web sites frequented by epilepsy sufferers (Schwartz, 2008). Others are hacktivists, targeting firms, Web sites, or even users as a protest measure. In 2009, Twitter was brought down and Facebook and LiveJournal were hobbled as Russian-sympathizing hacktivists targeted the social networking and blog accounts of the Georgian blogger known as Cyxymu. The silencing of millions of accounts was simply collateral damage in a massive DDoS attack meant to mute this single critic of the Russian government (Schectman, 2009).

And as power and responsibility is concentrated in the hands of a few revenge-seeking employees can do great damage. The San Francisco city government lost control of a large portion of its own computer network over a ten-day period when a single disgruntled employee refused to divulge critical passwords Vijayan, 2010).

The bad guys are legion and the good guys often seem outmatched and underresourced. Law enforcement agencies dealing with computer crime are increasingly outnumbered, outskilled, and underfunded. Many agencies are staffed with technically weak personnel who were trained in a prior era’s crime fighting techniques. Governments can rarely match the pay scale and stock bonuses offered by private industry. Organized crime networks now have their own R&D labs and are engaged in sophisticated development efforts to piece together methods to thwart current security measures.

Key Takeaways

- Computer security threats have moved beyond the curious teen with a PC and are now sourced from a number of motivations, including theft, leveraging compromised computing assets, extortion, espionage, warfare, terrorism, pranks, protest, and revenge.
- Threats can come from both within the firm as well as from the outside.
- Cybercriminals operate in an increasingly sophisticated ecosystem where data harvesters and tool peddlers leverage sophisticated online markets to sell to cash-out fraudsters and other crooks.
- Technical and legal complexity make pursuit and prosecution difficult.
- Many law enforcement agencies are underfunded, underresourced, and underskilled to deal with the growing hacker threat.

Questions and Exercises

1. What is a botnet? What sorts of exploits would use a botnet? Why would a botnet be useful to cybercriminals?
2. Why are threats to the power grid potentially so concerning? What are the implications of power-grid failure and of property damage? Who might execute these kinds of attacks? What are the implications for firms and governments planning for the possibility of cyberwarfare and cyberterror?
3. Scan the trade press for examples of hacking that apply to the various motivations mentioned in this chapter. What happened to the hacker? Were they caught? What penalties do they face?
4. Why do cybercriminals execute attacks across national borders? What are the implications for pursuit, prosecution, and law enforcement?
5. Why do law enforcement agencies struggle to cope with computer crime?
6. A single rogue employee effectively held the city of San Francisco's network hostage for ten days. What processes or controls might the city have created that could have prevented this kind of situation from taking place?

[1]Trend Micro, "Web Threats Whitepaper," March 2008.

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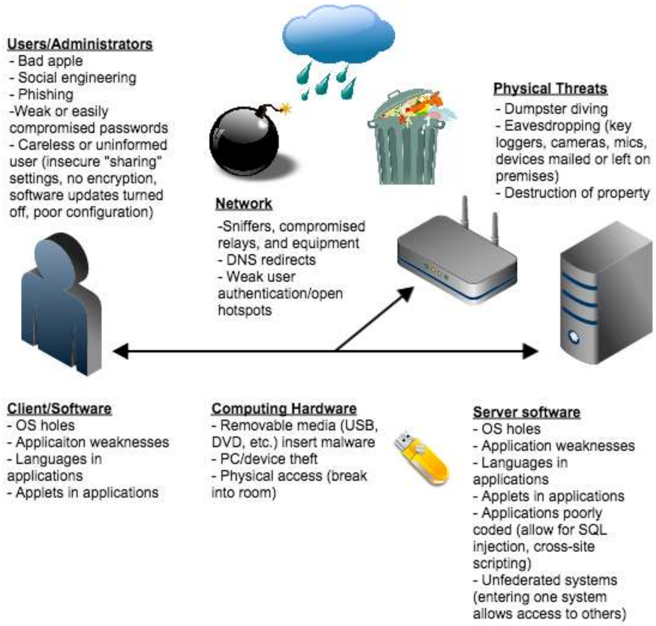
8.8.3: Where Are Vulnerabilities? Understanding the Weaknesses

Learning Objectives

After studying this section you should be able to do the following:

1. Recognize the potential entry points for security compromise.
2. Understand infiltration techniques such as social engineering, phishing, malware, Web site compromises (such as SQL injection), and more.
3. Identify various methods and techniques to thwart infiltration.

Figure 13.1



This diagram shows only some of the potential weaknesses that can compromise the security of an organization's information systems. Every physical or network "touch point" is a potential vulnerability. Understanding where weaknesses may exist is a vital step toward improved security.

Modern information systems have lots of interrelated components and if one of these components fails, there might be a way in to the goodies. This creates a large attack surface for potential infiltration and compromise, as well as one that is simply vulnerable to unintentional damage and disruption.

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8.8.4: Taking Action

Learning Objectives

After studying this section you should be able to do the following:

1. Identify critical steps to improve your individual and organizational information security.
2. Be a tips, tricks, and techniques advocate, helping make your friends, family, colleagues, and organization more secure.
3. Recognize the major information security issues that organizations face, as well as the resources, methods, and approaches that can help make firms more secure.

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Taking Action as a User

The weakest link in security is often a careless user, so don't make yourself an easy mark. Once you get a sense of threats, you understand the kinds of precautions you need to take. Security considerations then become more common sense than high tech. Here's a brief list of major issues to consider:

- *Surf smart.* Think before you click—question links, enclosures, download request, and the integrity of Web sites that you visit. Avoid suspicious e-mail attachments and Internet downloads. Be on guard for phishing, and other attempts to con you into letting in malware. Verify anything that looks suspicious before acting. Avoid using public machines (libraries, coffee shops) when accessing sites that contain your financial data or other confidential information.
- *Stay vigilant.* Social engineering con artists and rogue insiders are out there. An appropriate level of questioning applies not only to computer use, but also to personal interactions, be it in person, on the phone, or electronically.
- *Stay updated.* Turn on software update features for your operating system and any application you use (browsers, applications, plug-ins, and applets), and manually check for updates when needed. Malware toolkits specifically scan for older, vulnerable systems, so working with updated programs that address prior concerns lowers your vulnerable attack surface.
- *Stay armed.* Install a full suite of security software. Many vendors offer a combination of products that provide antivirus software that blocks infection, personal firewalls that repel unwanted intrusion, malware scanners that seek out bad code that might already be nesting on your PC, antiphishing software that identifies if you're visiting questionable Web sites, and more. Such tools are increasingly being built into operating systems, browsers, and are deployed at the ISP or service provider (e-mail firm, social network) level. But every consumer should make it a priority to understand the state of the art for personal protection. In the way that you regularly balance your investment portfolio to account for economic shifts, or take your car in for an oil change to keep it in top running condition, make it a priority to periodically scan the major trade press or end-user computing sites for reviews and commentary on the latest tools and techniques for protecting yourself (and your firm).
- *Be settings smart.* Don't turn on risky settings like unrestricted folder sharing that may act as an invitation for hackers to drop off malware payloads. Secure home networks with password protection and a firewall. Encrypt hard drives—especially on laptops or other devices that might be lost or stolen. Register mobile devices for location identification or remote wiping. Don't click the "Remember me" or "Save password" settings on public machines, or any device that might be shared or accessed by others. Similarly, if your machine might be used by others, turn off browser settings that auto-fill fields with prior entries—otherwise you make it easy for someone to use that machine to track your entries and impersonate you. And when using public hotspots, be sure to turn on your VPN software to encrypt transmission and hide from network eavesdroppers.
- *Be password savvy.* Change the default password on any new products that you install. Update your passwords regularly. Using guidelines outlined earlier, choose passwords that are tough to guess, but easy for you (and only you) to remember. Federate your passwords so that you're not using the same access codes for your most secure sites. Never save passwords in nonsecured files, e-mail, or written down in easily accessed locations.
- *Be disposal smart.* Shred personal documents. Wipe hard drives with an industrial strength software tool before recycling, donating, or throwing away—remember in many cases "deleted" files can still be recovered. Destroy media such as CDs and DVDs that may contain sensitive information. Erase USB drives when they are no longer needed.
- *Back up.* The most likely threat to your data doesn't come from hackers; it comes from hardware failure (Taylor, 2009). Yet most users still don't regularly back up their systems. This is another do-it-now priority. Cheap, plug-in hard drives work with

most modern operating systems to provide continual backups, allowing for quick rollback to earlier versions if you've accidentally ruined some vital work. And services like EMC's Mozy provide monthly, unlimited backup over the Internet for less than what you probably spent on your last lunch (a fire, theft, or similar event could also result in the loss of any backups stored on-site, but Internet backup services can provide off-site storage and access if disaster strikes).
- *Check with your administrator.* All organizations that help you connect to the Internet—your ISP, firm, or school—should have security pages. Many provide free security software tools. Use them as resources. Remember—it's in their interest to keep you safe, too!
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Taking Action as an Organization

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Frameworks, Standards, and Compliance

Developing organizational security is a daunting task. You're in an arms race with adversaries that are tenacious and constantly on the lookout for new exploits. Fortunately, no firm is starting from scratch—others have gone before you and many have worked together to create published best practices.

There are several frameworks, but perhaps the best known of these efforts comes from the International Organization for Standards (ISO), and is broadly referred to as ISO27k or the ISO 27000 series. According to ISO.org, this evolving set of standards provides "a model for establishing, implementing, operating, monitoring, reviewing, maintaining, and improving an Information Security Management System."

Firms may also face compliance requirements—legal or professionally binding steps that must be taken. Failure to do so could result in fine, sanction, and other punitive measures. At the federal level, examples include HIPAA (the Health Insurance Portability and Accountability Act), which regulates health data; the Graham-Leach-Bliley Act, which regulates financial data; and the Children's Online Privacy Protection Act, which regulates data collection on minors. U.S. government agencies must also comply with FISMA (the Federal Information Security Management Act), and there are several initiatives at the other government levels. By 2009, some level of state data breach laws had been passed by over thirty states, while multinationals face a growing number of statues throughout the world. Your legal team and trade associations can help you understand your domestic and international obligations. Fortunately, there are often frameworks and guidelines to assist in compliance. For example, the ISO standards include subsets targeted at the telecommunications and health care industries, and major credit card firms have created the PCI (payment card industry) standards. And there are skilled consulting professionals who can help bring firms up to speed in these areas, and help expand their organizational radar as new issues develop.

Here is a word of warning on frameworks and standards: compliance does not equal security. Outsourcing portions security efforts without a complete, organizational commitment to being secure can also be dangerous. Some organizations simply approach compliance as a necessary evil: a sort of checklist that can reduce the likelihood of a lawsuit or other punitive measure (Davis, 2009). While you want to make sure you're doing everything in your power not to get sued, this isn't the goal. The goal is taking all appropriate measures to ensure that your firm is secure for your customers, employees, shareholders, and others. Frameworks help shape your thinking and expose things you should do, but security doesn't stop there—this is a constant, evolving process that needs to pervade the organization from the CEO suite and board, down to front line workers and potentially out to customers and partners. And be aware of the security issues associated with any mergers and acquisitions. Bringing in new firms, employees, technologies, and procedures means reassessing the security environment for all players involved.

The Heartland Breach

On inauguration day 2009, credit card processor Heartland announced that it had experienced what was one of the largest security breaches in history. The Princeton, New Jersey, based firm was, at the time, the nation's fifth largest payments processor. Its business was responsible for handling the transfer of funds and information between retailers and cardholders' financial institutions. That means infiltrating Heartland was like breaking into Fort Knox.

It's been estimated that as many as 100 million cards issued by more than 650 financial services companies may have been compromised during the Heartland breach. Said the firm's CEO, this was "the worst thing that can happen to a payments company and it happened to us" (King, 2009). Wall Street noticed. The firm's stock tanked—within a month, its market capitalization had plummeted over 75 percent, dropping over half a billion dollars in value (Claburn, 2009).

The Heartland case provides a cautionary warning against thinking that security ends with compliance. Heartland had in fact passed multiple audits, including one conducted the month before the infiltration began. Still, at least thirteen pieces of malware were uncovered on the firm's servers. Compliance does not equal security. Heartland was complaint, but a firm can be compliant and not be secure. Compliance is not the goal, security is.

Since the breach, the firm's executives have championed industry efforts to expand security practices, including encrypting card information at the point it is swiped and keeping it secure through settlement. Such "cradle-to-grave" encryption can help create an environment where even compromised networking equipment or intercepting relay systems wouldn't be able to grab codes (Claburn, 2009; King, 2009). Recognize that security is a continual process, it is never done, and firms need to pursue security with tenacity and commitment.

Education, Audit, and Enforcement

Security is as much about people, process, and policy, as it is about technology.

From a people perspective, the security function requires multiple levels of expertise. Operations employees are involved in the day-to-day monitoring of existing systems. A group's R&D function is involved in understanding emerging threats and reviewing, selecting, and implementing updated security techniques. A team must also work on broader governance issues. These efforts should include representatives from specialized security and broader technology and infrastructure functions. It should also include representatives from general counsel, audit, public relations, and human resources. What this means is that even if you're a nontechnical staffer, you may be brought in to help a firm deal with security issues.

Processes and policies will include education and awareness—this is also everyone's business. As the Vice President of Product Development at security firm Symantec puts it, "We do products really well, but the next step is education. We can't keep the Internet safe with antivirus software alone" (Goldman, 2009). Companies should approach information security as a part of their "collective corporate responsibility…regardless of whether regulation requires them to do so[1]."

For a lesson in how important education is, look no further than the head of the CIA. Former U.S. Director of Intelligence John Deutch engaged in shockingly loose behavior with digital secrets, including keeping a daily journal of classified information—some 1,000+ pages—on memory cards he'd transport in his shirt pocket. He also downloaded and stored Pentagon information, including details of covert operations, at home on computers that his family used for routine Internet access (Lewis, 2000).

Employees need to know a firm's policies, be regularly trained, and understand that they will face strict penalties if they fail to meet their obligations. Policies without eyes (audit) and teeth (enforcement) won't be taken seriously. Audits include real-time monitoring of usage (e.g., who's accessing what, from where, how, and why; sound the alarm if an anomaly is detected), announced audits, and surprise spot checks. This function might also stage white hat demonstration attacks—attempts to hunt for and expose weaknesses, hopefully before hackers find them. Frameworks offer guidelines on auditing, but a recent survey found most organizations don't document enforcement procedures in their information security policies, that more than one-third do not audit or monitor user compliance with security policies, and that only 48 percent annually measure and review the effectiveness of security policies (Matwyshyn, 2009).

A firm's technology development and deployment processes must also integrate with the security team to ensure that from the start, applications, databases, and other systems are implemented with security in mind. The team will have specialized skills and monitor the latest threats and are able to advise on precautions necessary to be sure systems aren't compromised during installation, development, testing, and deployment.

What Needs to Be Protected and How Much Is Enough?

A worldwide study by PricewaterhouseCoopers and *Chief Security Officer* magazine revealed that most firms don't even know what they need to protect. Only 33 percent of executives responded that their organizations kept accurate inventory of the locations and jurisdictions where data was stored, and only 24 percent kept inventory of all third parties using their customer data

(Matwyshyn, 2009). What this means is that most firms don't even have an accurate read on where their valuables are kept, let alone how to protect them.

So information security should start with an inventory-style auditing and risk assessment. Technologies map back to specific business risks. What do we need to protect? What are we afraid might happen? And how do we protect it? Security is an economic problem, involving attack likelihood, costs, and prevention benefits. These are complex trade-offs that must consider losses from theft or resources, systems damage, data loss, disclosure of proprietary information, recovery, downtime, stock price declines, legal fees, government and compliance penalties, and intangibles such as damaged firm reputation, loss of customer and partner confidence, industry damage, promotion of adversary, and encouragement of future attacks.

While many firms skimp on security, firms also don't want to misspend, targeting exploits that aren't likely, while underinvesting in easily prevented methods to thwart common infiltration techniques. Hacker conventions like DefCon can show some really wild exploits. But it's up to the firm to assess how vulnerable it is to these various risks. The local donut shop has far different needs than a military installation, law enforcement agency, financial institution, or firm housing other high-value electronic assets. A skilled risk assessment team will consider these vulnerabilities and what sort of countermeasure investments should take place.

Economic decisions usually drive hacker behavior, too. While in some cases attacks are based on vendetta or personal reasons, in most cases exploit economics largely boils down to

Adversary ROI = Asset value to adversary – Adversary cost.

An adversary's costs include not only the resources, knowledge, and technology required for the exploit, but also the risk of getting caught. Make things tough to get at, and lobbying for legislation that imposes severe penalties on crooks can help raise adversary costs and lower your likelihood of becoming a victim.

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Technology's Role

Technical solutions often involve industrial strength variants of the previously discussed issues individuals can employ, so your awareness is already high. Additionally, an organization's approach will often leverage multiple layers of protection and incorporate a wide variety of protective measures.

Patch. Firms must be especially vigilant to pay attention to security bulletins and install software updates that plug existing holes, (often referred to as *patches*). Firms that don't plug known problems will be vulnerable to trivial and automated attacks. Unfortunately, many firms aren't updating all components of their systems with consistent attention. With operating systems automating security update installations, hackers have moved on to application targets. But a major study recently found that organizations took at least twice as long to patch application vulnerabilities as they take to patch operating system holes (Wildstrom, 2009). And remember, software isn't limited to conventional PCs and servers. Embedded systems abound, and connected, yet unpatched devices are vulnerable. Malware has infected everything from unprotected ATM machines (Lilly, 2009) to restaurant point-of-sale systems (McMillan, 2009) to fighter plane navigation systems (Matyszczyk, 2009).

As an example of unpatched vulnerabilities, consider the DNS cache poisoning exploit described earlier in this chapter. The discovery of this weakness was one of the biggest security stories the year it was discovered, and security experts saw this as a major threat. Teams of programmers worldwide raced to provide fixes for the most widely used versions of DNS software. Yet several months after patches were available, roughly one quarter of all DNS servers were still unpatched and exposed[2].

To be fair, not all firms delay patches out of negligence. Some organizations have legitimate concerns about testing whether the patch will break their system or whether the new technology contains a change that will cause problems down the road[3]. And there have been cases where patches themselves have caused problems. Finally, many software updates require that systems be taken down. Firms may have uptime requirements that make immediate patching difficult. But ultimately, unpatched systems are an open door for infiltration.

Lock down hardware. Firms range widely in the security regimes used to govern purchase through disposal system use. While some large firms such as Kraft are allowing employees to select their own hardware (Mac or PC, desktop or notebook, iPhone or BlackBerry) (Wingfield, 2009), others issue standard systems that prevent all unapproved software installation and force file saving to hardened, backed-up, scanned, and monitored servers. Firms in especially sensitive industries such as financial services may regularly reimage the hard drive of end-user PCs, completely replacing all the bits on a user's hard drive with a pristine, current version—effectively wiping out malware that might have previously sneaked onto a user's PC. Other lock-down methods might disable the boot capability of removable media (a common method for spreading viruses via inserted discs or USBs), prevent Wi-Fi use or require VPN encryption before allowing any network transmissions, and more. The cloud helps here, too. (See Chapter 10 "Software in Flux: Partly Cloudy and Sometimes Free".) Employers can also require workers to run all of their corporate applications inside a remote desktop where the actual executing hardware and software is elsewhere (likely hosted as a virtual machine session on the organization's servers), and the user is simply served an image of what is executing remotely. This seals the virtual PC off in a way that can be thoroughly monitored, updated, backed up, and locked down by the firm.

In the case of Kraft, executives worried that the firm's previously restrictive technology policies prevented employees from staying in step with trends. Employees opting into the system must sign an agreement promising they'll follow mandated security procedures. Still, financial services firms, law offices, health care providers, and others may need to maintain stricter control, for legal and industry compliance reasons.

Lock down the network. Network monitoring is a critical part of security, and a host of technical tools can help.

Firms employ firewalls to examine traffic as it enters and leaves the network, potentially blocking certain types of access, while permitting approved communication. Intrusion detection systems specifically look for unauthorized behavior, sounding the alarm and potentially taking action if something seems amiss. Some firms deploy honeypots—bogus offerings meant to distract attackers. If attackers take honeypot bait, firms may gain an opportunity to recognize the hacker's exploits, identify the IP address of intrusion, and take action to block further attacks and alert authorities.

Many firms also deploy blacklists—denying the entry or exit of specific IP addresses, products, Internet domains, and other communication restrictions. While blacklists block known bad guys, whitelists are even more restrictive—permitting communication only with approved entities or in an approved manner.

These technologies can be applied to network technology, specific applications, screening for certain kinds of apps, malware signatures, and hunting for anomalous patterns. The latter is important, as recent malware has become polymorphic, meaning different versions are created and deployed in a way that their signature, a sort of electronic fingerprint often used to recognize malicious code, is slightly altered. This also helps with zero-day exploits, and in situations where whitelisted Web sites themselves become compromised.

Many technical solutions, ranging from network monitoring and response to e-mail screening, are migrating to "the cloud." This can be a good thing—if network monitoring software immediately shares news of a certain type of attack, defenses might be pushed out to all clients of a firm (the more users, the "smarter" the system can potentially become—again we see the power of network effects in action).

Lock down partners. Insist partner firms are compliant, and audit them to ensure this is the case. This includes technology providers and contract firms, as well as value chain participants such as suppliers and distributors. Anyone who touches your network is a potential point of weakness. Many firms will build security expectations and commitments into performance guarantees known as service level agreements (SLAs).

Lock down systems. Audit for SQL injection and other application exploits. The security team must constantly scan exploits and then probe its systems to see if it's susceptible, advising and enforcing action if problems are uncovered. This kind of auditing should occur with all of a firm's partners.

Access controls can also compartmentalize data access on a need-to-know basis. Such tools can not only enforce access privileges, they can help create and monitor audit trails to help verify that systems are not being accessed by the unauthorized, or in suspicious ways.

Audit trails are used for deterring, identifying, and investigating these cases. Recording, monitoring, and auditing access allows firms to hunt for patterns of abuse. Logs can detail who, when, and from where assets are accessed. Giveaways of nefarious activity may include access from unfamiliar IP addresses, from nonstandard times, accesses that occur at higher than usual volumes, and so on. Automated alerts can put an account on hold or call in a response team for further observation of the anomaly.

Single-sign-on tools can help firms offer employees one very strong password that works across applications, is changed frequently (or managed via hardware cards or mobile phone log-in), and can be altered by password management staff.

Multiple administrators should jointly control key systems. Major configuration changes might require approval of multiple staffers, as well as the automatic notification of concerned personnel. And firms should employ a recovery mechanism to regain control in the event that key administrators are incapacitated or uncooperative. This balances security needs with an ability to respond in the event of a crisis. Such a system was not in place in the earlier described case of the rogue IT staffer who held the city of San Francisco's networks hostage by refusing to give up vital passwords.

Have failure and recovery plans. While firms work to prevent infiltration attempts, they should also have provisions in place that plan for the worst. If a compromise has taken place, what needs to be done? Do stolen assets need to be devalued (e.g., accounts terminated, new accounts issued)? What should be done to notify customers and partners, educate them, and advise them through any necessary responses? Who should work with law enforcement and with the media? Do off-site backups or redundant systems need to be activated? Can systems be reliably restored without risking further damage?

Best practices are beginning to emerge. While postevent triage is beyond the scope of our introduction, the good news is that firms are now sharing data on breaches. Given the potential negative consequences of a breach, organizations once rarely admitted they'd been compromised. But now many are obligated to do so. And the broad awareness of infiltration both reduces organizational stigma in coming forward, and allows firms and technology providers to share knowledge on the techniques used by cybercrooks.

Information security is a complex, continually changing, and vitally important domain. The exploits covered in this chapter seem daunting, and new exploits constantly emerge. But your thinking on key issues should now be broader. Hopefully you've now embedded security thinking in your managerial DNA, and you are better prepared to be a savvy system user and a proactive participant working for your firm's security. Stay safe!

Key Takeaways

- End users can engage in several steps to improve the information security of themselves and their organizations. These include surfing smart, staying vigilant, updating software and products, using a comprehensive security suite, managing settings and passwords responsibly, backing up, properly disposing of sensitive assets, and seeking education.
- Frameworks such as ISO27k can provide a road map to help organizations plan and implement an effective security regime.
- Many organizations are bound by security compliance commitments and will face fines and retribution if they fail to meet these commitments.
- The use of frameworks and being compliant is not equal to security. Security is a continued process that must be constantly addressed and deeply ingrained in an organization's culture.
- Security is about trade-offs—economic and intangible. Firms need to understand their assets and risks in order to best allocate resources and address needs.
- Information security is not simply a technical fix. Education, audit, and enforcement regarding firm policies are critical. The security team is broadly skilled and constantly working to identify and incorporate new technologies and methods into their organizations. Involvement and commitment is essential from the boardroom to frontline workers, and out to customers and partners.

Questions and Exercises

1. Visit the security page for your ISP, school, or employer. What techniques do they advocate that we've discussed here? Are there any additional techniques mentioned and discussed? What additional provisions do they offer (tools, services) to help keep you informed and secure?
2. What sorts of security regimes are in use at your university, and at firms you've worked or interned for? If you don't have experience with this, ask a friend or relative for their professional experiences. Do you consider these measures to be too restrictive, too lax, or about right?
3. While we've discussed the risks in having security that is too lax, what risk does a firm run if its security mechanisms are especially strict? What might a firm give up? What are the consequences of strict end-user security provisions?
4. What risks does a firm face by leaving software unpatched? What risks does it face if it deploys patches as soon as they emerge? How should a firm reconcile these risks?
5. What methods do firms use to ensure the integrity of their software, their hardware, their networks, and their partners?
6. An organization's password management system represents "the keys to the city." Describe personnel issues that a firm should be concerned with regarding password administration. How might it address these concerns?

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8.9: Summary

Summary

As computing and networking resources have become more and more an integral part of business, they have also become a target of criminals. Organizations must be vigilant with the way they protect their resources. The same holds true for us personally: as digital devices become more and more intertwined with our lives, it becomes crucial for us to understand how to protect ourselves.

Study Questions

1. Briefly define each of the three members of the information security triad.
2. What does the term *authentication* mean?
3. What is multi-factor authentication?
4. What is role-based access control?
5. What is the purpose of encryption?
6. What are two good examples of a complex password?
7. What is pretexting?
8. What are the components of a good backup plan?
9. What is a firewall?
10. What does the term *physical security* mean?

Exercises

1. Describe one method of multi-factor authentication that you have experienced and discuss the pros and cons of using multi-factor authentication.
2. What are some of the latest advances in encryption technologies? Conduct some independent research on encryption using scholarly or practitioner resources, then write a two- to three-page paper that describes at least two new advances in encryption technology.
3. What is the password policy at your place of employment or study? Do you have to change passwords every so often? What are the minimum requirements for a password?
4. When was the last time you backed up your data? What method did you use? In one to two pages, describe a method for backing up your data. Ask your instructor if you can get extra credit for backing up your data.
5. Find the information security policy at your place of employment or study. Is it a good policy? Does it meet the standards outlined in the chapter?
6. How are you doing on keeping your own information secure? Review the steps listed in the chapter and comment on how well you are doing.

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CHAPTER OVERVIEW

9: Appendix

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SECTION OVERVIEW

9.1: supplemental- Logical Models

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SECTION OVERVIEW

9.1.1: Networking

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9.1.1.1: Applications

Most people know the Internet through its applications: the World Wide Web, email, social media, streaming music or movies, videoconferencing, instant messaging, file-sharing, to name just a few examples. That is to say, we interact with the Internet as *users* of the network. Internet users represent the largest class of people who interact with the Internet in some way, but there are several other important constituencies.

There is the group of people who *create* the applications—a group that has greatly expanded in recent years as powerful programming platforms and new devices such as smartphones have created new opportunities to develop applications quickly and to bring them to a large market.

Then there are those who *operate* or *manage* networks—mostly a behind-the-scenes job, but a critical one and often a very complex one. With the prevalence of home networks, more and more people are also becoming, if only in a small way, network operators.

Finally, there are those who *design* and *build* the devices and protocols that collectively make up the Internet. That final constituency is the traditional target of networking textbooks such as this one and will continue to be our main focus. However, throughout this book we will also consider the perspectives of application developers and network operators.

Considering these perspectives will enable us to better understand the diverse requirements that a network must meet. Application developers will also be able to make applications that work better if they understand how the underlying technology works and interacts with the applications. So, before we start figuring out how to build a network, let's look more closely at the types of applications that today's networks support.

Classes of Applications

The World Wide Web is the Internet application that catapulted the Internet from a somewhat obscure tool used mostly by scientists and engineers to the mainstream phenomenon that it is today. The Web itself has become such a powerful platform that many people confuse it with the Internet, and it's a bit of a stretch to say that the Web is a single application.

In its basic form, the Web presents an intuitively simple interface. Users view pages full of textual and graphical objects and click on objects that they want to learn more about, and a corresponding new page appears. Most people are also aware that just under the covers each selectable object on a page is bound to an identifier for the next page or object to be viewed. This identifier, called a Uniform Resource Locator (URL), provides a way of identifying all the possible objects that can be viewed from your web browser. For example,

```
http://www.cs.princeton.edu/llp/index.html
```

is the URL for a page providing information about one of this book's authors: the string `http` indicates that the Hypertext Transfer Protocol (HTTP) should be used to download the page, `www.cs.princeton.edu` is the name of the machine that serves the page, and `/llp/index.html` uniquely identifies Larry's home page at this site.

What most web users are not aware of, however, is that by clicking on just one such URL over a dozen messages may be exchanged over the Internet, and many more than that if the web page is complicated with lots of embedded objects. This message exchange includes up to six messages to translate the server name (`www.cs.princeton.edu`) into its Internet Protocol (IP) address (`128.112.136.35`), three messages to set up a Transmission Control Protocol (TCP) connection between your browser and this server, four messages for your browser to send the HTTP "GET" request and the server to respond with the requested page (and for each side to acknowledge receipt of that message), and four messages to tear down the TCP connection. Of course, this does not include the millions of messages exchanged by Internet nodes throughout the day, just to let each other know that they exist and are ready to serve web pages, translate names to addresses, and forward messages toward their ultimate destination.

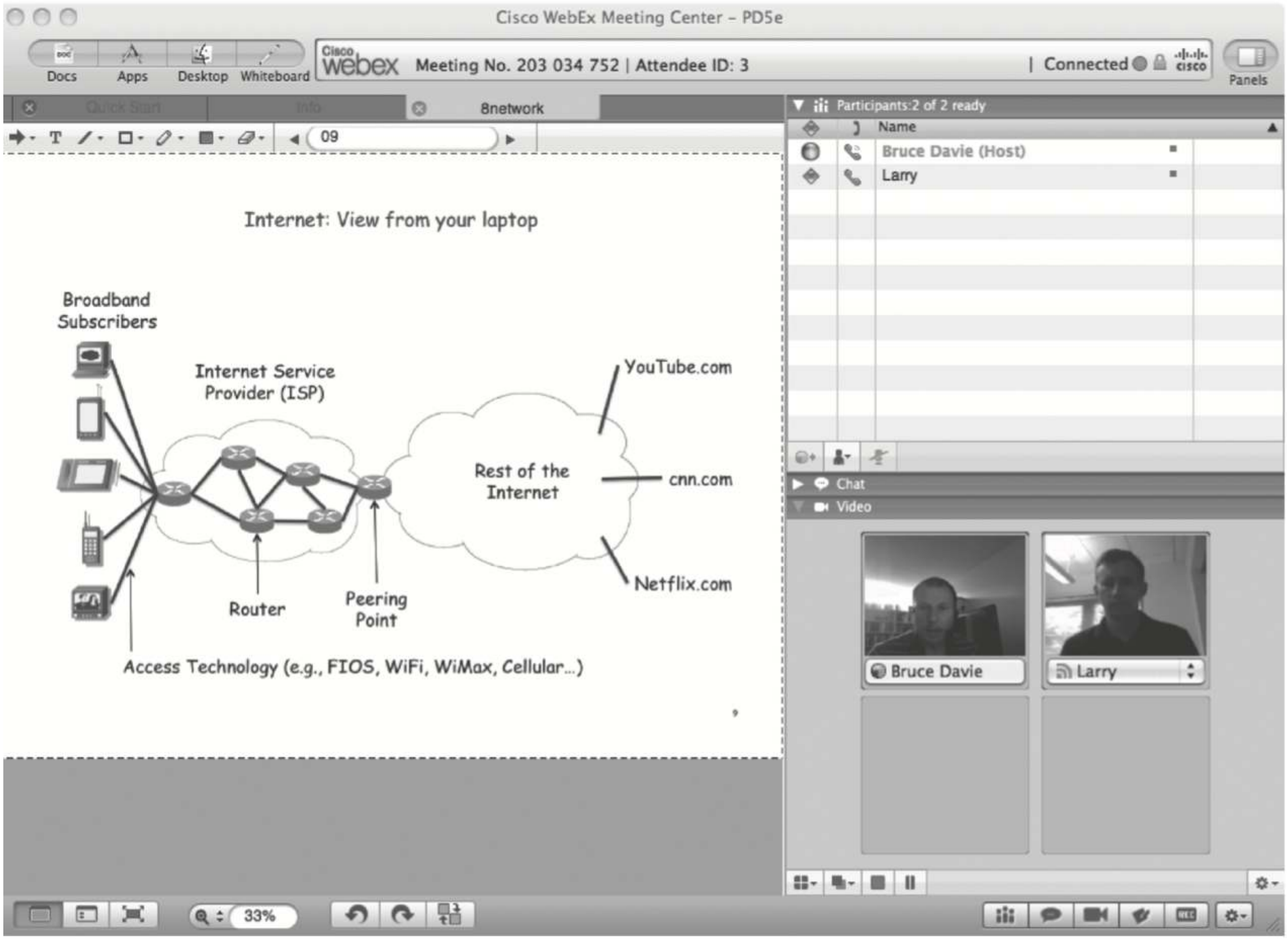
Another widespread application class of the Internet is the delivery of "streaming" audio and video. Services such as video on demand and Internet radio use this technology. While we frequently start at a website to initiate a streaming session, the delivery of audio and video has some important differences from fetching a simple web page of text and images. For example, you often don't want to download an entire video file—a process that might take a few minutes—before watching the first scene. Streaming audio and video implies a more timely transfer of messages from sender to receiver, and the receiver displays the video or plays the audio pretty much as it arrives.

Note that the difference between streaming applications and the more traditional delivery of a page of text or still images is that humans consume audio and video streams in a continuous manner, and discontinuity—in the form of skipped sounds or stalled video—is not acceptable. By contrast, a page of text can be delivered and read in bits and pieces. This difference affects how the network supports these different classes of applications.

A subtly different application class is *real-time* audio and video. These applications have considerably tighter timing constraints than streaming applications. When using a voice-over-IP application such as Skype or a videoconferencing application, the interactions among the participants must be timely. When a person at one end gestures, then that action must be displayed at the other end as quickly as possible.

> *Not quite "as soon as possible"... Human factors research indicates 300 ms is a reasonable upper bound for how much round-trip delay can be tolerated in a telephone call before humans complain, and a 100-ms delay sounds very good.*

When one person tries to interrupt another, the interrupted person needs to hear that as soon as possible and decide whether to allow the interruption or to keep talking over the interrupter. Too much delay in this sort of environment makes the system unusable. Contrast this with video on demand where, if it takes several seconds from the time the user starts the video until the first image is displayed, the service is still deemed satisfactory. Also, interactive applications usually entail audio and/or video flows in both directions, while a streaming application is most likely sending video or audio in only one direction.



A multimedia application including videoconferencing.

Videoconferencing tools that run over the Internet have been around now since the early 1990s but have achieved widespread use in the last few years, with several commercial products on the market. An example of one such system is shown in Figure 1. Just as downloading a web page involves a bit more than meets the eye, so too with video applications. Fitting the video content into a relatively low bandwidth network, for example, or making sure that the video and audio remain in sync and arrive in time for a good user experience are all problems that network and protocol designers have to worry about. We'll look at these and many other issues related to multimedia applications later in the book.

Although they are just two examples, downloading pages from the web and participating in a videoconference demonstrate the diversity of applications that can be built on top of the Internet and hint at the complexity of the Internet's design. Later in the book we will develop a more complete taxonomy of application types to help guide our discussion of key design decisions as we seek to build, operate, and use networks that such a wide range of applications. The book concludes by revisiting these two specific applications, as well as several others that illustrate the breadth of what is possible on today's Internet.

For now, this quick look at a few typical applications will suffice to enable us to start looking at the problems that must be addressed if we are to build a network that supports such application diversity.

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9.1.1.2: Requirements

Requirements

We have established an ambitious goal for ourselves: to understand how to build a computer network from the ground up. Our approach to accomplishing this goal will be to start from first principles and then ask the kinds of questions we would naturally ask if building an actual network. At each step, we will use today's protocols to illustrate various design choices available to us, but we will not accept these existing artifacts as gospel. Instead, we will be asking (and answering) the question of *why* networks are designed the way they are. While it is tempting to settle for just understanding the way it's done today, it is important to recognize the underlying concepts because networks are constantly changing as technology evolves and new applications are invented. It is our experience that once you understand the fundamental ideas, any new protocol that you are confronted with will be relatively easy to digest.

Stakeholders

As we noted above, a student of networks can take several perspectives. When we wrote the first edition of this book, the majority of the population had no Internet access at all, and those who did obtained it while at work, at a university, or by a dial-up modem at home. The set of popular applications could be counted on one's fingers. Thus, like most books at the time, ours focused on the perspective of someone who would design networking equipment and protocols. We continue to focus on this perspective, and our hope is that after reading this book you will know how to design the networking equipment and protocols of the future.

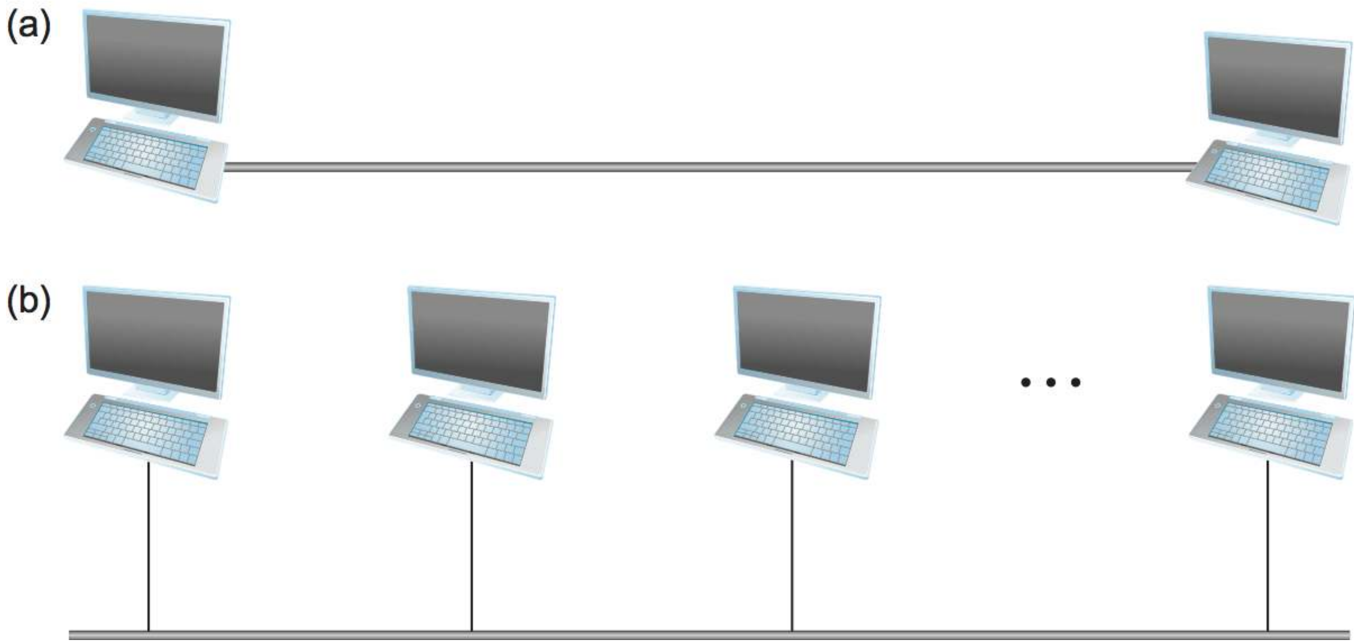
However, we also want to cover the perspectives of two additional stakeholders: those who develop networked applications and those who manage or operate networks. Let's consider how these three stakeholders might list their requirements for a network:

This section attempts to distill the requirements of different stakeholders into a high-level introduction to the major considerations that drive network design and, in doing so, identify the challenges addressed throughout the rest of this book.

Scalable Connectivity

Starting with the obvious, a network must provide connectivity among a set of computers. Sometimes it is enough to build a limited network that connects only a few select machines. In fact, for reasons of privacy and security, many private (corporate) networks have the explicit goal of limiting the set of machines that are connected. In contrast, other networks (of which the Internet is the prime example) are designed to grow in a way that allows them the potential to connect all the computers in the world. A system that is designed to support growth to an arbitrarily large size is said to *scale*. Using the Internet as a model, this book addresses the challenge of scalability.

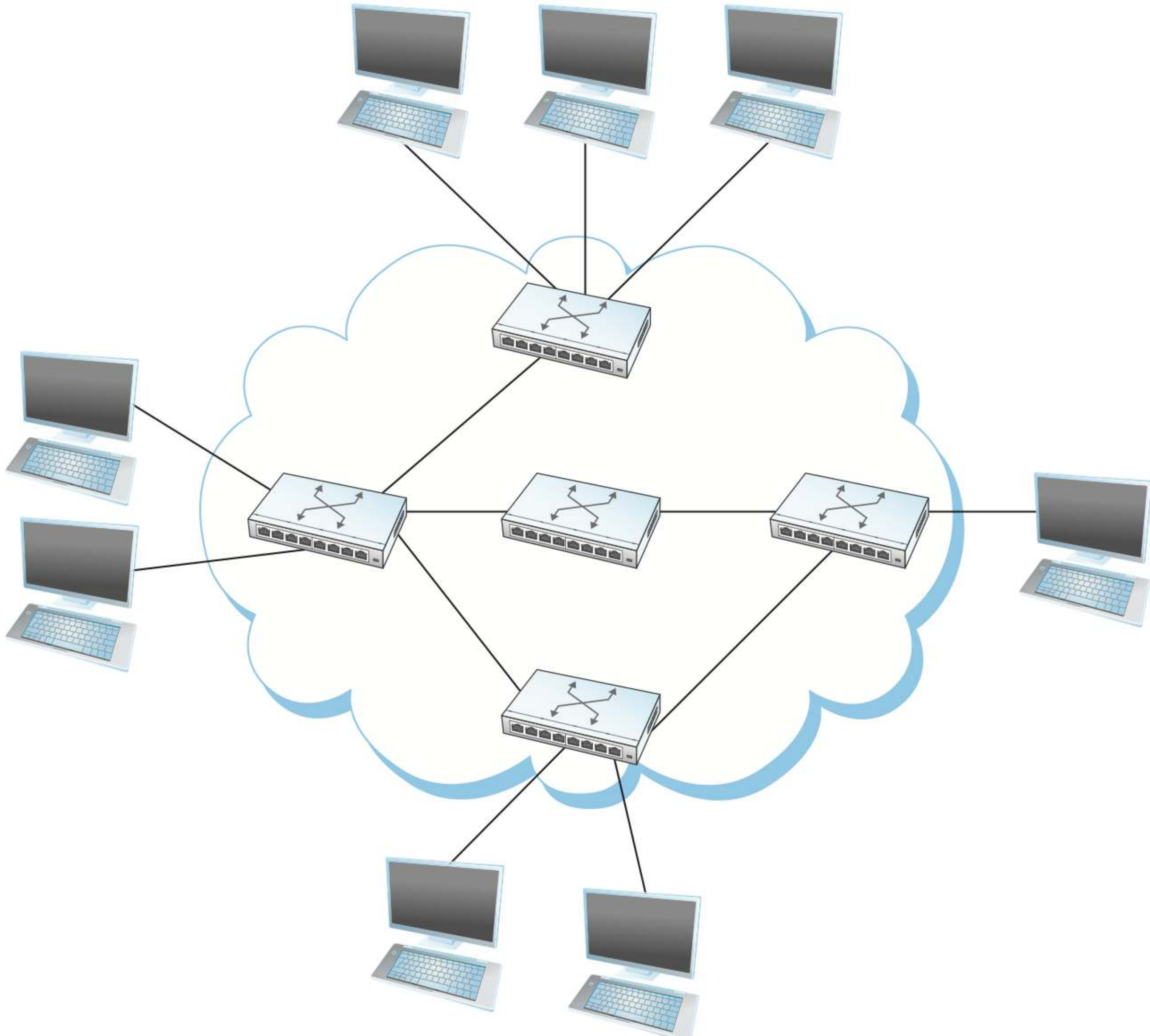
To understand the requirements of connectivity more fully, we need to take a closer look at how computers are connected in a network. Connectivity occurs at many different levels. At the lowest level, a network can consist of two or more computers directly connected by some physical medium, such as a coaxial cable or an optical fiber. We call such a physical medium a *link*, and we often refer to the computers it connects as *nodes*. (Sometimes a node is a more specialized piece of hardware rather than a computer, but we overlook that distinction for the purposes of this discussion.) As illustrated in Figure 1, physical links are sometimes limited to a pair of nodes (such a link is said to be *point-to-point*), while in other cases more than two nodes may share a single physical link (such a link is said to be *multiple-access*). Wireless links, such as those provided by cellular networks and Wi-Fi networks, are an important class of multiple-access links. It is always the case that multiple-access links are limited in size, in terms of both the geographical distance they can cover and the number of nodes they can connect.



Direct links: (a) point-to-point; (b) multiple-access.

If computer networks were limited to situations in which all nodes are directly connected to each other over a common physical medium, then either networks would be very limited in the number of computers they could connect, or the number of wires coming out of the back of each node would quickly become both unmanageable and very expensive. Fortunately, connectivity between two nodes does not necessarily imply a direct physical connection between them—indirect connectivity may be achieved among a set of cooperating nodes. Consider the following two examples of how a collection of computers can be indirectly connected.

Figure 2 shows a pair of shows a set of nodes, each of which is attached to one or more point-to-point links. Those nodes that are attached to at least two links run software that forwards data received on one link out on another. If organized in a systematic way, these forwarding nodes form a *switched network*. There are numerous types of switched networks, of which the two most common are *circuit switched* and *packet switched*. The former is most notably employed by the telephone system, while the latter is used for the overwhelming majority of computer networks and will be the focus of this book. (Circuit switching is, however, making a bit of a comeback in the optical networking realm, which turns out to be important as demand for network capacity constantly grows.) The important feature of packet-switched networks is that the nodes in such a network send discrete blocks of data to each other. Think of these blocks of data as corresponding to some piece of application data such as a file, a piece of email, or an image. We call each block of data either a *packet* or a *message*, and for now we use these terms interchangeably.



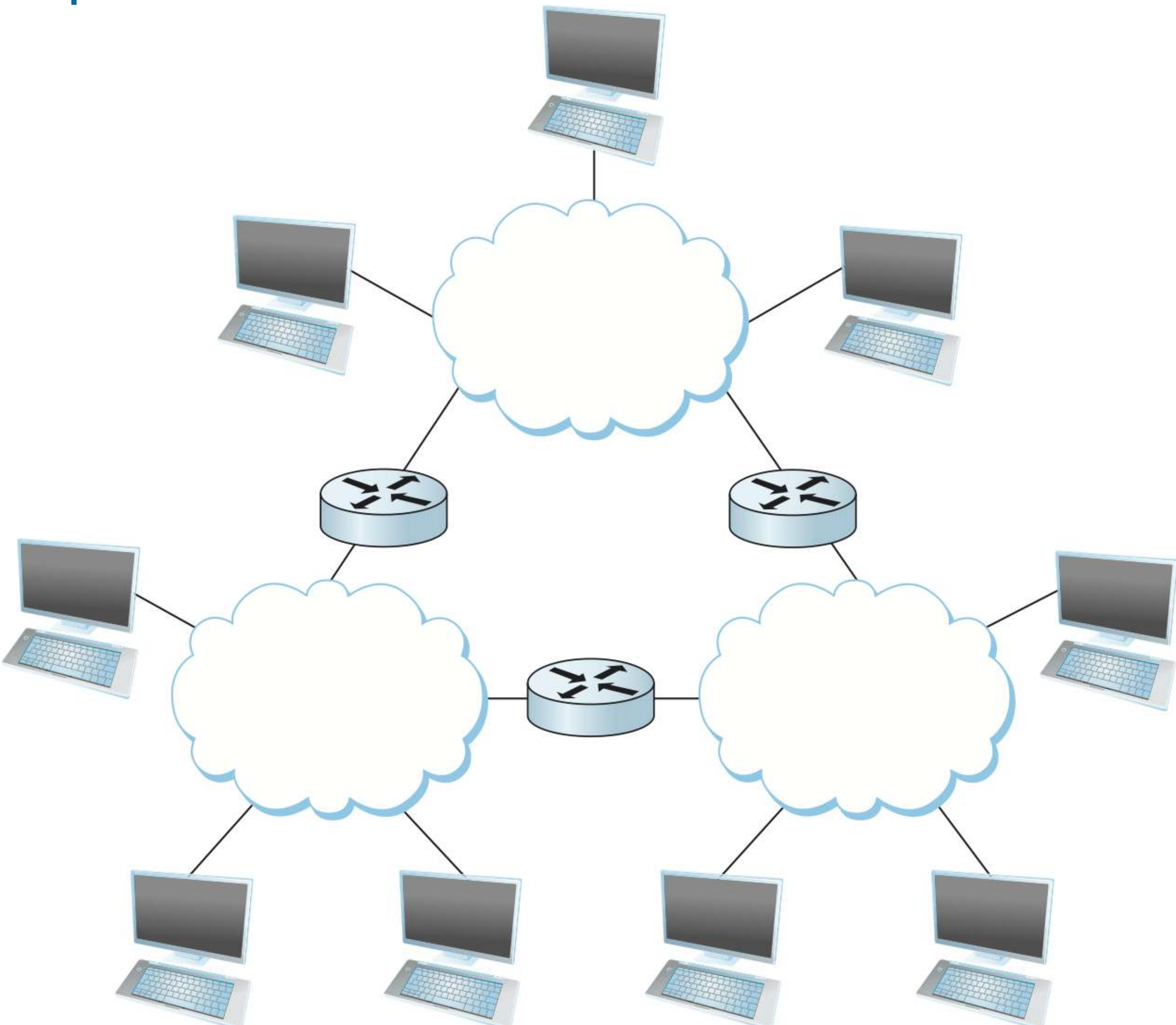
Switched network.

Packet-switched networks typically use a strategy called *store-and-forward*. As the name suggests, each node in a store-and-forward network first receives a complete packet over some link, stores the packet in its internal memory, and then forwards the complete packet to the next node. In contrast, a circuit-switched network first establishes a dedicated circuit across a sequence of links and then allows the source node to send a stream of bits across this circuit to a destination node. The major reason for using packet switching rather than circuit switching in a computer network is efficiency, discussed in the next subsection.

The cloud in Figure 2 distinguishes between the nodes on the inside that *implement* the network (they are commonly called *switches*, and their primary function is to store and forward packets) and the nodes on the outside of the cloud that *use* the network (they are traditionally called *hosts*, and they support users and run application programs). Also note that the cloud is one of the most important icons of computer networking. In general, we use a cloud to denote any type of network, whether it is a single point-to-point link, a multiple-access link, or a switched network. Thus, whenever you see a cloud used in a figure, you can think of it as a placeholder for any of the networking technologies covered in this book.

> *Interestingly, the use of clouds in this way predates the term cloud computing by at least a couple of decades, but there is a connection between these two usages, which we'll discuss*

later.



Interconnection of networks.

A second way in which a set of computers can be indirectly connected is shown in Figure 3. In this situation, a set of independent networks (clouds) are interconnected to form an *internetwork*, or internet for short. We adopt the Internet's convention of referring to a generic internetwork of networks as a lowercase *i* internet, and the currently operational TCP/IP Internet as the capital *I* Internet. A node that is connected to two or more networks is commonly called a *router* or *gateway*, and it plays much the same role as a switch—it forwards messages from one network to another. Note that an internet can itself be viewed as another kind of network, which means that an internet can be built from an of internets. Thus, we can recursively build arbitrarily large networks by interconnecting clouds to form larger clouds. It can reasonably be argued that this idea of interconnecting widely differing networks was the fundamental innovation of the Internet and that the successful growth of the Internet to global size and billions of nodes was the result of some very good design decisions by the early Internet architects, which we will discuss later.

Just because a set of hosts are directly or indirectly connected to each other does not mean that we have succeeded in providing host-to-host connectivity. The final requirement is that each node must be able to say which of the other nodes on the network it wants to communicate with. This is done by assigning an *address* to each node. An address is a byte string that identifies a node; that is, the network can use a node's address to distinguish it from the other nodes connected to the network. When a source node wants the network to deliver a message to a certain destination node, it specifies the address of the destination node. If the sending and receiving nodes are not directly connected, then the switches and routers of the network use this address to decide how to forward the message toward the destination. The process of determining systematically how to forward messages toward the destination node based on its address is called *routing*.

This brief introduction to addressing and routing has presumed that the source node wants to send a message to a single destination node (*unicast*). While this is the most common scenario, it is also possible that the source node might want to *broadcast* a message to all the nodes on the network. Or, a source node might want to send a message to some subset of the other nodes but not all of them, a situation called *multicast*. Thus, in addition to node-specific addresses, another requirement of a network is that it supports multicast and broadcast addresses.

> ***Key Takeaway***
>
> *The main idea to take away from this discussion is that we can define a network recursively as consisting of two or more nodes connected by a physical link, or as two or more networks connected by a node. In other words, a network can be constructed from a nesting of networks, where at the bottom level, the network is implemented by some physical medium. Among the key challenges in providing network connectivity are the definition of an address for each node that is reachable on the network (including support for broadcast and multicast), and the use of such addresses to forward messages toward the appropriate destination node(s).*

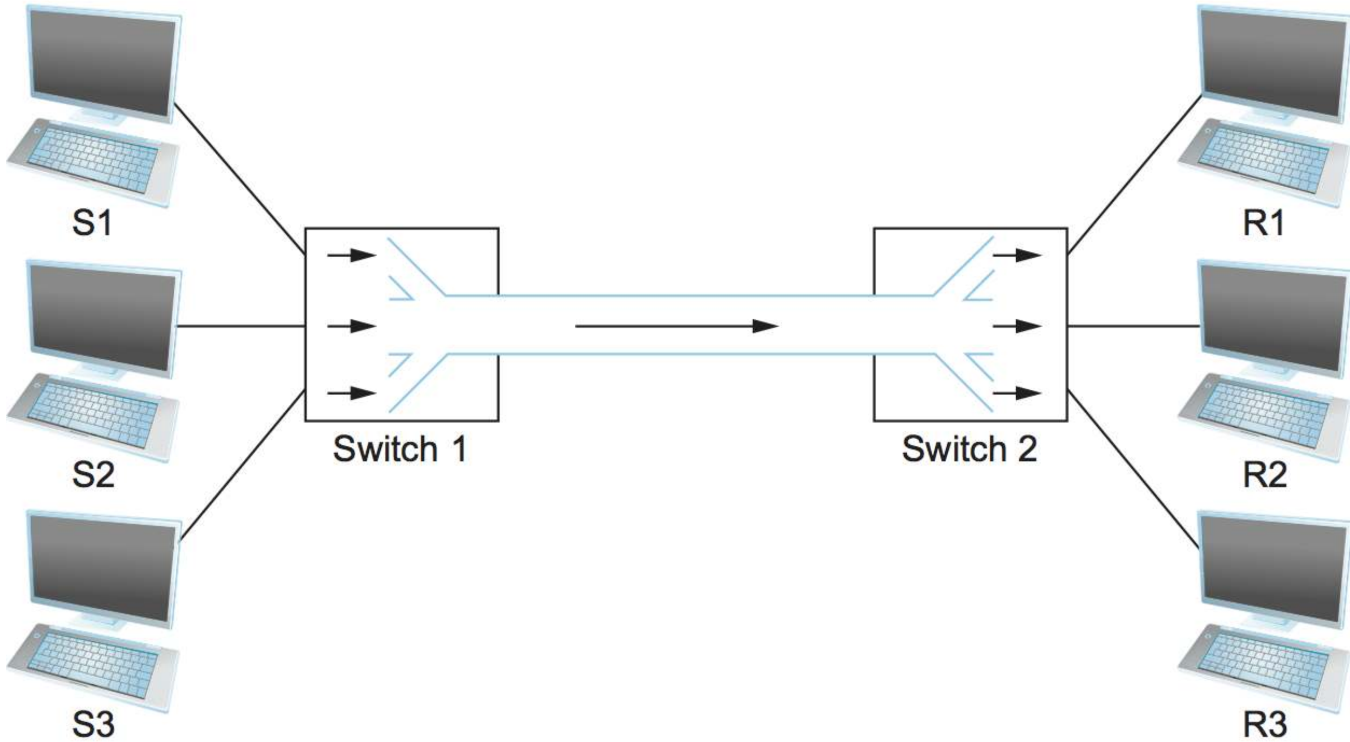
Cost-Effective Resource Sharing

As stated above, this book focuses on packet-switched networks. This section explains the key requirement of computer networks—efficiency—that leads us to packet switching as the strategy of choice.

Given a collection of nodes indirectly connected by a nesting of networks, it is possible for any pair of hosts to send messages to each other across a sequence of links and nodes. Of course, we want to do more than support just one pair of communicating hosts—we want to provide all pairs of hosts with the ability to exchange messages. The question, then, is how do all the hosts that want to communicate share the network, especially if they want to use it at the same time? And, as if that problem isn't hard enough, how do several hosts share the same *link* when they all want to use it at the same time?

To understand how hosts share a network, we need to introduce a fundamental concept, *multiplexing*, which means that a system resource is shared among multiple users. At an intuitive level, multiplexing can be explained by analogy to a timesharing computer system, where a single physical processor is shared (multiplexed) among multiple jobs, each of which believes it has its own private processor. Similarly, data being sent by multiple users can be multiplexed over the physical links that make up a network.

To see how this might work, consider the simple network illustrated in Figure 4, where the three hosts on the left side of the network (senders S1-S3) are sending data to the three hosts on the right (receivers R1-R3) by sharing a switched network that contains only one physical link. (For simplicity, assume that host S1 is sending data to host R1, and so on.) In this situation, three flows of data—corresponding to the three pairs of hosts—are multiplexed onto a single physical link by switch 1 and then *demultiplexed* back into separate flows by switch 2. Note that we are being intentionally vague about exactly what a "flow of data" corresponds to. For the purposes of this discussion, assume that each host on the left has a large supply of data that it wants to send to its counterpart on the right.



Multiplexing multiple logical flows over a single physical link.

There are several different methods for multiplexing multiple flows onto one physical link. One common method is *synchronous time-division multiplexing* (STDM). The idea of STDM is to divide time into equal-sized quanta and, in a round-robin fashion, give each flow a chance to send its data over the physical link. In other words, during time quantum 1, data from S1 to R1 is transmitted; during time quantum 2, data from S2 to R2 is transmitted; in quantum 3, S3 sends data to R3. At this point, the first flow (S1 to R1) gets to go again, and the process repeats. Another method is *frequency-division multiplexing* (FDM). The idea of FDM is to transmit each flow over the physical link at a different frequency, much the same way that the signals for different TV stations are transmitted at a different frequency over the airwaves or on a coaxial cable TV link.

Although simple to understand, both STDM and FDM are limited in two ways. First, if one of the flows (host pairs) does not have any data to send, its share of the physical link—that is, its time quantum or its frequency—remains idle, even if one of the other flows has data to transmit. For example, S3 had to wait its turn behind S1 and S2 in the previous paragraph, even if S1 and S2 had nothing to send. For computer communication, the amount of time that a link is idle can be very large—for example, consider the amount of time you spend reading a web page (leaving the link idle) compared to the time you spend fetching the page. Second, both STDM and FDM are limited to situations in which the maximum number of flows is fixed and known ahead of time. It is not practical to resize the quantum or to add additional quanta in the case of STDM or to add new frequencies in the case of FDM.

The form of multiplexing that addresses these shortcomings, and of which we make most use in this book, is called *statistical multiplexing*. Although the name is not all that helpful for understanding the concept, statistical multiplexing is really quite simple, with two key ideas. First, it is like STDM in that the physical link is shared over time—first data from one flow is transmitted over the physical link, then data from another flow is transmitted, and so on. Unlike STDM, however, data is transmitted from each flow on demand rather than during a predetermined time slot. Thus, if only one flow has data to send, it gets to transmit that data without waiting for its quantum to come around and thus without having to watch the quanta assigned to the other flows go by unused. It is this avoidance of idle time that gives packet switching its efficiency.

As defined so far, however, statistical multiplexing has no mechanism to ensure that all the flows eventually get their turn to transmit over the physical link. That is, once a flow begins sending data, we need some way to limit the transmission, so that the other flows can have a turn. To account for this need, statistical multiplexing defines an upper bound on the size of the block of data that each flow is permitted to transmit at a given time. This limited-size block of data is typically referred to as a *packet*, to distinguish it from the arbitrarily large *message* that an application program might want to transmit. Because a packet-switched network limits the maximum size of packets, a host may not be able to send a complete message in one packet. The source may need to fragment the message into several packets, with the receiver reassembling the packets back into the original message.

In other words, each flow sends a sequence of packets over the physical link, with a decision made on a packet-by-packet basis as to which flow's packet to send next. Notice that, if only one flow has data to send, then it can send a sequence of packets back-to-back; however, should more than one of the flows have data to send, then their packets are interleaved on the link. Figure 4 depicts a switch multiplexing packets from multiple sources onto a single shared link.

The decision as to which packet to send next on a shared link can be made in a number of different ways. For example, in a network consisting of switches interconnected by links such as the one in Figure 4, the decision would be made by the switch that transmits packets onto the shared link. (As we will see later, not all packet-switched networks actually involve switches, and they may use other mechanisms to determine whose packet goes onto the link next.) Each switch in a packet-switched network makes this decision independently, on a packet-by-packet basis. One of the issues that faces a network designer is how to make this decision in a fair manner. For example, a switch could be designed to service packets on a first-in, first-out (FIFO) basis. Another approach would be to transmit the packets from each of the different flows that are currently sending data through the switch in a round-robin manner. This might be done to ensure that certain flows receive a particular share of the link's bandwidth or that they never have their packets delayed in the switch for more than a certain length of time. A network that attempts to allocate bandwidth to particular flows is sometimes said to support *quality of service* (QoS).

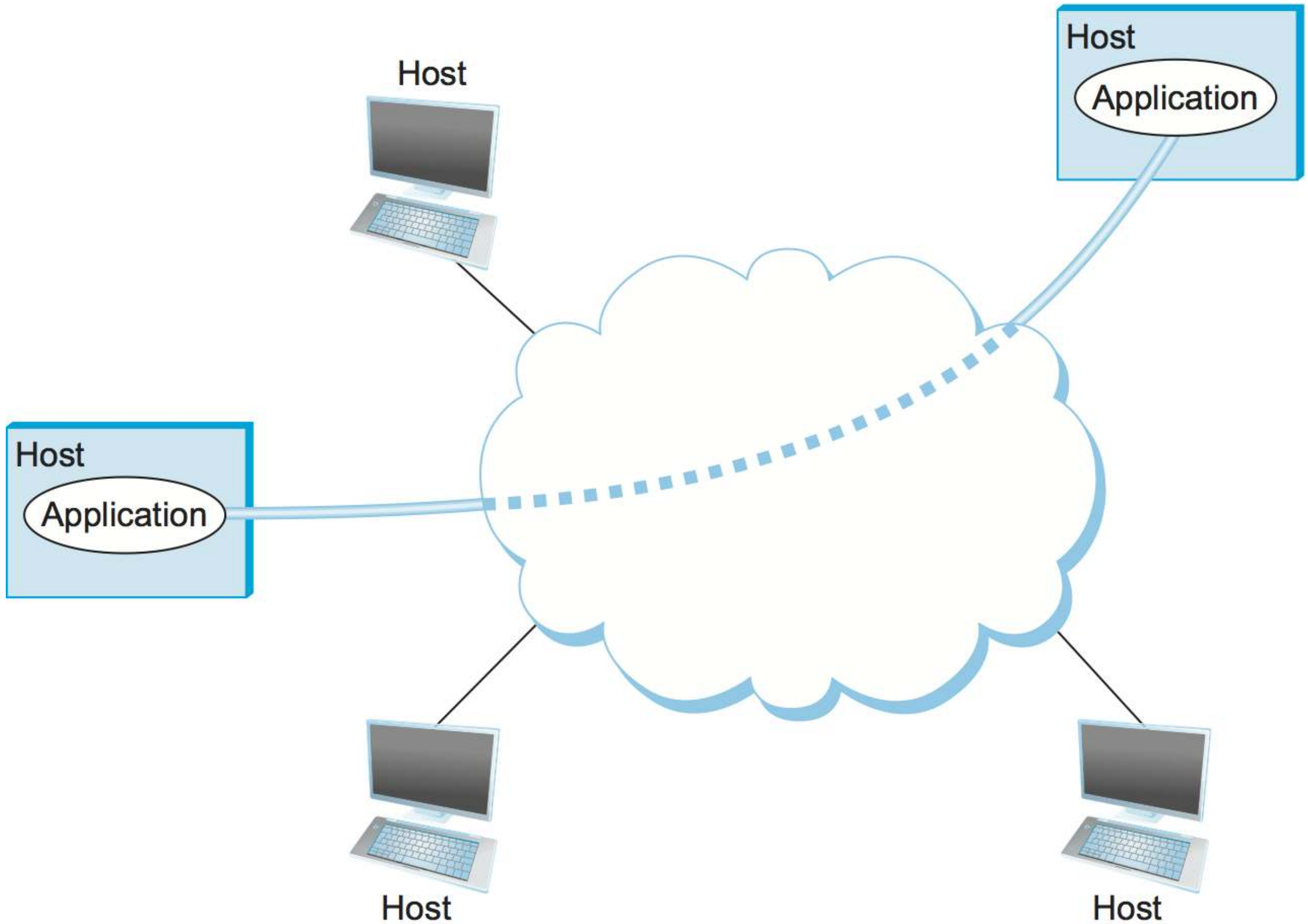
Also, notice in Figure 4 that since the switch has to multiplex three incoming packet streams onto one outgoing link, it is possible that the switch will receive packets faster than the shared link can accommodate. In this case, the switch is forced to buffer these packets in its memory. Should a switch receive packets faster than it can send them for an extended period of time, then the switch will eventually run out of buffer space, and some packets will have to be dropped. When a switch is operating in this state, it is said to be *congested*.

> ***Key Takeaway***
>
> *The bottom line is that statistical multiplexing defines a cost-effective way for multiple users (e.g., host-to-host flows of data) to share network resources (links and nodes) in a fine-grained manner. It defines the packet as the granularity with which the links of the network are allocated to different flows, with each switch able to schedule the use of the physical links it is connected to on a per-packet basis. Fairly allocating link capacity to different flows and dealing with congestion when it occurs are the key challenges of statistical multiplexing.*

Support for Common Services

The previous discussion focused on the challenges involved in providing cost-effective connectivity among a group of hosts, but it is overly simplistic to view a computer network as simply delivering packets among a collection of computers. It is more accurate to think of a network as providing the means for a set of application processes that are distributed over those computers to communicate. In other words, the next requirement of a computer network is that the application programs running on the hosts connected to the network must be able to communicate in a meaningful way. From the application developer's perspective, the network needs to make his or her life easier.

When two application programs need to communicate with each other, a lot of complicated things must happen beyond simply sending a message from one host to another. One option would be for application designers to build all that complicated functionality into each application program. However, since many applications need common services, it is much more logical to implement those common services once and then to let the application designer build the application using those services. The challenge for a network designer is to identify the right set of common services. The goal is to hide the complexity of the network from the application without overly constraining the application designer.



Processes communicating over an abstract channel.

Intuitively, we view the network as providing logical *channels* over which application-level processes can communicate with each other; each channel provides the set of services required by that application. In other words, just as we use a cloud to abstractly represent connectivity among a set of computers, we now think of a channel as connecting one process to another. Figure 5 shows a pair of application-level processes communicating over a logical channel that is, in turn, implemented on top of a cloud that connects a set of hosts. We can think of the channel as being like a pipe connecting two applications, so that a sending application can put data in one end and expect that data to be delivered by the network to the application at the other end of the pipe.

The challenge is to recognize what functionality the channels should provide to application programs. For example, does the application require a guarantee that messages sent over the channel are delivered, or is it acceptable if some messages fail to arrive? Is it necessary that messages arrive at the recipient process in the same order in which they are sent, or does the recipient not care about the order in which messages arrive? Does the network need to ensure that no third parties are able to eavesdrop on the channel, or is privacy not a concern? In general, a network provides a variety of different types of channels, with each application selecting the type that best meets its needs. The rest of this section illustrates the thinking involved in defining useful channels.

Identify Common Communication Patterns

Designing abstract channels involves first understanding the communication needs of a representative collection of applications, then extracting their common communication requirements, and finally incorporating the functionality that meets these requirements in the network.

One of the earliest applications supported on any network is a file access program like the File Transfer Protocol (FTP) or Network File System (NFS). Although many details vary—for example, whether whole files are transferred across the network or only single blocks of the file are read/written at a given time—the communication component of remote file access is characterized by a pair of processes, one that requests that a file be read or written and a second process that honors this request. The process that requests access to the file is called the *client*, and the process that supports access to the file is called the *server*.

Reading a file involves the client sending a small request message to a server and the server responding with a large message that contains the data in the file. Writing works in the opposite way—the client sends a large message containing the data to be written to the server, and the server responds with a small message confirming that the write to disk has taken place.

A digital library is a more sophisticated application than file transfer, but it requires similar communication services. For example, the *Association for Computing Machinery* (ACM) operates a large digital library of computer science literature at

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http://portal.acm.org/dl.cfm
```

This library has a wide range of searching and browsing features to help users find the articles they want, but ultimately much of what it does is respond to user requests for files, such as electronic copies of journal articles.

Using file access, a digital library, and the two video applications described in the introduction (videoconferencing and video on demand) as a representative sample, we might decide to provide the following two types of channels: *request/reply* channels and *message stream* channels. The request/reply channel would be used by the file transfer and digital library applications. It would guarantee that every message sent by one side is received by the other side and that only one copy of each message is delivered. The request/reply channel might also protect the privacy and integrity of the data that flows over it, so that unauthorized parties cannot read or modify the data being exchanged between the client and server processes.

The message stream channel could be used by both the video on demand and videoconferencing applications, provided it is parameterized to support both one-way and two-way traffic and to support different delay properties. The message stream channel might not need to guarantee that all messages are delivered, since a video application can operate adequately even if some video frames are not received. It would, however, need to ensure that those messages that are delivered arrive in the same order in which they were sent, to avoid displaying frames out of sequence. Like the request/reply channel, the message stream channel might want to ensure the privacy and integrity of the video data. Finally, the message stream channel might need to support multicast, so that multiple parties can participate in the teleconference or view the video.

While it is common for a network designer to strive for the smallest number of abstract channel types that can serve the largest number of applications, there is a danger in trying to get away with too few channel abstractions. Simply stated, if you have a hammer, then everything looks like a nail. For example, if all you have are message stream and request/reply channels, then it is tempting to use them for the next application that comes along, even if neither type provides exactly the semantics needed by the application. Thus, network designers will probably be inventing new types of channels—and adding options to existing channels—for as long as application programmers are inventing new applications.

Also note that independent of exactly *what* functionality a given channel provides, there is the question of *where* that functionality is implemented. In many cases, it is easiest to view the host-to-host connectivity of the underlying network as simply providing a *bit pipe*, with any high-level communication semantics provided at the end hosts. The advantage of this approach is that it keeps the switches in the middle of the network as simple as possible—they simply forward packets—but it requires the end hosts to take on much of the burden of supporting semantically rich process-to-process channels. The alternative is to push additional functionality onto the switches, thereby allowing the end hosts to be "dumb" devices (e.g., telephone handsets). We will see this question of how various network services are partitioned between the packet switches and the end hosts (devices) as a recurring issue in network design.

Reliable Message Delivery

As suggested by the examples just considered, reliable message delivery is one of the most important functions that a network can provide. It is difficult to determine how to provide this reliability, however, without first understanding how networks can fail. The first thing to recognize is that computer networks do not exist in a perfect world. Machines crash and later are rebooted, fibers are cut, electrical interference corrupts bits in the data being transmitted, switches run out of buffer space, and, as if these sorts of physical problems aren't enough to worry about, the software that manages the hardware may contain bugs and sometimes forwards packets into oblivion. Thus, a major requirement of a network is to recover from certain kinds of failures, so that application programs don't have to deal with them or even be aware of them.

There are three general classes of failure that network designers have to worry about. First, as a packet is transmitted over a physical link, *bit errors* may be introduced into the data; that is, a 1 is turned into a 0 or *vice versa*. Sometimes single bits are corrupted, but more often than not a *burst error* occurs—several consecutive bits are corrupted. Bit errors typically occur because outside forces, such as lightning strikes, power surges, and microwave ovens, interfere with the transmission of data. The good news is that such bit errors are fairly rare, affecting on average only one out of every 10^{6}6 to 10^{7}7 bits on a typical copper-based cable and one out of every 10^{12}12 to 10^{14}14 bits on a typical optical fiber. As we will see, there are techniques that detect these bit errors with high probability. Once detected, it is sometimes possible to correct for such errors—if we know which bit or bits are corrupted, we can simply flip them—while in other cases the damage is so bad that it is necessary to discard the entire packet. In such a case, the sender may be expected to retransmit the packet.

The second class of failure is at the packet, rather than the bit, level; that is, a complete packet is lost by the network. One reason this can happen is that the packet contains an uncorrectable bit error and therefore has to be discarded. A more likely reason, however, is that one of the nodes that has to handle the packet—for example, a switch that is forwarding it from one link to another—is so overloaded that it has no place to store the packet and therefore is forced to drop it. This is the problem of congestion just discussed. Less commonly, the software running on one of the nodes that handles the packet makes a mistake. For example, it might incorrectly forward a packet out on the wrong link, so that the packet never finds its way to the ultimate destination. As we will see, one of the main difficulties in dealing with lost packets is distinguishing between a packet that is indeed lost and one that is merely late in arriving at the destination.

The third class of failure is at the node and link level; that is, a physical link is cut, or the computer it is connected to crashes. This can be caused by software that crashes, a power failure, or a reckless backhoe operator. Failures due to misconfiguration of a network device are also common. While any of these failures can eventually be corrected, they can have a dramatic effect on the network for an extended period of time. However, they need not totally disable the network. In a packet-switched network, for example, it is sometimes possible to route around a failed node or link. One of the difficulties in dealing with this third class of failure is distinguishing between a failed computer and one that is merely slow or, in the case of a link, between one that has been cut and one that is very flaky and therefore introducing a high number of bit errors.

> ***Key Takeaway***
>
> *The key idea to take away from this discussion is that defining useful channels involves both understanding the applications' requirements and recognizing the limitations of the underlying technology. The challenge is to fill in the gap between what the application expects and what the underlying technology can provide. This is sometimes called the semantic gap.*

Manageability

A final requirement, which seems to be neglected or left till last all too often (as we do here), is that networks need to be managed. Managing a network includes upgrading equipment as the network grows to carry more traffic or reach more users, troubleshooting the network when things go wrong or performance isn't as desired, and adding new features in support of new applications.

This requirement is partly related to the issue of scalability discussed above—as the Internet has scaled up to support billions of users and at least hundreds of millions of hosts, the challenges of keeping the whole thing running correctly and correctly configuring new devices as they are added have become increasingly problematic. Configuring a single router in a network is often a task for a trained expert; configuring thousands of routers and figuring out why a network of such a size is not behaving as expected can become a task beyond any single human. Furthermore, to make the operation of a network scalable and cost-effective, network operators typically require many management tasks to be automated or at least performed by relatively unskilled personnel.

One way to make a network easier to manage is to avoid change. Once the network is working, simply *do not touch it!* This mindset exposes the fundamental tension between *stability* and *feature velocity*: the rate at which new capabilities are introduced into the network. Favoring stability is the approach the telecommunications industry (not to mention University system administrators and corporate IT departments) adopted for many years, making it one of the most slow moving and risk averse industries you will find anywhere. But the recent explosion of the cloud has changed that dynamic, making it necessary to bring stability and feature velocity more into balance. The impact of the cloud on the network is a topic that comes up over and over throughout the book, and one we pay particular attention to in the *Perspectives* section at the end of each chapter. For now, suffice it to say that managing a rapidly evolving network is arguably *the* central challenge in networking today.

- An *application programmer* would list the services that his or her application needs: for example, a guarantee that each message the application sends will be delivered without error within a certain amount of time or the ability to switch gracefully among different connections to the network as the user moves around.
- A *network operator* would list the characteristics of a system that is easy to administer and manage: for example, in which faults can be easily isolated, new devices can be added to the network and configured correctly, and it is easy to account for usage.
- A *network designer* would list the properties of a cost-effective design: for example, that network resources are efficiently utilized and fairly allocated to different users. Issues of performance are also likely to be important.

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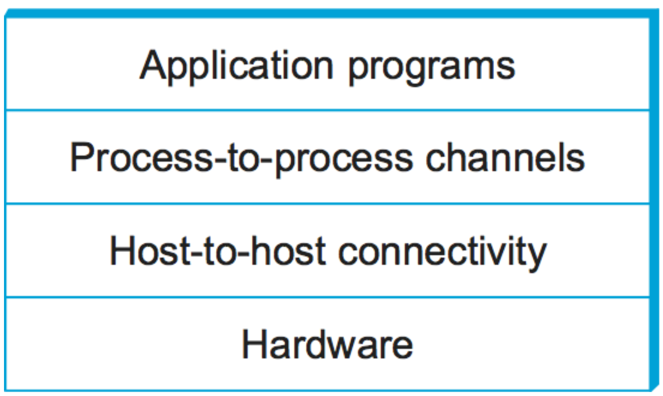
9.1.1.3: Architecture

In case you hadn't noticed, the previous section established a pretty substantial set of requirements for network design—a computer network must provide general, cost-effective, fair, and robust connectivity among a large number of computers. As if this weren't enough, networks do not remain fixed at any single point in time but must evolve to accommodate changes in both the underlying technologies upon which they are based as well as changes in the demands placed on them by application programs. Furthermore, networks must be manageable by humans of varying levels of skill. Designing a network to meet these requirements is no small task.

To help deal with this complexity, network designers have developed general blueprints—usually called *network architectures*—that guide the design and implementation of networks. This section defines more carefully what we mean by a network architecture by introducing the central ideas that are common to all network architectures. It also introduces two of the most widely referenced architectures—the OSI (or 7-layer) architecture and the Internet architecture.

Layering and Protocols

Abstraction—the hiding of details behind a well-defined interface—is the fundamental tool used by system designers to manage complexity. The idea of an abstraction is to define a model that can capture some important aspect of the system, encapsulate this model in an object that provides an interface that can be manipulated by other components of the system, and hide the details of how the object is implemented from the users of the object. The challenge is to identify abstractions that simultaneously provide a service that proves useful in a large number of situations and that can be efficiently implemented in the underlying system. This is exactly what we were doing when we introduced the idea of a channel in the previous section: we were providing an abstraction for applications that hides the complexity of the network from application writers.

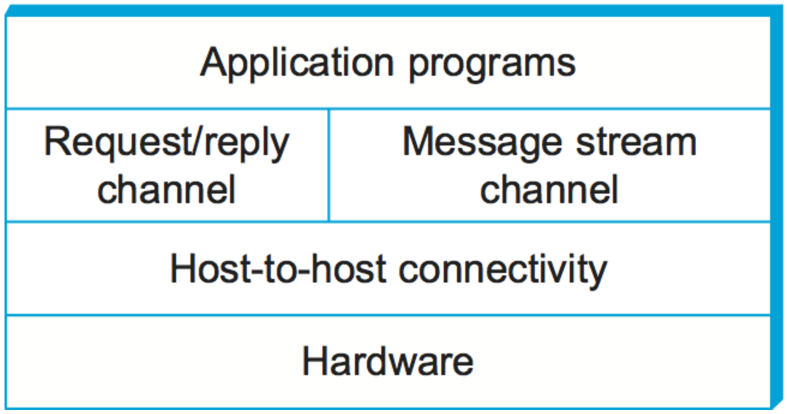


Example of a layered network system.

Abstractions naturally lead to layering, especially in network systems. The general idea is that you start with the services offered by the underlying hardware and then add a sequence of layers, each providing a higher (more abstract) level of service. The services provided at the high layers are implemented in terms of the services provided by the low layers. Drawing on the discussion of requirements given in the previous section, for example, we might imagine a simple network as having two layers of abstraction sandwiched between the application program and the underlying hardware, as illustrated in Figure 1. The layer immediately above the hardware in this case might provide host-to-host connectivity, abstracting away the fact that there may be an arbitrarily complex network topology between any two hosts. The next layer up builds on the available host-to-host communication service and provides support for process-to-process channels, abstracting away the fact that the network occasionally loses messages, for example.

Layering provides two nice features. First, it decomposes the problem of building a network into more manageable components. Rather than implementing a monolithic piece of software that does everything you will ever want, you can implement several layers, each of which solves one part of the problem. Second, it provides a more modular design. If you decide that you want to add some new service, you may only need to modify the functionality at one layer, reusing the functions provided at all the other layers.

Thinking of a system as a linear sequence of layers is an oversimplification, however. Many times there are multiple abstractions provided at any given level of the system, each providing a different service to the higher layers but building on the same low-level abstractions. To see this, consider the two types of channels discussed in the previous section. One provides a request/reply service and one supports a message stream service. These two channels might be alternative offerings at some level of a multilevel networking system, as illustrated in Figure 2.



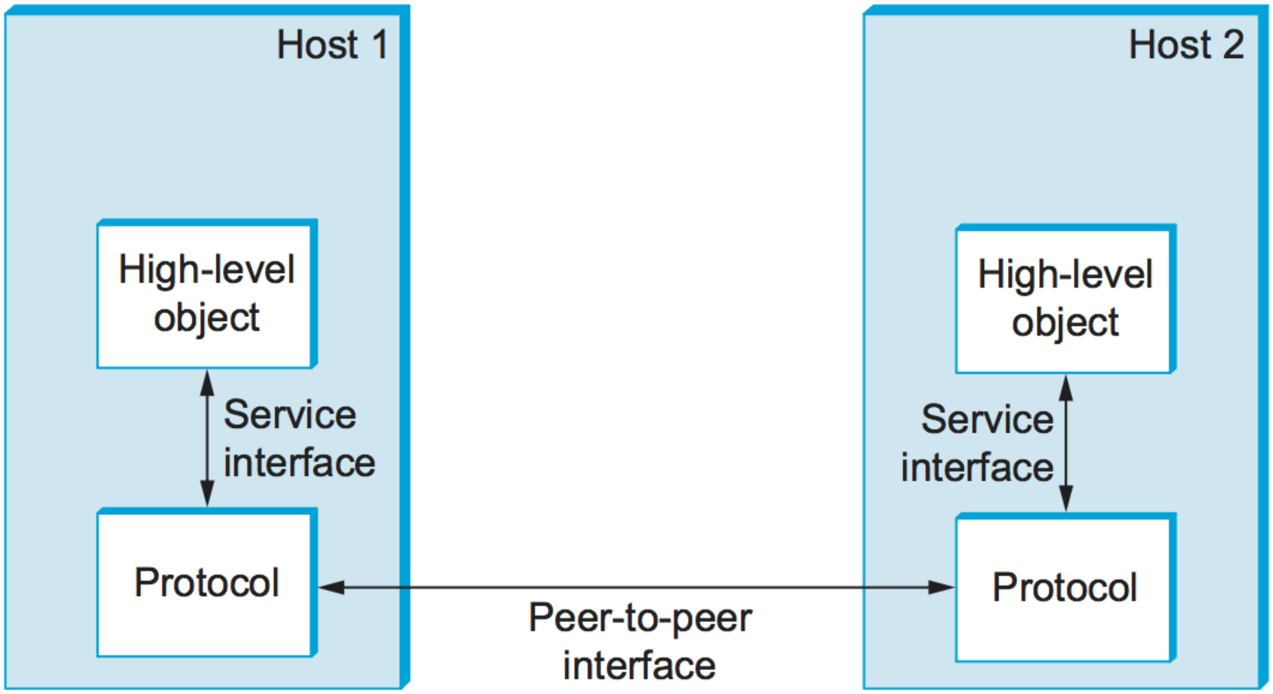
Layered system with alternative abstractions available at a given layer.

Using this discussion of layering as a foundation, we are now ready to discuss the architecture of a network more precisely. For starters, the abstract objects that make up the layers of a network system are called *protocols*. That is, a protocol provides a communication service that higher-level objects (such as application processes, or perhaps higher-level protocols) use to exchange messages. For example, we could imagine a network that supports a request/reply protocol and a message stream protocol, corresponding to the request/reply and message stream channels discussed above.

Each protocol defines two different interfaces. First, it defines a *service interface* to the other objects on the same computer that want to use its communication services. This service interface defines the operations that local objects can perform on the protocol. For example, a request/reply protocol would support operations by which an application can send and receive messages. An implementation of the HTTP protocol could support an operation to fetch a page of hypertext from a remote server. An application such as a web browser would invoke such an operation whenever the browser needs to obtain a new page (e.g., when the user clicks on a link in the currently displayed page).

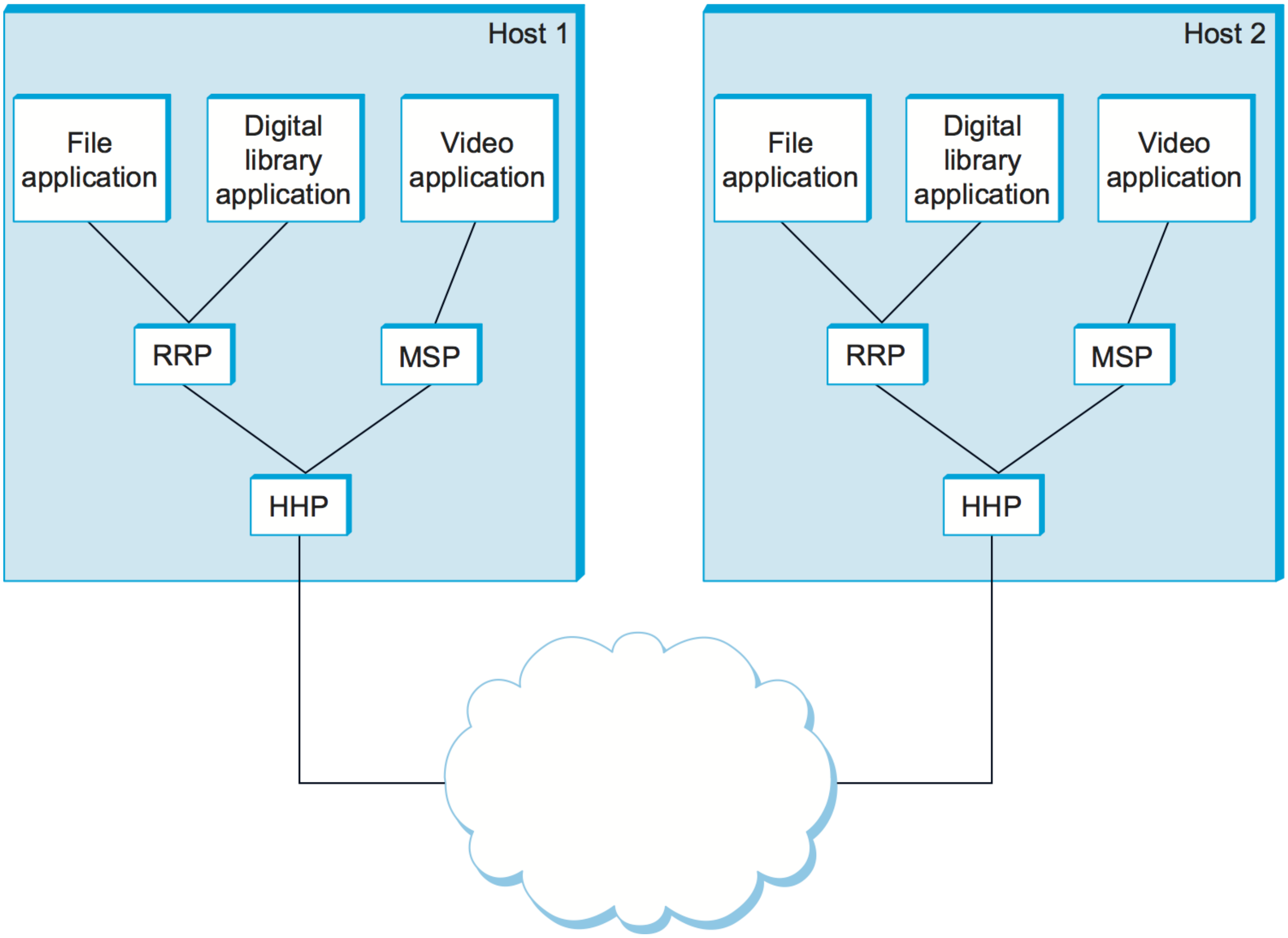
Second, a protocol defines a *peer interface* to its counterpart (peer) on another machine. This second interface defines the form and meaning of messages exchanged between protocol peers to implement the communication service. This would determine the way in which a request/reply protocol on one machine communicates with its peer on another machine. In the case of HTTP, for example, the protocol specification defines in detail how a *GET* command is formatted, what arguments can be used with the command, and how a web server should respond when it receives such a command.

To summarize, a protocol defines a communication service that it exports locally (the service interface), along with a set of rules governing the messages that the protocol exchanges with its peer(s) to implement this service (the peer interface). This situation is illustrated in Figure 3.



Service interfaces and peer interfaces.

Except at the hardware level, where peers directly communicate with each other over a physical medium, peer-to-peer communication is indirect—each protocol communicates with its peer by passing messages to some lower-level protocol, which in turn delivers the message to *its* peer. In addition, there are potentially more than one protocol at any given level, each providing a different communication service. We therefore represent the suite of protocols that make up a network system with a *protocol graph*. The nodes of the graph correspond to protocols, and the edges represent a *depends on* relation. For example, Figure 4 illustrates a protocol graph for the hypothetical layered system we have been discussing—protocols RRP (Request/Reply Protocol) and MSP (Message Stream Protocol) implement two different types of process-to-process channels, and both depend on the Host-to-Host Protocol (HHP) which provides a host-to-host connectivity service.



Example of a protocol graph.

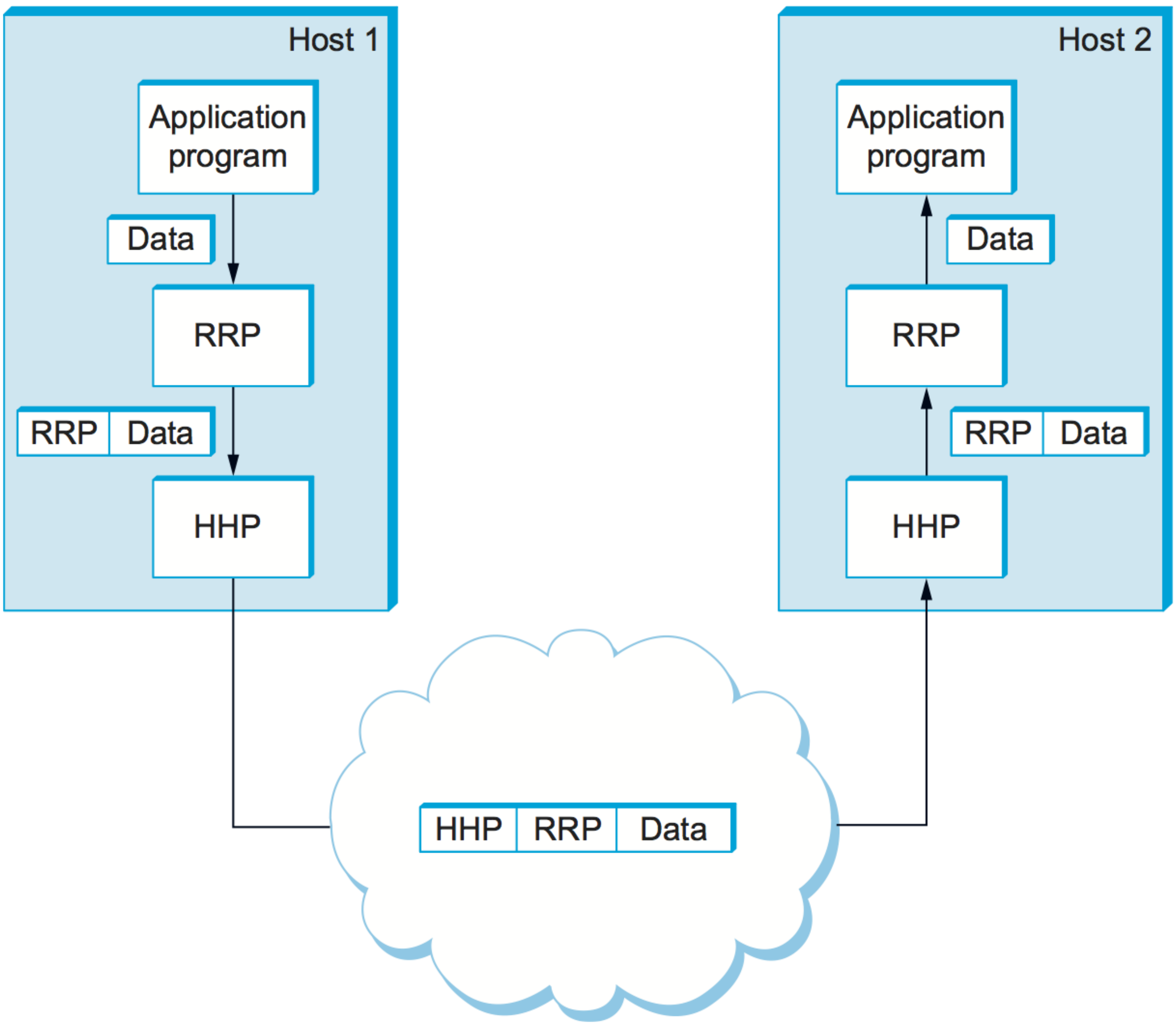
In this example, suppose that the file access program on host 1 wants to send a message to its peer on host 2 using the communication service offered by RRP. In this case, the file application asks RRP to send the message on its behalf. To communicate with its peer, RRP invokes the services of HHP, which in turn transmits the message to its peer on the other machine. Once the message has arrived at the instance of HHP on host 2, HHP passes the message up to RRP, which in turn delivers the message to the file application. In this particular case, the application is said to employ the services of the *protocol stack* RRP/HHP.

Note that the term *protocol* is used in two different ways. Sometimes it refers to the abstract interfaces—that is, the operations defined by the service interface and the form and meaning of messages exchanged between peers, and sometimes it refers to the module that actually implements these two interfaces. To distinguish between the interfaces and the module that implements these interfaces, we generally refer to the former as a *protocol specification*. Specifications are generally expressed using a combination of prose, pseudocode, state transition diagrams, pictures of packet formats, and other abstract notations. It should be the case that a given protocol can be implemented in different ways by different programmers, as long as each adheres to the specification. The challenge is ensuring that two different implementations of the same specification can successfully exchange messages. Two or more protocol modules that do accurately implement a protocol specification are said to *interoperate* with each other.

We can imagine many different protocols and protocol graphs that satisfy the communication requirements of a collection of applications. Fortunately, there exist standardization bodies, such as the Internet Engineering Task Force (IETF) and the International Standards Organization (ISO), that establish policies for a particular protocol graph. We call the set of rules governing the form and content of a protocol graph a *network architecture*. Although beyond the scope of this book, standardization bodies have established well-defined procedures for introducing, validating, and finally approving protocols in their respective architectures. We briefly describe the architectures defined by the IETF and ISO shortly, but first there are two additional things we need to explain about the mechanics of protocol layering.

Encapsulation

Consider what happens in when one of the application programs sends a message to its peer by passing the message to RRP. From RRP's perspective, the message it is given by the application is an uninterpreted string of bytes. RRP does not care that these bytes represent an array of integers, an email message, a digital image, or whatever; it is simply charged with sending them to its peer. However, RRP must communicate control information to its peer, instructing it how to handle the message when it is received. RRP does this by attaching a *header* to the message. Generally speaking, a header is a small data structure—from a few bytes to a few dozen bytes—that is used among peers to communicate with each other. As the name suggests, headers are usually attached to the front of a message. In some cases, however, this peer-to-peer control information is sent at the end of the message, in which case it is called a *trailer*. The exact format for the header attached by RRP is defined by its protocol specification. The rest of the message—that is, the data being transmitted on behalf of the application—is called the message's *body* or *payload*. We say that the application's data is *encapsulated* in the new message created by RRP.



High-level messages are encapsulated inside of low-level messages.

This process of encapsulation is then repeated at each level of the protocol graph; for example, HHP encapsulates RRP's message by attaching a header of its own. If we now assume that HHP sends the message to its peer over some network, then when the message arrives at the destination host, it is processed in the opposite order: HHP first interprets the HHP header at the front of the message (i.e., takes whatever action is appropriate given the contents of the header) and passes the body of the message (but not the

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HHP header) up to RRP, which takes whatever action is indicated by the RRP header that its peer attached and passes the body of the message (but not the RRP header) up to the application program. The message passed up from RRP to the application on host 2 is exactly the same message as the application passed down to RRP on host 1; the application does not see any of the headers that have been attached to it to implement the lower-level communication services. This whole process is illustrated in Figure 5. Note that in this example, nodes in the network (e.g., switches and routers) may inspect the HHP header at the front of the message.

Note that when we say a low-level protocol does not interpret the message it is given by some high-level protocol, we mean that it does not know how to extract any meaning from the data contained in the message. It is sometimes the case, however, that the low-level protocol applies some simple transformation to the data it is given, such as to compress or encrypt it. In this case, the protocol is transforming the entire body of the message, including both the original application's data and all the headers attached to that data by higher-level protocols.

Multiplexing and Demultiplexing

Recall from that a fundamental idea of packet switching is to multiplex multiple flows of data over a single physical link. This same idea applies up and down the protocol graph, not just to switching nodes. In Figure 4, for example, we can think of RRP as implementing a logical communication channel, with messages from two different applications multiplexed over this channel at the source host and then demultiplexed back to the appropriate application at the destination host.

Practically speaking, this simply means that the header that RRP attaches to its messages contains an identifier that records the application to which the message belongs. We call this identifier RRP's *demultiplexing key*, or *demux key* for short. At the source host, RRP includes the appropriate demux key in its header. When the message is delivered to RRP on the destination host, it strips its header, examines the demux key, and demultiplexes the message to the correct application.

RRP is not unique in its support for multiplexing; nearly every protocol implements this mechanism. For example, HHP has its own demux key to determine which messages to pass up to RRP and which to pass up to MSP. However, there is no uniform agreement among protocols—even those within a single network architecture—on exactly what constitutes a demux key. Some protocols use an 8-bit field (meaning they can support only 256 high-level protocols), and others use 16- or 32-bit fields. Also, some protocols have a single demultiplexing field in their header, while others have a pair of demultiplexing fields. In the former case, the same demux key is used on both sides of the communication, while in the latter case each side uses a different key to identify the high-level protocol (or application program) to which the message is to be delivered.

7-Layer OSI Model

The ISO was one of the first organizations to formally define a common way to connect computers. Their architecture, called the *Open Systems Interconnection* (OSI) architecture and illustrated in Figure 6, defines a partitioning of network functionality into seven layers, where one or more protocols implement the functionality assigned to a given layer. In this sense, the schematic given in is not a protocol graph, *per se*, but rather a *reference model* for a protocol graph. It is often referred to as the 7-layer model.

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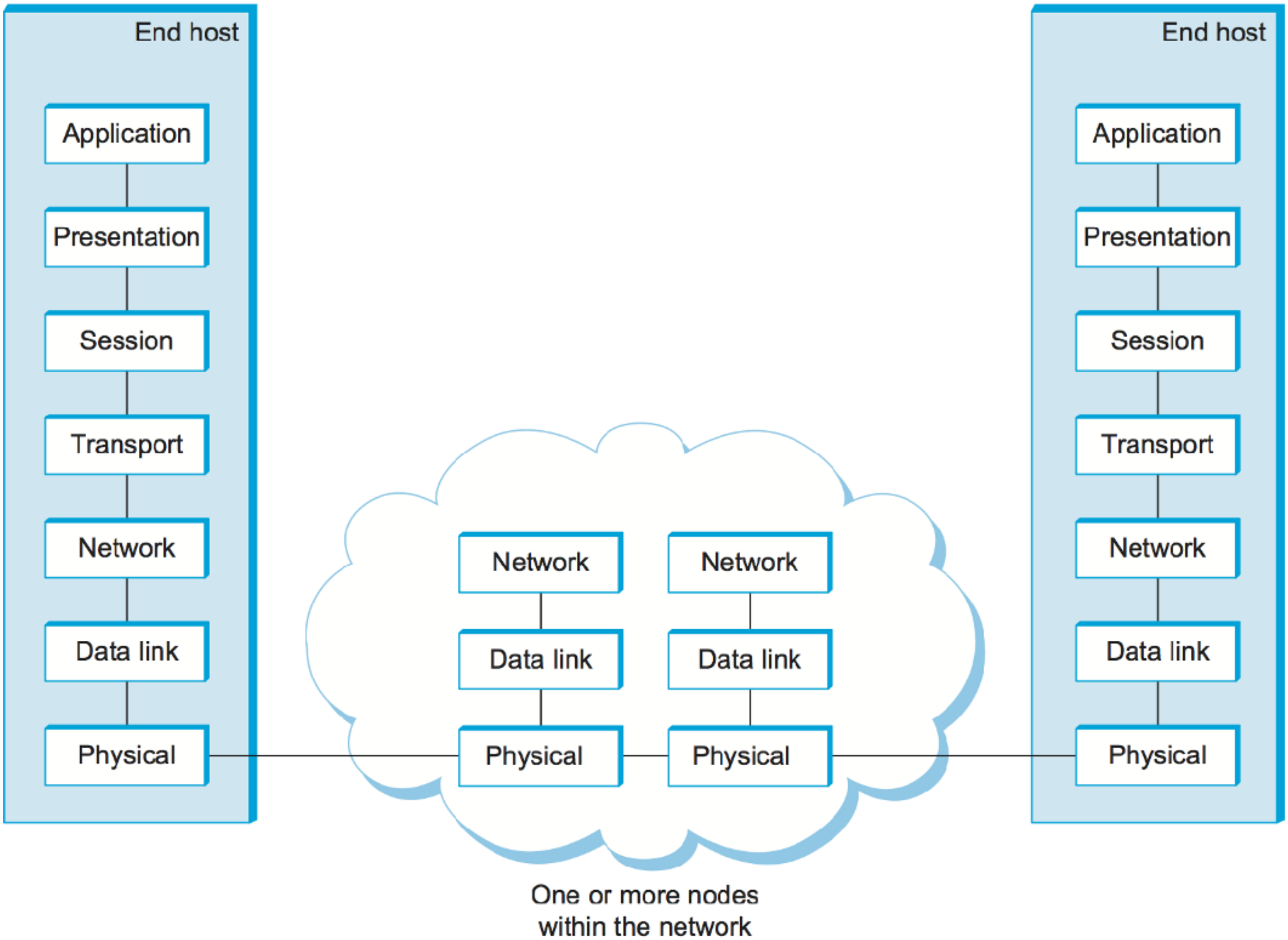


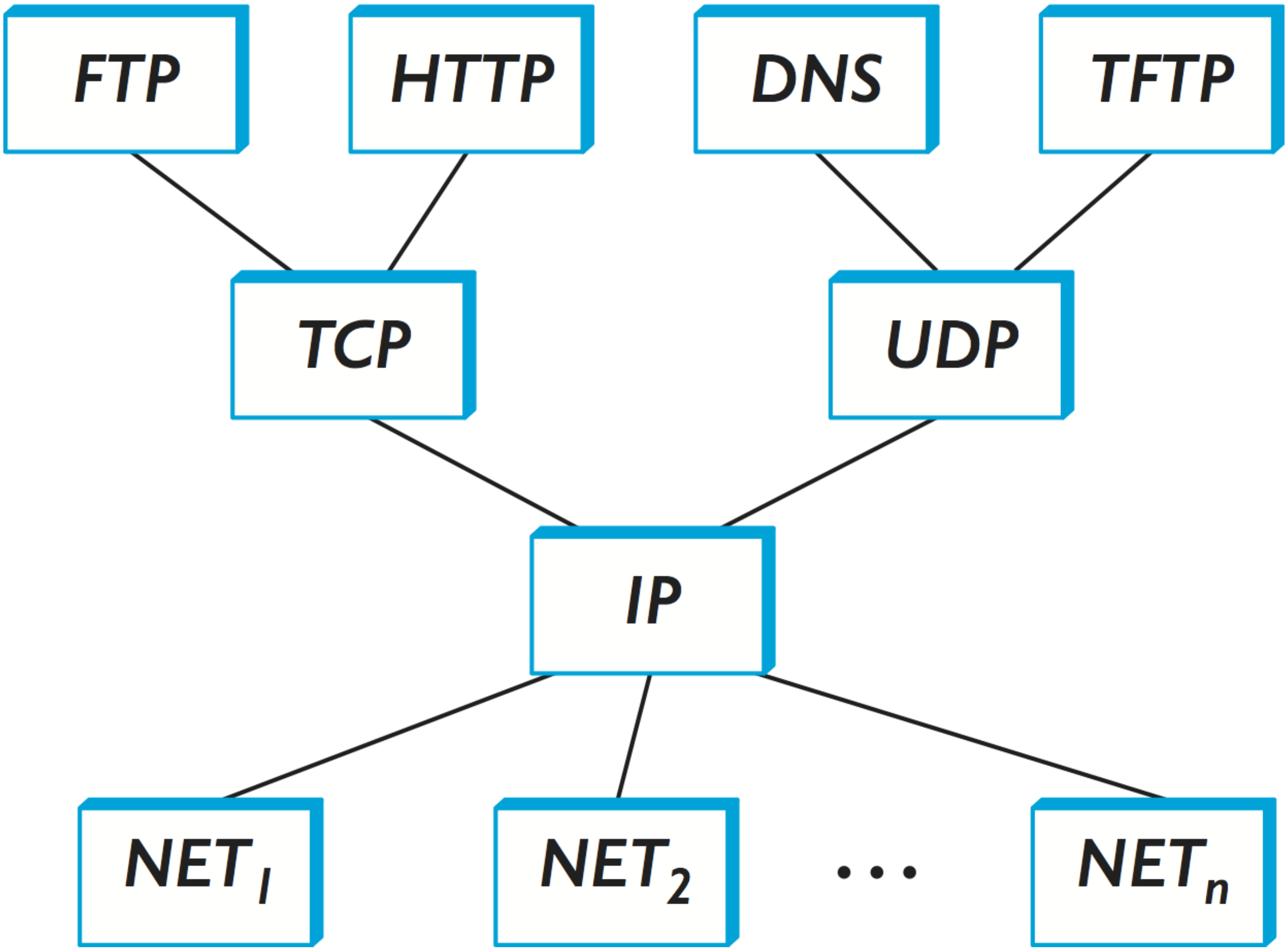
The OSI 7-layer model.

Starting at the bottom and working up, the *physical* layer handles the transmission of raw bits over a communications link. The *data link* layer then collects a stream of bits into a larger aggregate called a *frame*. Network adaptors, along with device drivers running in the node's operating system, typically implement the data link level. This means that frames, not raw bits, are actually delivered to hosts. The *network* layer handles routing among nodes within a packet-switched network. At this layer, the unit of data exchanged among nodes is typically called a *packet* rather than a frame, although they are fundamentally the same thing. The lower three layers are implemented on all network nodes, including switches within the network and hosts connected to the exterior of the network. The *transport* layer then implements what we have up to this point been calling a *process-to-process channel*. Here, the unit of data exchanged is commonly called a *message* rather than a packet or a frame. The transport layer and higher layers typically run only on the end hosts and not on the intermediate switches or routers.

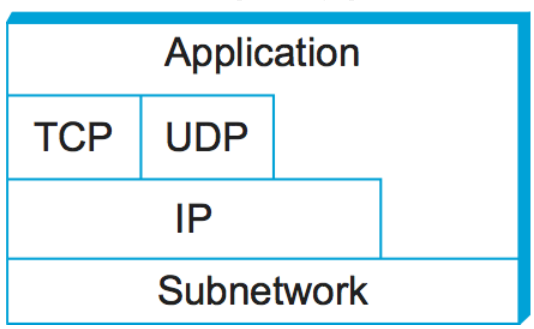
There is less agreement about the definition of the top three layers, in part because they are not always all present, as we will see below. Skipping ahead to the top (seventh) layer, we find the *application* layer. Application layer protocols include things like the Hypertext Transfer Protocol (HTTP), which is the basis of the World Wide Web and is what enables web browsers to request pages from web servers. Below that, the *presentation* layer is concerned with the format of data exchanged between peers—for example, whether an integer is 16, 32, or 64 bits long, whether the most significant byte is transmitted first or last, or how a video stream is formatted. Finally, the *session* layer provides a name space that is used to tie together the potentially different transport streams that are part of a single application. For example, it might manage an audio stream and a video stream that are being combined in a teleconferencing application.

Internet Architecture

The Internet architecture, which is also sometimes called the TCP/IP architecture after its two main protocols, is depicted in Figure 7. An alternative representation is given in Figure 8. The Internet architecture evolved out of experiences with an earlier packet-switched network called the ARPANET. Both the Internet and the ARPANET were funded by the Advanced Research Projects Agency (ARPA), one of the research and development funding agencies of the U.S. Department of Defense. The Internet and ARPANET were around before the OSI architecture, and the experience gained from building them was a major influence on the OSI reference model.



Internet protocol graph.



Alternative view of the Internet architecture. The "subnetwork" layer was historically referred to as the "network" layer and is now often referred to as "layer 2."

While the 7-layer OSI model can, with some imagination, be applied to the Internet, a 4-layer model is often used instead. At the lowest level is a wide variety of network protocols, denoted $NET_1$1, $NET_2$2, and so on. In practice, these protocols are implemented by a combination of hardware (e.g., a network adaptor) and software (e.g., a network device driver). For example, you might find Ethernet or wireless protocols (such as the 802.11 Wi-Fi standards) at this layer. (These protocols in turn may actually involve several sublayers, but the Internet architecture does not presume anything about them.) The second layer consists of a single protocol—the *Internet Protocol* (IP). This is the protocol that supports the interconnection of multiple networking technologies into a single, logical internetwork. The third layer contains two main protocols—the *Transmission Control Protocol* (TCP) and the *User Datagram Protocol* (UDP). TCP and UDP provide alternative logical channels to application programs: TCP provides a reliable byte-stream channel, and UDP provides an unreliable datagram delivery channel (*datagram* may be thought of as a synonym for message). In the language of the Internet, TCP and UDP are sometimes called *end-to-end* protocols, although it is equally correct to refer to them as *transport* protocols.

Running above the transport layer is a range of application protocols, such as HTTP, FTP, Telnet (remote login), and the Simple Mail Transfer Protocol (SMTP), that enable the interoperation of popular applications. To understand the difference between an application layer protocol and an application, think of all the different World Wide Web browsers that are or have been available (e.g., Firefox, Chrome, Safari, Netscape, Mosaic, Internet Explorer). There is a similarly large number of different implementations of web servers. The reason that you can use any one of these application programs to access a particular site on the Web is that they all conform to the same application layer protocol: HTTP. Confusingly, the same term sometimes applies to both an application and the application layer protocol that it uses (e.g., FTP is often used as the name of an application that implements the FTP protocol).

Most people who work actively in the networking field are familiar with both the Internet architecture and the 7-layer OSI architecture, and there is general agreement on how the layers map between architectures. The Internet's application layer is considered to be at layer 7, its transport layer is layer 4, the IP (internetworking or just network) layer is layer 3, and the link or subnet layer below IP is layer 2.

The Internet architecture has three features that are worth highlighting. First, as best illustrated by Figure 8, the Internet architecture does not imply strict layering. The application is free to bypass the defined transport layers and to directly use IP or one of the underlying networks. In fact, programmers are free to define new channel abstractions or applications that run on top of any of the existing protocols.

Second, if you look closely at the protocol graph in Figure 7, you will notice an hourglass shape—wide at the top, narrow in the middle, and wide at the bottom. This shape actually reflects the central philosophy of the architecture. That is, IP serves as the focal point for the architecture—it defines a common method for exchanging packets among a wide collection of networks. Above IP there can be arbitrarily many transport protocols, each offering a different channel abstraction to application programs. Thus, the issue of delivering messages from host to host is completely separated from the issue of providing a useful process-to-process communication service. Below IP, the architecture allows for arbitrarily many different network technologies, ranging from Ethernet to wireless to single point-to-point links.

A final attribute of the Internet architecture (or more accurately, of the IETF culture) is that in order for a new protocol to be officially included in the architecture, there must be both a protocol specification and at least one (and preferably two) representative implementations of the specification. The existence of working implementations is required for standards to be adopted by the IETF. This cultural assumption of the design community helps to ensure that the architecture's protocols can be efficiently implemented. Perhaps the value the Internet culture places on working software is best exemplified by a quote on T-shirts commonly worn at IETF meetings:

> *We reject kings, presidents, and voting. We believe in rough consensus and running code.* ***(David Clark)***
>
> ***Key Takeaway***
>
> *Of these three attributes of the Internet architecture, the hourglass design philosophy is important enough to bear repeating. The hourglass's narrow waist represents a minimal and carefully chosen set of global capabilities that allows both higher-level applications and lower-level communication technologies to coexist, share capabilities, and evolve rapidly. The narrow-waisted model is critical to the Internet's ability to adapt rapidly to new user demands and changing technologies.*

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SECTION OVERVIEW

9.1.2: Database Management

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9.1.2.1: Introduction

In the entity relationship approach to modeling we analyze system requirements and classify our knowledge in terms of entities, relationships, and attributes.

Entities

Entities are the things we decide to keep track of. For example, if one considers a system to support an educational environment, one is likely to decide that we need to keep track of students, instructors, courses, etc. Typically entities are the people, places, things, and events that we need to remember something about.

Suppose we know of four student entities and two course entities. For example, consider four students (say John, Amelia, Lee, and April) and two courses (Introduction to Art and Introduction to History). We can illustrate these in a number of ways:

As tables of information:

Students		
Name	Id Number	Phone
John	184	283-4984
Amelia	337	838-3737
Lee	876	933-2211
April	901	644-3838

Courses		
Title	Course Number	Department
Introduction to Art	661	Art
Introduction to History	765	History

Figure 9.1.2.1.1: Entities shown as rows in table.

As sets of entities:

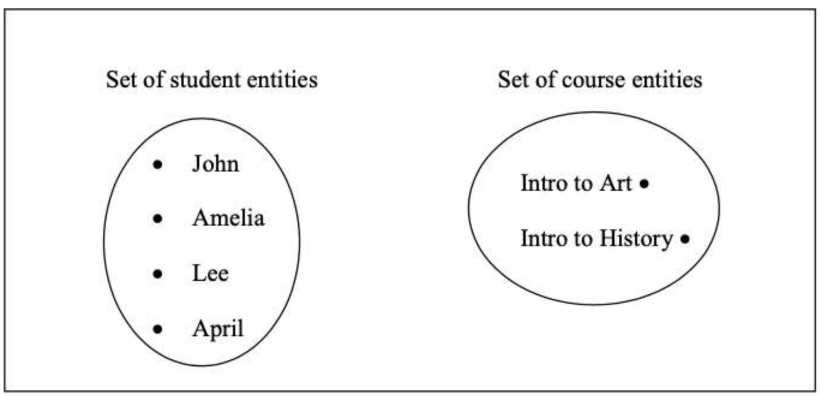


Figure 9.1.2.1.2: Entities shown as sets.

Relationships

Entities can be related to one another and so we use *relationships* to describe how entities relate to one another. Continuing with our educational example we know that students enroll in courses, and so this is one of the relationships we should know about. Suppose we have the two courses and four students listed previously. Suppose also that

- John and Amelia are enrolled in Introduction to Art
- John and Lee are enrolled in Introduction to History
- April is not enrolled in any course.

Below, we depict four instances of the *enroll-in* relationship by drawing a line from a student to a course. Each relationship pairs one student with one course.

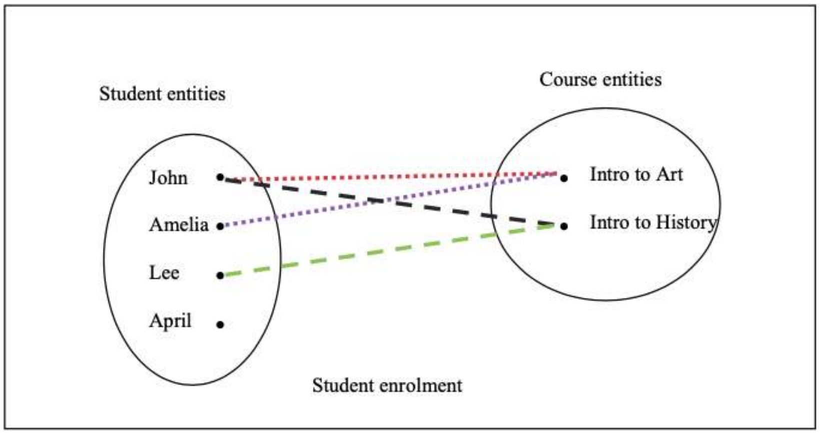


Figure 9.1.2.1.3: Relationships shown as lines connecting entities.

Attributes

Entities and relationships have characteristics that describe them. For instance, the students in our example are described by the values for their name, id number, and phone number. As we look back we can see there is a student named *John* whose id number is *184* and his phone number is *283-4984*.

Courses are shown with a course title, a course number, and to belong to a department. There is a course numbered *661* that is offered by the *Art* department and it is titled *Introduction to Art*.

If we consider the enroll-in relationship we know there is a date when the student enrolled in the course and a final grade that was awarded to the student when the course was completed. For instance, we could have that *John* enrolled in *Introduction to Art* on *July 1, 2010* and was awarded an *A+* on completion of that course.

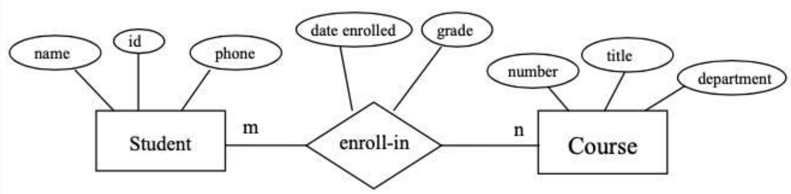
These characteristics that serve to describe entities and relationships are called attributes. We will be examining attributes in some detail. As we will see some attributes, such as student number, serve to distinguish one instance from another - each student has a student number distinct from any other student. Other attributes we consider to be purely descriptive, such as the name of a student - many students could have the same name.

Notation

There are many notations in use today that illustrate database designs. In this text, as is done in many database textbooks, the Peter Chen notation is used; other popular notations include IDEF1X, IE and UML. There are many similarities, and so once you master the Peter Chen notation it is not difficult to adapt to a different notation.

The following is an example of an ERD drawn using the Peter Chen notation. Note the following:

- Entity types are represented using rectangular shapes.
- Relationship types are shown with a diamond shape. Lines connect the relationship type to its related entity types with cardinality symbols (*m* and *n*).
- Attributes are shown as ovals with a line connecting it to the pertinent entity type or relationship type.



The *m* and *n* on the relationship lines are cardinality symbols meant to indicate that one course may have many students enrolled in it and that one student may enroll in many courses.

Figure 9.1.2.1.4: An ERD in Chen notation.

The various symbols we use with the Peter Chen notation:

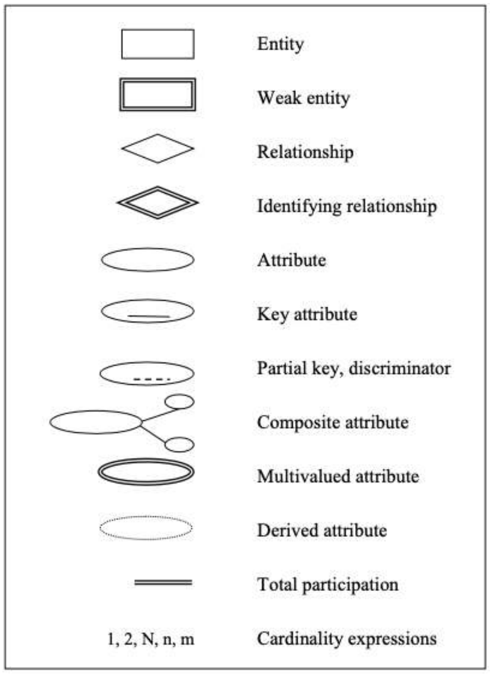


Figure 9.1.2.1.5: Symbols used in the Chen notation.

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9.1.2.2: Entities

Entities are the people, places, things, or events that are of interest for a system that we are planning to build. In the previous section we considered there were several entities: four students and two courses.

In general we find examples of entities when we think of people, places, things, or events in our area of interest:

> People: student, customer, employee
>
> Places: resort, city, country
>
> Things: restaurant, product, invoice, movie, painting, book, building, contract
>
> Events: registration, election, presentation, earthquake, hurricane

Entity sets are named collections of related entities. From our example we have two entity sets:

- The Student entity set comprises at least the 4 student entities: John, Amelia, Lee, and April.
- The Course entity set comprises at least the 2 course entities: Introduction to Art and Introduction to History.

Entity sets are the collections of entities of one type. We consider an *Entity Type* to be the definition of the entities in such a set. A common convention is to name entity types as singular nouns and that, at least, the first letter is capitalized.

In an ERD entity types are shown as named rectangular shapes. For example:

Figure $9.1.2.2.1$: ERD entity types example.

The Student and Department entity types shown above are drawn with a simple single-line border. This means that they are regular (or strong) entity types that are not existence-dependent on other entity types (see the next section).

Exercises (Set 1)

Exercise 9.1.2.2.1

Consider your educational institution. Your educational institution needs to keep track of its students. How many student entities does the institution have? You have provided the institution with information about you. In your opinion, what attributes describe these entities?

Exercise 9.1.2.2.2

Consider your place of work. The Human Resources department in your company needs to manage information about its employees. How many employee entities are there? What attributes describe these entities?

Exercise 9.1.2.2.3

Consider your educational institution or place of work.

1. What are some of the entity types that would be useful?
2. What relationships exist that relate entity types to one another?
3. What attributes would be useful to describe entities and relationships?
4. Draw an ERD.

Weak Entities

Sometimes we know certain entities only exist in relationship to others. For example, a typical educational institution comprises a number of departments that offer courses. So we could have a History department, an Art department and so on. These departments would design and deliver courses that students would register for. In this framework the courses exist in the context of a department, and the identifier for a course is typically a department code and course number combination. So the history course, Introduction to History, belongs to the History department and it would be known by the identifier HIST-765. HIST is a code representing the History department and 765 is a number assigned to the course; other departments could have a course with that same number, 765.

In these situations where the existence of an entity depends on the existence of another entity, we say the entity is a *weak* entity, and the corresponding entity type is a weak entity type. Weak entities often have identifiers that comprise multiple parts (such as department code and course number). Later on we will see other aspects of an ERD that relate to weak entity types. At this time we should be aware that weak entity types are illustrated in an ERD with a double-lined rectangle:

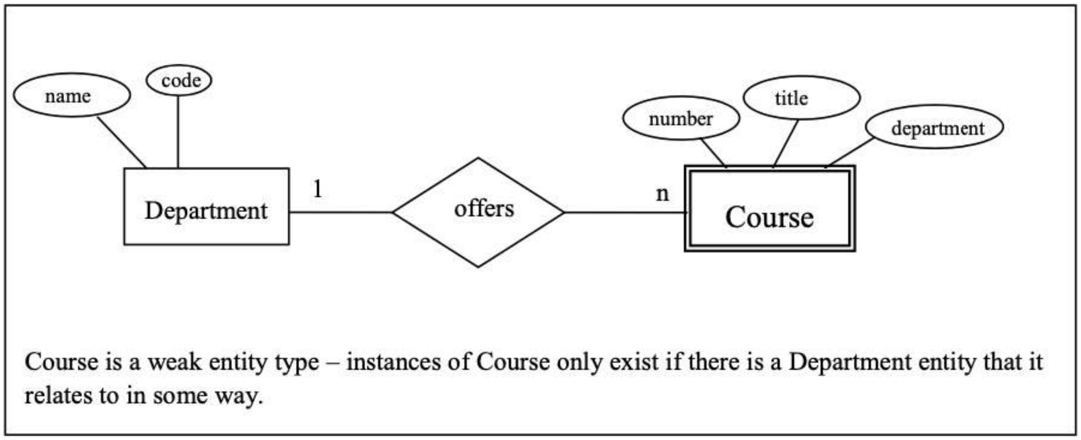
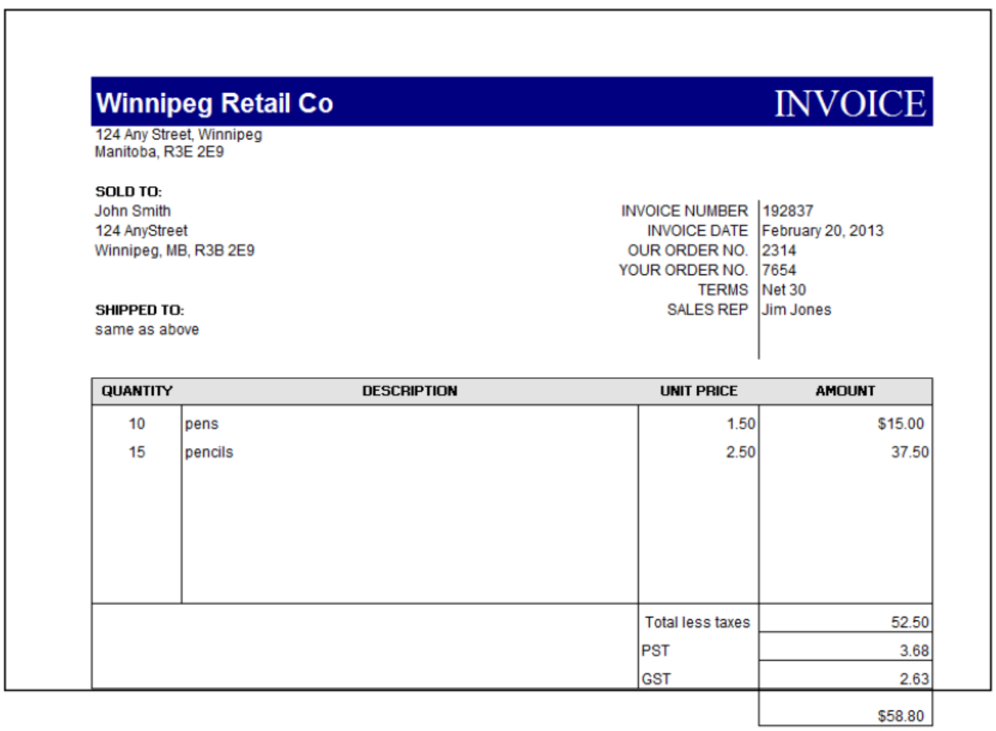


Figure 9.1.2.2.2: Course as a weak entity type.

Often when we purchase things the vendor provides an invoice giving details of each item that is purchased (see the sample invoice below). Appearing on the invoice are detail lines specifying the product, the quantity and price. Invoice lines are things that exist only in the context of an invoice and so each invoice line is a ***weak*** entity; the invoice lines are existence-dependent on an invoice:



Winnipeg Retail Co INVOICE

124 Any Street, Winnipeg
Manitoba, R3E 2E9

SOLD TO:
John Smith
124 AnyStreet
Winnipeg, MB, R3B 2E9

SHIPPED TO:
same as above

INVOICE NUMBER	192837
INVOICE DATE	February 20, 2013
OUR ORDER NO.	2314
YOUR ORDER NO.	7654
TERMS	Net 30
SALES REP	Jim Jones

QUANTITY	DESCRIPTION	UNIT PRICE	AMOUNT
10	pens	1.50	$15.00
15	pencils	2.50	37.50
		Total less taxes	52.50
		PST	3.68
		GST	2.63
			$58.80

Figure 9.1.2.2.3: Sample Invoice.

The following includes a few attributes to show how Invoice and Invoice Line could appear in an ERD.

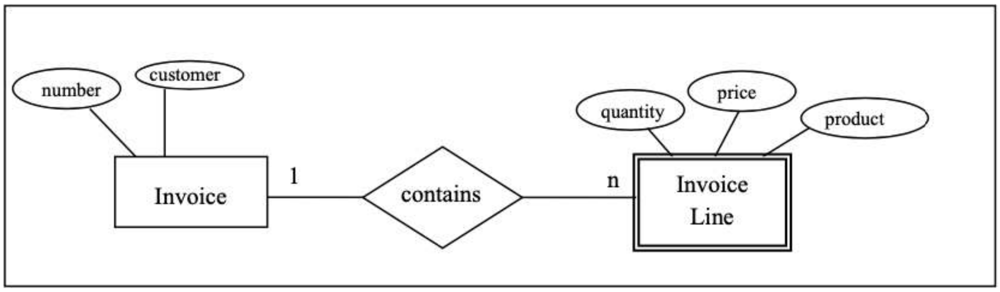


Figure 9.1.2.2.4: Invoices (regular entity type) and Invoice Lines (weak entity type).

Exercises (Set 2)

Exercise 9.1.2.2.4

Consider a requirement having to do with benefits that may be given to employees of a company. Suppose employees work in a department and that each employee may have several dependents (spouse, child). Draw an ERD that includes Department, Employee, and Dependent in your design. Include attributes for your entity types.

Exercise 9.1.2.2.5

When you buy items in a store you often get a cash register receipt that details the items you have purchased. Develop an ERD that includes Store, Customer, Receipt, and Detail Lines.

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9.1.2.3: Attributes

Attributes are the characteristics that describe entities and relationships. For example, a Student entity may be described by attributes including:

student number

name

first name

last name

address

date of birth

gender

An Invoice entity may be described by attributes including:

invoice number

invoice date

invoice total

A common convention for naming attributes is to use singular nouns. Further, a naming convention may require one of:

All characters are in upper case.

All characters are in lower case.

Only the first character is in upper case.

All characters are lower case but each subsequent part of a multipart name has the first character capitalized

Using the last convention mentioned, some examples of attribute names:

lastName *for* last name

empLastName *for* employee last name

deptCode *for* department code

prodCode *for* product code

invNum *for* invoice number

In practice a naming convention is important, and you should expect the organization you are working for to have a standard approach for naming things appearing in a model. A substantial data model will have tens, if not into the hundreds, of entity types, many more attributes and relationships. It becomes important to easily understand the concept underlying a specific name; a naming convention can be helpful.

There are many ways we can look at attributes including whether they are atomic, composite, single-valued, etc. We consider these next.

Atomic Attributes

A simple, or **atomic**, attribute is one that cannot be decomposed into meaningful components. For example, consider an attribute for gender – such an attribute will assume values such as Male or Female. Gender cannot be meaningfully decomposed into other smaller components.

As another example consider an attribute for product price. A sample value for product price is $21.03. Of course, one could decompose this into two attributes where one attribute represents the dollar component (21), and the other attribute represents the cents component (03), but our assumption here is that such decompositions are not meaningful to the intended application or system. So we would consider product price to be atomic because it cannot be usefully decomposed into meaningful components.

Similarly, an attribute for the employee's last name cannot be decomposed, because you cannot subdivide last name into a finer set of meaningful attributes.

Exercises (Set 1)

Exercise 9.1.2.3.1

Consider that a Human Resources system must keep track of employees. If we are only including atomic attributes, what attributes would you include for the employee's name. Some possibilities are first name, last name, middle name, fullname.

Exercise 9.1.2.3.2

In some large organizations where there are several buildings and floors we see room numbers that encode information about the building, floor, and room number. For example in case the room 3C13 stands for room 13 on the third floor of the Centennial building. Suppose we need to include Room in an ERD. How would you represent the room number given that you must include atomic attributes only?

Composite Attributes

Consider an attribute such as employee name which is to represent an employee's complete name. For example, suppose an employee's name is John McKenzie; the first name is John and the last name is McKenzie. It is easy to appreciate that one user may only need employee last names, and another user may need to display the first name followed by the last name, and yet another user may display the last name, a comma, and then the first name. If it's reasonable for one to refer to the complete concept of employee name and to its component parts, first name and last name, then we can use a *composite* attribute**.** An attribute is *composite* if it comprises other attributes. To show that an attribute is composite and contains other attributes we show the components as attribute ovals connected to the composite as in:

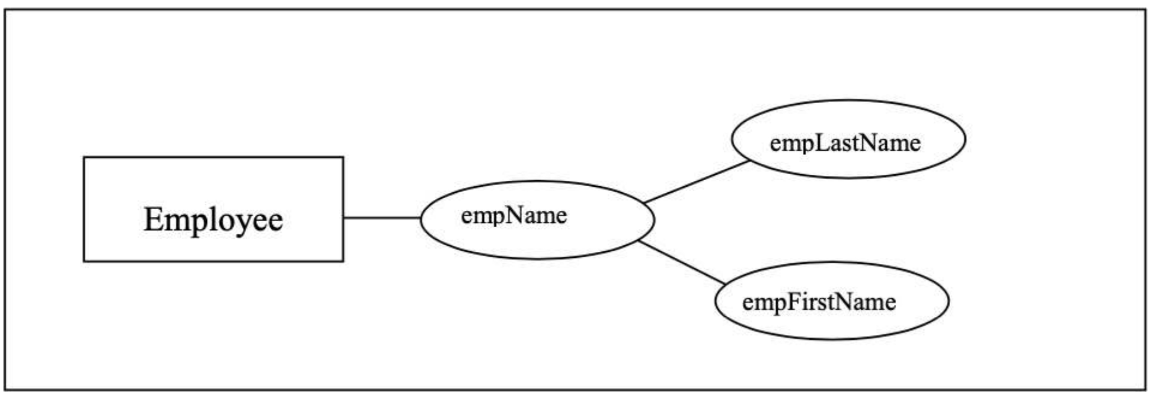

Figure 9.1.2.3.1: Composite attribute.

Attributes can be composite and some of its component attributes may be composite as well (see exercise 3).

Exercises (Set 2)

Exercise 9.1.2.3.3

How would you use a composite attribute to model a phone number.

Exercise 9.1.2.3.4

Consider the previous exercise set. Show how we can include room number as a composite attribute that has multiple components.

Exercise 9.1.2.3.5

Consider an address attribute. Show that this can be modeled as a multi-level composite attribute where the component attributes include street, city, province, country and where street includes apartment number, street number, street name.

Single-Valued Attributes

We characterize an attribute as being single-valued if there is only one value at a given time for the attribute.

Consider the Employee entity type for a typical business application where we need to include a gender attribute. Each employee is either male or female, and so there is only one value to store per employee. In this case, we have an attribute that is single-valued for each employee. Single-valued attributes are shown with a simple oval as in all diagrams up to this point. In all of our examples so far, we have assumed that each attribute was single-valued.

Exercises (Set 3)

Exercise 9.1.2.3.6

A college or university will keep track of several addresses for a student, but each of these can be named differently: for example, consider that a student has a mailing address and a home address. Create an ERD for a student entity type with two composite attributes for student addresses where each comprises several single-valued attributes.

Exercise 9.1.2.3.7

Consider a marriage entity type and attributes marriage date, marriage location, husband, wife. Each marriage will only have one value for each of these attributes. Illustrate the marriage entity and its single-valued attributes in an ERD .

Multi-Valued Attributes

Now, suppose someone proposes to track each employee's university degrees with an attribute named empDegree. Certainly many employees could have several degrees and so there are multiple values to be stored at one time. Consider the following sample data for three employees: each employee has a single employee number and phone number, but they have varying numbers of degrees.

Table 9.1.2.3.1: Employees – number, phone, degrees.

empNum	empPhone	empDegree
123	233-9876	
333	233-1231	BA, BSc, PhD
679	233-1231	BSc, MSc

For a given employee and point in time, empDegree could have multiple values as is the case for the last two employees listed above. In this case we say the attribute is *multi-valued*.

Multi-valued attributes are illustrated in an ERD with a double-lined oval.

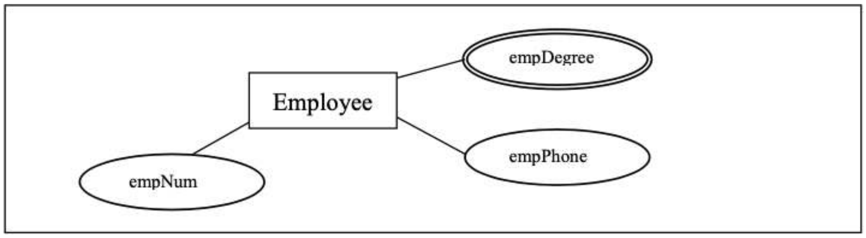

Figure 9.1.2.3.2: Employee degrees shown as multi-valued.

We can use multi-valued attributes to (at least) document a requirement, and at a later time, refine the model replacing the multi-valued attribute with a more detailed representation. The presence of a multi-valued attribute indicates an area that may require more analysis; multi- valued attributes are discussed again in Chapter 10.

Exercises (Set 4)

Exercise 9.1.2.3.8

Consider the employee entity type.

1. Suppose the company needs to track the names of dependents for each employee. Show the dependent name as a multi-valued attribute.
2. Modify your ERD to show empDependentName as a composite multi-valued attribute comprising first and last names and middle initials.

Exercise 9.1.2.3.9

Create an ERD that avoids the multi-valued attribute empDegrees in the previous example.

Hint

Consider including another entity type and a relationship for keeping track of degrees.

Derived Attributes

If an attribute's value can be derived from the values of other attributes, then the attribute is derivable, and is said to be a *derived* attribute. For example, if we have an attribute for birth date then age is derivable. Derived attributes are shown with a dotted lined oval.

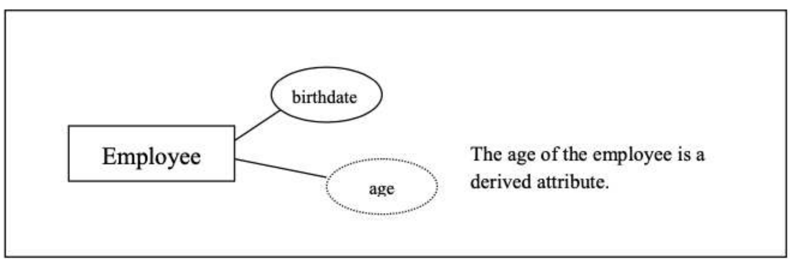

Figure 9.1.2.3.3: Age as a derived attribute.

Sometimes an attribute of one entity type is derived from attributes from other entity types. Consider the attribute for the total of an Invoice. A value of InvTotal is derivable; it can be computed from invoice lines. Someone who implements a database and applications that access the database would need to decide whether the value of a derivable attribute should be computed when the entity is stored or updated versus computing the value (on-the-fly) when it is needed.

Exercises (Set 5)

Exercise 9.1.2.3.10

Consider an educational environment where the institution tracks the performance of each student. Often this is called the students overall average, or overall grade point average. Is such an attribute a derived attribute? How is its value determined?

Exercise 9.1.2.3.11

Consider a library application that needs to keep track of books that have been borrowed. Suppose there is an entity type Loan that has attributes bookID, memberID, dateBorrowed and dateDue. Suppose the due date is always 2 weeks after the borrowed date. Show Loan and its attributes in an ERD.

Key Attributes

Some attributes, or combinations of attributes, serve to identify individual entities. For instance, suppose an educational institution assigns each student a student number that is different from all other student numbers. We say the student number attribute is a *key* attribute; student numbers are *unique* and distinguish students.

In an ERD, keys are shown underlined:

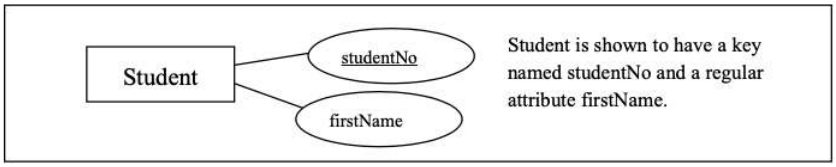

Figure 9.1.2.3.4: Key attribute is underlined.

We define a *key* to be a minimal set of attributes that uniquely identify entities in an entity type. By minimal we mean that all of the attributes are required – none can be omitted. For instance, a typical key for an invoice line entity type would be the combination of invoice number and invoice line number. Both attributes are required to identify a particular invoice line.

It is not unusual for an entity type to have several keys. For instance suppose an educational institution has many departments such as Mathematics, Physics, and Computer Science. Each department is given a unique name and as well the institution assigns each one a unique code: MATH, PHYS, and CS. Both attributes would be underlined to show this in the ERD:

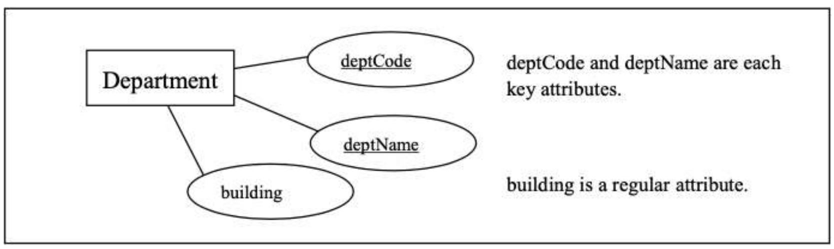

Figure 9.1.2.3.5: Multiple key attributes.

Exercises (Set 6)

Exercise 9.1.2.3.12

Suppose a company that sells products has a product entity type with the following attributes: prodNum, prodDesc, prodPrice. Suppose all three attributes are single-valued and that prodNum is a key attribute - each product has a different product number. Illustrate this information in an ERD.

Exercise 9.1.2.3.13

Consider a banking application where each account is identified first by an account number and then by its type (Savings, Chequing, and Loan). This scheme allows the customer to remember just one number instead of three, and then to pick a specific account by its type. Other attributes to be considered are the date the account was opened and the account's current balance. Draw an ERD for the entity type Account with the attributes account number, account type, date opened, current balance. What is the key of the entity type? Is there an attribute that is likely a derived attribute? Show these attributes appropriately in the ERD.

Partial Key

Sometimes we have attributes that distinguish entities of an entity type from other entities of the same type, but only relative to some other related entity. This situation arises naturally when we model things like invoices and invoice lines. If invoice lines are assigned line numbers (1, 2, 3, etc.), these line numbers distinguish lines on a single invoice from other lines of the same invoice. However, for any given line number value, there could be many invoice lines (from separate invoices) with that same line number.

A *partial key* (also called a *discriminator*) is an attribute that distinguishes instances of a weak entity type relative to a strong entity. Invoice line number is a partial key for invoice lines; each line on one invoice will have different line numbers. Using the Peter Chen notation the discriminator attribute is underlined with a dashed line:

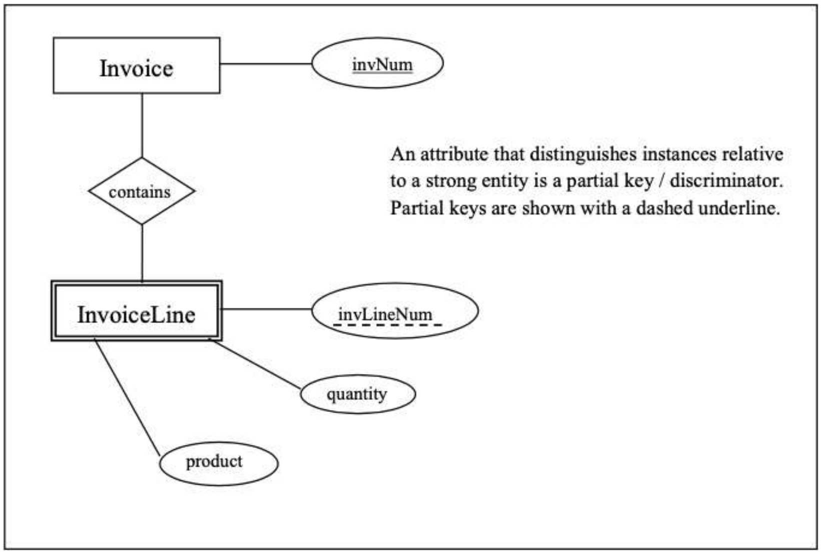

Figure 9.1.2.3.6: Line number distinguishes lines on the same invoice.

Later when relationships are covered it will be clearer that attributes for relationships can be discriminators too. Consider that a library has books that members will borrow. Any book could be borrowed many times and even by the same member. However when a member borrows the same book more than once the date/time will distinguish those events. Consider the following ERD for this case:

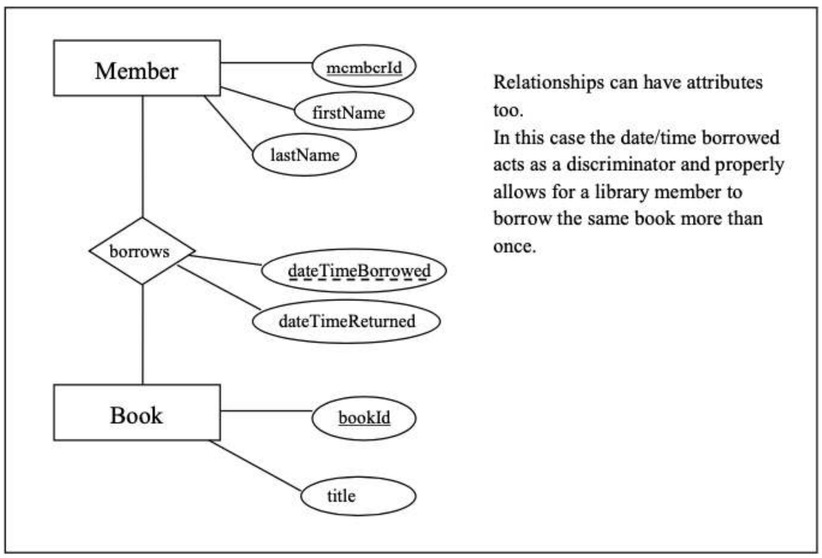

Figure 9.1.2.3.7: Relationship attribute as a discriminator.

Exercises (Set 7)

Exercise 9.1.2.3.14

Consider an educational institution that has departments and where each department offers courses. Suppose departments are assigned unique identifiers and so deptCode is a key for the department entity type. Courses are identified within a department by a course number; course numbers are unique within a department but not across departments. So, History may have a course numbered 215, and English could have a course numbered 215 too. In order to identify a particular course we need to know the department and we need to know the course number. Illustrate an ERD including department and course entity types. Include attributes for the Department (department code and department name), and for Course (course number, title, and description).

Exercise 9.1.2.3.15

Consider a company that owns and operates parking lots. Develop an ERD with two entity types Parking Lot and Space and where:

- The address of a parking lot serves to identify the lot.
- Each space within a lot is rented at the same monthly rental charge.
- Each parking space is known by its number within the lot (within a lot these always start at 1).
- Each parking space is rented out to at most one vehicle. The vehicle's identifier must be recorded. The identifier comprises a province code and license plate number.

Surrogate Key

When a key specified for an entity is meaningless to the entity and to end-users (it doesn't describe any characteristic of an entity), the key is referred to as a *surrogate* key. A key that is not a surrogate key is often referred to as a *natural* key. Often a surrogate key is just a simple integer value assigned by the database system.

When database designs are implemented surrogate keys can be useful to simplify references from one table to another (referential integrity) and the associated joins when tables are referenced in queries.

Exercises (Set 8)

Exercise 9.1.2.3.16

Assuming you have experience with some database system, what data type would you use for surrogate keys?

Non-Key Attributes

Non-key attributes are attributes that are not part of any key. Generally, most attributes are simply descriptive, and fall into this category. Determining key and non-key attributes is an important modeling exercise, one that requires careful consideration. Consider an Employee entity type that has attributes for first name, last name, birth date; these attributes would serve to describe an employee but would not serve to uniquely identify employees.

People may join an organization and their name is not likely unique for the organization; we expect many people in a large organization to have the same first name, same last name, and even the same combination of first and last name. Names cannot usually be used as a key.

However, names chosen for entities such as departments in an organization could be keys because of the way the company would choose department names - they wouldn't give two different departments the same name.

Exercises (Set 9)

Exercise 9.1.2.3.17

Consider an employee entity type and its attributes, and decide which attributes are key attributes and which ones are non-key attributes. Illustrate with an ERD.

Exercise 9.1.2.3.18

A birthdate attribute would appear for many entity types – for example students, employees, children. What is a birthdate likely to be: key or non-key?

Exercise 9.1.2.3.19

Consider a library and the fact that books are loaned out to library members. Dates could be used heavily for the date a book was borrowed, the date the book was returned, and the due date for a book. Consider an entity type Loan that has attributes book identifier, member identifier, date borrowed, date due, date returned. What combination of attributes would be a key? Which attributes are key attributes? Which attributes are non-key attributes?

Nulls

When a database design is implemented one of the important things to know for each attribute of an entity type is whether or not that attribute must have a value. For example when a book is borrowed from a library the date the book is borrowed is known, but the returned date is not known. Sometimes you will not know the value of an attribute until a certain event occurs.

Consider an educational environment and when a student registers for a course. The date the student registers would be known, but the grade is yet to be determined.

When an entity is created but some attribute does not have a value we say it is *null*. Null represents the absence of a value; null is different from zero or from blank.

Domains

To complete the analysis for a database design it is necessary to determine what constitutes a valid value for an attribute. A *domain* for an attribute is its set of valid values which includes a choice of datatype, but a full specification of domain is typically more than that.

For instance, analysis for student identifiers may lead one to state that a student identifier is a positive whole number of exactly 7 digits with no leading zeros. The analysis of requirements for person names may lead one to state that the values stored in a database for a first name, last name, or middle name will not be more than 50 characters in length, and that names will not have any spaces at the beginning or end.

For each attribute one must determine its domain. More than one attribute can share the same domain. Knowing the underlying domains in your model is important. They help to complete your analysis, they are indispensable for coding programs, and they are useful for defining meaningful error messages.

Attribute domains are not usually shown in an ERD. Rather, domains are included in accompanying documentation which can be referred to when the database is being implemented.

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9.1.2.4: Relationships

Up to this point we have made several references to the concept of relationship. Now, we will make our understanding of this concept more complete. A **relationship** is an association amongst entities. Relationships will have justification in business rules, in the way an enterprise manages its business.

There are several ways of classifying relationships, according to *degree*, *participation*, *cardinality*, whether *recursion* is involved, and whether or not a relationship is *identifying*.

Degree

We consider the *degree* as the number of entities that participate in the relationship. When we speak of a student enrolling in a course, we are considering a relationship (say, the *enroll in* relationship) where two entity types (Student and Course) are involved. This relationship is of degree 2 because each instance of the relationship will always involve one student entity and one course entity.

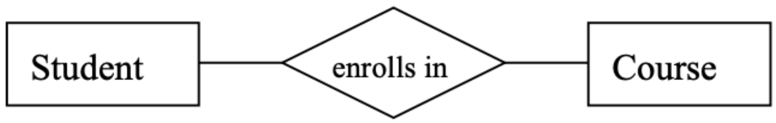


Figure 9.1.2.4.1: Binary relationship involves two entity types.

With binary relationships there must be two defining statements we can express, one from the perspective of each entity type. In this case our statements are:

- A student may enroll in any number of courses.
- A course may have any number of students enrolled.

Many database modeling tools only support binary relationships. However there are situations where relationships of higher degree are useful. A relationship involving 3 entity types is called *ternary*; more generally we refer to relationships with n entity types as *n-ary*. Our primary focus in this text is on binary relationships.

Participation

Suppose we are designing a database for a company that has several departments and employees. Suppose further that each employee must be assigned to work in one department. We can define a *works in* relationship involving Department and Employee. Employees must participate in the relationship and we show this using a double line joining the diamond symbol to the Employee entity type.

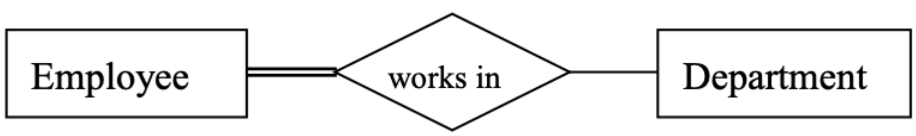


Figure 9.1.2.4.2: Employee must work in a department.

The double line stands for *total* or *mandatory* participation which means that instances of the adjacent entity type must participate in the relationship – in the case above, all instances of Employee must be assigned to some department. Any time we show a single line we are stating participation is *optional*; for the above we are saying that a department will have zero or more employees who work there.

Cardinality

Cardinality is a constraint on a relationship specifying the number of entity instances that a specific entity may be related to via the relationship. Suppose we have the following rules for departments and employees:

- A department can have several employees that work in the department

- An employee is assigned to work in one department.

From these rules we know the cardinalities for the *works in* relationship and we express them with the cardinality symbols *1* and *n* below.

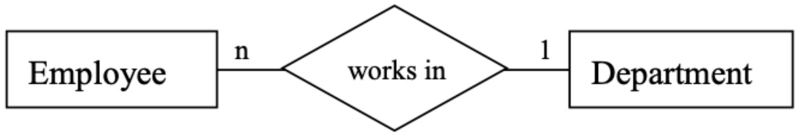


Figure 9.1.2.4.3: One-to-many relationships are most common.

The *n* represents an *arbitrary number of instances*, and the *1* represents *at most one instance*. For the above works in relationship we have

- a specific employee works in at most only one department, and
- a specific department may have many (zero or more) employees who work there.

n, *m*, *N*, and *M* are common symbols used in ER diagrams for representing an arbitrary number of occurrences; however, any alphabetic character will suffice.

Based on cardinality there are three types of binary relationships: *one-to-one*, *one-to-many*, and *many-to-many*.

One-to-One

One-to-one relationships have *1* specified for both cardinalities. Suppose we have two entity types Driver and Vehicle. Assume that we are only concerned with the current driver of a vehicle, and that we are only concerned with the current vehicle that a driver is operating. Our two rules associate an instance of one entity type with at most one instance of the other entity type:

a driver operates at most one vehicle, and

a vehicle is operated by at most one driver.

and so the relationship is one-to-one.

Figure 9.1.2.4.4: One-to-one relationship.

One-to-Many

One-to-many relationships are the most common ones in database designs. Suppose we have customer entities and invoice entities and:

- an invoice is for exactly one customer, and
- a customer could have any number (zero or more) of invoices at any point in time.

Because one instance of an Invoice can only be associated with a single instance of Customer, and because one instance of Customer can be associated with any number of Invoice instances, this is a one-to-many relationship:

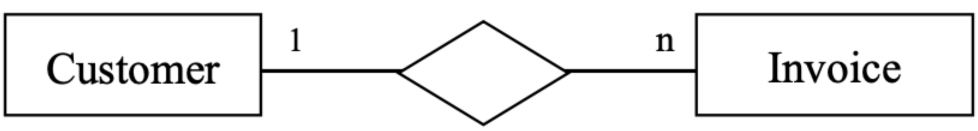


Figure 9.1.2.4.5: One-to-many relationship.

Many-to-Many

Suppose we are interested in courses and students and the fact that students register for courses. Our two rule statements are:

- any student may enroll in several courses,
- a course may be taken by several students.

This situation is represented as a many-to-many relationship between Course and Student:

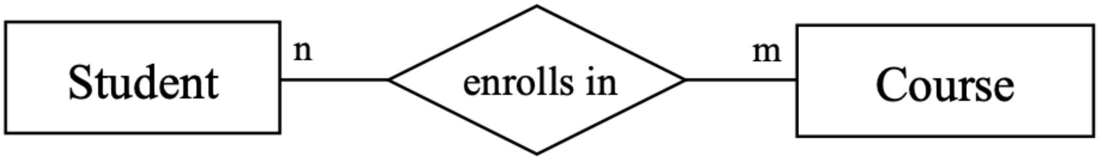


Figure 9.1.2.4.6: Many-to-many relationship.

As will be discussed again later, a many-to-many relationship is implemented in a relational database in a separate relation. In a relational database for the above, there would be three relations: one for Student, one for Course, and one for the many-to-many. (Sometimes this 3rd relation is called an intersection table, a composite table, a bridge table.)

Partly because of the need for a separate structure when the database is implemented, many modellers will 'resolve' a many-to-many relationship into two one-to-many relationships as they are modelling. We can restructure the above many-to-many as two one-to-many relationships where we have 'invented' a new entity type called Enrollment:

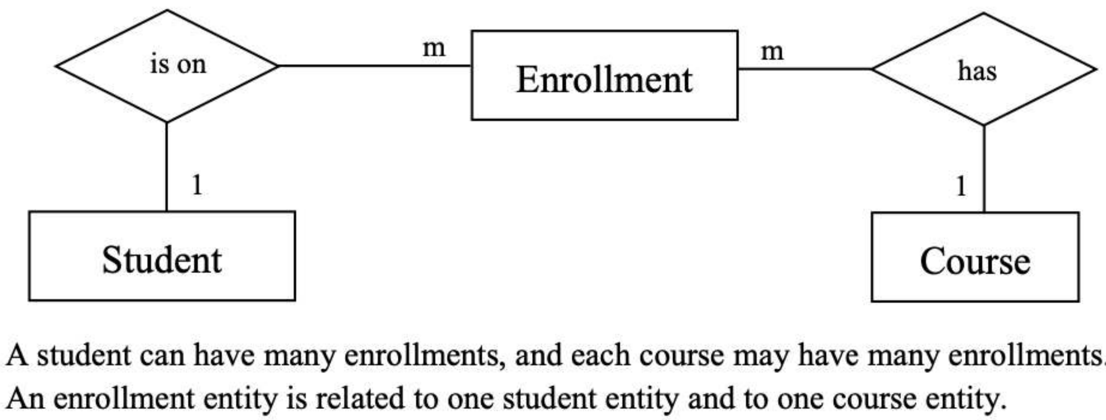


Figure 9.1.2.4.7: Many-to-many becomes two one-to-many relationships.

Recursive Relationships

A relationship is *recursive* if the same entity type appears more than once. A typical business example is a rule such as "an employee *supervises* other employees". The *supervises* relationship is recursive; each instance of *supervises* will specify two employees, one of which is considered a *supervisor* and the other the *supervised.* In the following diagram the relationship symbol joins to the Employee entity type twice by two separate lines. Note the relationship is one-to-many: an employee may supervise many employees, and, an employee may be supervised by one other employee.

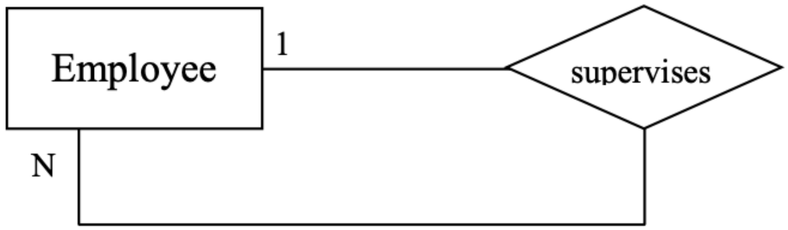


Figure 9.1.2.4.8: Recursive relationship involving Employee twice.

With recursive relationships it is appropriate to name the roles each entity type plays. Suppose we have an instance of the relationship:

> John *supervises* Terry

Then with respect to this instance, John is the *supervisor* employee and Terry is the *supervised* employee. We can show these two roles that entity types play in a relationship by placing labels on the relationship line:

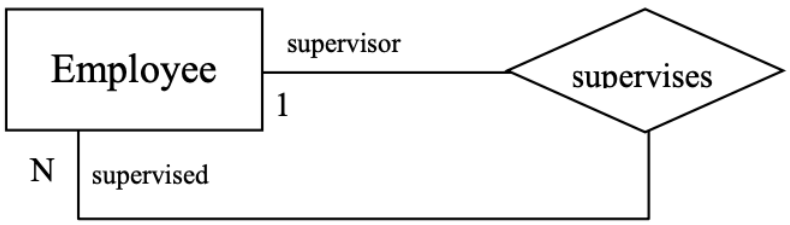


Figure 9.1.2.4.9: Recursive relationship with role names.

This one-to-many *supervises* relationship can be visualized as a hierarchy. In the following we show five instances of the relationship: John supervises Lee, John supervises Peter, Peter supervises Don, Peter supervises Mary, and John supervises Noel.

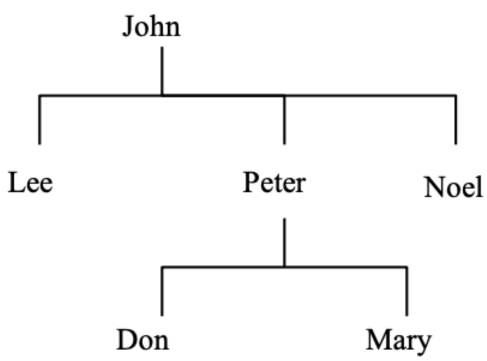


Figure 9.1.2.4.10: The supervising hierarchy.

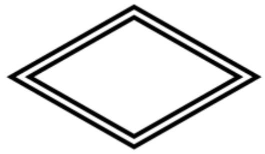
In the above example note the participation constraint at both ends of *supervises* is optional. This has to be the case because some employee will not be supervised, and, for some employees there are no employees they supervise.

Generally recursive relationships are difficult to master. Some other situations where recursive relationships can be used:

- A person marries another person
- A person is the parent of a person
- A team plays against another team
- An organizational units report to another organizational unit
- A part is composed of other parts.

Identifying Relationships

When entity types were first introduced we discussed an example where a department offers courses and that a course must exist in the context of a department. In that case the Course entity type is considered a weak entity type as it is existence-dependent on Department. It is typical in such situations that the key of the strong entity type is used in the identification scheme for the weak entity type. For example, courses could be identified as MATH-123 or PHYS-329, or as Mathematics-123 or Physics-329. In order to convey the composite identification scheme for a weak entity type we specify the relationship as an *identifying* relationship which is visualized using a double-lined diamond symbol:



Additionally in situations where we have an identifying relationship we usually have

- a weak entity type with a partial key
- a weak entity type that must participate in the relationship (total participation)

and so the ERD for our hypothetical educational institution could be:

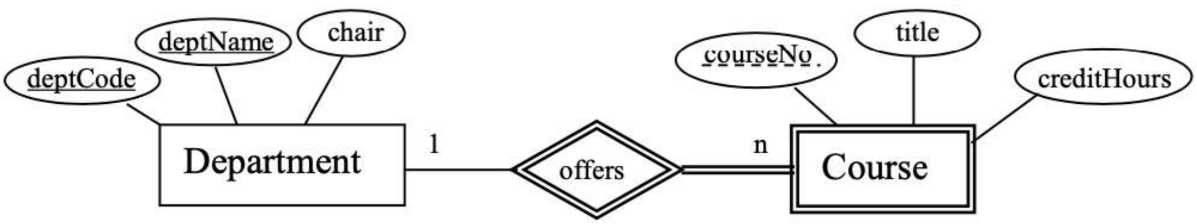


Figure 9.1.2.4.11: An identifying relationship.

Note the keys for the strong entity type appear only at the strong entity type. The identifying relationship tells one that a department key will be needed to complete the identification of a course.

Exercises

Exercise 9.1.2.4.1

Consider a company that owns and operates parking lots. Draw an ERD to include the following specifications. Each parking lot has a unique address (use the typical fields for addresses) and each parking lot has a certain number, say n, of parking spaces. Each space in a lot has a number between 1 and n. The cost of renting a parking space is the same for all spaces in a lot. The company rents individual spaces out to its customers. Each customer is identified by a driver’s license id, has a first and last name. Each customer will identify possibly several cars that they will park in the space rented to them. For each car the company needs to know the year, make, model, colour and its license plate number.

Exercise 9.1.2.4.2

Modify your model from the previous question to allow for scrambled parking. By this we mean that a customer is rented a space in a lot, but the customer may park in any available space.

Exercise 9.1.2.4.3

Draw an ERD involving employees and their dependents where each employee has a unique id number and where dependents of the same employee are numbered starting at 1. It may be rare, but we will allow for dependents of the same employee to have the same name and birthdates. Include typical attributes for an employee, and for a dependent include the birthdate, first and last names.

Exercise 9.1.2.4.4

Draw an ERD for marriages between two people. For persons include birthdate, first name, last name, and a unique person id. Consider marriage to be a relationship between two people and suppose we want our model to allow for people to have more than one marriage. Use the date of the marriage as a discriminator.

Exercise 9.1.2.4.5

Consider marriages again but now let marriage be an entity type. Suppose when people marry there is a marriage certificate that is granted by a government authority. Include attributes applicable to a marriage.

Exercise 9.1.2.4.6

Suppose we are modeling marriage as a relationship between two people. When, or under what circumstances, can we model this as a one-to-one relationship?

Exercise 9.1.2.4.7

Draw an ERD that allows for marriages between possibly more than two people.

Exercise 9.1.2.4.8

Consider the one-to-one *operates* relationship in this chapter. Modify the example so that drivers have attributes: driver license, name (which comprises first name and last name), and vehicles have attributes: license plate number, VIN, year, colour, make and model. Note that VIN stands for vehicle identification number and this is unique for each vehicle. Assume that each driver must be assigned to a vehicle.

Exercise 9.1.2.4.9

Consider the *enroll in* relationship used in this chapter. Suppose we must allow for a student to repeat a course to improve their grade. Develop an ERD and include typical attributes for student, course, etc. We need to keep a complete history of all course attempts by students.

Exercise 9.1.2.4.10

What problems arise if one makes the *supervises* relationship mandatory for either the supervising employee or the employee who is supervised?

Exercise 9.1.2.4.11

Consider requirements for teams, players and games, and develop a suitable ERD. Each team would have a unique name, have a non-player who is the coach, and have several players. Each player has a first and last name and is identified by a number (1, 2, 3, etc.). One player is designated the captain of the team. Assume a game occurs on some date and time, and is played by two teams where one team is called the home team and the other team is called the visiting team. At the end of the game the score must be recorded.

Exercise 9.1.2.4.12

Modify your ERD for the above to accommodate a specific sport such as curling, baseball, etc.

Exercise 9.1.2.4.13

Consider an ERD for modelling customers, phones, and phone calls. Each customer owns one phone and so the phone number identifies the customer. Include other attributes such as credit card number, first name, and last name for a customer. We must record information for each phone call that is made: for each call there is a start time, end time, and of course the phone number/customers involved.

Exercise 9.1.2.4.14

Create an ERD suitable for a database that will keep genealogy data. Suppose there is one entity type Person and you must model the two relationships: *marries* and *child of*.

Exercise 9.1.2.4.15

Develop an ERD to support home real estate sales. Consider there are several sales employees who list and sell properties. For each employee we need to know their name (first and last), the date they started working for this company, and the number of years they have been with the company. Each property has owners (one or more people), and may have certain features such as number of baths, number of levels, number of bedrooms. For each owner we must keep track of their names (first and last). Each property has an address; each address has the usual attributes: street (comprising apartment number, street number, street name), city, province, and postal code. A home is listed at a certain price and sold at possibly a different price. Of course, we need to track the names of the buyers, the date of a listing and the date of a sale.

Exercise 9.1.2.4.16

Develop an ERD to keep track of information for an educational institution. Assume each course is taught by one instructor, and an instructor could teach several courses. For each instructor suppose we have a unique identifier, a first name, a last name, and a gender. Each course belongs to exactly one department. Within a department courses are identified by a course number. Departments are identified by a department code.

Exercise 9.1.2.4.17

Develop an ERD to allow us to keep information on a survey. Suppose a survey will have several questions that can be answered true or false. Over a period of time the survey is conducted and there will be several responses.

Exercise 9.1.2.4.18

Modify the ERD above to allow for surveys that have multiple choice answers.

Exercise 9.1.2.4.19

Develop an ERD to support the management of credit cards. Each credit card has a unique number and has a customer associated with it. A customer may have several credit cards. The customer has a first name, last name, and an address. Each time a customer uses a credit card we must record the time, the date, the vendor, and the amount of money involved.

Exercise 9.1.2.4.20

Modify the ERD for the above to accommodate the monthly billing of customers. Each month a customer receives a statement detailing the activity that month.

Exercise 9.1.2.4.21

Develop an ERD to be used by a company to manage the orders it receives from its customers. Each customer is identified uniquely by a customer id; include the first name, last name, and address for each customer. The company has several products that it stocks and for which customers place orders. Each product has a unique id, unique name, unit price, and a quantity on hand. At any time a customer may place an order which will involve possibly many products. For each product ordered the database must know the quantity ordered and the unit price at that point in time. If the customer does this through a phone call then an employee is involved in the call and will be responsible for the order from the company side. Some orders are placed via the internet. For each order an order number is generated. For each order the database must keep track of the order number, the date the order was placed and the date by which the customer needs to receive the goods.

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SECTION OVERVIEW

9.1.2.5: Mapping an ERD to a Relational Database

We use an Entity Relationship Diagram to represent the informational needs of a system. When we are convinced it is satisfactory, we map the ERD to a relational database and implement as a physical database.

In general, relations are used to hold entity sets and to hold relationship sets. The considerations to be made are listed below. After we present the mapping rules, we illustrate their application in a few examples.

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9.1.2.5.1: Mapping Rules

To complete the mapping from an ERD to relations we must consider the entity types, relationship types, and attributes that are specified for the model.

Entity Types

Each entity type is implemented with a separate relation. Entity types are either strong entity types or weak entity types.

Strong Entities

Strong, or regular, entity types are mapped to their own relation. The PK is chosen from the set of keys available.

Weak Entities

Weak entity types are mapped to their own relation, but the primary key of the relation is formed as follows. If there are any identifying relationships, then the PK of the weak entity is the combination of the PKs of entities related through identifying relationships and the discriminator of the weak entity type; otherwise the PK of the relation is the PK of the weak entity.

Relationship Types

The implementation of relationships involves foreign keys. Recall, as discussed in point 1.b) above, that if the relationship is identifying, then the primary key of an entity type must be propagated to the relation for a weak entity type. We must consider both the degree and the cardinality of the relationship. In the following (1), (2), and (3) deal with binary relationships and (4) concerns *n*-ary relationships.

Binary One-To-One (1)

In general, with a one-to-one relationship, a designer has a choice regarding where to implement the relationship. One may choose to place a foreign key in one of the two relations, or in both. Consider placing the foreign key such that nulls are minimized. If there are attributes on the relationship those can be placed in either relation.

Binary One-To-Many (2)

With a one-to-many relationship the designer must place a foreign key in the relation corresponding to the 'many' side of the relationship. Any other attributes defined for the relationship are also included on the 'many' side.

Binary Many-To-Many (3)

A many-to-many relationship must be implemented with a separate relation for the relationship. This new relation will have a composite primary key comprising the primary keys of the participating entity types and any discriminator attribute, plus other attributes of the relationship if any.

n-ary, n>2 (4)

A new relation is generated for an *n*-ary relationship. This new relation has a composite primary key comprising the *n* primary keys of the participating entity types and any discriminator attribute, plus any other attributes. There is one exception to the formation of the PK: if the cardinality related for any entity type is 1, then the primary key of that entity type is only included as a foreign key and not as part of the primary key of the new relation.

Attributes

All attributes, with the exception of derived and composite attributes, must appear in relations. You choose to include derived attributes if their presence will improve performance. In the following we consider attributes according to whether they are simple, atomic, multi-valued, or composite.

Simple, atomic

These are included in the relation created for the pertinent entity type, many-to-many relationship, or *n*-ary relationship.

Multi-valued

Each multi-valued attribute is implemented using a new relation. This relation will include the primary key of the original entity type. The primary key of the new relation will be the primary key of the original entity type plus the multi-valued attribute. Note that in this new relation, the attribute is no longer multi-valued.

[Composite and Derived attributes are not included].

The above constitutes the standard rules for mapping an ERD to relations. A designer may make other choices but one expects there would be good reasons for doing so.

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9.1.2.5.2: Examples

Example 9.1.2.5.2.1

Consider the ERD

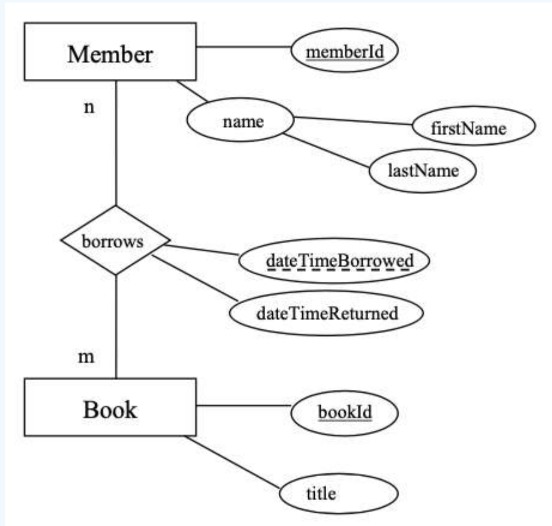


Figure 9.1.2.5.2.1: Example ERD #1.

The mapping rules lead to the relations:

Table 9.1.2.5.2.1: Book relations.

Book	
bookId	title

Table 9.1.2.5.2.2: Member relations.

Member		
memberId	firstName	lastName

Table 9.1.2.5.2.3: Borrow relations.

Borrow			
memberId	**bookId**	**dateTimeBorrowed**	dateTimeReturned

Notes:

- The Member relation does not have a composite attribute *name*.
- Since Borrows is a many-to-many relationship the Borrow relation is defined with a composite primary key {*memberId*, *bookId*, *dateTimeBorrowed*}.
- *memberId* in the Borrow relation is a foreign key referencing Member.
- *bookId* in the Borrow relation is a foreign key referencing Book.

Example 9.1.2.5.2.2

Consider the ERD

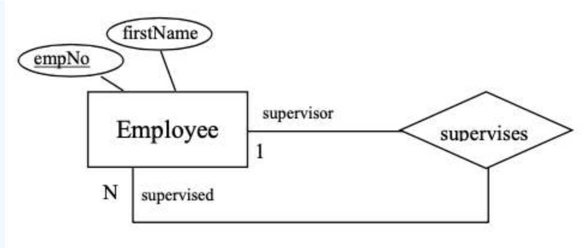


Figure 9.1.2.5.2.2: Example ERD #2.

The mapping rules lead to the relation:

Table 9.1.2.5.2.4: Employee relations.

Employee		
empNo	firstName	supervisor

Notes:

- The attribute *supervisor* is a foreign key referencing Employee.
- A foreign key is placed on the 'many' side of a relationship and so in this case the foreign key references the employee who is the supervisor (the role name on the 'one' side); hence the name *supervisor* was chosen as the attribute name.

Example 9.1.2.5.2.3

Consider the ERD

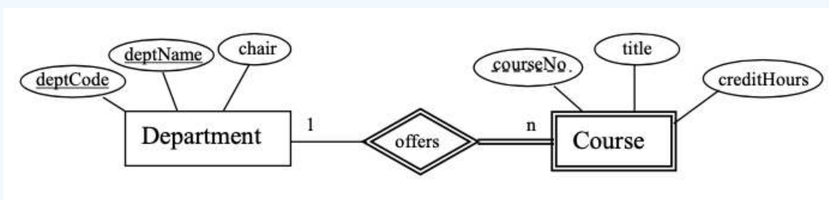


Figure 9.1.2.5.2.3: Example ERD #3.

The mapping rules lead to the relations.

Table 9.1.2.5.2.5: Department relations.

Department		
deptCode	deptName	chair

Table 9.1.2.5.2.6: Course relations.

Course			
deptCode	**courseNo**	title	creditHours

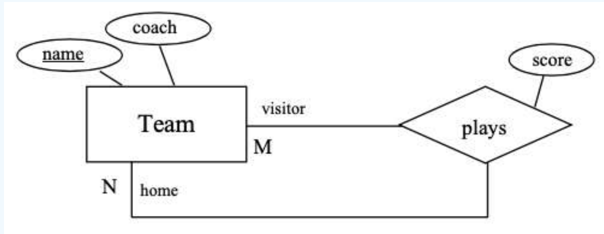
Notes:

- *deptCode* was chosen as the primary key of Department.
- *deptName* is a key and so a unique index can be defined to ensure uniqueness.
- Since Course is a weak entity type and is involved in an identifying relationship, the primary key of Course is composite comprising {*deptCode*, *courseNo*}.
- *deptCode* in Course is a foreign key referencing Department.

Exercises

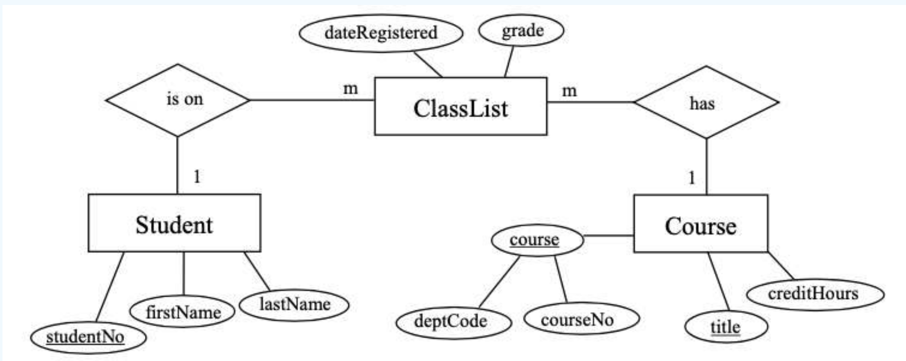
Exercise 9.1.2.5.2.1

Map the ERD to relations.



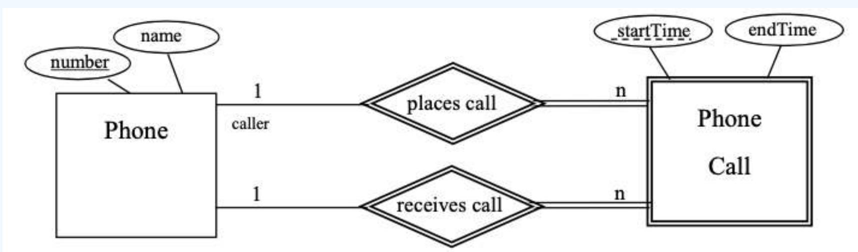
Exercise 9.1.2.5.2.2

Map the ERD to relations.



Exercise 9.1.2.5.2.3

Map the ERD to relations.



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SECTION OVERVIEW

9.1.3: Application Development

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9.1.3.1: Pseudocode

Overview

Pseudocode is an informal high-level description of the operating principle of a computer program or other algorithm.[1]

Discussion

Pseudocode is one method of designing or planning a program. **Pseudo** means false, thus pseudocode means false code. A better translation would be the word fake or imitation. Pseudocode is fake (not the real thing). It looks like (imitates) real code but it is NOT real code. It uses English statements to describe what a program is to accomplish. It is fake because no compiler exists that will translate the pseudocode to any machine language. Pseudocode is used for documenting the program or module design (also known as the algorithm).

The following outline of a simple program illustrates pseudocode. We want to be able to enter the ages of two people and have the computer calculate their average age and display the answer.

Outline using Pseudocode

```
Input
    display a message asking the user to enter the first age
    get the first age from the keyboard
    display a message asking the user to enter the second age
    get the second age from the keyboard

Processing
    calculate the answer by adding the two ages together and dividing by two

Output
    display the answer on the screen
    pause so the user can see the answer
```

After developing the program design, we use the pseudocode to write code in a language (like C++, Java, Python, etc.) where you must follow the rules of the language (syntax) in order to code the logic or algorithm presented in the pseudocode. Pseudocode usually does not include other items produced during programming design such as identifier lists for variables or test data.

There are other methods for planning and documenting the logic for a program. One method is HIPO. It stands for Hierarchy plus Input Process Output and was developed by IBM in the 1960s. It involved using a hierarchy (or structure) chart to show the relationship of the sub-routines (or functions) in a program. Each sub-routine had an IPO piece. Since the above problem/task was simple, we did not need to use multiple sub-routines, thus we did not produce a hierarchy chart. We did incorporate the IPO part of the concept for the pseudocode outline.

Key Terms

pseudo

Means false and includes the concepts of fake or imitation.

References

- cnx.org: Programming Fundamentals – A Modular Structured Approach using C++

1. Wikipedia: Pseudocode ↵

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9.1.3.2: Flowcharts

Overview

A **flowchart** is a type of diagram that represents an algorithm, workflow or process. The flowchart shows the steps as boxes of various kinds, and their order by connecting the boxes with arrows. This diagrammatic representation illustrates a solution model to a given problem. Flowcharts are used in analyzing, designing, documenting or managing a process or program in various fields.[1]

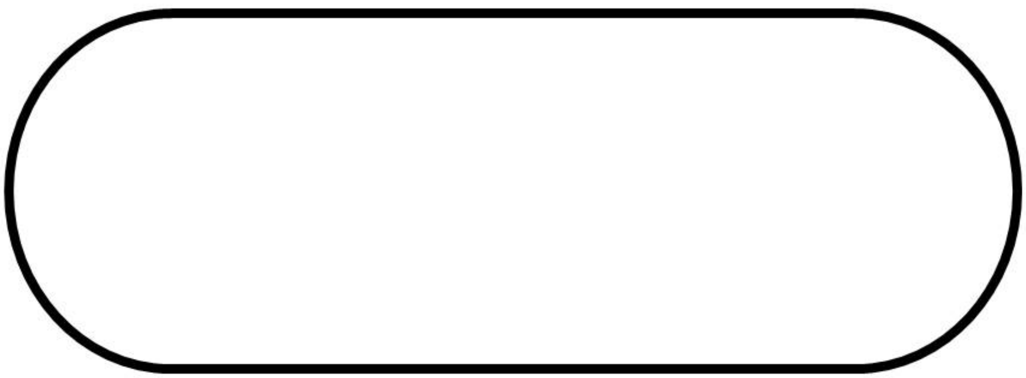
Discussion

Common flowcharting symbols and examples follow. When first reading this section, focus on the simple symbols and examples. Return to this section in later chapters to review the advanced symbols and examples.

Simple Flowcharting Symbols

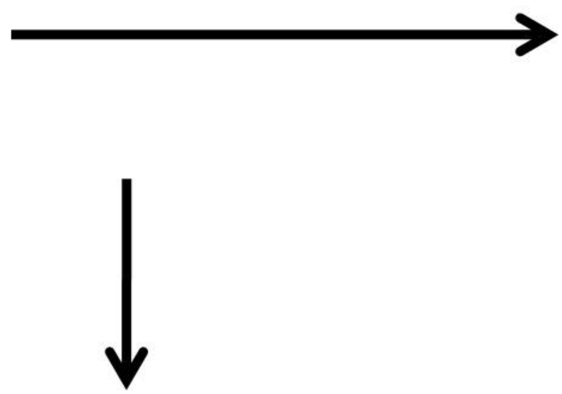
Terminal

The rounded rectangles, or terminal points, indicate the flowchart’s starting and ending points.



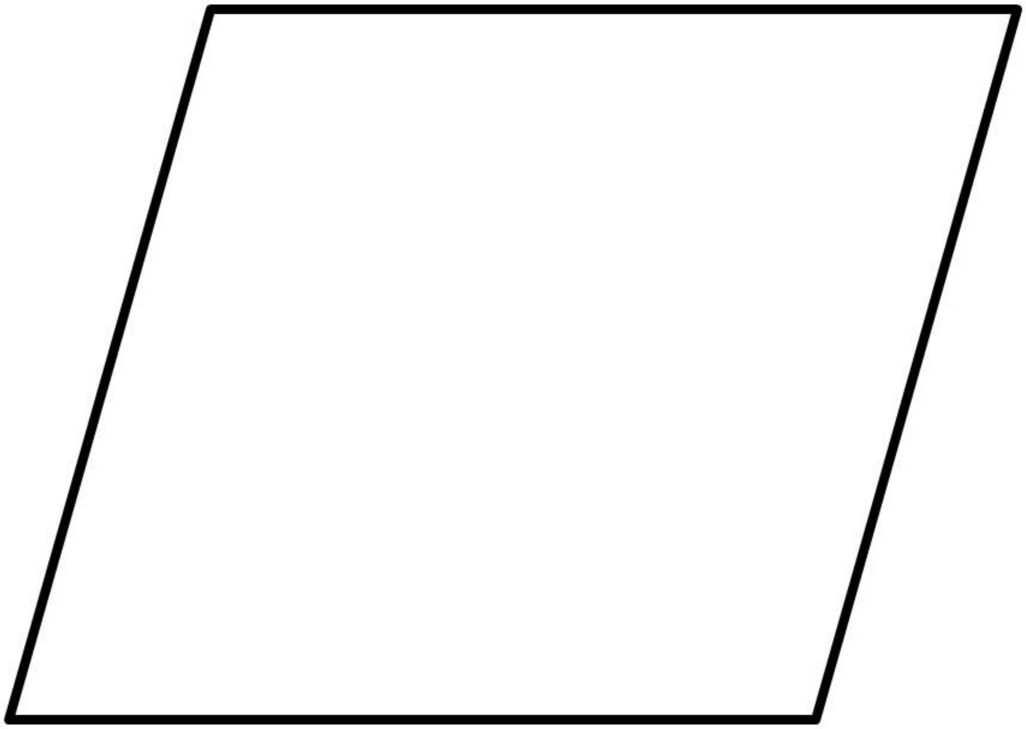
Flow Lines

Note: The default flow is left to right and top to bottom (the same way you read English). To save time arrowheads are often only drawn when the flow lines go contrary the normal.



Input/Output

The parallelograms designate input or output operations.

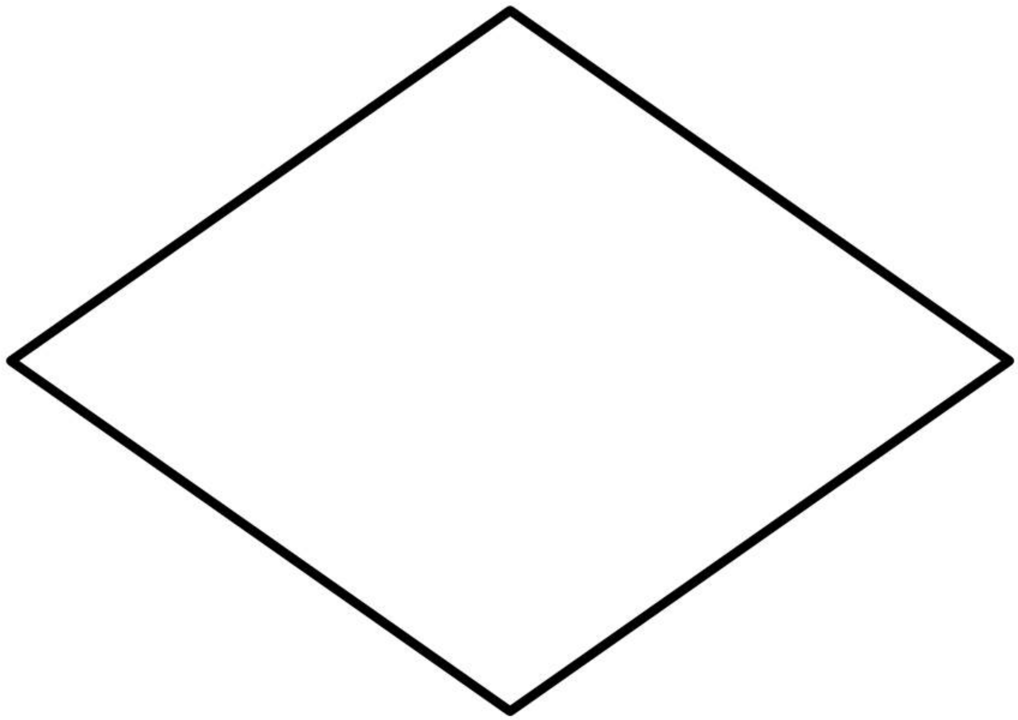


Process

The rectangle depicts a process such as a mathematical computation, or a variable assignment.

Decision

The diamond is used to represent the true/false statement being tested in a decision symbol.

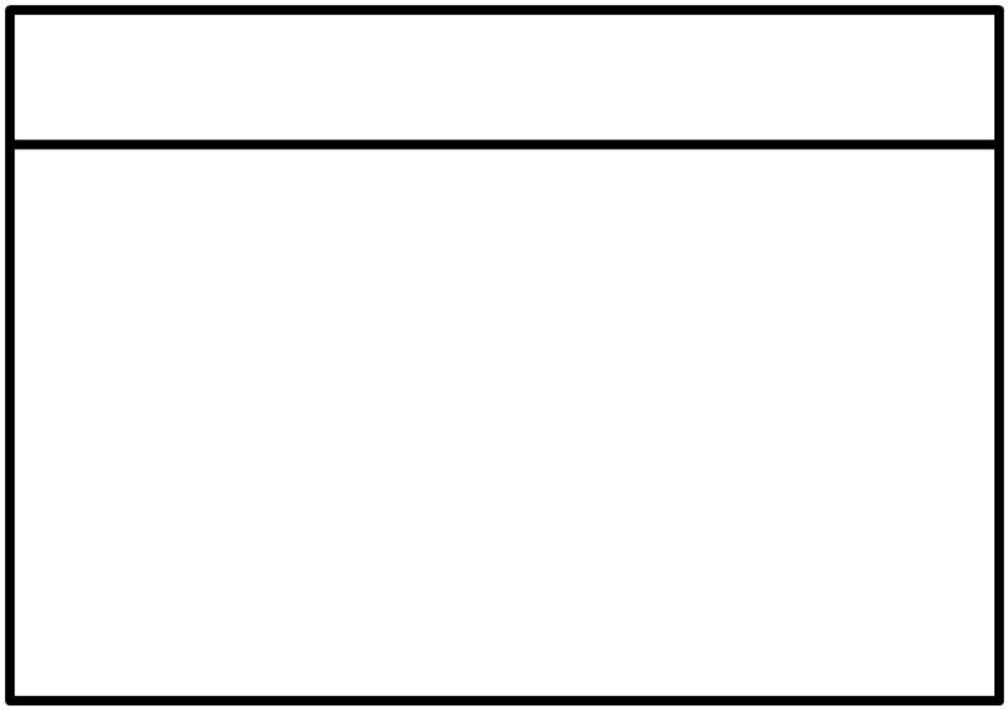


Advanced Flowcharting Symbols

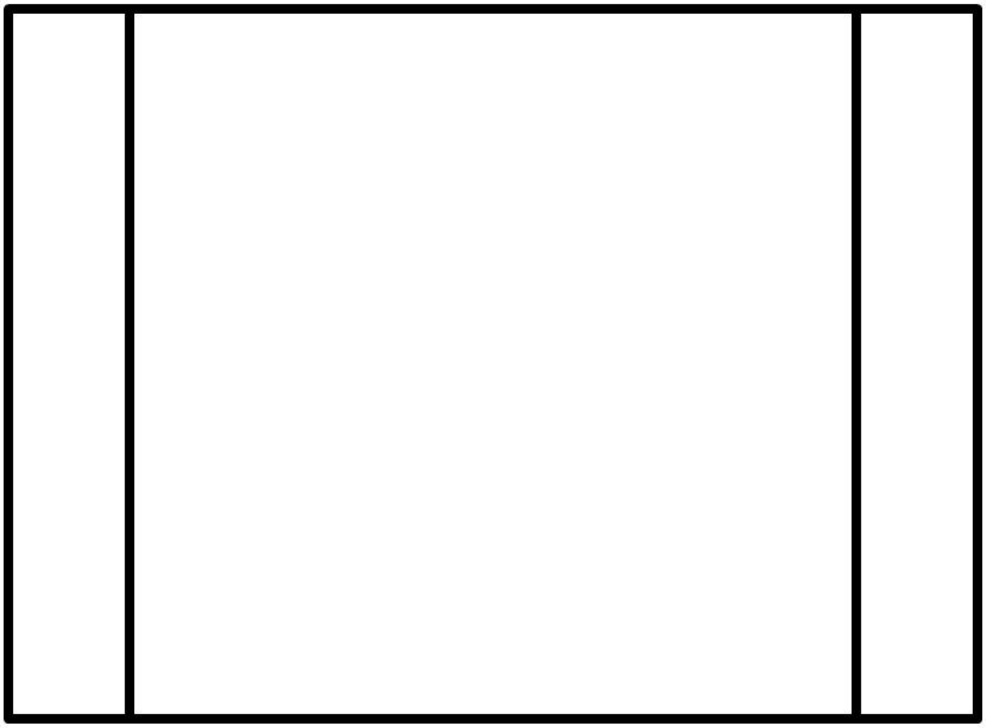
Module Call

A program module is represented in a flowchart by rectangle with some lines to distinguish it from process symbol. Often programmers will make a distinction between program control and specific task modules as shown below.

Local module: usually a program control function.



Library module: usually a specific task function.



Connectors

Sometimes a flowchart is broken into two or more smaller flowcharts. This is usually done when a flowchart does not fit on a single page, or must be divided into sections. A connector symbol, which is a small circle with a letter or number inside it, allows you to connect two flowcharts on the same page. A connector symbol that looks like a pocket on a shirt, allows you to connect to a flowchart on a different page.

On-Page Connector

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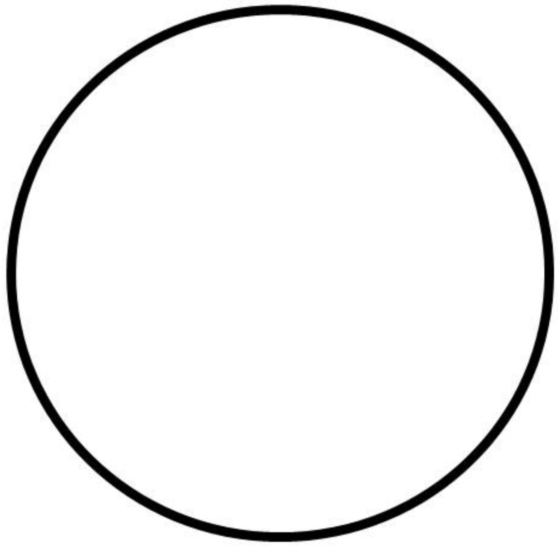
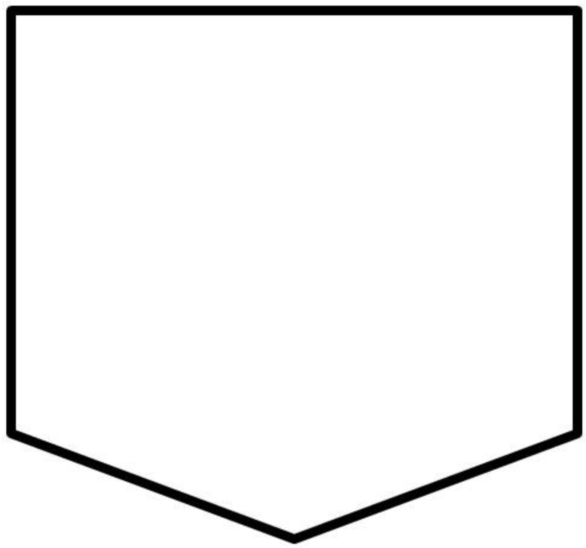


Off-Page Connector



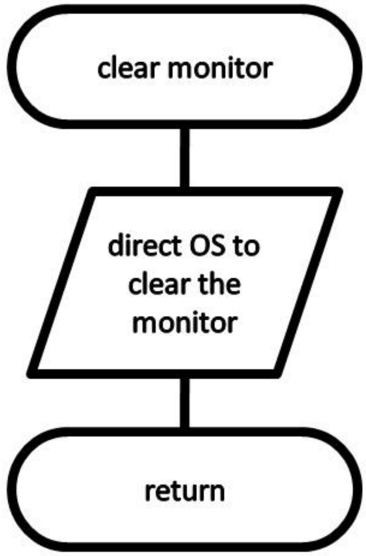
Simple Examples

We will demonstrate various flowcharting items by showing the flowchart for some pseudocode.

Functions

pseudocode: Function with no parameter passing

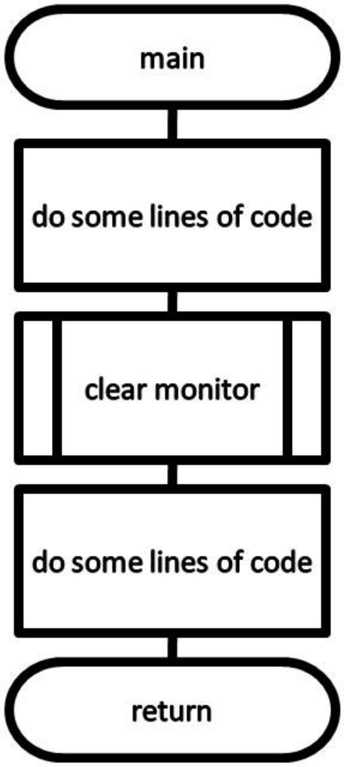
```
Function clear monitor
    Pass In: nothing
    Direct the operating system to clear the monitor
    Pass Out: nothing
End function
```



Function clear monitor

pseudocode: Function main calling the clear monitor function

```
Function main
    Pass In: nothing
    Doing some lines of code
    Call: clear monitor
    Doing some lines of code
    Pass Out: value zero to the operating system
End function
```



Function main

Sequence Control Structures

The next item is pseudocode for a simple temperature conversion program. This demonstrates the use of both the on-page and off-page connectors. It also illustrates the sequence control structure where nothing unusual happens. Just do one instruction after another in the sequence listed.

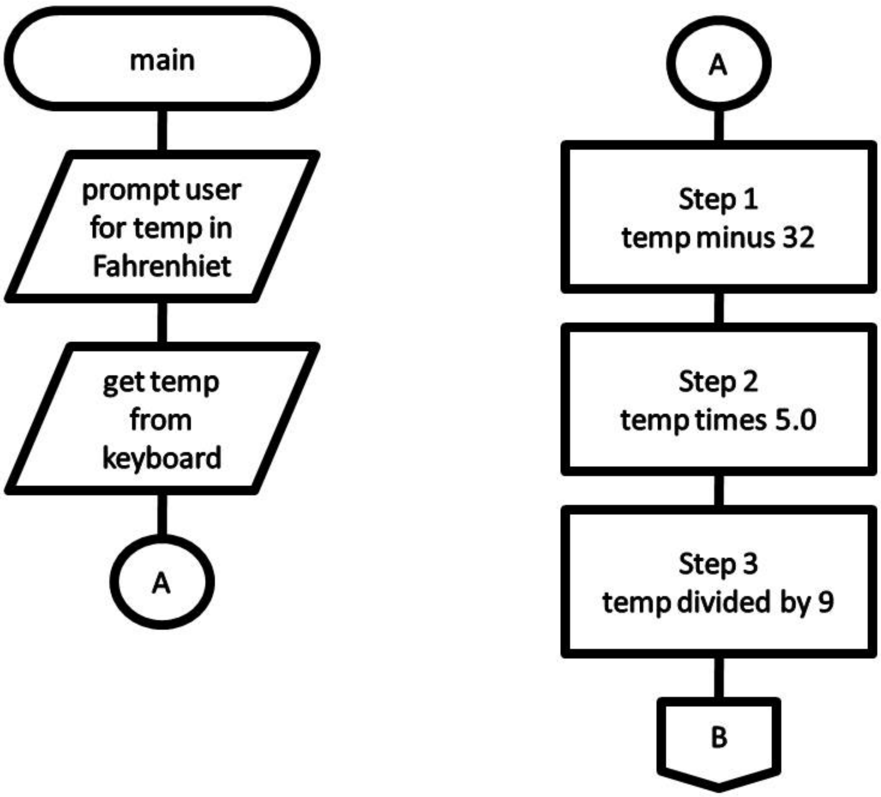
pseudocode: Sequence control structure

```
Filename: Solution_Lab_04_Pseudocode.txt
Purpose:  Convert Temperature from Fahrenheit to Celsius
Author:   Ken Busbee; © 2008 Kenneth Leroy Busbee
Date:     Dec 24, 2008

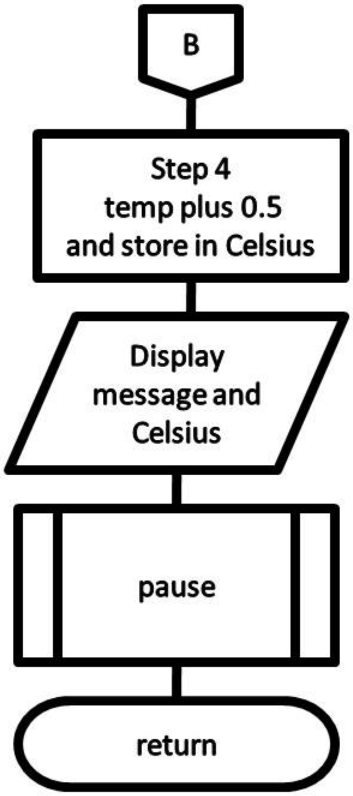
Pseudocode = IPO Outline

input
    display a message asking user for the temperature in Fahrenheit
    get the temperature from the keyboard
```

```
processing
    calculate the Celsius by subtracting 32 from the Fahrenheit
    temperature then multiply the result by 5 then
    divide the result by 9. Round up or down to the whole number.      output
    HINT: Use 32.0 when subtracting to ensure floating-point accuracy.      display t
                                                                            pause so
```



Sequence control structure



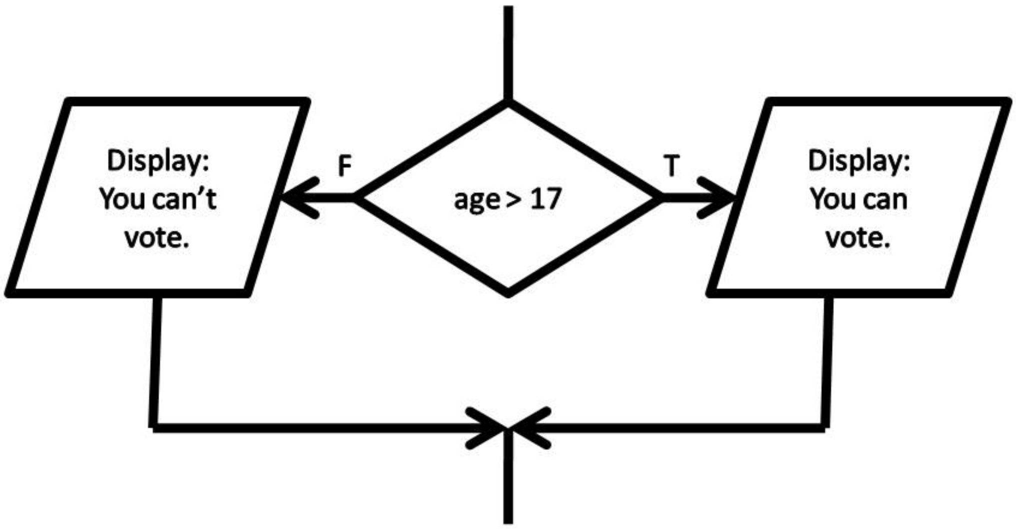
Sequence control structured continued

Advanced Examples

Selection Control Structures

pseudocode: If then Else

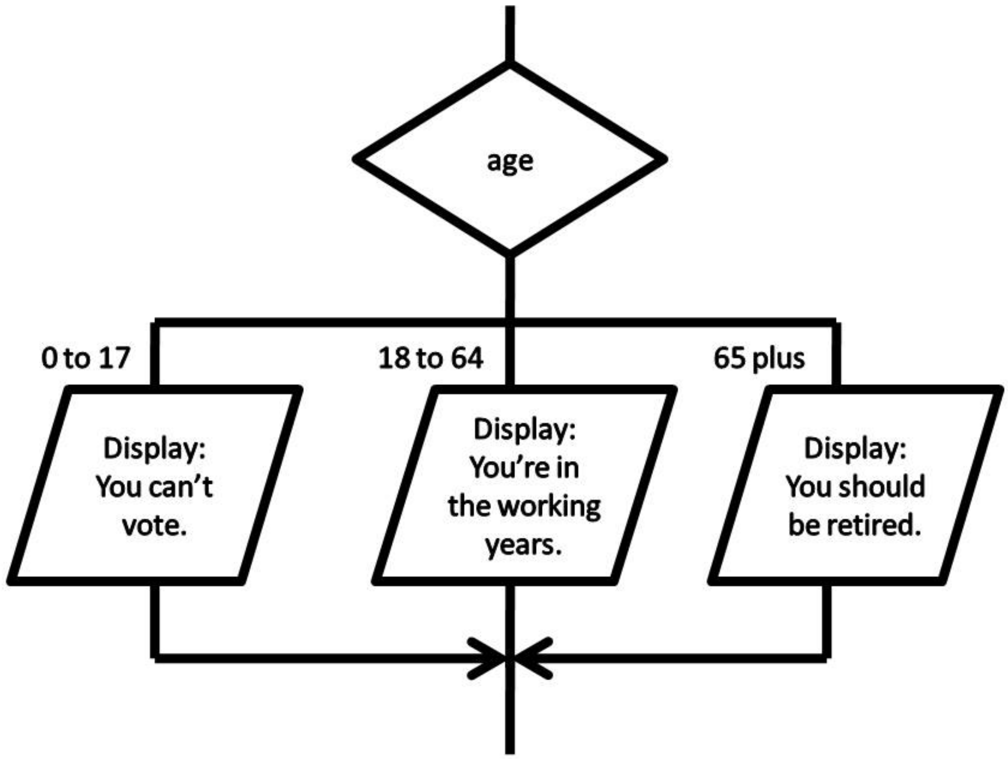
```
If age > 17
    Display a message indicating you can vote.
Else
    Display a message indicating you can't vote.
Endif
```



If then Else control structure

pseudocode: Case

```
Case of age
    0 to 17   Display "You can't vote."
    18 to 64  Display "You are in your working years."
    65 +      Display "You should be retired."
End case
```

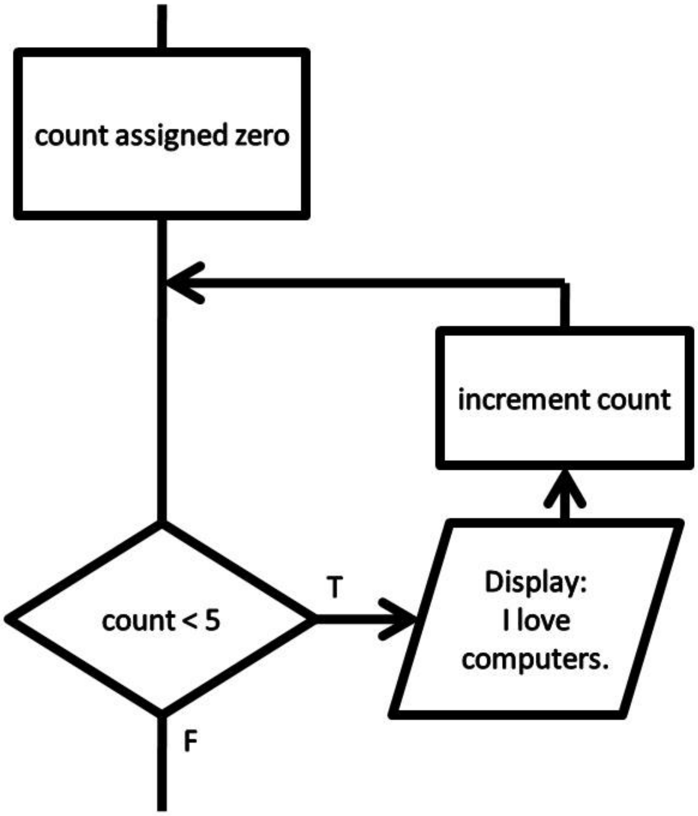


Case control structure

Iteration (Repetition) Control Structures

pseudocode: While

```
count assigned zero
While count < 5
    Display "I love computers!"
    Increment count
End while
```

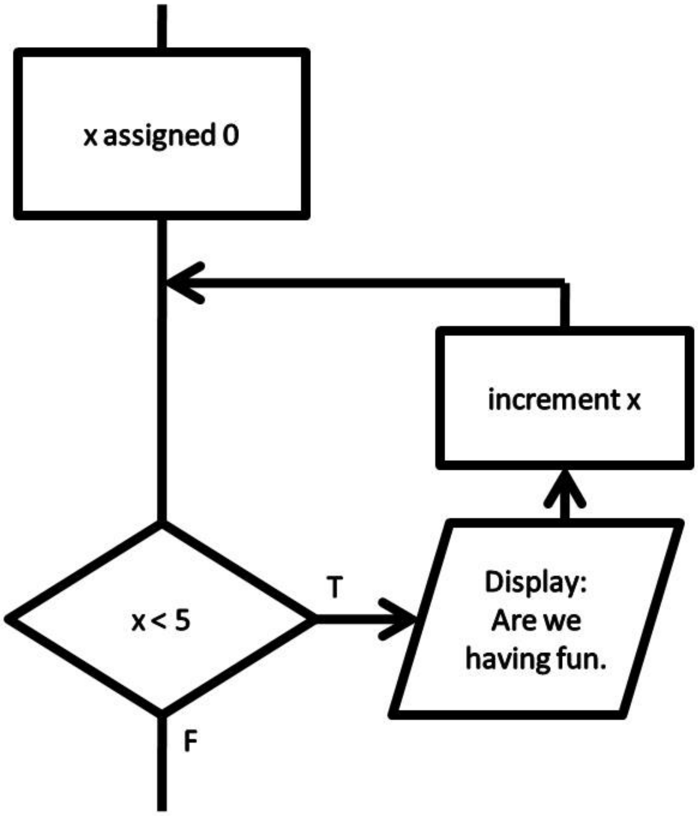


While control structure

pseudocode: For

```
For x starts at 0, x < 5, increment x
    Display "Are we having fun?"
End for
```

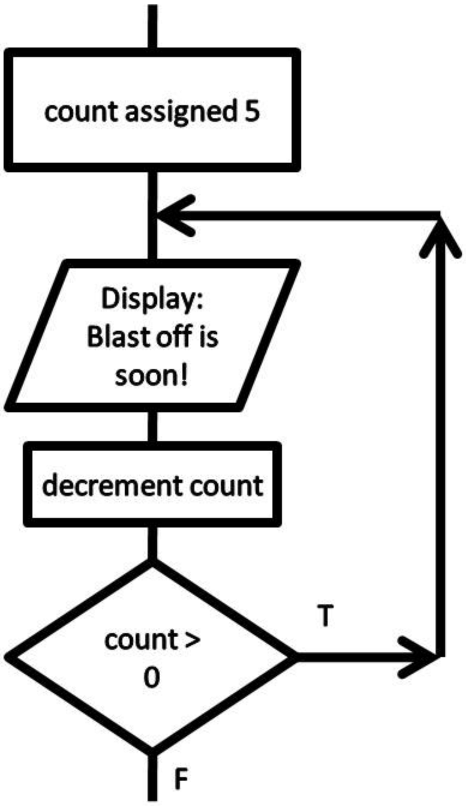
The for loop does not have a standard flowcharting method and you will find it done in different ways. The for loop as a counting loop can be flowcharted similar to the while loop as a counting loop.



For control structure

pseudocode: Do While

```
count assigned five
Do
    Display "Blast off is soon!"
    Decrement count
While count > zero
```



Do While control structure

pseudocode: Repeat Until

```
count assigned five
Repeat
    Display "Blast off is soon!"
    Decrement count
Until count < one
```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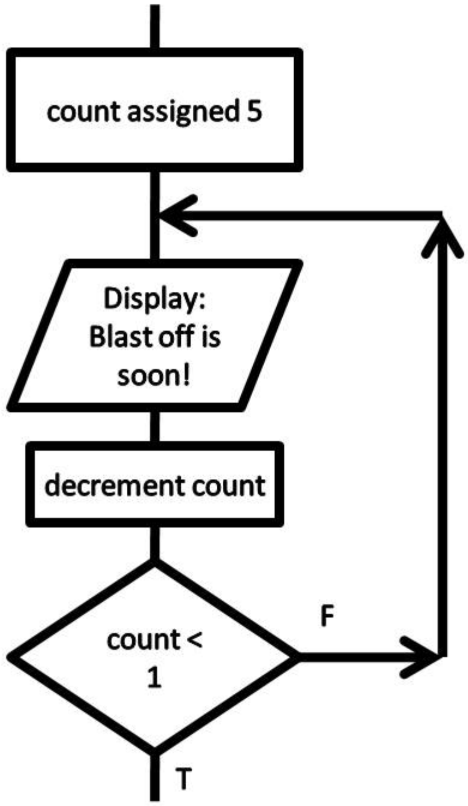

Repeat Until control structure

Key Terms

decision symbol

A diamond used in flowcharting for asking a question and making a decision.

flow lines

Lines (sometimes with arrows) that connect the various flowcharting symbols.

flowcharting

A programming design tool that uses graphical elements to visually depict the flow of logic within a function.

input/output symbol

A parallelogram used in flowcharting for input/output interactions.

process symbol

A rectangle used in flowcharting for normal processes such as assignment.

References

- cnx.org: Programming Fundamentals – A Modular Structured Approach using C++

1. Wikipedia: Flowchart ↩

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SECTION OVERVIEW

9.2: Project Management

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9.2.1: Stakeholder Management

A project is successful when it achieves its objectives and meets or exceeds the expectations of the stakeholders. But who are the stakeholders? Stakeholders are individuals who either care about or have a vested interest in your project. They are the people who are actively involved with the work of the project or have something to either gain or lose as a result of the project. When you manage a project to add lanes to a highway, motorists are stakeholders who are positively affected. However, you negatively affect residents who live near the highway during your project (with construction noise) and after your project with far-reaching implications (increased traffic noise and pollution).

NOTE: Key stakeholders can make or break the success of a project. Even if all the deliverables are met and the objectives are satisfied, if your key stakeholders aren't happy, nobody's happy.

The project sponsor, generally an executive in the organization with the authority to assign resources and enforce decisions regarding the project, is a stakeholder. The customer, subcontractors, suppliers, and sometimes even the government are stakeholders. The project manager, project team members, and the managers from other departments in the organization are stakeholders as well. It's important to identify all the stakeholders in your project upfront. Leaving out important stakeholders or their department's function and not discovering the error until well into the project could be a project killer.

Figure 5.1 shows a sample of the project environment featuring the different kinds of stakeholders involved on a typical project. A study of this diagram confronts us with a couple of interesting facts.

First, the number of stakeholders that project managers must deal with ensures that they will have a complex job guiding their project through the lifecycle. Problems with any of these members can derail the project.

Second, the diagram shows that project managers have to deal with people external to the organization as well as the internal environment, certainly more complex than what a manager in an internal environment faces. For example, suppliers who are late in delivering crucial parts may blow the project schedule. To compound the problem, project managers generally have little or no direct control over any of these individuals.

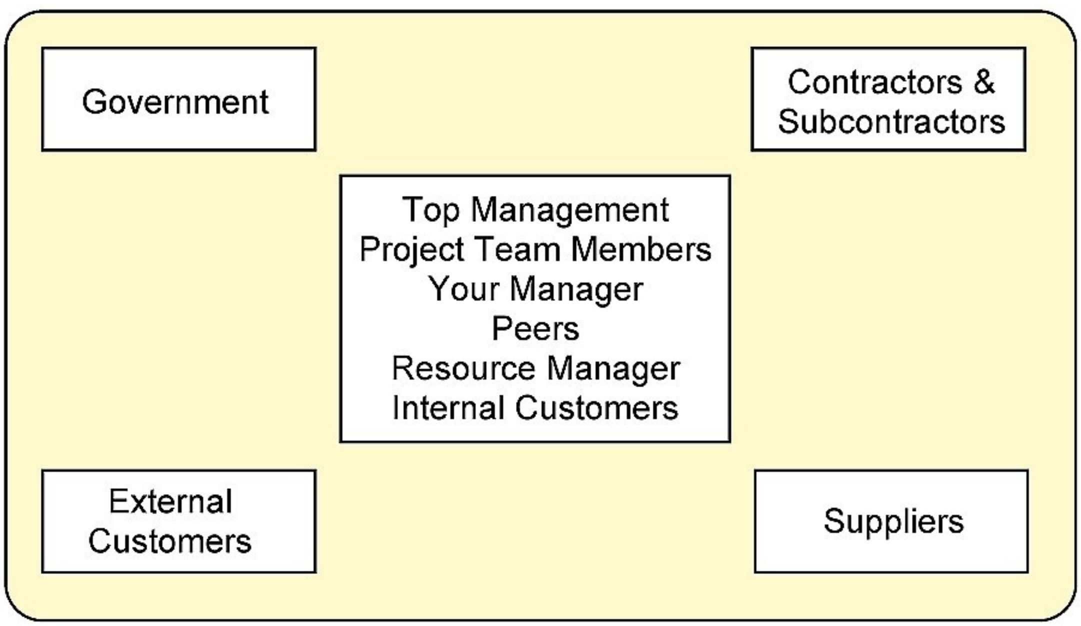

Figure 5.1: Project stakeholders. In a project, there are both internal and external stakeholders. Internal stakeholders may include top management, project team members, your manager, peers, resource manager, and internal customers. External stakeholders may include external customers, government, contractors and subcontractors, and suppliers.

Let's take a look at these stakeholders and their relationships to the project manager.

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Project Stakeholders

Top Management

Top management may include the president of the company, vice-presidents, directors, division managers, the corporate operating committee, and others. These people direct the strategy and development of the organization.

On the plus side, you are likely to have top management support, which means it will be easier to recruit the best staff to carry out the project, and acquire needed material and resources; also visibility can enhance a project manager's professional standing in the company.

On the minus side, failure can be quite dramatic and visible to all, and if the project is large and expensive (most are), the cost of failure will be more substantial than for a smaller, less visible project.

Some suggestions in dealing with top management are:

- Develop in-depth plans and major milestones that must be approved by top management during the planning and design phases of the project.
- Ask top management associated with your project for their information reporting needs and frequency.
- Develop a status reporting methodology to be distributed on a scheduled basis.
- Keep them informed of project risks and potential impacts at all times.

The Project Team

The project team is made up of those people dedicated to the project or borrowed on a part-time basis. As project manager, you need to provide leadership, direction, and above all, the support to team members as they go about accomplishing their tasks. Working closely with the team to solve problems can help you learn from the team and build rapport. Showing your support for the project team and for each member will help you get their support and cooperation.

Here are some difficulties you may encounter in dealing with project team members:

- Because project team members are borrowed and they don't report to you, their priorities may be elsewhere.
- They may be juggling many projects as well as their full-time job and have difficulty meeting deadlines.
- Personality conflicts may arise. These may be caused by differences in social style or values or they may be the result of some bad experience when people worked together in the past.
- You may find out about missed deadlines when it is too late to recover.

Managing project team members requires interpersonal skills. Here are some suggestions that can help:

- Involve team members in project planning.
- Arrange to meet privately and informally with each team member at several points in the project, perhaps for lunch or coffee.
- Be available to hear team members' concerns at any time.
- Encourage team members to pitch in and help others when needed.
- Complete a project performance review for team members.

Your Manager

Typically the boss decides what the assignment is and who can work with the project manager on projects. Keeping your manager informed will help ensure that you get the necessary resources to complete your project.

If things go wrong on a project, it is nice to have an understanding and supportive boss to go to bat for you if necessary. By supporting your manager, you will find your manager will support you more often.

- Find out exactly how your performance will be measured.
- When unclear about directions, ask for clarification.
- Develop a reporting schedule that is acceptable to your boss.
- Communicate frequently.

Peers

Peers are people who are at the same level in the organization as you and may or may not be on the project team. These people will also have a vested interest in the product. However, they will have neither the leadership responsibilities nor the accountability for the success or failure of the project that you have.

Your relationship with peers can be impeded by:

- Inadequate control over peers
- Political maneuvering or sabotage
- Personality conflicts or technical conflicts
- Envy because your peer may have wanted to lead the project
- Conflicting instructions from your manager and your peer's manager

Peer support is essential. Because most of us serve our self-interest first, use some investigating, selling, influencing, and politicking skills here. To ensure you have cooperation and support from your peers:

- Get the support of your project sponsor or top management to empower you as the project manager with as much authority as possible. It's important that the sponsor makes it clear to the other team members that their cooperation on project activities is expected.
- Confront your peer if you notice a behaviour that seems dysfunctional, such as bad-mouthing the project.
- Be explicit in asking for full support from your peers. Arrange for frequent review meetings.
- Establish goals and standards of performance for all team members.

Resource Managers

Because project managers are in the position of borrowing resources, other managers control their resources. So their relationships with people are especially important. If their relationship is good, they may be able to consistently acquire the best staff and the best equipment for their projects. If relationships aren't good, they may find themselves not able to get good people or equipment needed on the project.

Internal Customers

Internal customers are individuals within the organization who are customers for projects that meet the needs of internal demands. The customer holds the power to accept or reject your work. Early in the relationship, the project manager will need to negotiate, clarify, and document project specifications and deliverables. After the project begins, the project manager must stay tuned in to the customer's concerns and issues and keep the customer informed.

Common stumbling blocks when dealing with internal customers include:

- A lack of clarity about precisely what the customer wants
- A lack of documentation for what is wanted
- A lack of knowledge of the customer's organization and operating characteristics
- Unrealistic deadlines, budgets, or specifications requested by the customer
- Hesitancy of the customer to sign off on the project or accept responsibility for decisions
- Changes in project scope

To meet the needs of the customer, client, or owner, be sure to do the following:

- Learn the client organization's buzzwords, culture, and business.
- Clarify all project requirements and specifications in a written agreement.
- Specify a change procedure.
- Establish the project manager as the focal point of communications in the project organization.

External customer

External customers are the customers when projects could be marketed to outside customers. In the case of Ford Motor Company, for example, the external customers would be the buyers of the automobiles. Also if you are managing a project at your company for Ford Motor Company, they will be your external customer.

Government

Project managers working in certain heavily regulated environments (e.g., pharmaceutical, banking, or military industries) will have to deal with government regulators and departments. These can include all or some levels of government from municipal, provincial, federal, to international.

Contractors, subcontractors, and suppliers

There are times when organizations don't have the expertise or resources available in-house, and work is farmed out to contractors or subcontractors. This can be a construction management foreman, network consultant, electrician, carpenter, architect, or anyone who is not an employee. Managing contractors or suppliers requires many of the skills needed to manage full-time project team members.

Any number of problems can arise with contractors or subcontractors:

- Quality of the work
- Cost overruns
- Schedule slippage

Many projects depend on goods provided by outside suppliers. This is true for example of construction projects where lumber, nails, bricks, and mortar come from outside suppliers. If the supplied goods are delivered late or are in short supply or of poor quality or if the price is greater than originally quoted, the project may suffer.

Depending on the project, managing contractor and supplier relationships can consume more than half of the project manager's time. It is not purely intuitive; it involves a sophisticated skill set that includes managing conflicts, negotiating, and other interpersonal skills.

Politics of Projects

Many times, project stakeholders have conflicting interests. It's the project manager's responsibility to understand these conflicts and try to resolve them. It's also the project manger's responsibility to manage stakeholder expectations. Be certain to identify and meet with all key stakeholders early in the project to understand all their needs and constraints.

Project managers are somewhat like politicians. Typically, they are not inherently powerful or capable of imposing their will directly on coworkers, subcontractors, and suppliers. Like politicians, if they are to get their way, they have to exercise influence effectively over others. On projects, project managers have direct control over very few things; therefore their ability to influence others – to be a good politician – may be very important

Here are a few steps a good project politician should follow. However, a good rule is that when in doubt, stakeholder conflicts should always be resolved in favour of the customer.

Assess the environment

Identify all the relevant stakeholders. Because any of these stakeholders could derail the project, you need to consider their particular interest in the project.

- Once all relevant stakeholders are identified, try to determine where the power lies.
- In the vast cast of characters, who counts most?
- Whose actions will have the greatest impact?

Identify goals

After determining who the stakeholders are, identify their goals.

- What is it that drives them?
- What is each after?
- Are there any hidden agendas or goals that are not openly articulated?
- What are the goals of the stakeholders who hold the power? These deserve special attention.

Define the problem

- The facts that constitute the problem should be isolated and closely examined.
- The question "What is the real situation?" should be raised over and over.

Culture of Stakeholders

When project stakeholders do not share a common culture, project management must adapt its organizations and work processes to cope with cultural differences. The following are three major aspects of cultural difference that can affect a project:

1. Communications
2. Negotiations
3. Decision making

Communication is perhaps the most visible manifestation of culture. Project managers encounter cultural differences in communication in language, context, and candor.

Language is clearly the greatest barrier to communication. When project stakeholders do not share the same language, communication slows down and is often filtered to share only information that is deemed critical.

The barrier to communication can influence project execution where quick and accurate exchange of ideas and information is critical.

The interpretation of information reflects the extent that context and candor influence cultural expressions of ideas and understanding of information. In some cultures, an affirmative answer to a question does not always mean yes. The cultural influence can create confusion on a project where project stakeholders represent more than one culture.

Example: Culture Affects Communication in Mumbai

A project management consultant from the United States was asked to evaluate the effectiveness of a U.S. project management team executing a project in Mumbai, India. The project team reported that the project was on schedule and within budget. After a project review meeting where each of the engineering leads reported that the design of the project was on schedule, the consultant began informal discussions with individual engineers and began to discover that several critical aspects of the project were behind schedule. Without a mitigating strategy, the project would miss a critical window in the weather between monsoon seasons. The information on the project flowed through a cultural expectation to provide positive information. The project was eventually canceled by the U.S. corporation when the market and political risks increased.

Not all cultural differences are related to international projects. Corporate cultures and even regional differences can create cultural confusion on a project.

Example: Cultural Differences between American Regions

On a major project in South America that included project team leaders from seven different countries, the greatest cultural difference that affected the project communication was between two project leaders from the United States. Two team members, one from New Orleans and one from Brooklyn, had more difficulty communicating than team members from Lebanon and Australia.

Managing Stakeholders

Often there is more than one major stakeholder in the project. An increase in the number of stakeholders adds stress to the project and influences the project's complexity level. The business or emotional investment of the stakeholder in the project and the ability of the stakeholder to influence the project outcomes or execution approach will also influence the stakeholder complexity of the project. In addition to the number of stakeholders and their level of investment, the degree to which the project stakeholders agree or disagree influences the project's complexity.

A small commercial construction project will typically have several stakeholders. All the building permitting agencies, environmental agencies, and labour and safety agencies have an interest in the project and can influence the execution plan of the project. The neighbours will have an interest in the architectural appeal, the noise, and the purpose of the building.

Example: Tire Plant in India

A U.S. chemical company chartered a project team to design and build a plant to produce the raw materials for building truck tires designed for unpaved roads. The plant was to be built in India a few years after an accident that killed several Indians and involved a different U.S. chemical company. When the company announced the new project and began to break ground, the community backlash was so strong that the project was shut down. A highly involved stakeholder can significantly influence your project.

Example: Wind Turbine on a College Campus

A small college in South Carolina won a competitive grant to erect and operate a wind turbine on campus. The engineering department submitted the grant as a demonstration project for engineering students to expose students to wind technology. The campus facilities department found only one location for the wind turbine that would not disrupt the flow of traffic on campus. The engineering department found that location unacceptable for students who had to maintain the wind turbine. The county construction permitting department had no policies for permitting a wind turbine and would not provide a building permit. The college had to go to the county council and get an exception to county rules. The marketing department wanted the wind turbine placed in a highly visible location to promote the innovative approach of the college.

Each of the college's stakeholders had a legitimate interest in the location of the wind turbine. The number of stakeholders on the project, multiplied by their passion for the subject and the lack of agreement on the location, increased the complexity of the project. Significant time and resources of a project will be dedicated to identifying, understanding, and managing client expectations.

Example: Stakeholders and a Bridge Project

The Department of Highways chartered a project to upgrade a number of bridges that crossed the interstate in one of the larger cities in South Carolina. The closing of these bridges severely impacted traffic congestion, including a large shopping mall. The contract included provisions for minimizing the impact on the traffic and communities near the construction areas. This provision allowed businesses or interested parties to review the project schedule and make suggestions that would lessen the impact of the construction. The project leadership invested significant time and resources in developing alignment among the various political stakeholders on the project approach and schedule.

Relationship Building Tips

Take the time to identify all stakeholders before starting a new project. Include those who are impacted by the project, as well as groups with the ability to impact the project. Then, begin the process of building strong relationships with each one using the following method.

- **Analyze stakeholders:** Conduct a stakeholder analysis, or an assessment of a project's key participants, and how the project will affect their problems and needs. Identify their individual characteristics and interests. Find out what motivates them, as well as what provokes them. Define roles and level of participation, and determine if there are conflicts of interest among groups of stakeholders.
- **Assess influence**: Measure the degree to which stakeholders can influence the project. The more influential a stakeholder is, the more a project manager will need their support. Think about the question, "What's in it for them?" when considering stakeholders. Knowing what each stakeholder needs or wants from the project will enable the project manager to gauge his or her level of support. And remember to balance support against influence. Is it more important to have strong support from a stakeholder with little influence, or lukewarm support from one with a high level of influence?
- **Understand their expectations**: Nail down stakeholders' specific expectations. Ask for clarification when needed to be sure they are completely understood.
- **Define "success"**: Every stakeholder may have a different idea of what project success looks like. Discovering this at the end of the project is a formula for failure. Gather definitions up front and include them in the objectives to help ensure that all stakeholders will be supportive of the final outcomes.
- **Keep stakeholders involved**: Don't just report to stakeholders. Ask for their input. Get to know them better by scheduling time for coffee, lunch, or quick meetings. Measure each stakeholder's capacity to participate and honour time constraints.
- **Keep stakeholders informed**: Send regular status updates. Daily may be too much; monthly is not enough. One update per week is usually about right. Hold project meetings as required, but don't let too much time pass between meetings. Be sure to

answer stakeholders' questions and emails promptly. Regular communication is always appreciated – and may even soften the blow when you have bad news to share.

These are the basics of building strong stakeholder relationships. But as in any relationship, there are subtleties that every successful project manager understands – such as learning the differences between and relating well to different types stakeholders.

How to Relate to Different Types of Stakeholders

By conducting a stakeholder analysis, project managers can gather enough information on which to build strong relationships – regardless of the differences between them. For example, the needs and wants of a director of marketing will be different from those of a chief information officer. Therefore, the project manager's engagement with each will need to be different as well.

Stakeholders with financial concerns will need to know the potential return of the project's outcomes. Others will support projects if there is sound evidence of their value to improving operations, boosting market share, increasing production, or meeting other company objectives.

Keep each stakeholder's expectations and needs in mind throughout each conversation, report or email, no matter how casual or formal the communication may be. Remember that the company's interests are more important than any individual's – yours or a stakeholder's. When forced to choose between them, put the company's needs first.

No matter what their needs or wants, all stakeholders will respect the project manager who:

- Is always honest, even when telling them something they don't want to hear
- Takes ownership of the project
- Is predictable and reliable
- Stands by his or her decisions
- Takes accountability for mistakes

Supportive Stakeholders are Essential to Project Success

Achieving a project's objectives takes a focused, well-organized project manager who can engage with a committed team and gain the support of all stakeholders. Building strong, trusting relationships with interested parties from the start can make the difference between project success and failure.

Tools to Help Stakeholder Management

There are many project decelerators, among them lack of stakeholder support. Whether the stakeholders support your project or not, if they are important to your project, you must secure their support. How do you do that?

First, you must identify who your stakeholders are. Just because they are important in the organization does not necessarily mean they are important to your project. Just because they think they are important does not mean they are. Just because they don't think they need to be involved does not mean they do not have to be. The typical suspects: your manager, your manager's manager, your client, your client's manager, any SME (subject matter expert) whose involvement you need, and the board reviewing and approving your project. Note that in some situations there are people who think they are stakeholders. From your perspective they may not be, but be careful how you handle them. They could be influential with those who have the power to impact your project. Do not dismiss them out of hand.

Second, you need to determine what power they have and what their intentions toward your project are. Do they have the power to have an impact on your project? Do they support or oppose you? What strategies do you follow with them?

Third, what's the relationship among stakeholders? Can you improve your project's chances by working with those who support you to improve the views of those who oppose you? Table 5.1 summarizes the options based on an assessment of your stakeholders' potential for cooperation and potential for threat.

Table 5.1 Stakeholder Analysis (Solera, 2009)

	Low threat potential	High threat potential
Low potential for cooperation	Type: Marginal Strategy: Monitor	Type: Non-supportive Strategy: Defend
High potential for cooperation	Type: Supportive Strategy: Involve	Type: Mixed blessing Strategy: Collaborative

Now that you have this information, you can complete a stakeholder analysis template (Table 5.2) that will help you define your strategies to improve their support:

Table 5.2 Stakeholder Analysis Template (Solera, 2009)

Stakeholder Names and Roles	How important? (Low – Med – High)	Current level of support? (Low – Med – High)	What do you want from stakeholders?	What is important to stakeholders?	How could stakeholders block your efforts?	What is your strategy for enhancing stakeholder support?

Finally, a key piece of your stakeholder management efforts is constant communication to your stakeholders. Using the information developed above, you should develop a communications plan that secures your stakeholders' support. The template in Figure 5.2 can be used.

Project Scope:

Key Messages:

Communication Goals:

Communication Team:

Project Team:

Other stakeholders:

Communication Date	Deliverable	Audience	Message	Action Item or FYI (Info?)	Plans	Status

Figure 5.2 Stakeholder Communication Template [Image description]

References

Solera, J. (2009). Project Decelerators – Lack of Stakeholder Support. *Silicon Valley Project Management*. Retrieved from https://svprojectmanagement.com/proj...holder-support.

Image descriptions

Figure 5.2 Stakeholder Communication Template

The stakeholder analysis template has six fields plus a table to be filled out. The lines ask for: the project scope, key messages, communication goals, communication teams, project team, and other stakeholders. Then, there is a table with seven columns where you can track the communication plan. The column headers of this table are: communication date, deliverable, audience, message, action item or FYI (info?), plans, and status. [Return to Figure 5.2]

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9.2.2: Culture and Project Management

What Is Organizational Culture?

When working with internal and external customers on a project, it is essential to pay close attention to relationships, context, history, and the corporate culture. Corporate culture refers to the beliefs, attitudes, and values that the organization's members share and the behaviours consistent with them (which they give rise to). Corporate culture sets one organization apart from another, and dictates how members of the organization will see you, interact with you, and sometimes judge you. Often, projects too have a specific culture, work norms, and social conventions.

Some aspects of corporate culture are easily observed; others are more difficult to discern. You can easily observe the office environment and how people dress and speak. In one company, individuals work separately in closed offices; in another, teams may work in a shared environment. The more subtle components of corporate culture, such as the values and overarching business philosophy, may not be readily apparent, but they are reflected in member behaviours, symbols, and conventions used.

Project Manager's Checklist

Once the corporate culture has been identified, members should try to adapt to the frequency, formality, and type of communication customary in that culture. This adaptation will strongly affect project members' productivity and satisfaction internally, as well as with the client organization.

- Which stakeholders will make the decision in this organization on this issue? Will your project decisions and documentation have to go up through several layers to get approval? If so, what are the criteria and values that may affect acceptance there? For example, is being on schedule the most important consideration? Cost? Quality?
- What type of communication among and between stakeholders is preferred? Do they want lengthy documents? Is "short and sweet" the typical standard?
- What medium of communication is preferred? What kind of medium is usually chosen for this type of situation? Check the files to see what others have done. Ask others in the organization.
- What vocabulary and format are used? What colours and designs are used (e.g., at Hewlett-Packard, all rectangles have curved corners)?

Project Team Challenges

Today's globally distributed organizations (and projects) consist of people who have differing "worldviews." *Worldview* is a looking glass through which people see the world as Bob Shebib describes: "[It is] a belief system about the nature of the universe, its perceived effect on human behaviour, and one's place in the universe. Worldview is a fundamental core set of assumptions explaining cultural forces, the nature of humankind, the nature of good and evil, luck, fate, spirits, the power of significant others, the role of time, and the nature of our physical and natural resources" (Shebib, 2003, p. 296).

If, for example, a Canadian manager is sent to India to manage an R&D team or a joint venture, they are likely to have to "[cope] with eco-shock or the physiological, psychological, and social reaction to a new assignment ecology." Hanging a shingle in a fluid and culturally diverse organization, project team, and work culture, a project manager may find new working relationships and hidden challenges have significant implications for performance and knowledge exchange – for the manager and colleagues at home and in the host country.

In most situations, there is simply **no** substitute for having a well-placed person from the host culture to guide the new person through the cultural nuances of getting things done. In fact, if this "intervention" isn't present, it is likely to affect the person's motivation or desire to continue trying to break through the cultural (and other) barriers. Indeed, optimal effectiveness in such situations requires learning of cultures in developing countries or international micro-cultures and sharing perceptions among the culturally diverse task participants on how to get things done. Project leaders require sensitivity and awareness of multicultural preferences. The following broad areas should be considered:

- Individual identity and role within the project versus family of origin and community
- Verbal and emotional expressiveness
- Relationship expectations

- Style of communication
- Language
- Personal priorities, values, and beliefs
- Time orientation

There are many interpersonal dynamics and intra-project challenges faced by a globally distributed team. Individual members and the team itself requires important social supports to mitigate uncertainty, conflict, motivational challenges, culture shock, and the more-encompassing eco-shock that comes from facing head-on the unfamiliar and diverse situations consistent with a different cultural and geographically distributed context.

Diverse and globally distributed project teams (i.e., different ethnic cultures, genders, ages, and functional capabilities), often working on complex projects spanning multiple time zones, geography, and history, and operating with tight deadlines in cost-conscious organizations, need to make time and resources available to physically meet each other, and connect (at the very least) at a formal "kick-off" meeting. Especially when working with team members from high-context cultures, it is essential to meet face-to-face, discover member's individual identities and cultural preferences, share professional knowledge and personal stories, and observe critical verbal and non-verbal cues (that may not easily be observed online, or on the telephone). This is key to establishing a safer climate and building trust for stronger relationships among both team members and management.

Dealing with Conflict

The question isn't whether, when, or with what frequency conflict will occur among intercultural team members — or what will create the conflict. If a team wants to overcome (or harness) conflict for effectiveness and productivity, the question is how to navigate and resolve the conflicts. Conflict that springs from diversity can actually assist the team in completing complex problem solving. However, if not navigated successfully, it can create relationship strain and derail achievement due to increased difficulties in communication and coordination.

As the global marketplace continues its rapid expansion, researchers are increasingly turning their attention to the issue of conflict management. Differing social and cultural values don't necessarily increase the number of conflicts a team will experience, but they can have an impact on how conflicts are managed and resolved. Cultural awareness is needed for understanding and appreciating others' values and behavioural norms. Without that, foreign assignments will become an overwhelming challenge. Self-awareness and skill development can aid in resolving the problematic conflict arising from cultural differences to help a team maintain good relations and remain productive.

References

Shebib, B. (2003). Choices: Interviewing and Counselling Skills for Canadians, 2nd edition, Pearson Education Canada Inc.

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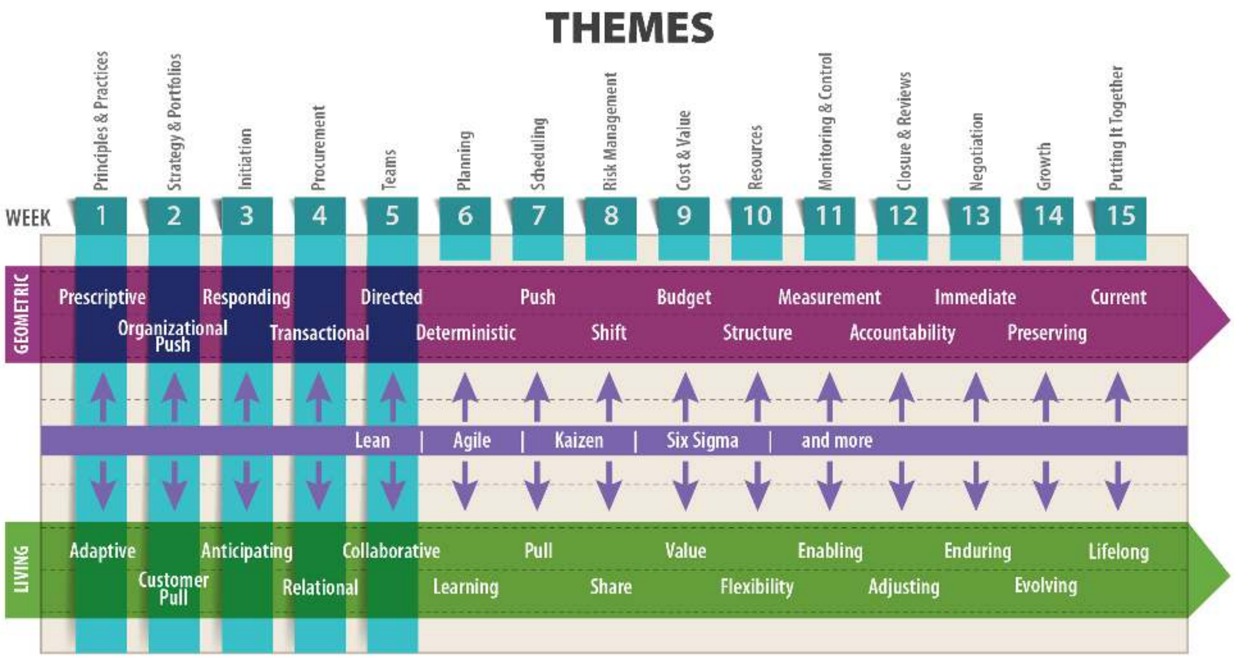
9.2.3: Team Formation, Team Management, and Project Leadership

Leadership takes place in the living order. Management takes place in the geometric order.
—John Nelson, PE – *Chief Technical Officer, Global Infrastructure Asset Management*
Adjunct Professor, Civil & Environmental Engineering, University of Wisconsin-Madison



Objectives

After reading this chapter, you will be able to

- List advantages of teams and strong leadership
- Discuss the role of trust in building a team, and describe behaviors that help build trust
- List motivators and demotivators that can affect a team's effectiveness
- Explain issues related to managing transitions on a team
- Explain the role of self-organizing teams in Agile
- Describe the advantages of diverse teams and provide some suggestions for managing them
- Discuss the special challenges of virtual teams

The Big Ideas in this Lesson

- Building trust is key to creating an effective team. Reliable promising, emotional intelligence, realistic expectations, and good communication all help team members learn to rely on each other.
- The most effective project managers focus on building collaborative teams, rather than teams that require constant direction from management.
- Teams made up of diverse members are more creative, and better at processing information and coming up with innovative solutions. Organizations with a diverse workforce are significantly more profitable than organizations a homogeneous workforce.

5.1 Teams in a Changing World

According to Jon. R. Katzenbach and Douglas K. Smith, authors of the *Wisdom of Teams: Creating the High-Performance Organization*, a **team** is a "small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable" (1993, 45).

Of course, this describes an ideal team. A real team might be quite different. You have probably suffered the pain of working on a team lacking in complementary skills, with no clear common purpose, and plagued by uncommitted members who refuse to hold themselves accountable. However, as a project manager, you need to work with the team you have, not with the team you wish you had, leading your group through the uncertainty inherent in a living order project, and encouraging collaboration at every turn.

Attributes of a good team leader:

Most important tool: ears.

Most important skills: active listening and reflection (Nelson).

The most powerful sources of uncertainty in any project are the people charged with carrying it out. What's more, because a project is, by definition, a temporary endeavor, the team that completes it is usually temporary as well, and often must come together very quickly. These facts can exacerbate leadership challenges that are not an issue in more stable situations. Some organizations maintain standing teams that tackle a variety of projects as they arise. But even in those cases, individual team members come and go. These minor changes in personnel can hugely affect the team's overall cohesion and effectiveness.

How can you make your team as effective as possible? For starters, it helps to feel good about being on a team in the first place. According to Katzenbach and Smith, most people either undervalue the power of teams or actually dislike them. They point to three sources for this skepticism about teams: "a lack of conviction that a team or teams can work better than other alternatives; personal styles, capabilities, and preferences that make teams risky or uncomfortable; and weak organizational performance ethics that discourage the conditions in which teams flourish" (1993, 14). But research shows that highly functioning teams are far more than the sum of their individual members:

First, they bring together complementary skills and experiences that, by definition, exceed those of any individual on the team. This broader mix of skills and know-how enables teams to respond to multifaceted challenges like innovation, quality, and customer service. Second, in jointly developing clear goals and approaches, teams establish communications that support real-time problem solving and initiative. Teams are flexible and responsive to changing event and demands…. Third, teams provide a unique social dimension that enhances the economic and administrative aspects of work…. Both the meaning of work and the effort brought to bear upon it deepen, until team performance eventually becomes its own reward. Finally, teams have more fun. This is not a trivial point because the kind of fun they have is integral to their performance. (1993, 12)

Viewed through the lens of living order, perhaps the most important thing about teams is the way they, by their very nature, encourage members to adapt to changing circumstances:

Because of their collective commitment, teams are not as threatened by change as are individuals left to fend for themselves. And, because of their flexibility and willingness to enlarge their solution space, teams offer people more room for growth and change than do groups with more narrowly defined task assignments associated with hierarchical job assignments. (1993, 13)

A Word on Risk

Joining a team—that is, fully committing yourself to a group of people with a shared goal—is always a risk. But risk can bring rewards for those willing to take a chance. Jon R. Katzenbach and Douglas K. Smith, explain that, in their studies of scores of teams, they discovered

an underlying pattern: real teams do not emerge unless the individuals on them take risks involving conflict, trust, interdependence, and hard work. Of the risks required, the most formidable involve building the trust and interdependence necessary to move from individual accountability to mutual accountability. People on real teams must trust and depend on one another— not totally or forever — but certainly with respect to the team's purpose, performance goals, and approach. For most of us such trust and interdependence do not come easily; it must be earned and demonstrated repeatedly if it is to change behavior. (Katzenbach and Smith 1993)

5.2 Behaviors that Build Trust

Years of psychological research has demonstrated the importance of trust in building effective teams (Breuer, Hüffmeier and Hertel 2016). Because teams often need to come together in a hurry, building trust quickly among members is essential. A team of strangers who are brought together to complete a task in three months can't draw on the wellspring of interpersonal knowledge and loyalty that might exist among people who have worked side-by-side for years. So as a team leader, you need to focus on establishing trusting relationships at the outset. Your ultimate goal is to encourage an overall sense of **psychological safety**, which is "a shared belief held by members of a team that the team is safe for interpersonal risk taking." Teams that do their work under the umbrella of psychological safety are more effective, in part because they are willing to take the risks required to learn and innovate (Edmondson 1999).

Let's look at a few important traits, techniques, and behaviors that can help you build trust and a sense of psychological safety.

Who is the "Right" Person for Your Project?

As Laufer et al. explain in their book *Becoming a Project Leader*, "When it comes to projects, one thing is very clear: 'right' does not mean 'stars.' Indeed, one of the primary reasons for project 'dream teams' to fail is 'signing too many all-stars.'" More important than an all-star is a project team member fully committed to the project goals. Chuck Athas was one such team member. He worked for Frank Snow, the Ground System and Flight Operations Manager at NASA's Goddard Space Flight Center. Officially listed as the project scheduler and planner, Chuck was eager to help Frank once the schedule was completed and needed less attention. "Anything that needed to be done, and he didn't care what it was, he would attack with the same gusto and unflappable drive to succeed," says Frank. "Whatever it took to get the job done, Chuck would do. Was there anything he couldn't make happen? Probably something. But with Chuck on the team I felt like I could ask for Cleveland, and the next day he would show up with the deed" (Snow 2003). Chuck demonstrated a lack of ego that most all-stars don't have. His can-do attitude is the antidote to the not-my-job thinking that can sometimes cause team cohesiveness and project completion to falter. His adherence to the project goals over his own goals made him an ideal team member (Laufer, et al. 2018).

Reliable Promising

Nothing erodes trust like a broken promise. We all know this. As Michelle Gielan explains in a blog post for *Psychology Today*:

When we don't keep a promise to someone, it communicates to that person that we don't value him or her. We have chosen to put something else ahead of our commitment. Even when we break small promises, others learn that they cannot count on us. Tiny fissures develop in our relationships marked by broken promises. (2010)

Unfortunately, in fast-moving, highly technical projects, breaking ordinary, everyday promises is inevitable. In living order, it's just not possible to foresee every eventuality, so the task at the top of today's To Do list, the one you promised to complete before lunch, might get swept aside in the flood of new tasks associated with a sudden crisis.

Keeping Track of Reliable Promises

It's helpful to keep a reliable promise log in a spreadsheet. On a big project, you might have 15-20 reliable promises logged at any one time. At every meeting, open the log and go through the reliable promises to find out which were met and which weren't. Record a success rate in the log for each person. If you craft the promises correctly, this is an extremely helpful metric on team functionality and performance. A success rate of 70% is marginal. The mid- to high '80s is good. The low '90s is very good. A success rate above that means someone's not telling the truth.

That's why it's important to distinguish between an ordinary promise, and a reliable promise. In Lean terminology, a **reliable promise** is an official commitment to complete a task by an agreed-upon time. In order to make a reliable promise, you need to have:

- **Authority**: You are responsible and accountable for the task.
- **Competence**: You have the knowledge to properly assess the situation, or you have the ability to engage someone who can advise you.
- **Capacity:** You have a thorough understanding of your current commitments and are saying "Yes" because you are confident that you can take on an additional task, not because you want to please the team or the team leader.
- **Honesty**: You sincerely commit to complete the task, with the understanding that if you fail, other people on your team will be unable to complete their work.
- **Willingness to correct**: After making a reliable promise, if you miss the completion date, then you must immediately inform your team and explain how you plan to resolve the situation. (Nelson, Motivators and Demotivators for Teams 2017)

Not every situation calls for an official, reliable promise. John Nelson estimates that, on most projects, no more than 10 to 20 percent of promises are so important that they require a reliable promise (2019). As Hal Macomber explains in a white paper for Lean Project Consulting, you should save reliable promises for tasks that must be completed so that other work can proceed. And keep in mind that you'll get the best results from reliable promises if they are made in a group setting, where other teammates can chime in with ideas on how to complete the task efficiently or suggest alternatives to the proposed task. Finally, remember that people tend to feel a more positive sense of commitment to a promise if they understand that they have the freedom to say no:

A sincere "no" is usually better than a half-hearted "ok." You know exactly what to do with the no—ask someone else. What do you do with a half-hearted "ok?" You can worry, or investigate, or not have time to investigate and then worry about that. Make it your practice to remove fear from promising conversations. (2010)

You can read Hal Macomber's helpful introduction to reliable promising here: "Securing Reliable Promises on Projects: A Guide to Developing a New Practice."

The practice of reliable promising was developed as a way to keep Lean projects unfolding efficiently in unpredictable environments. Ultimately, reliable promises are an expression of respect for people, which, as discussed in Lesson 1, is one of the six main principles of Lean. They encourage collaboration and help build relationships among team members. In Agile, the commitments made in every Scrum are another version of reliable promises. And the sincere commitment offered by a reliable promise can be useful in any kind of project. Here are some examples of situations in which reliable promising could be effective:

- For a product development project, when will an important safety test will be completed?
- For a medical technology project, will a report required to seek regulatory approval be completed on time?
- For an IT project, will the procurement team execute a renewal contract for the maintenance agreement before the current agreement expires? If not, the organization risks having no vendor to support an essential software component.

Using Emotional Intelligence

As a manager of technical projects, you might be inclined to think that, as long as you have the technical details under control, you have the whole project under control. But if you do any reading at all in the extensive literature on leadership, you'll find that one characteristic is crucial to building trusting relationships with other people: **emotional intelligence**, or the ability to recognize your own feelings and the feelings of others.

High emotional intelligence is the hallmark of a mature, responsible, trustworthy person. In fact, a great deal of new research suggests that skills associated with emotional intelligence—"attributes like self-restraint, persistence, and self-awareness—might actually be better predictors of a person's life trajectory than standard academic measures" (Kahn 2013). An article in the *Financial Post* discusses numerous studies that have tied high emotional intelligence to success at work:

A recent study, published in the Journal of Organizational Behavior, by Ernest O'Boyle Jr. at Virginia Commonwealth University, concludes that emotional intelligence is the strongest predictor of job performance. Numerous other studies have shown that high emotional intelligence boosts career success. For example, the U.S. Air Force found that the most successful recruiters scored significantly higher on the emotional intelligence competencies of empathy and self-awareness. An analysis of more than 300 top level executives from 15 global companies showed that six emotional competencies distinguished the stars from the average. In a large beverage firm, using standard methods to hire division presidents, 50% left within two years, mostly because of poor performance. When the firms started selecting based on emotional competencies, only 6% left and they performed in the top third of executive ranks. Research by the Center for Creative Leadership has found the primary cause of executive derailment involves deficits in emotional competence. (Williams 2014)

According to Daniel Goleman, author of the influential book *Emotional Intelligence: Why It Can Matter More Than IQ*, it's well established that "people who are emotionally adept—who know and manage their own feelings well, and who read and deal effectively with other people's feelings—are at an advantage in any domain of life, whether romance and intimate relationships or picking up the unspoken rules that govern success in organizational politics" (1995, 36). In all areas of life, he argues, low emotional intelligence increases the chance that you will make decisions that you think are rational, but that are in fact irrational, because they are based on unrecognized emotion. And nothing erodes trust like a leader who imposes irrational decisions on a team.

To keep your team working smoothly, make regular use of these important words:

- I'm not sure.
- What do you think?
- I don't know.
- Please.
- Thank you.
- I was wrong. You were right.
- Good job!

Some people are born with high emotional intelligence. Others can cultivate it by developing qualities and skills associated with emotional intelligence, such as self-awareness, self-control, self-motivation, and relationship skills. Of course, it's no surprise that these are also useful for anyone working on a team. Treating others the way they want to want to be treated—not how you want to be treated—is a sign of a mature leader, and something that is only possible for people who have cultivated the emotional intelligence required to understand what other people want.

The following resources offer more information about emotional intelligence:

- To find out where you fit on the emotional intelligence scale, try this Harvard Business Review quiz: "Quiz Yourself: Do You Lead With Emotional Intelligence?"
- This helpful video breaks down emotional intelligence into five components, as defined by Daniel Goleman, and makes suggestions on how to up your own emotional intelligence quotient: "The Explainer: Emotional Intelligence."
- Daniel Goleman's five components are summarized at the end of this article: "Best Practice Report: Workplace Conflict Resolution."
- In job interviews, employers are increasingly asking questions designed to gauge an applicant's level of emotional intelligence. This article by Alison Doyle provides sample questions: https://www.thebalancecareers.com/interview-questions-about-your-emotional-intelligence-2059962.

Cultivating a Realistic Outlook

You might have had experience with an overly negative project manager who derailed a project with constant predictions of doom and gloom. But in fact, the more common enemy of project success is too much positivity, in which natural human optimism blinds team members to reality. That's a sure-fire way to destroy painstakingly built bridges of trust between team members. In her book *Bright-Sided: How Positive Thinking is Undermining America*, social critic Barbara Ehrenrich explains the downside of excessive optimism, which, she argues, is a special failing of American businesses (2009). The optimist clings to the belief that everything will turn out fine, even when the facts indicate otherwise, and so fails to prepare for reality. The optimist also has a tendency to blame the victims of unfortunate events: "If only they'd had a more positive attitude in the first place, nothing bad would have happened."

In the planning phase, an overly optimistic project manager can make it difficult for team members to voice their realistic concerns. In a widely cited article in the *Harvard Business Review*, psychologist Gary Klein argues that projects fail at a "spectacular rate," in part because "too many people are reluctant to speak up about their reservations during the all-important planning phase." To counteract this effect, Klein pioneered the idea of a troubleshooting session—which he calls a **premortem**—early on in a project in which people who understand the project but are concerned about its potential for failure feel free to express their thoughts. This widely used technique encourages stakeholders to look to the future and analyze the completed project as if it were already known to be a total failure:

A premortem is the imaginary converse of an autopsy; the hindsight this intelligence assessment offers is prospective. In sum, tasking a team to imagine that its plan has already been implemented and failed miserably increases the ability of its members to correctly identify reasons for negative future outcomes. This is because taking a team out of the context of defending its plan and shielding it from flaws opens new perspectives from which the team can actively search for faults. Despite its original high level of confidence, a team can then candidly identify multiple explanations for failure, possibilities that were not mentioned let alone considered when the team initially proposed then developed the plan. The expected outcomes of such stress-testing are increased appreciation of the uncertainties inherent in any projection of the future and identification of markers that, if incorporated in the team's design and monitoring framework and subsequently tracked, would give early warning that progress is not being achieved as expected. (Serrat 2012)

Communicating Clearly, Sometimes Using Stories

Reliable promises, emotional intelligence, and a realistic outlook are all meaningless as trust-building tools if you don't have the skills to communicate with your team members. In his book *Mastering the Leadership Role in Project Management*, Alexander Laufer explains the vital importance of team communication:

Because a project functions as an ad hoc temporary and evolving organization, composed of people affiliated with different organizations, communication serves as the glue that binds together all parts of the organization. When the project suffers from high uncertainty, the role played by project communication is even more crucial. (2012, 230)

Unfortunately, many people think they are better communicators than they actually are. Sometimes a person will excel at one form of communication but fail at others. For instance, someone might be great at small talk before a meeting but continually confuse co-workers with poorly written emails.

This is one area where getting feedback from your co-workers can be especially helpful. Another option is taking a class, or at the very least, consulting the numerous online guides to developing effective communication skills. To help you get started, here are a few quick resources for improving vital communication skills:

- **Making small talk—**People often say they dislike small talk, but polite conversation on unimportant matters is the lubricant that keeps the social gears moving, minimizing friction, and making it possible for people to join forces on important matters. If you're bad at small talk, then put some time into learning how to improve; you'll get better with practice. There's no better way to put people at ease. This article includes a few helpful tips: "An Introvert's Guide to Small Talk: Eight Painless Tips."
- **Writing good emails—**An ideal email is clear, brief, calm, and professional. Avoid jokes, because you can never be certain how team members (especially team members in other countries) will interpret them. A good emailer also understands the social rules that apply to email exchanges, as explained here: "The Art of the Effective Business Email."

- **Talking one-on-one—**Nothing beats a face-to-face conversation for building trust and encouraging an efficient exchange of ideas, as long as both participants feel comfortable. In fact, Alexander Laufer suggests using face-to-face conversation as the primary communication mode for your team (2012, 230). As a team leader, it's your job to be aware of the many ways conversations can go awry, particularly when subordinates fear speaking their mind. This excellent introduction to the art of conversation includes tips for recognizing signs of discomfort in others: "The Art of Conversation: How to Improve Face-to-Face Communication in a Digital World."

Telling stories is an especially helpful way to share experiences with your team. Indeed, stories are "a form of communication that has been used to entertain, persuade, inspire, impart wisdom, and teach for thousands of years. This wide range of uses is due to a story's remarkable effect on human emotion, experience, and cognition" (Kerby, DeKorver and Cantor 2018).

You've probably experienced the way people lower their defenses when they realize they are hearing a tale about specific characters, with an uncertain outcome, rather than a simple recitation of events, or worse, a lecture. Master storytellers seem to do it effortlessly, but in fact they usually shape their stories around the same basic template. Holly Walter Kerby, executive director of Fusion Science Theater, and a long-time science educator, describes the essential story elements as follows:

- **A main character your audience can identify with—**Include enough details to allow your audience to feel a connection with the main character, and don't be afraid to make yourself the protagonist of your own stories.
- **A specific challenge—**Set up the ending of the story by describing a problem encountered by the main character. This will raise a question in the minds of the audience members and make them want to listen to the rest of the story to find out what happens.
    - Can Sam and Danielle recover from a supplier's bankruptcy and figure out how to get three hundred light fixtures delivered to a new office building in time for the grand opening?
    - Can Hala, a mere intern, prevent seasoned contractors from using an inferior grade of concrete?[1]
- **Three to five events related by cause and effect—**The events should build on each other, and show the characters learning something along the way. Describe the events in a way that helps build a sense of tension.
- **One or two physical details—**People tend to remember specific physical details. Including one or two is a surprisingly effective way to make an entire story more memorable.
    - The first new vendor Sam and Danielle contacted agreed to sell them all the light fixtures they needed, but ended up sending only one fixture in a beaten-up box with the corners bashed in.
    - Hala, a small person, had to wear an oversized helmet and vest on the job site, which emphasized that she was younger and less experienced than the contractors.
- **An outcome that answers the question—** The outcome should be simple and easy to understand. Most importantly, it should answer the question posed at the beginning of the story.
    - Yes—by collaborating with a new supplier, Sam and Danielle were able to acquire the light fixtures in time for the grand opening.
    - No—Hala could not stop the contractors from using inferior concrete, but she did report the problem to her boss, who immediately halted construction until the concrete could be tested, and, in the end, replaced.
- **Satisfying Ending—**Explain how the events in the story led to some kind of change in the characters' world.
    - Sam and Danielle learned to focus on building relationships with reliable, financially stable vendors.
    - Hala learned that even an intern can safeguard a project by speaking up when she sees something wrong.

Keep in mind that in some high-stakes situations, the last thing you want is more tension. In that case, you want the opposite of a story—a straightforward recitation of the facts. For example, when confronting a team member about poor work habits, or negotiating with an unhappy client, it's best to keep everything simple. Draining the drama from a situation helps everyone stay focused on the facts, keeping resentment and other negative emotions to a minimum (Manning 2018, 64). For more on good techniques for difficult conversations, see Trevor Manning's book *Help! I need to Master Critical Conversations.*

[1] Thanks to Hala Nassereddine for sharing her story of her experience as an intern on a construction site in Beirut, Lebanon.

The Beauty of Face-to-Face Communication

As Laufer et al. point out in their book *Becoming a Project Leader*, "In contrast to interactions through other media that are largely sequential, face-to-face interaction makes it possible for two people to send and receive messages almost simultaneously. Furthermore, the structure of face-to-face interaction offers a valuable opportunity for interruption, repair, feedback, and learning that is virtually instantaneous. By seeing how others are responding to a verbal message even before it is complete, the speaker can alter it midstream in order to clarify it. The immediate feedback in face-to-face communication allows understanding to be checked, and interpretation to be corrected. Additionally, face-to-face communication captures the full spectrum of human interaction, allowing multiple cues to be observed simultaneously. It covers all the senses—sight, hearing, smell, taste, and touch—that provide the channels through which individuals receive information" (2018).

Certainly, in today's world of project management, in which distributed digital teams are becoming common practice, it may be impossible to sit down in the same room with all team members. But as much as possible, project managers should push for using technology that allows a fuller communication environment—one in which interactions are not just isolated to text. For more, see "The Place of Face-to-Face Communication in Distributed Work" by Bonnie A. Nardi and Steve Whittaker."

5.3 Team Motivators and Demotivators

To build believable performances, actors start by figuring out their characters' motivations—their reasons for doing what they do. As a team leader, you can use the same line of thinking to better understand your team members. Start by asking this question: Why do your team members do what they do? Most people work because they have to, of course. But their contributions to a team are motivated by issues that go way beyond the economic pressures of holding onto a job.

In their book *The Progress Principle: Using Small Wins to Ignite Joy, Engagement, and Creativity at Work*, Teresa Amabile and Steven Kramer argue that the most important motivator for any team is making meaningful daily progress toward an important goal. In their study of 12,000 daily journal entries from team members in a variety of organizations and industries, they found that a sense of accomplishment does more to encourage teamwork, on-the-job happiness, and creativity than anything else. "Even when progress happens in small steps," the researchers explain, "a person's sense of steady forward movement toward an important goal can make all the difference between a great day and a terrible one" (2011, 77).

According to Amabile and Kramer, the best managers focus on facilitating progress by removing roadblocks and freeing people up to focus on work that matters:

When you do what it takes to facilitate progress in work people care about, managing them—and managing the organization—becomes much more straightforward. You don't need to parse people's psyches or tinker with their incentives, because helping them succeed at making a difference virtually guarantees good inner work life *and* strong performance. It's more cost-effective than relying on massive incentives, too. When you don't manage for progress, no amount of emotional intelligence or incentive planning will save the day (2011, 10).

As you might expect, setbacks on a project can have the opposite effect, draining ambition and creativity from a team that, only days before, was charging full steam ahead toward its goal. But setbacks can be counterbalanced by even small wins—"seemingly minor progress events"—which have a surprising power to lift a team's spirits, making them eager to get back to work the next day (2011, 80). You've probably experienced the pleasure that comes from checking at least one task off your to-do list. Even completing a small task can generate a sense of forward momentum that can propel a team toward larger achievements.

Amabile and Kramer's book is a great resource for team managers looking to improve their motivational abilities. If you don't have time to read the whole book, they summarize their research and advice in this *Harvard Business Review* article: https://hbr.org/2011/05/the-power-of-small-wins.

Through years of practical experience as an executive, consultant, project engineer, and project manager, John Nelson has gained a finely honed understanding of how to manage teams. According to Nelson, the following are essential for motivators for any team:

- **A sense of purpose**—Individually, and as a whole, a team needs an overarching sense of purpose and meaning. This sense of purpose should go beyond each individual's project duties. On the macro level, the sense of purpose should align with the organization's strategy. But it should also align, at least sometimes, with each individual's career and personal goals.
- **Clear performance metrics**—How will the team and its individual members be evaluated? What does success look like? You need to be clear about this, but you don't have to be formulaic. Evaluations can be as subjective as rating a dozen characteristics as good/not-good, or on a score of 1-5.

- **Assigning the right tasks to the right people—**People aren't commodities. They aren't interchangeable, like a router or a hand saw. They are good at specific things. Whenever possible, avoid assigning people to project tasks based on capacity—that is, how much free time they have—and instead try to assign tasks that align with each individual's goals and interests.
- **Encouraging individual achievement—**Most people have long-term aspirations, and sometimes even formalized professional development plans. As team leader, you should be on the lookout for ways to nudge team members toward these goals. It's not your job to ensure that they fully achieve their personal goals, but you should try to allow for at least a little forward movement.
- **Sailboat rules communication, in which no one takes offense for clear direction—**On a sailboat, once the sail goes up, you need to be ready to take direction from the captain, who is responsible for the welfare of all on board, and not take offense if he seems critical or unfriendly. In other words, you can't take things personally. Likewise, team members need to set their egos aside and let perceived slights go for the sake of the team. When you start a big project, explain that you are assuming sailboat rules communication. That means that, in a meeting, no one has the privilege of taking anything personally.
- **Mentorship—**Team members need to be able to talk things over with more experienced people. Encourage your team to seek out mentors. They don't necessarily have to be part of the project.
- **Consistency and follow-through—**Team morale falls off when inconsistency is tolerated or when numerous initiatives are started and then abandoned. Encourage a team environment in which everyone does what they commit to do, without leaving loose ends hanging. Be on the lookout for gaps in a project, where things are simply not getting done. (Nelson 2017)

Nelson also recommends avoiding the following demotivators, which can sap the life out of any team:

- **Unrealistic or unarticulated expectations—**Nothing discourages people like the feeling that they can't succeed no matter how hard they try. Beware of managers who initiate an impossible project, knowing full well that it cannot be accomplished under the established criteria. Such managers think that, by setting unrealistic expectations, they'll get the most out of their people, because they'll strive hard to meet the goal. In fact, this approach has the opposite effect—it drains people of enthusiasm for their work and raises suspicions that another agenda, to which they are not privy, is driving the project. Once that happens, team members will give up trying to do a good job.
- **Ineffective or absent accountability—**Individual team members pay very close attention to how their leader handles the issue of accountability. If members sense little or no reason to stay on course, they'll often slack off. As often as possible, stop and ask your team two essential question: 1) How are we doing relative to the metrics? 2) How do we compare to what we said we were going to do? If the answers are encouraging, that's great. But if not, you need to ask this question: What are we going to do to get back on track?
- **Lack of discipline—**An undisciplined team fails to follow through on its own rules. Members show up late for meetings, fail to submit reports on time, and generally ignore agreed-upon standards. This kind of lackadaisical attitude fosters poor attention to detail, and a general sense of shoddiness. As a team leader, you can encourage discipline by setting a good example, showing up bright and early every day, and following the team rules. Make sure to solicit input from team members on those rules, so everyone feels committed to them at the outset.
- **Anti-team behavior—**Self-centered, aggressive bullies can destroy a team in no time, making it impossible for less confrontational members to contribute meaningfully. Overly passive behavior can also be destructive because it makes people think the passive team member lacks a commitment to project success. Finally, bad communication—whether incomplete or ineffective—is a hallmark of any poorly functioning team. (Nelson 2017)

The Best Reward Isn't Always What You Think

In his book, *Drive*, Daniel Pink digs into the question of how to have a meaningful, purpose-driven work life. For a quick summary of his often surprising ideas, see this delightful, eleven-minute animated lecture: "Autonomy, Mastery, Purpose: The Science of What Motivates Us, Animated." Among other things, Pink explains that cash rewards aren't always the motivators we think they are. For simple, straight-forward tasks, a large reward does indeed encourage better performance. But for anything involving conceptual, creative thinking, rewards have the opposite effect: the higher the reward, the poorer the performance. This has been replicated time and time again by researchers in the fields of psychology, economics, and sociology. It turns out the best way to nurture engaged team members is to create an environment that allows for autonomy, mastery, and a sense of purpose (Pink 2009).

One form of motivation—uncontrolled external influences—can have positive or negative effects. For example, in 2017, Hurricanes Harvey and Irma inflicted enormous damage in Texas and Florida. That had the effect of energizing people to jump in and help out, creating a nationwide sense of urgency. By contrast, the catastrophic damage inflicted on Puerto Rico by Hurricane Maria, and the U.S. government's slow response, generated a sense of outrage and despair. One possible reason for this difference is that, on the mainland, people could take action on their own, arriving in Florida or Texas by boat or car. Those successes encouraged other people to join the effort, creating a snowball effect. But the geographic isolation of Puerto Rico, and the complete failure of the power grid, made it impossible for the average person to just show up and help out. That, in turn, contributed to the overall sense of hopelessness.

This suggests that small successes in the face of uncontrolled external influences can encourage people to band together and work even harder as a team. But when even small signs of success prove elusive, uncontrolled external influences can be overwhelming.

As a technical team leader, you can help inoculate your team against the frustration of external influences by making it clear that you expect the unexpected. Condition your team to be prepared for external influences at some point throughout the project. For example, let your team know if you suspect that your project could possibly be terminated in response to changes in the market. By being upfront about the possibilities, you help defuse the kind of worried whispering that can go on in the background, as team members seek information about the things they fear.

If you're working in the public domain, you'll inevitably have to respond to influences that might seem pointless or downright silly—long forms that must be filled out in triplicate, unhelpful training sessions, and so on. Take the time to prepare your team for these kinds of things, so they don't become demotivated by them.

5.4 Managing Transitions

High performing teams develop a rhythm. They have a way of working together that's hard to quantify and that is more than just a series of carefully implemented techniques. Once you have the pleasure of working on a team like that, you'll begin to recognize this rhythm in action and you'll learn to value it. Unfortunately, you might also experience the disequilibrium that results from a change in personnel.

Endless books and articles have been written on the topic of change management, with a focus on helping people deal with new roles and personalities. Your Human Resources department probably has many resources to recommend. Really, the whole discipline comes down to, as you might expect with all forms of team management, good communication and sincere efforts to build trust among team members. Here are a few resources with practical tips on dealing with issues related to team transitions:

- In his book, *Managing Transitions*, William Bridges presents an excellent model for understanding the stages of transition people go through as they adapt to change. The first stage—Ending, Losing, and Letting Go—often involves great emotional turmoil. Then, as they move on to the second stage—the Neutral Zone—people deal with the repercussions of the first stage, perhaps by feeling resentment, anxiety, or low morale. In the third stage—the New Beginning—acceptance and renewed energy kick in, and people begin to move forward (Mind Tools n.d.). You can read more about the Transition Model here: "Bridges' Transition Model: Guiding People Through Change."
- A single toxic personality can undermine months of team-building. This article gives some helpful tips on dealing with difficult people: "Ten Keys to Handling Unreasonable and Difficult People: 10 Strategies for Handling Aggressive or Problem Personalities."
- This article offers suggestions on how to encourage likability, and, when that doesn't work, how to get the most out of unpleasant people: "Competent Jerks, Lovable Fools, and the Formation of Social Networks."
- A change in leadership can stir up all sorts of issues. This article suggests some ideas for dealing with change when you are the one taking command: "Five Steps New Managers Should Take To Transition Successfully From Peer To Boss."
- As you've probably learned from personal experience, when individual members are enduring personal or professional stress, their feelings can affect the entire group. And when a team member experiences some kind of overwhelming trauma, shock waves can reverberate through the whole group in ways you might not expect. This article explains how an individual's experience of stress and trauma can affect a workplace, and provides some tips for managing the emotions associated with traumatic events: "Trauma and How It Can Adversely Affect the Workplace."

5.5 Self-Organizing Agile Teams

Agile software development was founded as a way to help team members work together more efficiently and companionably. In fact, three of the twelve founding principles of the methodology focus on building better teams:

- The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
- The best architectures, requirements, and designs emerge from self-organizing teams.

- At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly. (Beedle et al. 2001)

The term "self-organizing teams" is especially important to Agile. Nitin Mittal, writing for Scrum Alliance, describes a **self-organizing team** as a "group of motivated individuals, who work together toward a goal, have the ability and authority to take decisions, and readily adapt to changing demands" (2013).

But that doesn't mean Agile teams have no leaders. On the contrary, the Agile development process relies on the team leader (known as the ScrumMaster in Scrum) to guide the team, ideally by achieving "a subtle balance between command and influence" (Cohn 2010). Sometimes that means moving problematic team members to new roles, where they can be more effective, or possibly adding a new team member who has the right personality to interact with the problematic team member. In a blog for Mountain Goat Software, Mike Cohn puts it like this:

There is more to leading a self-organizing team than buying pizza and getting out of the way. Leaders influence teams in subtle and indirect ways. It is impossible for a leader to accurately predict how a team will respond to a change, whether that change is a different team composition, new standards of performance, a vicarious selection system, or so on. Leaders do not have all the answers. What they do have is the ability to agitate teams (and the organization itself) toward becoming more agile. (2010)

5.6 The Power of Diversity

The rationale for putting together a team is to combine different people, personalities, and perspectives to solve a problem. Difference is the whole point. Diverse teams are more effective than homogenous teams because they are better at processing information and using it to come up with new ideas. According to David Rock and Heidi Grant, diverse teams tend to focus more on facts, process those facts more carefully, and are more innovative (2016). What's more, researchers investigating creativity and innovation have consistently demonstrated "the value of exposing individuals to experiences with multiple perspectives and worldviews. It is the combination of these various perspectives in novel ways that results in new ideas 'popping up.' Creative 'aha' moments do not happen by themselves" (Viki 2016). In his book: *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies*, Scott Page puts it like this:

As individuals we can accomplish only so much. We're limited in our abilities. Our heads contain only so many neurons and axons. Collectively, we face no such constraint. We possess incredible capacity to think differently. These differences can provide the seeds of innovation, progress, and understanding. (2007, xxx)

Despite these widely documented advantages of diverse teams, people often approach a diverse team with trepidation. Indeed, bridging differences can be a challenge, especially if some team members feel threatened by ideas and perspectives that feel foreign to them. But diversity can result in conflict, even when everyone on the team only wants the best for others. This is especially true on teams made up of people from different countries. Such teams are vulnerable to cultural misunderstandings that can transform minor differences of opinion into major conflicts. Cultural differences can also make it hard for team members to trust each other, because different cultures have different ways of demonstrating respect and trust.

In her book *The Culture Map: Breaking Through the Invisible Boundaries of Global Business*, Erin Meyer describes negotiations between people from two companies, one American and one Brazilian. The first round of negotiations took place in Jacksonville, Mississippi, with the American hosts taking care stick to the agenda, so as to avoid wasting any time:

At the end of the two days, the American team felt great about all they had accomplished. The discussions, they believed, were efficient and productive. The short lunches and tight scheduling signified respect for the time the Brazilians invested in preparing for the negotiations and traveling to an out-of-the-way location. The Brazilians, on the other hand, were less upbeat and felt the meetings had not gone as well as hoped. (2014, 164)

As it turned out, the Brazilians felt that the efficient, organized American approach left them no time to get to know their potential new business partners. During the next round of negotiations, in Brazil, the South American hosts left time for long lunches and dinners that "stretched into the late evening," lots of good food and conversation. But this "socializing marathon" made the Americans uncomfortable because they thought the Brazilians weren't taking the negotiations seriously. In fact the opposite was true—the Brazilians were attempting to show respect for the Americans by attempting to get to know them so as to develop "personal connection and trust" (2014, 163-165).

Decades of psychology research has established that the best way to convince someone to adopt a new behavior is to convince him that other people have already adopted that behavior. So if you want individual team members to start showing up on time for meetings, for example, you can start by pointing out that the majority of team members do show up on time. As Leon Neyfakh writes in an article about how to change the way people do things: "a culture of respect and kindness isn't necessarily made up of angels—just people who have come to believe that that's what everyone else thinks is the right way to act" (Neyfakh 2012).

When they go unrecognized, cross-cultural misunderstandings like this can cause a host of ill-feelings. The first step toward preventing these misunderstandings is self-knowledge. What are your cultural biases, and how do they affect what you expect of other people? To find out, take this helpful quiz based on Erin Meyer's research on cross-cultural literary: "What's Your Cultural Profile?"

When thinking about culture, keep in mind that different generations have different cultures, too. Behavior that might feel perfectly acceptable to a twenty-four-year-old (texting during a meeting, wearing casual clothes to work) are often frowned on by older workers. Like cross-cultural differences, generational traits can cause unexpected conflicts on a team. This can be exacerbated if older team members feel threatened by younger workers, perhaps because younger workers are better at mastering new technology. Meanwhile, because of their lack of experience, younger workers might lack the ability to synthesize new information about a project. Your attempts to manage a multi-generational team can really go off the rails if you make the mistake of confusing "character issues like immaturity, laziness, or intractability with generational traits" (Wall Street Journal n.d.). This helpful guide suggests some ways to bridge the generation gap: "How to Manage Different Generations."

Teams also have their own cultures, and sometimes you'll have to navigate widely-diverging cultures on multiple teams. Take the time to get to know your team's set of norms and expectations, especially if you're joining a well-established group. After a little bit of observation, you might conclude that your team's culture is preventing it from achieving its goals, in which case, if you happen to be the team leader, you'll need to lead the team in a new direction.

Personality Power

Even among people from similar backgrounds, differences in personality can invigorate a team, injecting fresh perspectives and new ideas. A team of diverse personality types can be a challenge to manage, but such a team generates richer input on the project's progress, increasing the odds of project success. For more on teams with diverse personalities, see this article from the American Society of Mechanical Engineers: "More Diverse Personalities Mean More Successful Teams." For tips on managing a truly toxic individual, see this *Harvard Business Review* article: "How To Manage a Toxic Employee."

5.7 Virtual Teams: A Special Challenge

Managing a team of people who work side-by-side in the same office is difficult enough. But what about managing a **virtual team**—that is, a team whose members are dispersed at multiple geographical locations? In the worldwide marketplace, such teams are essential. Deborah L. Duarte and Nancy Tennant Snyder explain the trend in their helpful workbook, *Mastering Virtual Teams*:

Understanding how to work in or lead a virtual team is now a fundamental requirement for people in many organizations…. The fact is that leading a virtual team is not like leading a traditional team. People who lead and work on virtual teams need to have special skills, including an understanding of human dynamics and performance without the benefit of normal social cues, knowledge of how to manage across functional areas and national cultures, skill in managing their careers and others without the benefit of face-to-face interactions, and the ability to use leverage and electronic communication technology as their primary means of communicating and collaborating. (Duarte and Tennant Snyder 2006, 4)

Names Matter

People like to hear their names used in conversation because it suggests that you are trying to get to know them and to address their concerns. But names can be tricky when you are working with people from cultures other than your own. Use this site to learn how to pronounce names from languages you don't speak: PronounceNames.com.
For some tips on using and remembering names, see this article: "The Power of Using a Name."

When properly managed, collaboration over large distances can generate serious advantages. For one thing, the diversity of team members "exposes members to heterogeneous sources of work experience, feedback, and networking opportunities." At the same time, the team's diversity enhances the "overall problem-solving capacity of the group by bringing more vantage points to bear on a particular project" (Siebdrat, Hoegel and Ernst 2009, 65). Often, engaging with stakeholders via email allows for more intimacy and understanding than face-to-face conversations, which, depending on the personality types involved, can sometimes be awkward or ineffective.

However, research consistently underscores the difficulties in getting a dispersed team to work effectively. In a widely cited study of 70 virtual teams, Vijay Govindarajan and Anil K. Gupta found that "only 18% considered their performance 'highly successful' and the remaining 82% fell short of their intended goals. In fact, fully one-third of the teams … rated their performance as largely unsuccessful" (2001). Furthermore, research has consistently shown that virtual team members are "overwhelmingly unsatisfied" with the technology available for virtual communication and do not view it "as an adequate substitute for face-to-face communication" (Purvanova 2014).

Given these challenges, what's a virtual team manager to do? It helps to be realistic about the barriers to collaboration that arise when your team is scattered around the office park or around the globe.

The Perils of Virtual Distance

Physical distance—the actual space between team members—can impose all sorts of difficulties. According to Frank Siebdrat, Martin Hoegl, and Holger Ernst, most studies have shown that teams who are located in the same space, where members can build personal, collaborative relationships with one another, are usually more effective than teams that are dispersed across multiple geographical locations.

Potential issues include difficulties in communication and coordination, reduced trust, and an increased inability to establish a common ground…. Distance also brings with it other issues, such as team members having to negotiate multiple time zones and requiring them to reorganize their work days to accommodate others' schedules. In such situations, frustration and confusion can ensue, especially if coworkers are regularly unavailable for discussion or clarification of task-related issues. (Siebdrat, Hoegel and Ernst 2009, 64)

Even dispersing teams on multiple floors of the same building can decrease the team's overall effectiveness, in part because team members "underestimate the barriers to collaboration deriving from, for instance, having to climb a flight of stairs to meet a teammate face-to-face." Team members end up behaving as if they were scattered across the globe. As one team leader at a software company noted, teams spread out within the same building tend to "use electronic communication technologies such as e-mail, telephone, and voicemail just as much as globally dispersed teams do" (Siebdrat, Hoegel and Ernst 2009, 64).

Communication options like video conferences, text messages, and email can do wonders to bridge the gap. But you do need to make sure your communication technology is working seamlessly. Studies show that operational glitches (such as failed Skype connections or thoughtlessly worded emails) can contribute to a pernicious sense of distance between team members. Karen Sobel-Lojeski and Richard Reilly coined the term **virtual distance** to refer to the "psychological distance created between people by an over-reliance on electronic communications" (2008, xxii). Generally speaking, it is tough to build a team solely through electronic communication. That's why it's helpful to meet face-to-face occasionally. A visit from a project manager once a year or once a quarter can do wonders to nurture relationships among all team members and keep everyone engaged and focused on project success.

In their book *Uniting the Virtual Workforce*, Sobel-Lojeski and Reilly document some "staggering effects" of virtual distance:

- 50% decline in project success (on-time, on-budget delivery)
- 90% drop in innovation effectiveness
- 80% plummet in work satisfaction
- 83% fall off in trust
- 65% decrease in role and goal clarity
- 50% decline in leader effectiveness (2008, xxii)

The Special Role of Trust on a Virtual Team

So what's the secret to making virtual teams work for you? We've already discussed the importance of building trust on any team. But on virtual teams, building trust is a special concern. Erin Meyer describes the situation like this: "Trust takes on a whole new meaning in virtual teams. When you meet your workmates by the water cooler or photocopier every day, you know instinctively who you can and cannot trust. In a geographically distributed team, trust is measured almost exclusively in terms of reliability" (Meyer 2010).

All sorts of problems can erode a sense of reliability on a virtual team, but most of them come down to a failure to communicate. Sometimes the problem is an actual, technical inability to communicate (for example, because of unreliable cell phone service at a remote factory); sometimes the problem is related to scheduling (for example, a manager in Japan being forced to hold phone meetings at midnight with colleagues in North America); and sometimes the problem is simply a failure to understand a message once it is received. Whatever the cause, communication failures have a way of eroding trust among team members as they begin to see each other as unreliable.

And as illustrated in Figure 5-1, communicating clearly will lead your team members to perceive you as a reliable person, which will then encourage them to trust you.

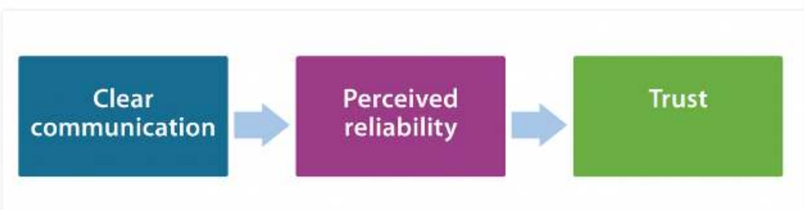


Figure 5-1: The benefits of clear communication
You can learn more about Leigh Thompson's ideas in this entertaining four-minute video: "Optimizing Virtual Teams."

Leigh Thompson, a professor at Northwestern University's Kellogg School of Management, offers a number of practical suggestions for improving virtual team work, including the following:

- Verify that your communication technology works reliably, and that team members know how to use it.
- Take a few minutes before each virtual meeting to share some personal news, so that team members can get to know each other.
- Use video conferencing whenever possible, so everyone can see each other. The video image can go a long way toward humanizing your counterparts in distant locales. If video conferencing is not an option, try at least to keep a picture of the person you're talking to visible, perhaps on your computer. Studies have shown that even a thumbnail image can vastly improve your ability to reach an agreement with a remote team member. (2015)

Here are a few other resources on virtual teams. You'll notice that they all emphasize good communication and building trust among team members:

- Ten basic principles for making virtual teams work: "Making Virtual Teams Work: Ten Basic Principles."
- A helpful ebook on managing virtual teams: *Influencing Virtual Teams: 17 Tactics That Get Things Done with Your Remote Employees*.
- Tips for leveraging technology to keep your virtual team running smoothly: "Working in a Virtual Team: Using Technology to Communicate and Collaborate."

5.8 Core Considerations of Leadership

Good teamwork depends, ultimately, on a leader with a clear understanding of what it means to lead. To judge by the countless books on the topic, you'd think the essential nature of leadership was widely understood. However, few people really understand the meaning of "leadership."

In his book, *Leadership Theory: Cultivating Critical Perspectives*, John P. Dugan examines "core considerations of leadership," zeroing in on misunderstood terms and also false dichotomies that are nevertheless widely accepted as accurate explanations of the nature of leadership. Dugan argues that a confused understanding of these essential ideas makes becoming a leader seem like a far-off dream, which only a select few can attain (Dugan 2017). But in fact, he argues, anyone can learn how to be a better leader.

Here's what Dugan has to say about core considerations of leadership:

- **Born Versus Made*:*** This is one of the most pernicious false dichotomies regarding leadership. Dugan explains, "that there is even a need to address a consideration about whether leaders are born or made in this day and age is mind-numbingly frustrating. Ample empirical research illustrates that leadership is unequivocally learnable when defined according to most contemporary theoretical parameters."
- **Leader Versus Leadership*:*** People tend to conflate the terms *leader* and *leadership*, but, according to Dugan, ***"****Leader* refers to an individual and is often, but not always, tied to the enactment of a particular role. This role typically flows from some form of formal or informal authority (e.g., a supervisor, teacher, coach). When not tied to a particular role, the term *leader* reflects individual actions within a larger group, the process of individual leader development, or individual enactments attempting to leverage movement on an issue or goal. *Leadership*, on the other hand, reflects a focus on collective processes of people working together toward common goals or collective leadership development efforts."
- **Leader Versus Follower*:*** "The conflation of leader and leadership makes it easier to create an additional false dichotomy around the terms *leader* and *follower,"* with *follower* considered a lesser role. "The label of *leader/follower*, then, is tied solely to positional authority rather than the contributions of individuals within the organization. If we flip the example to one from social movements, I often see an interesting shift in labeling. In the Civil Rights Movement in the United States there are multiple identified leaders (e.g., Martin Luther King, Jr., Malcom X, Rosa Parks, James Baldwin) along with many followers. However, the followers are often concurrently characterized as being leaders in their own right in the process. In social movements it seems we are more willing to simultaneously extend labels of leader and follower to a person."
- **Leadership Versus Management***:* "Also tied up in leader/leadership and leader/follower dichotomies are arguments about whether leadership and management represent the same or unique phenomena. Once again, the role of authority gets tied up in the understanding of this. Many scholars define management as bound to authority and focused on efficiency, maintenance of the status quo, and tactics for goal accomplishment. An exceptional manager keeps systems functioning through the social coordination of people and tasks. Leadership, on the other hand, is less concerned with the status quo and more attentive to issues of growth, change, and adaptation."

Emergent Leadership

Traditionally, engineers tended to be rewarded primarily for their analytical skills and their ability to work single-mindedly to complete a task according to a fixed plan. But in the modern world, plans are rarely fixed, and a single-minded focus blinds you to the ever-changing currents of living order. This is especially true when multiple people come together as a team to work on a project.

The old, geometric order presumes the continuation of the status quo, with humans working in a strict hierarchy, directed from above, performing their prescribed tasks like ants storing food for winter. By contrast, living order unfolds amidst change, risk-taking, collaboration, and innovation. This is like an ant colony after a gardener turns on a hose, washing away carefully constructed pathways and cached supplies with a cold gush of water, transforming order into chaos, after which the ants immediately adapt, and get to work rebuilding their colony. In such an unpredictable environment, the truly effective project manager is one who can adapt, learn, and perceive a kind of order—living order—in the chaos. At the same time, the truly effective project leader knows how to create and lead a team that is adaptable and eager to learn.

~Practical Tips

- **At the end of every day, summarize what you and your team accomplished:** In *The Progress Principle*, Teresa Amabile and Steven Kramer include a detailed daily checklist to help managers identify events throughout the day that promoted progress on the team's goals, or that contributed to setbacks (2011, 170-171). "Ironically," they explain, "such a microscope focus on what's happening every day is the best way to build a widespread, enduring climate of free-flowing communication, smooth coordination, and true consideration for people and their ideas. It's the accumulation of similar events, day by day, that creates that climate" (2011, 173). Or if you prefer a less regimented approach, consider writing periodic snippets, five-minute summaries of what you and your team accomplished, and then emailing them to stakeholders. Snippets became famous as a productivity tool at Google. You can learn all about snippets here: http://blog.idonethis.com/google-snippets-internal-tool/.
- **Establish a clear vision of what constitutes project success, and then work hard in the early stages to overcome any hurdles:** This is job one for any project team leader. Focus all your teamwork skills on this essential goal.
- **Build trust by establishing clear rules for communication:** This is important for all teams, but especially for virtual teams spanning multiple cultures:

Virtual teams need to concentrate on creating a highly defined process where team members deliver specific results in a repeated sequence. Reliability, aka trust, is thus firmly established after two or three cycles. Because of that, face-to face meetings can be limited to once a year or so. (Meyer 2010)

- **Take time to reassess:** In an article summarizing work on teams completed by faculty at the Wharton School of the University of Pennsylvania, Jennifer S. Mueller, a Wharton professor of management, explains how to get a team back on track:

While teams are hard to create, they are also hard to fix when they don't function properly. So how does one mend a broken team? "You go back to your basics," says Mueller. "Does the team have a clear goal? Are the right members assigned to the right task? Is the team task focused? We had a class on the 'no-no's of team building, and having vague, not clearly defined goals is a very, very clear no-no. Another no-no would be a leader who has difficulty taking the reins and structuring the process. Leadership in a group is very important. And third? The team goals cannot be arbitrary. The task has to be meaningful in order for people to feel good about doing it, to commit to the task. (Wharton School 2006)

- **Keep your team small if possible:** Social psychologists have been studying the question of the ideal team size for decades. The latest research suggests that smaller is better. So for large projects, it's sometimes helpful to divide a team into layers of sub-teams of about ten members. As Jennifer S. Mueller explains, when deciding on team size, you have to consider the type of project:

Is there an optimal team size? Mueller has concluded … that it depends on the task. "If you have a group of janitors cleaning a stadium, there is no limit to that team; 30 will clean faster than five. But," says Mueller, "if companies are dealing with coordination tasks and motivational issues, and you ask, 'What is your team size and what is optimal?' that correlates to a team of six" (2006).

- **Pick the right people:** In his book *Mastering the Leadership Role in Project Management*, Alexander Laufer describes project managers who succeeded in part because they "selected people not only on the basis of their technical, functional, or problem-solving skills, but also on the basis of their interpersonal skills"(2012, 223-224). He emphasizes the importance of selecting the best possible members for your team:

With the right people, almost anything is possible. With the wrong team, failure awaits. Thus, recruiting should be taken seriously, and considerable time should be spent finding and attracting, and at times fighting for, the right people. Even greater attention may have to be paid to the selection of the right project manager. (2012, 222)

- **Use a buddy system:** One way to deal with large, virtual teams is to pair individuals in a specific area (design, purchasing, marketing) with a buddy in another group, company, or team. This will encourage direct contact between peers, making it more likely that they will pick up the phone to resolve issues one-on-one outside the normal team meetings or formal communications. Often these two-person teams within a team will go on to build personal relationships, especially if they get to meet face-to-face on occasion, and even better, socialize.
- **Use Skype or other video conference options when possible:** Video conferences can do wonders to improve team dynamics and collaboration. After all, only a small percentage of communication is shared via words. The remainder is body language and other visual cues.
- **Bring in expert help:** It's common for a team to realize it is underperforming because of interpersonal problems among team members but then fail to do anything about perhaps because of a natural aversion to conflict. But this is when the pros in your company's human resources department can help. If your team is struggling, all you need to do is ask. As explained in this article, you may be surprised by all the ways your human resources department can help you and your team: "6 Surprising Ways That Human Resources Can Help Your Career." Other resources for repairing a dysfunctional team include peer mentors and communities of practice.
- **Consider the possibility that you are the problem:** If most or all of the teams you join turn out to be dysfunctional, then it's time to consider the possibility that you are the problem. Examine your own behavior honestly to see how you can become a better team member. Peer mentors and communities of practice can be an invaluable way to sharpen your teamwork skills. It's also essential to understand the role you typically play in a team. This 28-question quiz is a good way to start evaluating your teamwork skills: "Teamworking Skills."
- **Learn how to facilitate group interactions:** Just as musicians need to study and practice their instruments, leaders need to study and practice the best ways to facilitate team interactions. Here are two helpful resources:
  - Ingrid Bens, the author of *Faciliating with Ease*, is a widely recognized expert on group facilitation. Her web site provides helpful resources, include free templates and videos: "Facilitation Techniques for Consultants: Books by Ingrid Bens."

- Liberating Structures offers a wealth of tools and techniques for teams and groups here: "Liberating Structures."
- **Do your team-building exercises:** People often claim to dislike team-building exercises, but they can be essential when kicking off major projects. This is especially true for teams that do not know each other, but also for teams that have worked together before or that inhabit the same building. Your team-building efforts don't need to be major events. In fact, the less planned they appear to be, the better.
- **Take time to socialize:** The camaraderie generated by a few hours of socializing helps build the all-important trust needed for a team to collaborate effectively. Try to make your work hours fun, too. Of course, if you are working with teams that span multiple cultures, you need to be sensitive to the fact that what's fun for one person might not be fun for another. But at the very least, most people enjoy a pleasant conversation about something other than work. Encourage team members to tell you stories about their lives. In the process, you'll learn a lot about your team members and how they filter information. Sharing stories also makes work more interesting and helps nurture relationships between team members.
- **Have some fun:** Something as simple as having your team choose a name for a project and creating a project logo can help create a sense of camaraderie. Consider encouraging friendly competitions between teams, such as 'first to get a prototype built' or 'most hours run on a test cell in the week.' If your office culture is relatively relaxed, you might want to try some of the fun ideas described in this article: "25 Ways to Have Fun at Work."
- **Celebrate success:** Too often teams are totally focused on the next task or deliverable. Take the time to celebrate a mid-project win. This is especially helpful with lengthy, highly complex projects.

~Summary

- A team is a "small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable" (Katzenbach and Smith 1993, 45). A high-functioning team is more than the sum of its individual members. They offer complementary sets of skills and varying perspectives that make it possible to solve problems as they arise. Perhaps most importantly, teams are good at adapting to changing circumstances.
- Trust is the magic ingredient that allows team members to work together effectively. Because teams often come together in a hurry, building trust quickly is essential. Several techniques, traits, and behaviors help foster trusting relationships:
  - Reliable promises—a specialized type of commitment pioneered in Lean—formalizes the process of agreeing to a task. A reliable promise is predicated on a team member's honest assessment that she does indeed have the authority, competence, and capacity to make a promise, and a willingness to correct if she fails to follow through.
  - Emotional intelligence, or the ability to recognize your own feelings and the feelings of others, is crucial to a team's effectiveness. Some people are born with high emotional intelligence. Others can cultivate it by developing skills associated with emotional intelligence such as self-awareness, self-control, self-motivation, and relationship skills.
  - An unrealistically positive attitude can destroy painstakingly built bridges of trust between team members. Especially in the planning phase, an overly optimistic project manager can make it difficult for team members to voice their realistic concerns.
  - Reliable promises, emotional intelligence, and a realistic outlook are only helpful if you have the skills to communicate with your team members. This is one area where getting feedback from your co-workers or taking classes can be especially helpful.
- According to John Nelson, team motivators include a sense of purpose; clear performance metrics; assigning the right tasks to the right people; encouraging individual achievement; sailboat rules communication, in which no one takes offense for clear direction; options for mentorship; and consistency and follow-through. Team demotivators include unrealistic or unarticulated expectations; ineffective or absent accountability; a lack of discipline; and selfish, anti-team behavior. One form of motivation—uncontrolled external influences—can have positive or negative effects, depending on the nature of the team and its members' abilities to adapt.
- Even high-performing teams can be knocked off their stride by personnel transitions or other changes. The Transition Model, developed by William Bridges, describes the stages of transition people go through as they adapt to change: 1) Ending, Losing, and Letting Go; 2) the Neutral Zone; and 3) New Beginning. Many resources are available to help teams manage transitions.
- In Agile, a self-organizing team is a "group of motivated individuals, who work together toward a goal, have the ability and authority to take decisions, and readily adapt to changing demands" (Mittal 2013).
- Diverse teams are more effective than homogenous teams because they are better at processing information and are more resourceful at using new information to generate innovative ideas. Companies with a diverse workforce are far more successful than homogeneous organizations.
- Virtual teams present special challenges due to physical distance, communication difficulties resulting from unreliable or overly complicated technology, and cross-cultural misunderstandings. For this reason, building trust is especially important on virtual teams.

~Glossary

- **emergent leaders**—People who emerge as leaders in response to a particular set of circumstances.
- **emotional intelligence**—The ability to recognize your own feelings and the feelings of others.
- **physical distance**—The actual space between team members.
- **premortem**—A meeting at the beginning of a project in which team members imagine that the project has already failed and then list the plausible reasons for its failure.
- **reliable promise**—A commitment to complete a task by an agreed-upon time. In order to make a reliable promise, you need to have the authority to make the promise and the competence to fulfill the promise. You also need to be honest and sincere in your commitment and be willing to correct the situation if you fail to keep the promise.
- **self-organizing team**—As defined in Agile, a "group of motivated individuals, who work together toward a goal, have the ability and authority to take decisions, and readily adapt to changing demands" (Mittal 2013).
- **team**—A "small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable" (Katzenbach and Smith 1993, 45).
- **virtual distance**—The "psychological distance created between people by an over-reliance on electronic communications" (Lojeski and Reilly 2008, xxii).

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9.2.4: Project Initiation

The project initiation phase is the first phase within the project management life cycle, as it involves starting up a new project. Within the initiation phase, the business problem or opportunity is identified, a solution is defined, a project is formed, and a project team is appointed to build and deliver the solution to the customer. A business case is created to define the problem or opportunity in detail and identify a preferred solution for implementation. The business case includes:

- A detailed description of the problem or opportunity with headings such as Introduction, Business Objectives, Problem/Opportunity Statement, Assumptions, and Constraints
- A list of the alternative solutions available
- An analysis of the business benefits, costs, risks, and issues
- A description of the preferred solution
- Main project requirements
- A summarized plan for implementation that includes a schedule and financial analysis

The project sponsor then approves the business case, and the required funding is allocated to proceed with a feasibility study. It is up to the project sponsor to determine if the project is worth undertaking and whether the project will be profitable to the organization. The completion and approval of the feasibility study triggers the beginning of the planning phase. The feasibility study may also show that the project is not worth pursuing and the project is terminated; thus the next phase never begins.

All projects are created for a reason. Someone identifies a need or an opportunity and devises a project to address that need. How well the project ultimately addresses that need defines the project's success or failure.

The success of your project depends on the clarity and accuracy of your business case and whether people believe they can achieve it. Whenever you consider past experience, your business case is more realistic; and whenever you involve other people in the business case's development, you encourage their commitment to achieving it.

Often the pressure to get results encourages people to go right into identifying possible solutions without fully understanding the need or what the project is trying to accomplish. This strategy can create a lot of immediate activity, but it also creates significant chances for waste and mistakes if the wrong need is addressed. One of the best ways to gain approval for a project is to clearly identify the project's objectives and describe the need or opportunity for which the project will provide a solution. For most of us, being misunderstood is a common occurrence, something that happens on a daily basis. At the restaurant, the waiter brings us our dinner and we note that the baked potato is filled with sour cream, even though we expressly requested "no sour cream." Projects are filled with misunderstandings between customers and project staff. What the customer ordered (or more accurately what they think they ordered) is often not what they get. The cliché is "I know that's what I said, but it's not what I meant." Figure 7.1 demonstrates the importance of establishing clear objectives.

The need for establishing clear project objectives cannot be overstated. An objective or goal lacks clarity if, when shown to five people, it is interpreted in multiple ways. Ideally, if an objective is clear, you can show it to five people who, after reviewing it, hold a single view about its meaning. The best way to make an objective clear is to state it in such a way that it can be verified. Building in ways to measure achievement can do this. It is important to provide quantifiable definitions to qualitative terms.

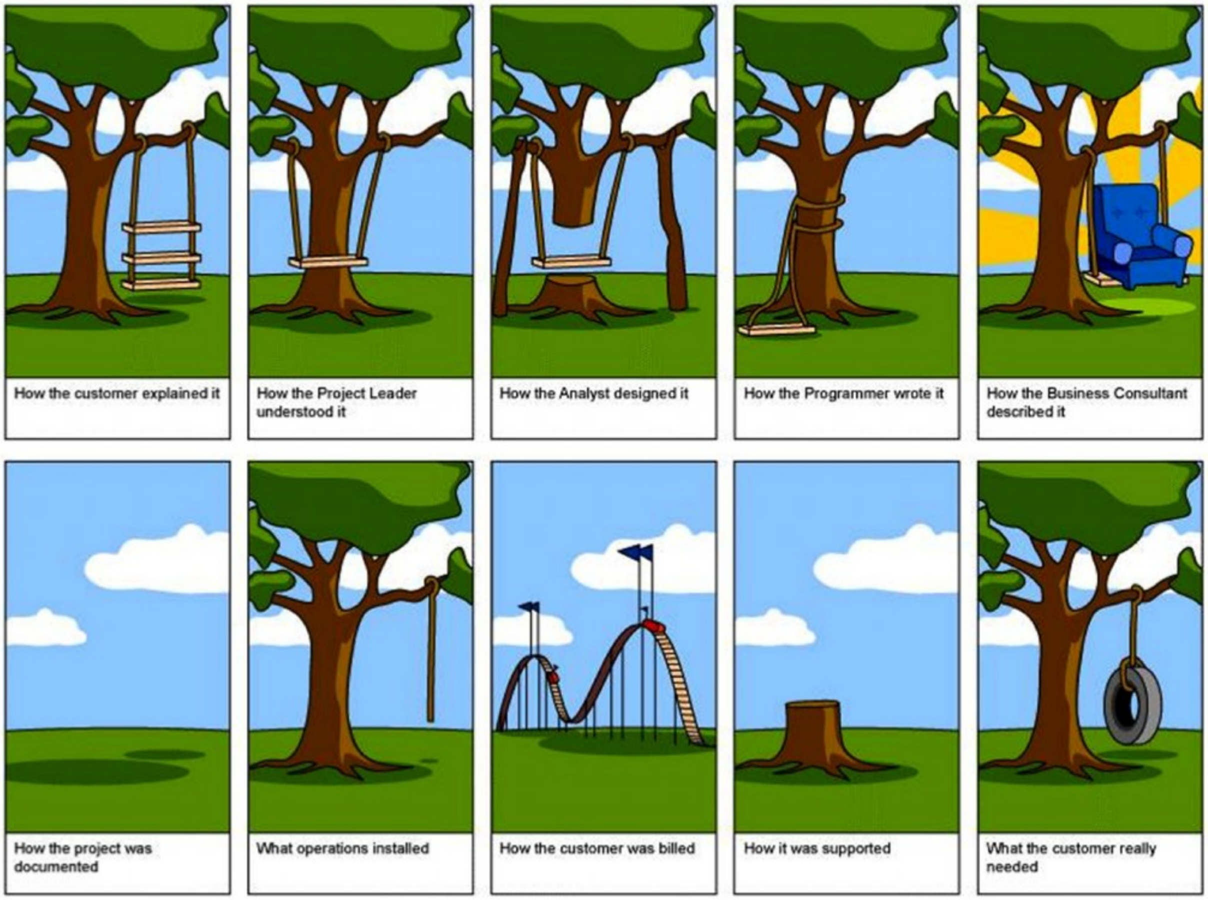

Figure 7.1 Project Management.

For example, an objective of the team principle (project manager) of a Formula 1 racing team may be that their star driver, “finish the lap as fast as possible.” That objective is filled with ambiguity.

How fast is “fast as possible?” Does that mean the fastest lap time (the time to complete one lap) or does it mean the fastest speed as the car crosses the start/finish line (that is at the finish of the lap)?

By when should the driver be able to achieve the objective? It is no use having the fastest lap after the race has finished, and equally the fastest lap does not count for qualifying and therefore starting position, if it is performed during a practice session.

The ambiguity of this objective can be seen from the following example. Ferrari’s Michael Schumacher achieved the race lap record at the Circuit de Monaco of 1 min 14.439 sec in 2004 (Figure 7.2). However, he achieved this on lap 23 of the race, but crashed on lap 44 of a 77-lap race. So while he achieved a fastest lap and therefore met the specific project goal of “finish the lap as fast as possible,” it did not result in winning the race, clearly a different project goal. In contrast, the fastest qualifying time at the same event was by Renault’s Jarno Trulli (1 min 13.985 sec), which gained him pole position for the race, which he went on to win (Figure 7.2). In his case, he achieved the specific project goal of “finish the lap as fast as possible,” but also the larger goal of winning the race.

The objective can be strengthened considerably if it is stated as follows: “To be able to finish the 3.340 km lap at the Circuit de Monaco at the Monaco Grand Prix in 1 min 14.902 sec or less, during qualifying on May 23, 2009.” This was the project objective achieved by Brawn GP’s Jenson Button (Figure 7.2).


Figure 7.2: Despite achieving the project goal of the “finish the lap as fast as possible,” Ferrari’s Michael Schumacher crashed 21 laps later and did not finish the race (top); Renault’s Jarno Trulli celebrating his win at the 2004 Monaco Grand Prix (middle); Jenson Button took his Brawn GP car to pole position at the Monaco Grand Prix with a lap time of 1 min 14.902 sec. He also went on to win the race, even though he did not achieve that lap time during the race (bottom).

There is still some ambiguity in this objective; for example, it assumes the star driver will be driving the team’s race car and not a rental car from Hertz. However, it clarifies the team principal’s intent quite nicely. It should be noted that a clear goal is not enough. It must also be achievable. The team principal’s goal becomes unachievable, for example, if he changes it to require his star driver to finish the 3.340 km lap in 30 sec or less.

To ensure the project’s objectives are achievable and realistic, they must be determined jointly by managers and those who perform the work. Realism is introduced because the people who will do the work have a good sense of what it takes to accomplish a particular task. In addition, this process assures some level of commitment on all sides: management expresses its commitment to support the work effort and workers demonstrate their willingness to do the work.

Imagine an office manager has contracted a painter to paint his office. His goal or objective is to have the office painted a pleasing blue colour. Consider the conversation that occurs in Figure 7.3 after the job was finished.

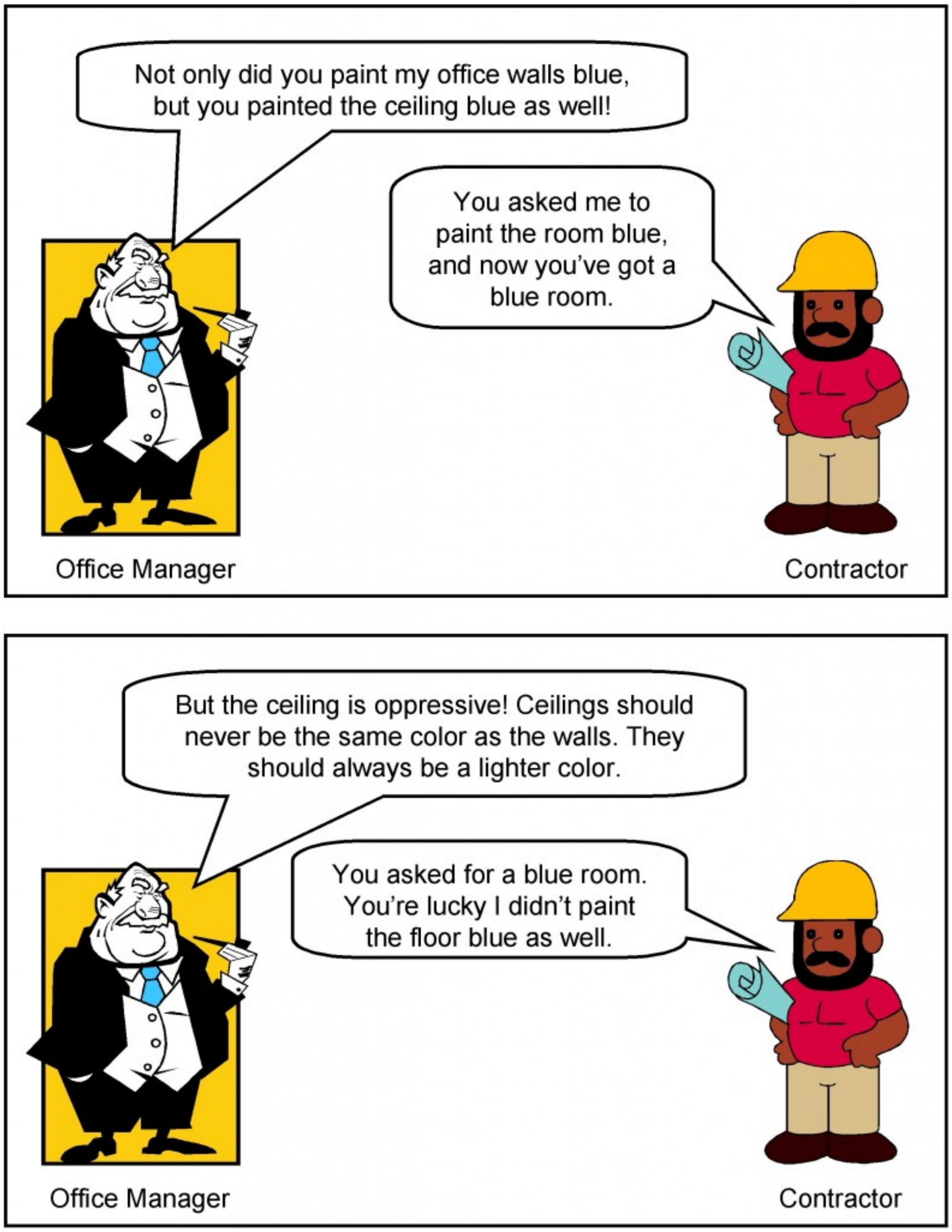

Figure 7.3: The consequence of not making your objective clear. [Image Description]

This conversation captures in a nutshell the essence of a major source of misunderstandings on projects: the importance of setting clear objectives. The office manager's description of how he wanted the room painted meant one thing to him and another to the painter. As a consequence, the room was not painted to the office manager's satisfaction. Had his objective been more clearly defined, he probably would have had what he wanted.

Comparing Options Using a Weighted Decision Matrix

Sometimes we have multiple options to choose from when determining requirements and deciding which project to work on. To select the best option, we can use tools such as a weighted decision matrix.

A basic decision matrix consists of establishing a set of criteria for options that are scored and summed to gain a total score that can then be ranked. Importantly, it is not weighted to allow a quick selection process.

A weighted decision matrix operates in the same way as the basic decision matrix but introduces the concept of weighting the criteria in order of importance. The resultant scores better reflect the importance to the decision maker of the criteria involved. The more important a criterion, the higher the weighting it should be given. Each of the potential options is scored and then multiplied by the weighting given to each of the criteria to produce a result.

The advantage of the weighted decision matrix is that subjective opinions about one alternative versus another can be made more objective. Another advantage of this method is that sensitivity studies can be performed. An example of this might be to see how much your opinion would have to change in order for a lower-ranked alternative to outrank a competing alternative.

A **weighted decision matrix** therefore allows decision makers to structure and solve their problem by:

1. **Specifying** and **prioritizing** their needs with a list a criteria; then
2. **Evaluating**, **rating**, and **comparing** the different solutions; and
3. **Selecting** the best matching solution.

A weighted decision matrix is a decision tool used by decision makers.

A *decision matrix* is basically an array presenting on one axis a list of **alternatives**, also called *options* or *solutions*, that are evaluated regarding, on the other axis, a list of **criteria**, which are *weighted* depending on their respective importance in the final decision to be taken.

Weighted Decision Matrix Sample

The example in Figure 7.4 shows a weighted decision matrix that compared three options for a web development project (SJS Enterprises). This method is especially useful when choosing purchase alternatives and comparing them against specific desirable system requirements.

Weighted Decision Matrix for Game Delivery System

Criteria	Weight	SJS Enterprises	Game Access	DVD Link
Educational	15%	90	0	0
Sports-related	15%	90	90	90
Secure payment area with the ability to use Paypal, bank payments, cheque, school payment systems as a payment source	10%	90	50	50
Live Support	15%	90	0	0
Search Option	5%	50	50	30
Games available for all platforms currently on the market including school learning systems	10%	60	30	30
Longer Rental Periods (1 to 2 weeks)	5%	40	20	40
Sidebar with categories such as most popular, multiplayer and just released	5%	50	50	20
Registered customers must be able to order the videos, track delivery, return of videos and be able to provide reviews of views	10%	50	30	30
Age/grade appropriate section (can isolate certain games to certain ages or grade levels)	10%	70	5	0
Weighted Project Scores	**100%**	**74.5**	**31**	**29**

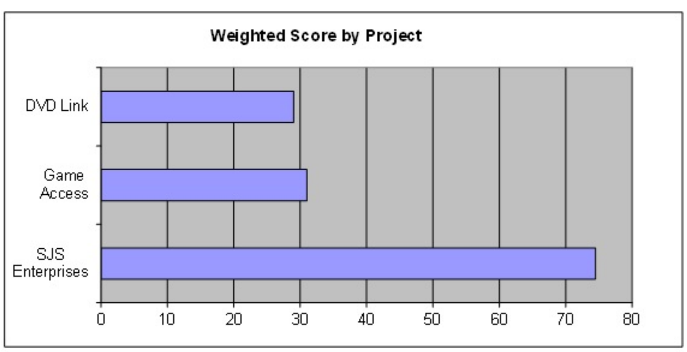

Figure 7.4: Weighted Decision Matrix for Game Delivery Project. [Image description]

Financial Considerations

In many new project endeavors, we need to find out if our project is financially feasible. We do that by using net present value (NPV), rate of return (ROI), and payback analysis.

NPV

A dollar earned today is worth more than a dollar earned one or more years from now. The NPV of a time series of cash flows, both incoming and outgoing, is defined as the sum of the present values (PVs) of the individual cash flows of the same entity.

In the case when all future cash flows are incoming and the only outflow of cash is the purchase price, the NPV is simply the PV of future cash flows minus the purchase price (which is its own PV). NPV is a standard method for using the time value of money to appraise long-term projects. Used for capital budgeting and widely used throughout economics, finance, and accounting, it measures the excess or shortfall of cash flows, in present value terms, once financing charges are met.

NPV can be described as the "difference amount" between the sums of discounted cash inflows and cash outflows. It compares the present value of money today to the present value of money in the future, taking inflation and returns into account.

The NPV of a sequence of cash flows takes as input the cash flows and a discount rate or discount curve and outputs a price.

Each cash inflow/outflow is discounted back to its present value (PV). Then they are summed. Therefore NPV is the sum of all terms.

$$\frac{R_t}{(1+i)^t}$$

where

- t is the time of the cash flow
- i is the discount rate (the rate of return that could be earned on an investment in the financial markets with similar risk; the opportunity cost of capital)
- R_t is the net cash flow (i.e., cash inflow − cash outflow, at time t).

NPV is an indicator of how much value an investment or project adds to the firm. With a particular project, if NPV is a positive value, the project is in the status of positive cash inflow in the time t. If NPV is a negative value, the project is in the status of discounted cash outflow in the time t. Sometimes risky projects with a positive NPV could be accepted. This does not necessarily mean that they should be undertaken since NPV at the cost of capital may not account for opportunity cost (i.e., comparison with other available investments). In financial theory, if there is a choice between two mutually exclusive alternatives, the one yielding the higher NPV should be selected.

Table 7.1 Net Present Value

If…	It means…	Then…
NPV > 0	The investment would add value to the firm.	The project may be accepted.
NPV < 0	The investment would subtract value from the firm.	The project should be rejected.
NPV = 0	The investment would neither gain nor lose value for the firm.	We should be indifferent in the decision whether to accept or reject the project. This project adds no monetary value. Decision should be based on other criteria (e.g., strategic positioning or other factors not explicitly included in the calculation).

Table 7.2: Present Value Table
(Take note of the decreasing value of money as the period increases from 1 to 10 years.)

Periods (years)	6%	8%	10%	12%	14%
1	0.943	0.926	0.909	0.893	0.877
2	0.890	0.857	0.826	0.797	0.769
3	0.840	0.794	0.751	0.712	0.675
4	0.792	0.735	0.683	0.636	0.592
5	0.747	0.681	0.621	0.567	0.519
6	0.705	0.630	0.564	0.507	0.456
7	0.665	0.583	0.513	0.452	0.400
8	0.627	0.540	0.467	0.404	0.351
9	0.592	0.500	0.424	0.361	0.308
10	0.558	0.463	0.386	0.322	0.270

NPV Example

The following example is calculating the NPV of a project at a discount rate of 12%. The project takes five years to complete with given benefits and costs for each year. In Year 0, there is no benefit to the organization, just an initial cost of $75,000 with no discount rate. In Year 1, the discount rate is 89%. This means that at 12% assumed interest, the time value of money says that the $1 today is worth $0.89 in one year, $0.80 in two years, etc. By calculating the NPV for the benefits and the costs, you subtract the NPV of all costs from the NPV of all benefits. The final result is a positive value of $105,175.

	A	B	C	D	E	F	G	H
1	NPV		Discount Factors (12%) (used Row 10)					
2			0.893	0.797	0.712	0.636	0.567	
3	EXAMPLE							
4								
5	Interest rate	12%						
6								
7	Year	0	1	2	3	4	5	
8								
9	Benefits		85,000	85,000	85,000	85,000	85,000	
10	PV factor	100%	89%	80%	71%	64%	57%	
11	PV of Benefits	-	75,905	67,745	60,520	54,060	48,195	
12	Cumulative Benefits PV	-	75,905	143,650	204,170	258,230	306,425	
13	Net Present Value	306,425						
14								
15								
16								
17								
18	Year	0	1	2	3	4	5	
19								
20	Costs	75,000	35,000	35,000	35,000	35,000	35,000	
21	PV factor	100%	89%	80%	71%	64%	57%	
22	PV of Costs	75,000	31,255	27,895	24,920	22,260	19,845	
23	Cumulative Costs PV	75,000	106,255	134,150	159,070	181,330	201,175	
24	Net Present Value	201,175						
25								
26	Overall NPV	105,250		NPV of Benefits - NPV of Costs				
27								
28	ROI	0.523		benefits-costs/ costs				
29								
30	Payback	(75,000)	(30,350)	9,500	45,100	76,900	105,250	
31								
32								

Table 7.3: Table of NPV of costs and benefits.

ROI

Return on investment (ROI) is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. It is one way of considering profits in relation to capital invested.

This is calculated by subtracting the project’s costs from the benefits and then dividing by the costs. For example, if you invest $100 and your investment is worth $110 next year, the ROI is (110 − 100) ÷ 100 = 0.1 or a 10% return.

In our example: (306,425 − 201,175) ÷ 201,175 = 0.52, or a 52% return. That’s considered a nice return on investment.

Payback Analysis

Payback analysis is important in determining the amount of time it will take for a project to recoup its investments. This is the point at which the benefits start to outweigh the costs. The best way to see that is by charting the cumulative benefits and costs. As you can see in the example in Figure 7.5, the cumulative benefits outweigh the cumulative costs in the second year.

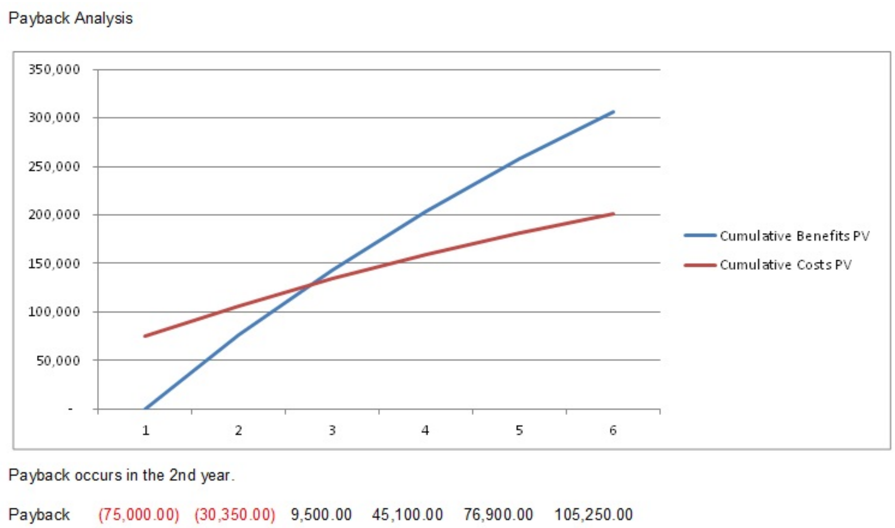

Figure 7.5: Payback Analysis Chart

Project Charter

A project charter, project definition, or project statement is a statement of the scope, objectives, and participants in a project. It provides a preliminary delineation of roles and responsibilities, outlines the project objectives, identifies the main stakeholders, and defines the authority of the project manager. It serves as a reference of authority for the future of the project.

The purpose of a project charter is to:

- Provide an understanding of the project, the reason it is being conducted, and its justification
- Establish early on in the project the general scope
- Establish the project manager and his or her authority level. A note of who will review and approve the project charter must be included.

Example of a Project Charter

> Sample Project Charter

Identification Section

List the project name, the date of the current version of the project charter, the sponsor’s name and authority, and the project manager’s name.

Example:

Project Name: Rice University Computer Store Creation

Project Sponsor: Jane Ungam, Facilities Manager

Date: Jan 12, 2010

Revision: 1

Project Manager: Fred Rubens

Overview of the Project

Provide a simple but precise statement of the project.

Example: Rice University is planning to create a store to sell computer supplies.

Objective

State the objectives of the project clearly and ensure they contain a measure of how to assess whether they have been achieved. The statement should be realistic and should follow the ***SMART*** *protocol:*

- ***Specific*** *(get into the details)*
- ***Measurable*** *(use quantitative language so that you know when you are finished)*
- ***Acceptable*** *(to stakeholders)*
- ***Realistic*** *(given project constraints)*
- ***Time based*** *(deadlines, not durations)*

Example: The objective of this project is to implement a campus store that is ready to sell computer supplies such as memory sticks, mouse pads, and cables, when class starts in August 2010, with enough inventory to last through the first two weeks of classes.

Scope

Specify the scope of the project by identifying the domain or range of requirements.

Example: The scope of Rice's school supplies store project includes the activities listed below:

1. Determine what supplies will be sold in the store.
2. Establish competitive prices for the computer supplies.
3. Source and secure supply vendors.
4. Establish marketing, procurement, operations, and any other necessary departments, schools, centres, and institutes.

It is equally important to include in the scope what is not included in the project.

Example: The scope of the project does not include:

- Development of any other school store departments
- Store design or construction

Major Milestones

List all major milestones needed to ensure successful project completion.

Example:

- All vendors selected
- Contracts or orders completed with all vendors
- Supplies delivered to the store
- Pricing determined

Major Deliverables

List and describe the major deliverables that will result from the project.

Example:

- Supplies procured
- Operations, procurement, marketing, and other teams established
- Store supplies stocked and displayed
- Store staffing completed, including work schedules
- Store operations policies, including hours of operation, established

Assumptions

Outline the assumptions made in creating the project. An assumption is a fact you are unsure of but can either confirm at a later time or are simply stating so that the project can proceed as if the statement were true.

Example:

- Only computer supplies will be sold in the store.
- Customers will be the Rice University student body and faculty.
- Rice University students will manage the project and be responsible for ongoing operations.
- A store sponsor from the university faculty or staff will be assigned to mentor students and provide oversight.
- Store hours of operation will be approved by the Rice University students or store sponsor.
- Supplier deliveries will be arranged or the store sponsor will pick them up with students.
- Students will be empowered to contact vendors for order placement and inquiries via telephone.

Constraints

Define any and all constraints on the project or those working on the project. This is an important part of the project charter. A constraint is anything that limits the range of solutions or approaches.

Example:

- Student availability to meet for project planning is limited to school hours.
- Software is not available for project planning and control.

Business Need or Opportunity (Benefits)

Provide a concise statement of the business need or opportunity that led to the creation of the project. Why was it created? What are the benefits? How does the project contribute to organizational objectives?

Example: The goal of this project is to provide income for the Rice Student Centre while supplying necessary items to students and faculty at competitive prices. The school store will be a convenience to students since necessary supplies will be available on campus. This will help students learn to manage their personal supplies.

Preliminary Cost for the Project

Provide a statement indicating how the cost of the project will be defined and controlled.

Example: The procurement team will assemble a proposal based on expected costs for review by the Dean of Undergraduate Studies.

Project Risks

A risk is anything uncertain that may occur that will reduce or decrease the chances of project success.

Example:

1. There is a state election coming and the new government may change the taxation rules for private university retail outlets.
2. The cloud is changing student demand for media such as flash drives in somewhat unpredictable ways. If this happens faster than we forecast, we may be building a store that students don't need.
3. Deliveries of store shelves, etc. will be delayed if a major hurricane occurs.

Project Charter Acceptance

Provide the names, titles, and signature lines of the individuals who will sign off on the project charter.

Project Stakeholders

Provide the key stakeholders and team members by function, name, and role.

Function	Name	Role
Project Manager	Monica Styles	Leads the project
Sponsor	Adrienne Watt	Project sponsor
etc.		

Image Descriptions

Figure 7.3 image description: A conversation between an office manager and a contractor.

Office manager: Not only did you paint my office walls blue, but you painted the ceiling blue as well.

Contractor: You asked me to paint the room blue, and now you've got a blue room.

Office manager: But the ceiling is oppressive! Ceilings should never be the same colour as the walls. They should always be a lighter colour.

Contractor: You asked for a blue room. You're lucky I didn't paint the floor blue as well.

[Return to Figure 7.3]

Figure 7.4 image description:

Weighted Decision Matrix for Game Delivery System

Criteria	Weight	SJS Enterprises	Game Access	DVD Link
Educational	15%	90	0	0
Sports-related	15%	90	90	90
Secure payment area with the ability to use Payplay, bank payments, cheques, and school payment systems as a payment source.	10%	90	50	50
Live Support	15%	90	0	0
Search Option	5%	50	50	30
Games available for all platforms currently on the market including school learning systems.	10%	60	30	30
Longer rental periods (1 to 2 weeks)	5%	40	20	40
Sidebar with categories, such as most popular, multiplayer, and just released.	5%	50	50	20
Registered customers must be able to order the videos, track delivery, return videos, and be able to provide reviews of views.	10%	50	30	30
Age/grade appropriate section (can isolate certain games to certain ages or grade levels)	10%	70	5	0
Weighted project scores:	100%	75.4	31	29

[Return to Figure 7.4]

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9.2.5: Project Schedule Planning

In order to develop our schedule, we first need to define the activities, sequence them in the right order, estimate the resources needed, and estimate the time it will take to complete the tasks.

Defining Activities

The activity definition process is a further breakdown of the work package elements of the WBS. It documents the specific activities needed to fulfill the deliverables detailed in the WBS. These activities are not the deliverables themselves but the individual units of work that must be completed to fulfill the deliverables. Activity definition uses everything we already know about the project to divide the work into activities that can be estimated. You might want to look at all the lessons learned from similar projects your company has done to get a good idea of what you need to do on the current one.

Expert judgment in the form of project team members with prior experience developing project scope statements and WBS can help you define activities. If you are asked to manage a project in a new domain, you might also use experts in that particular field to help define tasks so you can understand what activities are going to be involved. You may want to create an activity list and then have the expert review it and suggest changes. Alternatively, you could involve the expert from the very beginning and ask to have an activity definition conversation with him or her before even making your first draft of the list.

Sometimes you start a project without knowing a lot about the work that you'll be doing later. Rolling-wave planning lets you plan and schedule only the portion that you know enough about to plan well. When you don't know enough about a project, you can use placeholders for the unknown portions until you know more. These are extra items that are put at high levels in the WBS to allow you to plan for the unknown.

A Case Study

Susan and Steve have decided to tie the knot, but they don't have much time to plan their wedding. They want the big day to be unforgettable. They want to invite many people and provide a great time. They've always dreamed of a June wedding, but it's already January. Just thinking about all of the details involved is overwhelming. Susan has been dreaming of the big day since she was 12, but it seems that there's so little time for all the tasks to be completed. When they were choosing the paper for the invitations, the couple realized that they needed help.

Susan: Steve, we need some help.
Steve: Don't worry. My sister's wedding planner was great. Let me give her a call. [Steve calls the wedding planner Sally.]
Wedding Planner: Hello, Susan and Steve.
Steve: We want everything to be perfect.
Susan: There is so much to do! Invitations, food, guests, and music.
Steve: Oh no, we haven't even booked a place!
Susan: And it has to be done right. We can't print the invitations until we have the menu planned. We can't do the seating arrangements until we have the RSVPs. We aren't sure what kind of band to get for the reception, or should it be a DJ? We're just overwhelmed.
Steve: My sister said you really saved her wedding. I know she gave you over a year to plan. But I've always dreamed of a June wedding, and I'm not willing to give that up. I know it's late, but Sally, can you help us?
Wedding Planner: Take it easy. I've got it under control. We've a lot of people and activities to get under control. You really should have called six months ago, but we'll still make this wedding happen on time.

Much work has to be done before June. First, Sally figures out what work needs to be done. She starts to put together a to-do list:

- Invitations
- Flowers
- Wedding cake
- Dinner menu
- Band

Since many different people are involved in the making of the wedding, it takes much planning to coordinate all the work in the right order by the right people at the right time. Initially, Sally was worried that she didn't have enough time to make sure that everything would be done properly. However, she knew that she had some powerful time management tools on her side when she took the job, and these tools would help her to synchronize all the required tasks.

To get started, Sally arranged all the activities in a work breakdown structure. The next exercise presents part of the WBS Sally made for the wedding.

WBS Exercise

Arrange the following activities into the WBS (Figure 10.1) to show how the work items decompose into activities.

- Shop for shoes
- Create guest list
- Have the tailoring and fitting done
- Shop for dress
- Find caterer
- Cater the wedding
- Wait for RSVPs
- Mail the invitations
- Finalize the menu
- Print the invitations
- Choose the bouquet

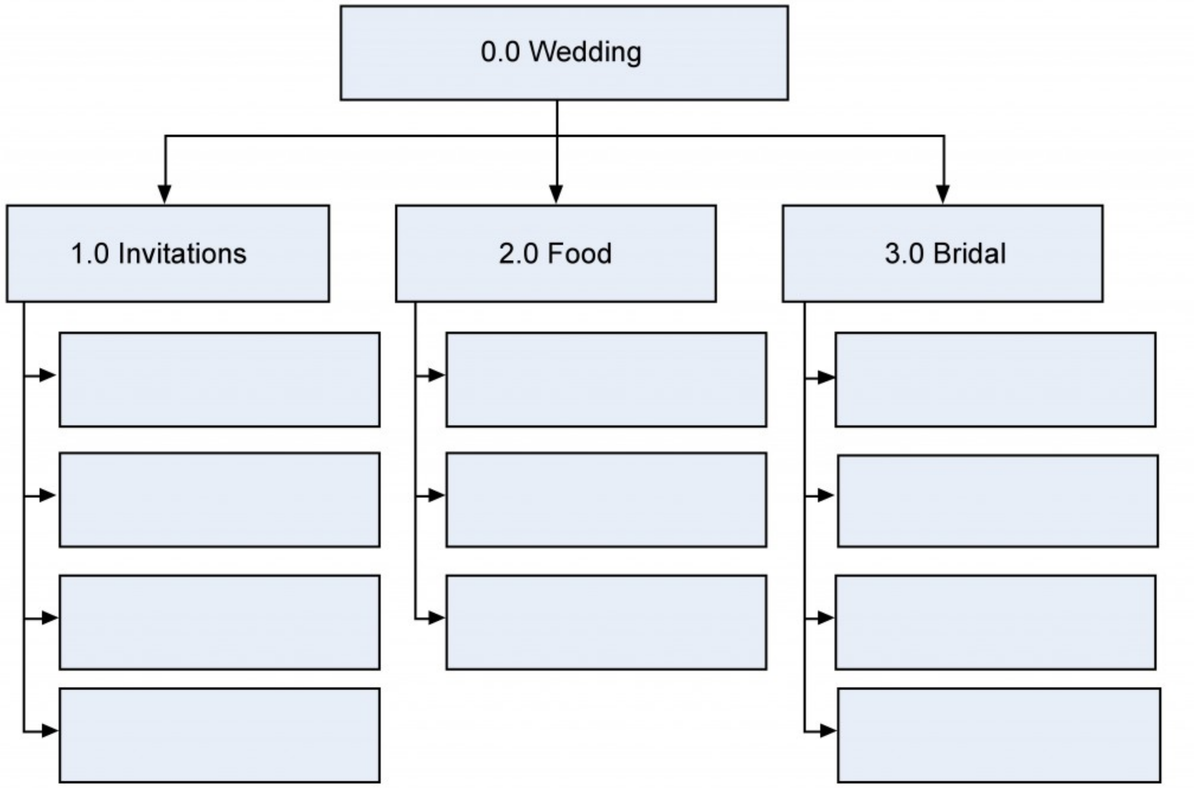

Figure 10.1

Work breakdown structure (WBS) based on the project phase.

Solution to Exercise:

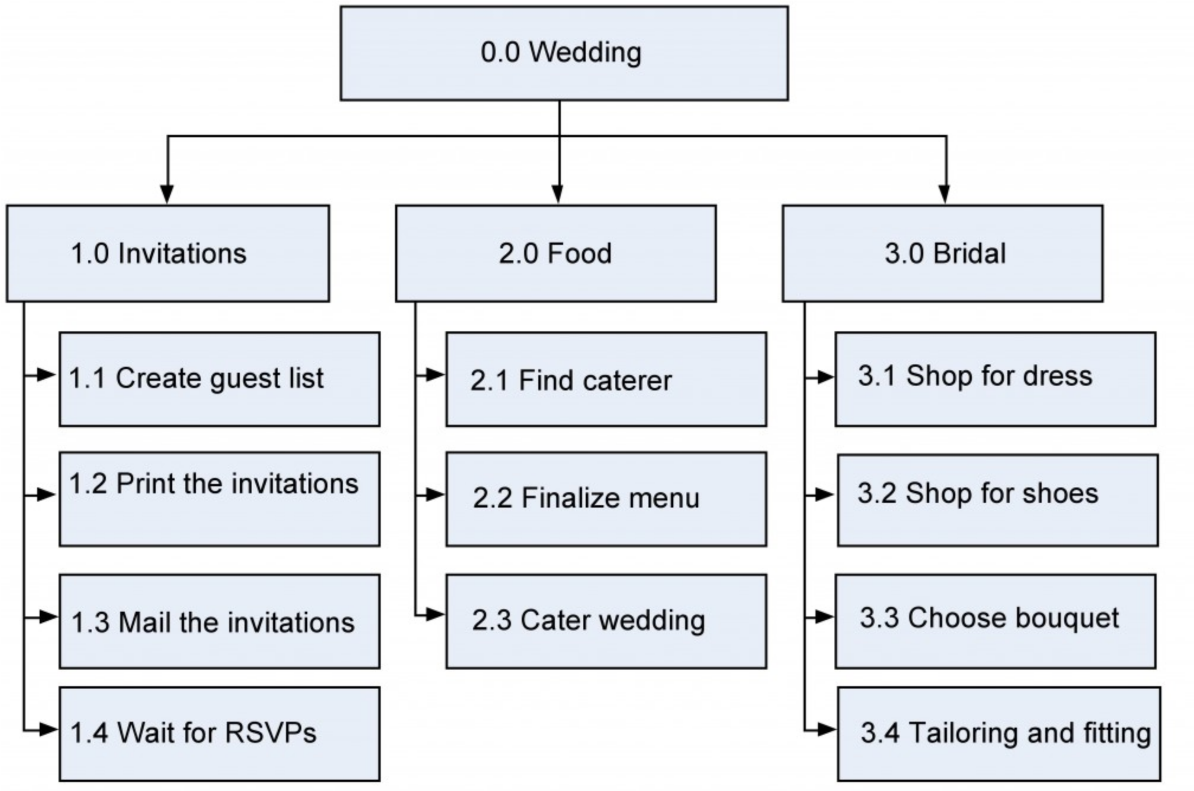

Figure 10.2

WSB Wedding Exercises Solution. [Image description]

Activity List

Now that the activity definitions for the work packages have been completed, the next task is to complete the activity list. The project activity list is a list of everything that needs to be done to complete your project, including all the activities that must be accomplished to deliver each work package. Next you want to define the activity attributes. Here's where the description of each activity is kept. It includes all the information you need to figure out plus the order of the work. Any predecessor activities, successor activities, or constraints should be listed in the attributes along with descriptions and any other information about resources or time that you need for planning. The three main kinds of predecessors are finish-to-start (FS), start-to-start (SS), and finish-to-finish (FF). The most common kind of predecessor is the finish-to-start. It means that one task needs to be completed before another one can start. When you think of predecessors, this is what you usually think of; one thing needs to end before the next can begin. It's called finish-to-start because the first activity's finish leads into the second activity's start (Figure 10.3).

Figure 10.3: An example of a finish-to-start (FS) predecessor.

The start-to-start predecessor is a little less common, but sometimes you need to coordinate activities so they begin at the same time (Figure 10.4).

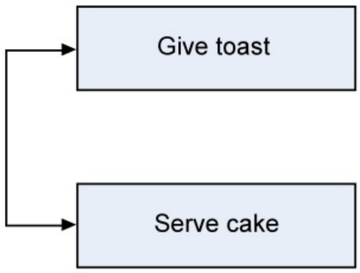

Figure 10.4: An example of a start-to-start (SS) predecessor.

The finish-to-finish predecessor shows activities that finish at the same time (Figure 10.5).

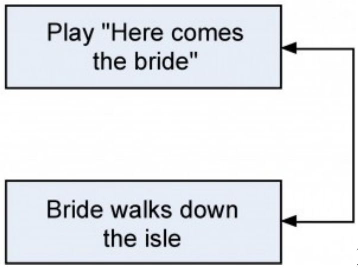

Figure 10.5: An example of a finish-to-finish (FF) predecessor.

It is possible to have start-to-finish (SF) predecessors. This happens when activities require that another task be started before the successor task can finish. An example might be that the musicians cannot finish playing until the guests have started leaving the ceremony. In addition, there are some particular types of predecessors that must be considered.

External Predecessors

Sometimes your project will depend on things outside the work you're doing. For the wedding, we are depending on the wedding party before us to be out of the reception hall in time for us to decorate. The decoration of the reception hall then depends on that as an external predecessor.

Discretionary Predecessors

These are usually process- or procedure-driven or best-practice techniques based on past experience. In the wedding example, Steve and Susan want the bridesmaids to arrive at the reception before the couple arrives. There's no necessity; it is just a matter of preference.

Mandatory Predecessors

You can't address an invitation that hasn't been printed yet. So printing invitations is a mandatory predecessor for addressing them. Mandatory predecessors are the kinds that have to exist just because of the nature of the work.

Leads and Lags

Sometimes you need to give some extra time between activities. Lag time is when you purposefully put a delay between the predecessor task and the successor. For example, when the bride and her father dance, the others wait awhile before they join them (Figure 10.6).

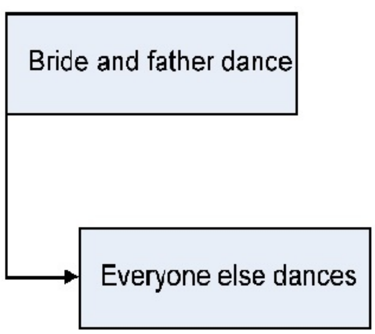

Figure 10.6 A lag means making sure that one task waits a while before it gets started.

Lead time is when you give a successor task some time to get started before the predecessor finishes (Figure 10.7). So you might want the caterer preparing dessert an hour before everybody is eating dinner.

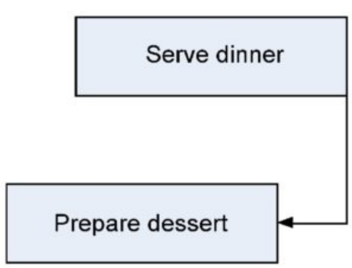

Figure 10.7: A lead is when you let a task get started before its predecessor is done.

Milestones

All of the important checkpoints of your project are tracked as milestones. Some of them could be listed in your contract as requirements of successful completion; some could just be significant points in the project that you want to keep track of. The milestone list needs to let everyone know which milestones are required and which are not.

Some milestones for Susan and Steve's wedding might be:

- Invitations sent
- Menu finalized
- Location booked
- Bridesmaids' dresses fitted

As you figure out which activities will need to be done, you may realize that the scope needs to change. When that happens, you need to create a change request and send it through the change control system.

Some things that could go wrong:

Wedding Planner: We just got the programs back from the printer and they're all wrong.
Steve: The quartet cancelled. They had another wedding that day.
Susan: Aunt Jane is supposed to sing at the service, but after what happened at her uncle's funeral, I think I want someone else to do it.
Steve: Should we really have a pan flute player? I'm beginning to think it might be overkill.
Susan: Apparently! Maybe we should hold off on printing the invitations until these things are worked out.
Wedding Planner: OK, let's think about exactly how we want to do this. I think we need to be sure about how we want the service to go before we do any more printing.

The Activity Sequencing Process

Now that we know what we have to do to make the wedding a success, we need to focus on the order of the work. Sally sat down with all of the activities she had defined for the wedding and decided to figure out exactly how they needed to happen. That's where she used the activity sequencing process.

The activity attribute list Sally created had most of the predecessors and successors necessary written in it. This is where she thought of what comes first, second, third, etc. Sally's milestone list had major pieces of work written down, and there were a couple of changes to the scope she had discovered along the way that were approved and ready to go.

Example milestone list: Steve and Susan had asked that the invitations be printed at least three months in advance to be sure that everyone had time to RSVP. That's a milestone on Sally's list.
Example change request: When Sally realized that Steve and Susan were going to need another limo to take the bridesmaids to the reception hall, she put that change through change control, including running everything by Susan's mother, and it was approved.

Creating the Gantt Chart

A Gantt chart is a type of bar chart, developed by Henry Gantt, that illustrates a project schedule. Gantt charts are easy to read and are commonly used to display schedule activities. These charts display the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project. Some Gantt charts also show the dependency relationships (i.e., precedence network) between activities.

Gantt charts show all the key stages of a project and their duration as a bar chart, with the time scale across the top. The key stages are placed on the bar chart in sequence, starting in the top left corner and ending in the bottom right corner (Figure 10.8). A Gantt chart can be drawn quickly and easily and is often the first tool a project manager uses to provide a rough estimate of the time that it will take to complete the key tasks. Sometimes it is useful to start with the target deadline for completion of the whole project, because it is soon apparent if the time scale is too short or unnecessarily long. The detailed Gantt chart is usually constructed after the main objectives have been determined.

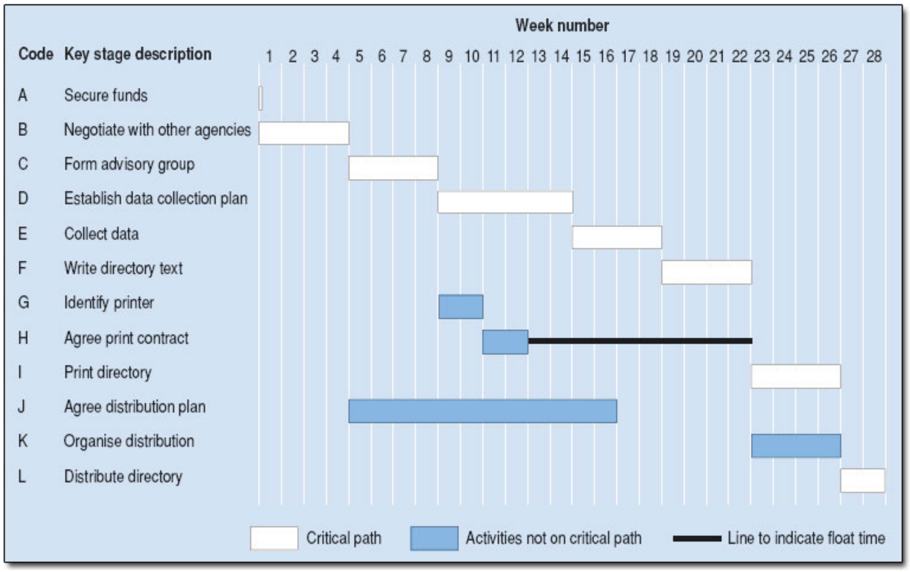

Figure 10.8 Gantt chart for directory production

In this example in Figure 10.8, key stage K (Organize distribution) starts at week 23 so that its end point coincides with key stage L (Distribute directory). However, K could begin as early as week 17, as soon as key stage J is completed. Key stage K is therefore said to have "slack." Key stage H (Agree print contract) has been placed to end at week 12. However, it could end as late as week 22, because key stage I (Print directory) does not begin until week 23. Key stage H is therefore said to have "float." Float time can be indicated on the chart by adding a line ahead of the bar to the latest possible end point. Slack and float show you where there is flexibility in the schedule, and this can be useful when you need to gain time once the project is up and running.

You can add other information to a Gantt chart, for example:

- Milestones could be indicated by using a symbol such as a diamond or triangle.
- Project meetings could be indicated by another symbol such as a circle.
- Reviews of progress could be indicated by a square.

For a complex project, you may decide to produce a separate Gantt chart for each of the key stages. If you do this shortly before each key stage begins, you will be able to take any last-minute eventualities into account. These charts provide a useful tool for monitoring and control as the project progresses.

Gantt charts are relatively easy to draw by hand, but this doesn't offer the same level of flexibility during monitoring that you would get from a software package. Various programs are available to assist project managers in scheduling and control. Once the data have been entered, a program helps you to work on "what if" scenarios, showing what might happen if a key stage is delayed or speeded up. This is more difficult if you are working manually.

Creating the Network Diagram

Many project managers use network diagrams when scheduling a project. The network diagram is a way to visualize the interrelationships of project activities. Network diagrams provide a graphical view of the tasks and how they relate to one another. The tasks in the network are the work packages of the WBS. All of the WBS tasks must be included in the network because they have to be accounted for in the schedule. Leaving even one task out of the network could change the overall schedule duration, estimated costs, and resource allocation commitments.

The first step is to arrange the tasks from your WBS into a sequence. Some tasks can be accomplished at any time throughout the project where other tasks depend on input from another task or are constrained by time or resources.

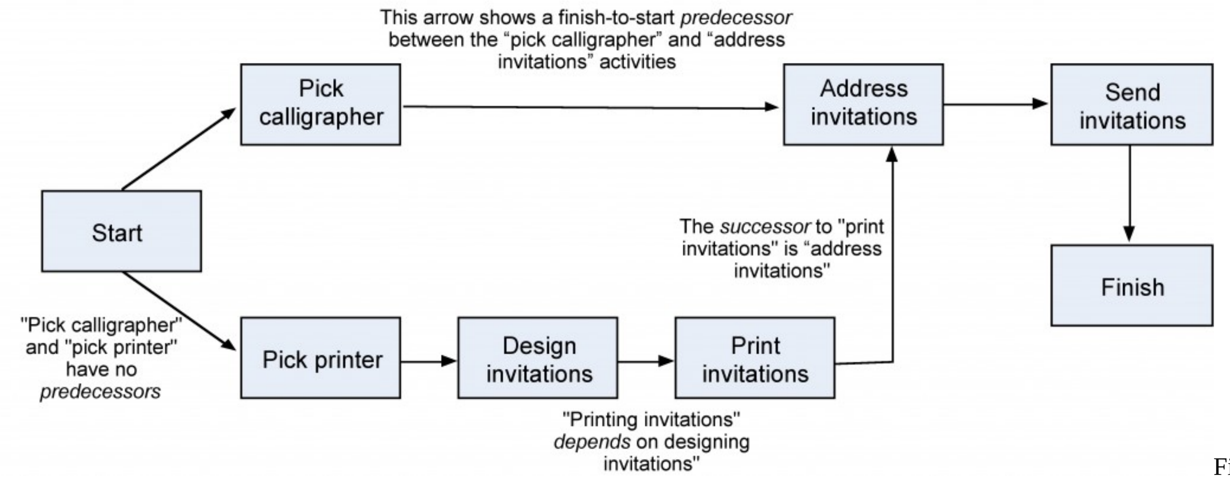

Figure 10.9: The relationship between the work breakdown structure (WBS) and the network diagram.

The WBS is *not* a schedule, but it is the basis for it. The network diagram *is* a schedule but is used primarily to identify key scheduling information that ultimately goes into user-friendly schedule formats, such as milestone and Gantt charts.

The network diagram provides important information to the project team. It provides information about how the tasks are related (Figure 10.9), where the risk points are in the schedule, how long it will take as currently planned to finish the project, and when each task needs to begin and end.

In our wedding planner example, Sally would look for relationships between tasks and determine what can be done in parallel and what activities need to wait for others to complete. As an example, Figure 10.10 shows how the activities involved in producing the invitations depend on one another. Showing the activities in rectangles and their relationships as arrows is called a precedence diagramming method (PDM). This kind of diagram is also called an activity-on-node (AON) diagram.

Another way to show how tasks relate is with the activity-on-arrow (AOA) diagram. Although AON is more commonly used and is supported by all project management programs, PERT is the best-known AOA-type diagram and is the historical basis of all network diagramming. The main difference is the AOA diagram is traditionally drawn using circles as the nodes, with nodes representing the beginning and ending points of the arrows or tasks. In the AOA network, the arrows represent the activities or tasks (Figure 10.11).

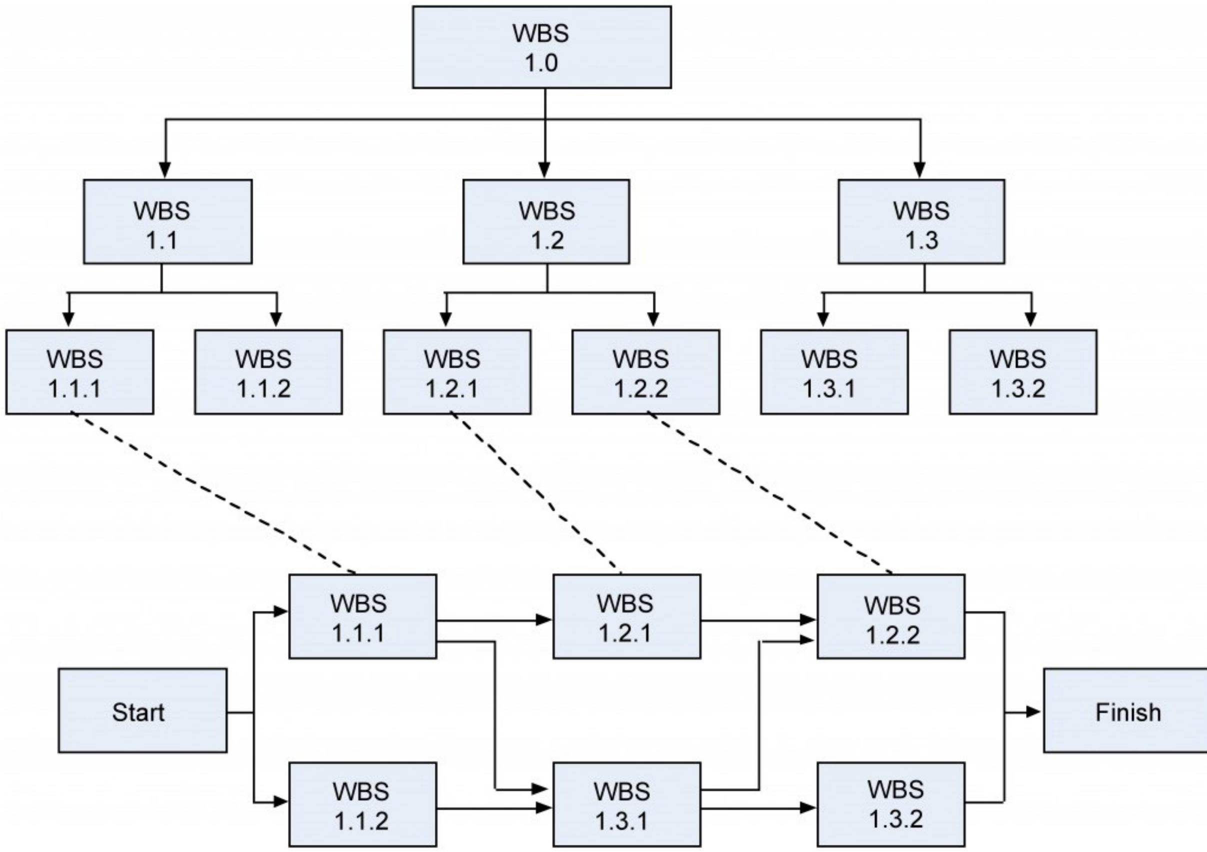

Figure 10.10: An example of an activity on node (AON) diagram.

All network diagrams have the advantages of showing task interdependencies, start and end times, and the critical path (the longest path through the network) but the AOA network diagram has some disadvantages that limit the use of the method.

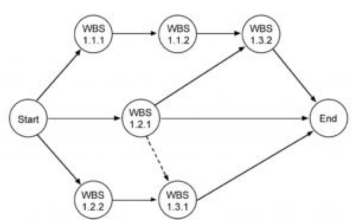

Figure 10.11: An example of an activity arrow (AOA) network diagram.

The three major disadvantages of the AOA method are:

- The AOA network can only show finish-to-start relationships. It is not possible to show lead and lag except by adding or subtracting time, which makes project tracking difficult.
- There are instances when dummy activities can occur in an AOA network. Dummy activities are activities that show the dependency of one task on other tasks but for other than technical reasons. For example, one task may depend on another because it would be more cost effective to use the same resources for the two; otherwise the two tasks could be accomplished in parallel. Dummy activities do not have durations associated with them. They simply show that a task has some kind of dependence on another task.
- AOA diagrams are not as widely used as AON diagrams simply because the latter are somewhat simpler to use, and all project management software programs can accommodate AON networks, whereas not all can accommodate AOA networks.

The Critical Path

The critical path describes the sequence of tasks that would enable the project to be completed in the shortest possible time. It is based on the idea that some tasks must be completed before others can begin. A critical path diagram is a useful tool for scheduling dependencies and controlling a project. In order to identify the critical path, the length of time that each task will take must be calculated.

Let's take a look at an example. The length of time in weeks for each key stage is estimated:

Table 10.1 Stages of the Critical Path

Key stage	Estimated time in weeks
A. Secure funds	0
B. Negotiate with other agencies	4
C. Form advisory group	4
D. Establish data collection plan	6
E. Collect data	4
F. Write directory text	4
G. Identify printer	2
H. Agree print contract	2
I. Print directory	4
J. Agree distribution plan	12
K. Organize distribution	4
L. Distribute directory	2

We have given the key stage "Secure funds" an estimated time of zero weeks because the project cannot start without the availability of some funding, although estimates would provide detail at a later stage. The stages can now be lined up to produce a network diagram that shows that there are three paths from start to finish and that the lines making up each path have a minimum duration (Figure 10.12).

If we now trace each of the possible paths to "Distribute directory" (the finishing point), taking dependencies into account, the route that has the longest duration is known as the critical path. This is the minimum time in which it will be possible to complete the project.

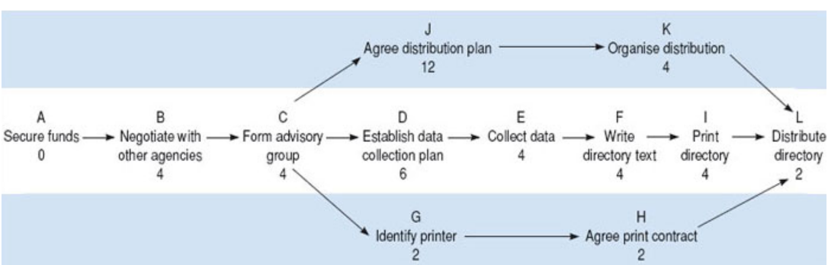

Figure 10.12: Critical Path Diagram

In this example, the critical path is A–B–C–D–E–F–I–L, and the earliest completion date for the project is the sum of the estimated times for all the stages on the critical path – 28 weeks – from the point of securing the funding. All the key stages on the critical path must be completed on time if the project is to be finished on schedule.

If the projected total time is much longer than the project sponsor's expectations, you will need to renegotiate the time scale. Mapping the critical path helps to identify the activities that need to be monitored most closely.

Image Descriptions

Figure 10.2 image description:

0.0 Wedding

- 1.0 Invitations
  - 1.1 Create guest list
  - 1.2 Wait for RSVPs
  - 1.3 Mail the invitations
  - 1.4 Print the invitations
- 2.0 Food
  - 2.1 Find caterer
  - 2.2 Cater the wedding
  - 2.3 Finalize the menu
- 3.0 Bridal
  - 3.1 Shop for shoes
  - 3.2 Tailoring and fitting
  - 3.3 Shop for dress
  - 3.4 Choose the bouquet

[Return to Figure 10.2]

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9.2.6: Resource Planning

In the previous wedding case study, it is clear that Steve and Susan have resource problems. Getting a handle on all of the tasks that have to be done is a great start, but it's not enough to know the tasks and the order they come in. Before you can put the final schedule together, you need to know who is going to do each job, and the things they need so they can do it.

"We've got so much to do! Invitations, catering, music… and I've got no idea who's going to do it all. I'm totally overwhelmed." From this statement it is clear that Susan is worried about human resources. In comparison, Steve realizes that not all resources are people: "And it's not just people. We need food, flowers, a cake, a sound system, and a venue. How do we get a handle on this?"

Resources are people, equipment, place, money, or anything else that you need in order to do all of the activities that you planned for. Every activity in your activity list needs to have resources assigned to it. Before you can assign resources to your project, you need to know their availability. Resource availability includes information about what resources you can use on your project, when they're available to you, and the conditions of their availability. Don't forget that some resources, like consultants or training rooms, have to be scheduled in advance, and they might only be available at certain times. You'll need to know this before you can finish planning your project. If you are starting to plan in January, a June wedding is harder to plan than one in December, because the wedding halls are all booked up in advance. That is clearly a resource constraint. You'll also need the activity list that you created earlier, and you'll need to know how your organization typically handles resources. Once you've got a handle on these things, you're set for resource estimation.

Estimating the Resources

The goal of activity resource estimating is to assign resources to each activity in the activity list. There are five tools and techniques for estimating activity resources.

Expert judgment means bringing in experts who have done this sort of work before and getting their opinions on what resources are needed.

Alternative analysis means considering several different options for how you assign resources. This includes varying the number of resources as well as the kind of resources you use. Many times, there's more than one way to accomplish an activity and alternative analysis helps decide among the possibilities.

Published estimatingdata is something that project managers in a lot of industries use to help them figure out how many resources they need. They rely on articles, books, journals, and periodicals that collect, analyze, and publish data from other people's projects.

Project management software such as Microsoft Project will often have features designed to help project managers estimate resource needs and constraints and find the best combination of assignments for the project.

Bottom-up estimating means breaking down complex activities into pieces and working out the resource assignments for each piece. It is a process of estimating individual activity resource need or cost and then adding these up together to come up with a total estimate. Bottom-up estimating is a very accurate means of estimating, provided the estimates at the schedule activity level are accurate. However, it takes a considerable amount of time to perform bottom-up estimating because every activity must be assessed and estimated accurately to be included in the bottom-up calculation. The smaller and more detailed the activity, the greater the accuracy and cost of this technique.

Estimating Activity Durations

Once you're done with activity resource estimating, you've got everything you need to figure out how long each activity will take. That's done in a process called activity duration estimating. This is where you look at each activity in the activity list, consider its scope and resources, and estimate how long it will take to perform.

Estimating the duration of an activity means starting with the information you have about that activity and the resources that are assigned to it, and then working with the project team to come up with an estimate. Most of the time you'll start with a rough estimate and then refine it to make it more accurate. You'll use these five tools and techniques to create the most accurate estimates:

Expert judgment will come from your project team members who are familiar with the work that has to be done. If you don't get their opinion, there's a huge risk that your estimates will be wrong.

Analogous estimating is when you look at similar activities from previous projects and how long they took. This only works if the activities and resources are similar.

Parametric estimating means plugging data about your project into a formula, spreadsheet, database, or computer program that comes up with an estimate. The software or formula that you use for parametric estimating is based on a database of actual durations from past projects.

Three-point estimating is when you come up with three numbers: a realistic estimate that's most likely to occur, an optimistic one that represents the best-case scenario, and a pessimistic one that represents the worst-case scenario. The final estimate is the weighted average of the three.

Reserve analysis means adding extra time to the schedule (called a *contingency reserve* or a *buffer*) to account for extra risk.

(Solutions follow.)

Exercises

In each of the following scenarios of planning Steve and Susan's wedding, determine which of the five activity resource estimation tools and techniques is being used.

1. Sally has to figure out what to do for the music at Steve and Susan's wedding. She considers using a DJ, a rock band, or a string quartet.
2. The latest issue of *Wedding Planner's Journal* has an article on working with caterers. It includes a table that shows how many waiters work with various guest-list sizes.
3. There's a national wedding consultant who specializes in Caribbean-themed weddings. Sally gets in touch with her to ask about menu options.
4. Sally downloads and fills out a specialized spreadsheet that a project manager developed to help with wedding planning.
5. There's so much work that has to be done to set up the reception hall that Sally has to break it down into five different activities in order to assign jobs.
6. Sally asks Steve and Susan to visit several different caterers and sample various potential items for the menu.
7. Sally calls up her friend who knows specifics of the various venues in their area for advice on which one would work best.
8. There are two different catering companies at the wedding. Sally asks the head chef at each of them to give her an estimate of how long it will take each of them to do the job.
9. There's a spreadsheet Sally always uses to figure out how long it takes guest to RSVP. She enters the number of guests and their zip codes, and it calculates estimates for her.
10. Sally's done four weddings that are very similar to Steve and Susan's, and in all four of them, it took exactly the same amount of time for the caterers to set up the reception hall.

Solutions

1. Alternative analysis
2. Published estimating data
3. Expert judgment
4. Project management software
5. Bottom-up estimating
6. Alternative analysis
7. Expert judgment
8. Expert judgment
9. Parametric estimating
10. Analogous estimating

The activity duration estimates are an estimate of how long each activity in the activity list will take. This is a quantitative measure usually expressed in hours, weeks, days, or months. Any work period is fine, and you'll use different work periods for different jobs. A small job (like booking a DJ) may take just a few hours; a bigger job (like catering, including deciding on a menu, ordering ingredients, cooking food, and serving guests on the big day) could take days.

Another thing to keep in mind when estimating the duration of activities is determining the effort involved. Duration is the amount of the time that an activity takes, while effort is the total number of person-hours that are expended. If it takes two people six hours to carve the ice sculpture for the centrepiece of a wedding, the duration is six hours. But if two people worked on it for the whole time, it took 12 person-hours of effort to create.

You'll also learn more about the specific activities while you're estimating them. That's something that always happens. You have to really think through all of the aspects of a task in order to estimate it. As you learn more about the specific activities remember to update the activity attributes.

If we go back to our case study of the wedding, we can see that while Sally has a handle on how long things are going to take, she still has some work to do before she has the whole project under control. Steve and Susan know where they want to get married, and they have the place booked now. But, what about the caterer? They have no idea who's going to be providing food. And what about the band they want? Will the timing with their schedule work out? "If the caterers come too early, the food will sit around under heat lamps. But if they come too late, the band won't have time to play. I just don't see how we'll ever work this out."

It's not easy to plan for a lot of resources when they have tight time restrictions and overlapping constraints. How do you figure out a schedule that makes everything fit together? You're never going to have the complete resource picture until you have finished building the schedule. And the same goes for your activity list and duration estimates! It's only when you lay out the schedule that you'll figure out that some of your activities and durations didn't quite work.

Project Schedule and Critical Path

The project schedule should be approved and signed off by stakeholders and functional managers. This ensures they have read the schedule, understand the dates and resource commitments, and will cooperate. You'll also need to obtain confirmation that resources will be available as outlined in the schedule. The schedule cannot be finalized until you receive approval and commitment for the resource assignments outlined in it. Once the schedule is approved, it will become your baseline for the remainder of the project. Project progress and task completion will be monitored and tracked against the project schedule to determine if the project is on course as planned.

The schedule can be displayed in a variety of ways, some of which are variations of what you have already seen. Project schedule network diagrams will work as schedule diagrams when you add the start and finish dates to each activity. These diagrams usually show the activity dependencies and critical path.

The critical path method is an important tool for keeping your projects on track. Every network diagram has something that is called the critical path. It's the string of activities that, if you add up all of the durations, is longer than any other path through the network. It usually starts with the first activity in the network and usually ends with the last one.

Steve: Aunt Jane is a vegetarian. That won't be a problem, right?

Susan: Well, let's see. What menu did we give the caterers?

Steve: We didn't give it to them yet because we won't have the final menu until everyone RSVPs and lets us know which entrée they want.

Susan: But they can't RSVP because we haven't sent out the invitations! What's holding that up?

Steve: We're still waiting to get them back from the printer. We can't send them out if we don't have them yet!

Susan: Oh no! I still have to tell the printer what to print on the invitations and what paper to use.

Steve: But you were waiting on that until we finished the guest list.

Susan: What a mess!

Steve thought Aunt Jane being a vegetarian was just a little problem. But it turns out to be a lot bigger than either Steve or Susan realized at first. How did a question about one guest's meal lead to such a huge mess?

The reason that the critical path is critical is that every single activity on the path must finish on time in order for the project to come in on time. A delay in any one of the critical path activities will cause the entire project to be delayed (Figure 11.1).

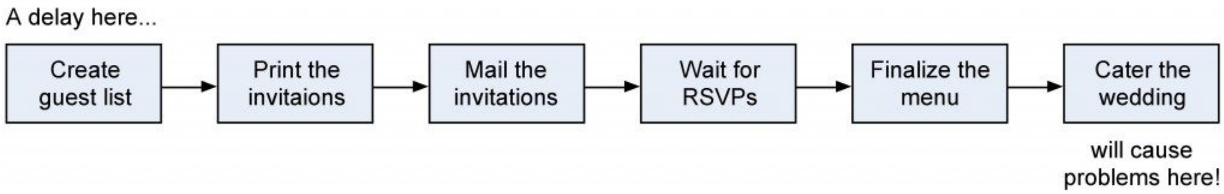


Figure 11.1: An example of problems that can be caused within the critical path.

Knowing where your critical path is can give you a lot of freedom. If you know an activity is not on the critical path, then you know a delay in that activity may not necessarily delay the project. This can really help you handle emergency situations. Even better, it means that if you need to bring your project in earlier than was originally planned, you know that adding resources to the critical path will be much more effective than adding them elsewhere.

It's easy to find the critical path in any project. Of course, on a large project with dozens or hundreds of tasks, you'll probably use software like Microsoft Project to find the critical path for you. But when it does, it's following the same exact steps that are followed here (Figure 11.12).

Step 1. Start with a network diagram.

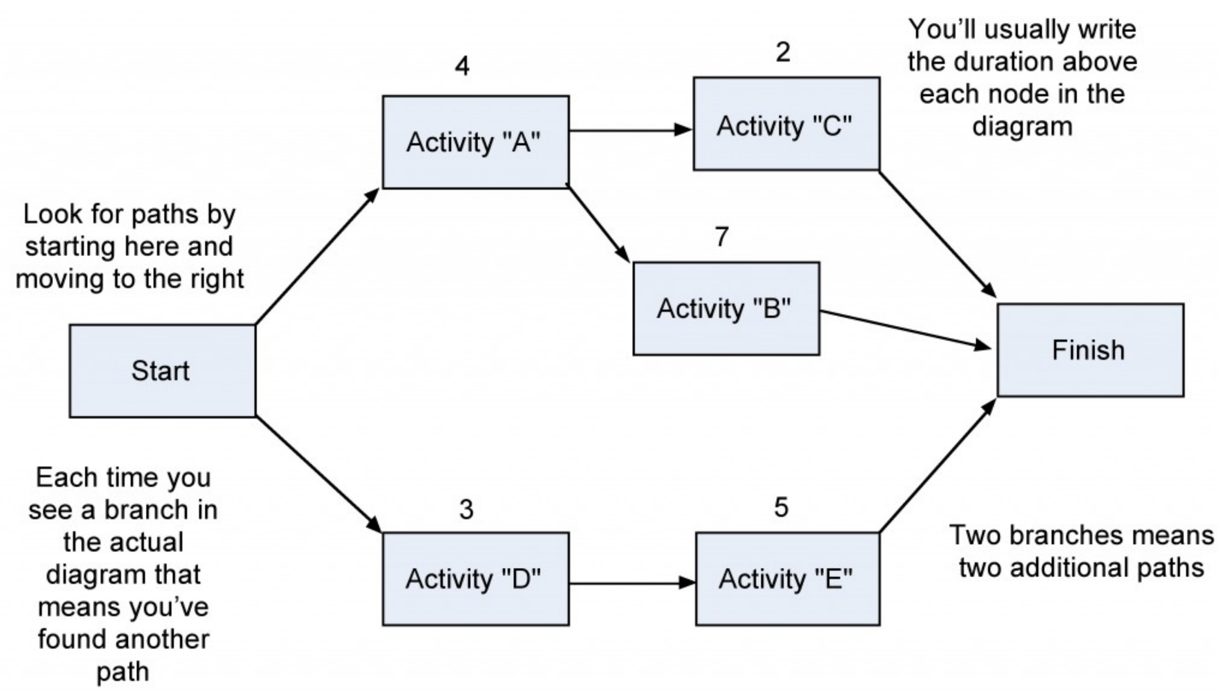


Figure 11.2 Step 1. Create a Network Diagram

Step 2. Find all the paths in the diagram. A path is any string of activities that goes from the start of the project to the end.[1]

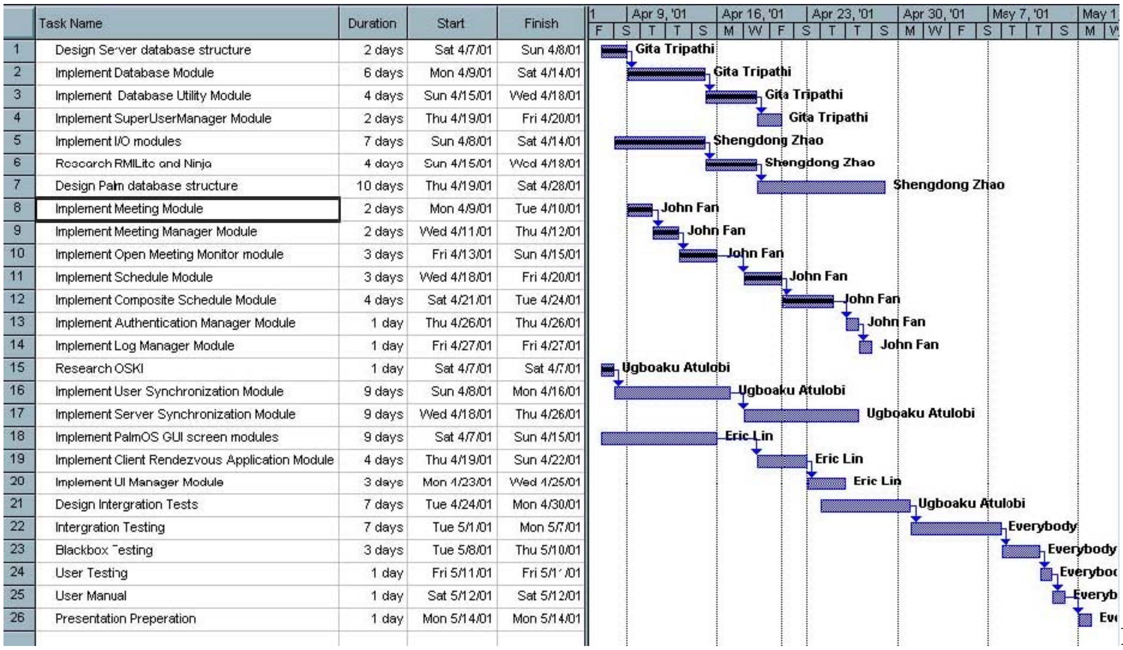
- Start > Activity "A" > Activity "B" > Finish
- Start > Activity "A" > Activity "C" > Finish
- Start > Activity "D" > Activity "E" > Finish

Step 3. Find the duration of each path by adding up the durations of each of the activities on the path.

- Start > Activity "A" > Activity "B" > Finish = 4 + 7 = 11
- Start > Activity "A" > Activity "C" > Finish = 4 + 2 = 6
- Start > Activity "D" > Activity "E" > Finish = 3 + 5 = 8

Step 4. The first path has a duration of 11, which is longer than the other paths, so it's the critical path.

The schedule can also be displayed using a Gantt chart (Figure 11.3).



	Task Name	Duration	Start	Finish
1	Design Se'ver database structure	2 days	Sat 4/7/01	Sun 4/8/01
2	Implement Database Module	6 days	Mon 4/9/01	Sat 4/14/01
3	Implement Database Utility Module	4 days	Sun 4/15/01	Wed 4/18/01
4	Implement SuperUserManager Module	2 days	Thu 4/19/01	Fri 4/20/01
5	Implement I/O modules	7 days	Sun 4/8/01	Sat 4/14/01
6	Research RMILite and Ninja	4 days	Sun 4/15/01	Wed 4/18/01
7	Design Palm database structure	10 days	Thu 4/19/01	Sat 4/28/01
8	Implement Meeting Module	2 days	Mon 4/9/01	Tue 4/10/01
9	Implement Meeting Manager Module	2 days	Wed 4/11/01	Thu 4/12/01
10	Implement Open Meeting Monitor module	3 days	Fri 4/13/01	Sun 4/15/01
11	Implement Schedule Module	3 days	Wed 4/18/01	Fri 4/20/01
12	Implement Composite Schedule Module	4 days	Sat 4/21/01	Tue 4/24/01
13	Implement Authentication Manager Module	1 day	Thu 4/26/01	Thu 4/26/01
14	Implement Log Manager Module	1 day	Fri 4/27/01	Fri 4/27/01
15	Research OSKI	1 day	Sat 4/7/01	Sat 4/7/01
16	Implement User Synchronization Module	9 days	Sun 4/8/01	Mon 4/16/01
17	Implement Server Synchronization Module	9 days	Wed 4/18/01	Thu 4/26/01
18	Implement PalmOS GUI screen modules	9 days	Sat 4/7/01	Sun 4/15/01
19	Implement Client Rendezvous Application Module	4 days	Thu 4/19/01	Sun 4/22/01
20	Implement UI Manager Module	3 days	Mon 4/23/01	Wed 4/25/01
21	Design Intergration Tests	7 days	Tue 4/24/01	Mon 4/30/01
22	Intergration Testing	7 days	Tue 5/1/01	Mon 5/7/01
23	Blackbox Testing	3 days	Tue 5/8/01	Thu 5/10/01
24	User Testing	1 day	Fri 5/11/01	Fri 5/11/01
25	User Manual	1 day	Sat 5/12/01	Sat 5/12/01
26	Presentation Preperation	1 day	Mon 5/14/01	Mon 5/14/01

Figure 11.3: An example of a Gantt chart.

Resource Management

Resource management is the efficient and effective deployment of an organization's resources when they are needed. Such resources may include financial resources, inventory, human skills, production resources, or information technology (IT). In the realm of project management, processes, techniques, and philosophies for the best approach for allocating resources have been developed. These include discussions on functional versus cross-functional resource allocation as well as processes espoused by organizations like the Project Management Institute (PMI) through the methodology of project management outlined in their publication *A Guide to the Project Management Body of Knowledge (PMBOK)*. Resource management is a key element to activity resource estimating and project human resource management. As is the case with the larger discipline of project management, there are resource management software tools available that automate and assist the process of resource allocation to projects.

HR Planning

The most important resource to a project is its people—the project team. Projects require specific expertise at specific moments in the schedule, depending on the milestones being delivered or the given phase of the project. An organization can host several strategic projects concurrently over the course of a budget year, which means that its employees can be working on more than one project at a time. Alternatively, an employee may be seconded away from his or her role within an organization to become part of a project team because of a particular expertise. Moreover, projects often require talent and resources that can only be acquired via contract work and third party vendors. Procuring and coordinating these human resources, in tandem with managing the time aspect of the project, is critical to overall success.

Managing the Team

In order to successfully meet the needs of a project, it is important to have a high-performing project team made up of individuals who are both technically skilled and motivated to contribute to the project's outcome. One of the many responsibilities of a project manager is to enhance the ability of each project team member to contribute to the project, while also fostering individual growth and accomplishment. At the same time, each individual must be encouraged to share ideas and work with others toward a common goal.

Through performance evaluation, the manager will get the information needed to ensure that the team has adequate knowledge, to establish a positive team environment and a healthy communication climate, to work properly, and to ensure accountability.

Managing the project team includes appraisal of employee performance and project performance. The performance reports provide the basis for managerial decisions on how to manage the project team.

Employee performance includes the employee's work results such as:

- Quality and quantity of outputs
- Work behaviour (such as punctuality)
- Job-related attributes (such as cooperation and initiative)

After conducting employee performance reviews, project managers should:

- Provide feedback to employees about how well they have performed on established goals
- Provide feedback to employees about areas in which they are weak or could do better
- Take corrective action to address problems with employees performing at or below minimum expectations
- Reward superior performers to encourage their continued excellence

Techniques for Managing Resources

One resource management technique is resource leveling. It aims at smoothing the stock of resources on hand, reducing both excess inventories and shortages.

The required data are the demands for various resources, forecast by time period into the future as far as is reasonable; the resources' configurations required in those demands; and the supply of the resources, again forecast by time period into the future as far as is reasonable.

The goal is to achieve 100% utilization. However that is very unlikely, when weighted by important metrics and subject to constraints; for example: meeting a minimum quality level, but otherwise minimizing cost.

Resource Leveling

Resource leveling is used to examine unbalanced use of resources (usually people or equipment) over time and for resolving over-allocations or conflicts.

When performing project planning activities, the manager will attempt to schedule certain tasks simultaneously. When more resources such as machines or people are needed than are available, or perhaps a specific person is needed in both tasks, the tasks will have to be rescheduled sequentially to manage the constraint. Resource leveling during project planning is the process of resolving these conflicts. It can also be used to balance the workload of primary resources over the course of the project, usually at the expense of one of the traditional triple constraints (time, cost, scope).

When using specially designed project software, leveling typically means resolving conflicts or over-allocations in the project plan by allowing the software to calculate delays and update tasks automatically. Project management software leveling requires delaying tasks until resources are available. In more complex environments, resources could be allocated across multiple, concurrent projects thus requiring the process of resource leveling to be performed at company level.

In either definition, leveling could result in a later project finish date if the tasks affected are in the critical path.

Working with Individuals

Working with other people involves dealing with them both logically and emotionally. A successful working relationship between individuals begins with appreciating the importance of emotions and how they relate to personality types, leadership styles, negotiations, and setting goals.

Emotional Intelligence

Emotions are both a mental and physiological response to environmental and internal stimuli. Leaders need to understand and value their emotions to appropriately respond to the client, project team, and project environment.

Emotional intelligence includes the following:

- Self-awareness
- Self-regulation

- Empathy
- Relationship management

Emotions are important to generating energy around a concept, building commitment to goals, and developing high-performing teams. Emotional intelligence is an important part of the project manager's ability to build trust among the team members and with the client. It is an important factor in establishing credibility and an open dialogue with project stakeholders. Emotional intelligence is critical for project managers, and the more complex the project profile, the more important the project manager's emotional intelligence becomes to project success.

Personality Types

Personality types refer to the differences among people in such matters as what motivates them, how they process information, how they handle conflict, etc. Understanding people's personality types is acknowledged as an asset in interacting and communicating with them more effectively. Understanding your personality type as a project manager will assist you in evaluating your tendencies and strengths in different situations. Understanding others' personality types can also help you coordinate the skills of your individual team members and address the various needs of your client.

The Myers-Briggs Type Indicator (MBTI) is one of most widely used tools for exploring personal preference, with more than two million people taking the MBTI each year. The MBTI is often referred to as simply the Myers-Briggs. It is a tool that can be used in project management training to develop awareness of preferences for processing information and relationships with other people.

Based on the theories of psychologist Carl Jung, the Myers-Briggs uses a questionnaire to gather information on the ways individuals prefer to use their perception and judgment. Perception represents the way people become aware of people and their environment. Judgment represents the evaluation of what is perceived. People perceive things differently and reach different conclusions based on the same environmental input. Understanding and accounting for these differences is critical to successful project leadership.

The Myers-Briggs identifies 16 personality types based on four preferences derived from the questionnaire. The preferences are between pairs of opposite characteristics and include the following:

- Extroversion (E)-Introversion (I)
- Sensing (S)-Intuition (N)
- Thinking (T)-Feeling (F)
- Judging (J)-Perceiving (P)

Sixteen Myers-Briggs types can be derived from the four dichotomies. Each of the 16 types describes a preference: for focusing on the inner or outer world (E-I), for approaching and internalizing information (S-I), for making decisions (T-F), and for planning (J-P). For example, an ISTJ is a Myers-Briggs type who prefers to focus on the inner world and basic information, prefers logic, and likes to decide quickly.

It is important to note that there is no best type and that effective interpretation of the Myers-Briggs requires training. The purpose of the Myers-Briggs is to understand and appreciate the differences among people. This understanding can be helpful in building the project team, developing common goals, and communicating with project stakeholders. For example, different people process information differently. Extroverts prefer face-to-face meetings as the primary means of communicating, while introverts prefer written communication. Sensing types focus on facts, and intuitive types want the big picture.

On larger, more complex projects, some project managers will use the Myers-Briggs as a team-building tool during project start-up. This is typically a facilitated work session where team members take the Myers-Briggs and share with the team how they process information, what communication approaches they prefer, and what decision-making preferences they have. This allows the team to identify potential areas of conflict, develop communication strategies, and build an appreciation for the diversity of the team.

Another theory of personality typing is the DISC method, which rates people's personalities by testing a person's preferences in word associations in the following four areas:

- **Dominance/Drive**—relates to control, power, and assertiveness
- **Inducement/Influence**—relates to social situations and communication
- **Submission/Steadiness**—relates to patience, persistence, and thoughtfulness

- **Compliance/Conscientiousness—**relates to structure and organization

Understanding the differences among people is a critical leadership skill. This includes understanding how people process information, how different experiences influence the way people perceive the environment, and how people develop filters that allow certain information to be incorporated while other information is excluded. The more complex the project, the more important the understanding of how people process information, make decisions, and deal with conflict. There are many personality-type tests that have been developed and explore different aspects of people's personalities. It might be prudent to explore the different tests available and utilize those that are most beneficial for your team.

Leadership Styles

Leadership style is a function of both the personal characteristics of the leader and the environment in which the leadership must occur, and a topic that several researchers have attempted to understand. Robert Tannenbaum and Warren Schmidt described leaders as either autocratic or democratic (1958). Harold Leavitt described leaders as pathfinders (visionaries), problem solvers (analytical), or implementers (team oriented) (1986). James MacGregor Burns conceived leaders as either transactional (focused on actions and decisions) or transformational (focused on the long-term needs of the group and organization) (1978).

Fred Fiedler introduced his contingency theory, which is the ability of leaders to adapt their leadership approach to the environment (1971). Most leaders have a dominant leadership style that is most comfortable for them. For example, most engineers spend years training in analytical problem solving and often develop an analytical approach to leadership.

A leadership style reflects personal characteristics and life experiences. Although a project manager's leadership style may be predominantly a pathfinder (using Leavitt's taxonomy), most project managers become problem solvers or implementers when they perceive the need for these leadership approaches. The leadership approach incorporates the dominant leadership style and Fiedler's contingency focus on adapting to the project environment.

No particular leadership approach is specifically appropriate for managing a project. Due to the unique circumstances inherent in each project, the leadership approach and the management skills required to be successful vary depending on the complexity profile of the project. However, the Project Management Institute published Shi and Chen's research that studied project management leadership traits and concluded that good communication skills and the ability to build harmonious relationships and motivate others are essential (2006). Beyond this broad set of leadership skills, the successful leadership approach will depend on the profile of the project. For example, a transactional project manager with a strong command-and-control leadership approach may be very successful on a small software development project or a construction project, where tasks are clear, roles are well understood, and the project environment is cohesive. This same project manager is less likely to be successful on a larger, more complex project with a diverse project team and complicated work processes.

Matching the appropriate leadership style and approach to the complexity profile of the project is a critical element of project success. Even experienced project managers are less likely to be successful if their leadership approach does not match the complexity profile of the project.

Each project phase may also require a different leadership approach. During the start-up phase of a project, when new team members are first assigned to the project, the project may require a command-and-control leadership approach. Later, as the project moves into the conceptual phase, creativity becomes important, and the project management takes on a more transformational leadership approach. Most experienced project managers are able to adjust their leadership approach to the needs of the project phase. Occasionally, on very large and complex projects, some companies will bring in different project managers for various phases of a project. Changing project managers may bring the right level of experience and the appropriate leadership approach, but is also disruptive to a project. Senior management must balance the benefit of matching the right leadership approach with the cost of disrupting established relationships.

> Example: Multinational Textbook Publishing Project

On a project to publish a new textbook at a major publisher, a project manager led a team that included members from partners that were included in a joint venture. The editorial manager was Greek, the business manager was German, and other members of the team were from various locations in the United States and Europe. In addition to the traditional potential for conflict that arises from team members from different cultures, the editorial manager and business manager were responsible for protecting the interest of their company in the joint venture.

The project manager held two alignment or team-building meetings. The first was a two-day meeting held at a local resort and included only the members of the project leadership team. An outside facilitator was hired to facilitate discussion, and the topic of cultural conflict and organizational goal conflict quickly emerged. The team discussed several methods for developing understanding and addressing conflicts that would increase the likelihood of finding mutual agreement.

The second team-building session was a one-day meeting that included the executive sponsors from the various partners in the joint venture. With the project team aligned, the project manager was able to develop support for the publication project's strategy and commitment from the executives of the joint venture. In addition to building processes that would enable the team to address difficult cultural differences, the project manager focused on building trust with each of the team members. The project manager knew that building trust with the team was as critical to the success of the project as the technical project management skills and devoted significant management time to building and maintaining this trust.

Leadership Skills

The project manager must be perceived to be credible by the project team and key stakeholders. A successful project manager can solve problems and has a high degree of tolerance for ambiguity. On projects, the environment changes frequently, and the project manager must apply the appropriate leadership approach for each situation.

The successful project manager must have good communication skills. All project problems are connected to skills needed by the project manager:

- Breakdown in communication represents the lack of communication skills
- Uncommitted team members represents the lack of team-building skills
- Role confusion represents the lack of organizational skill

Project managers need a large numbers of skills. These skills include administrative skills, organizational skills, and technical skills associated with the technology of the project. The types of skills and the depth of the skills needed are closely connected to the complexity profile of the project. Typically on smaller, less complex projects, project managers need a greater degree of technical skill. On larger, more complex projects, project managers need more organizational skills to deal with the complexity. On smaller projects, the project manager is intimately involved in developing the project schedule, cost estimates, and quality standards. On larger projects, functional managers are typically responsible for managing these aspects of the project, and the project manager provides the organizational framework for the work to be successful.

Listening

One of the most important communication skills of the project manager is the ability to actively listen. Active listening is placing oneself in the speaker's position as much as possible, understanding the communication from the point of view of the speaker, listening to the body language and other environmental cues, and striving not just to hear, but to understand. Active listening takes focus and practice to become effective. It enables a project manager to go beyond the basic information that is being shared and to develop a more complete understanding of the information.

> Example: Client's Body Language

A client just returned from a trip to Australia where he reviewed the progress of the project with his company's board of directors. The project manager listened and took notes on the five concerns expressed by the board of directors to the client.

The project manager observed that the client's body language showed more tension than usual. This was a cue to listen very carefully. The project manager nodded occasionally and clearly demonstrated he was listening through his posture, small agreeable sounds, and body language. The project manager then began to provide feedback on what was said using phrases like "What I hear you say is…" or "It sounds like.…" The project manager was clarifying the message that was communicated by the client.

The project manager then asked more probing questions and reflected on what was said. "It sounds as if it was a very tough board meeting." "Is there something going on beyond the events of the project?" From these observations and questions, the project manager discovered that the board of directors meeting did not go well. The company had experienced losses on other projects, and budget cuts meant fewer resources for the project and an expectation that the project would finish earlier than planned. The project manager also discovered that the client's future with the company would depend on the success of the project. The project manager asked, "Do you think we will need to do things differently?" They began to develop a plan to address the board of directors' concerns.

Through active listening, the project manager was able to develop an understanding of the issues that emerged from the board meeting and participate in developing solutions. Active listening and the trusting environment established by the project manager enabled the client to safely share information he had not planned on sharing and to participate in creating a workable plan that resulted in a successful project.

In the example above, the project manager used the following techniques:

- Listening intently to the words of the client and observing the client's body language
- Nodding and expressing interest in the client without forming rebuttals
- Providing feedback and asking for clarity while repeating a summary of the information back to the client
- Expressing understanding and empathy for the client

Active listening was important in establishing a common understanding from which an effective project plan could be developed.

Negotiation

When multiple people are involved in an endeavor, differences in opinions and desired outcomes naturally occur. Negotiation is a process for developing a mutually acceptable outcome when the desired outcome for each party conflicts. A project manager will often negotiate with a client, team members, vendors, and other project stakeholders. Negotiation is an important skill in developing support for the project and preventing frustration among all parties involved, which could delay or cause project failure.

Negotiations involve four principles:

1. Separate people from the problem. Framing the discussions in terms of desired outcomes enables the negotiations to focus on finding new outcomes.
2. Focus on common interests. By avoiding the focus on differences, both parties are more open to finding solutions that are acceptable.
3. Generate options that advance shared interests. Once the common interests are understood, solutions that do not match with either party's interests can be discarded, and solutions that may serve both parties' interests can be more deeply explored.
4. Develop results based on standard criteria. The standard criterion is the success of the project. This implies that the parties develop a common definition of project success.

For the project manager to successfully negotiate issues on the project, he or she should first seek to understand the position of the other party. If negotiating with a client, what is the concern or desired outcome of the client? What are the business drivers and personal drivers that are important to the client? Without this understanding, it is difficult to find a solution that will satisfy the client. The project manager should also seek to understand what outcomes are desirable to the project. Typically, more than one outcome is acceptable. Without knowing what outcomes are acceptable, it is difficult to find a solution that will produce that outcome.

One of the most common issues in formal negotiations is finding a mutually acceptable price for a service or product. Understanding the market value for a product or service will provide a range for developing a negotiating strategy. The price paid on the last project or similar projects provides information on the market value. Seeking expert opinions from sources who would know the market is another source of information. Based on this information, the project manager can then develop an expected range within the current market from the lowest price to the highest price.

Additional factors will also affect the negotiated price. The project manager may be willing to pay a higher price to assure an expedited delivery or a lower price if delivery can be made at the convenience of the supplier or if payment is made before the product is delivered. Developing as many options as possible provides a broader range of choices and increases the possibility of developing a mutually beneficial outcome.

The goal of negotiations is not to achieve the lowest costs, although that is a major consideration, but to achieve the greatest value for the project. If the supplier believes that the negotiations process is fair and the price is fair, the project is more likely to receive higher value from the supplier. The relationship with the supplier can be greatly influenced by the negotiation process and a project manager who attempts to drive the price unreasonably low or below the market value will create an element of distrust in the relationship that may have negative consequences for the project. A positive negotiation experience may create a positive relationship that may be beneficial, especially if the project begins to fall behind schedule and the supplier is in a position to help keep the project on schedule.

Conflict Resolution

Conflict on a project is to be expected because of the level of stress, lack of information during early phases of the project, personal differences, role conflicts, and limited resources. Although good planning, communication, and team building can reduce the amount of conflict, conflict will still emerge. How the project manager deals with the conflict results in the conflict being destructive or an opportunity to build energy, creativity, and innovation.

David Whetton and Kim Cameron developed a response-to-conflict model that reflected the importance of the issue balanced against the importance of the relationship (2005). The model presented five responses to conflict:

- Avoiding
- Forcing
- Collaborating
- Compromising
- Accommodating

Each of these approaches can be effective and useful depending on the situation. Project managers will use each of these conflict resolution approaches depending on the project manager's personal approach and an assessment of the situation.

Most project managers have a default approach that has emerged over time and is comfortable. For example, some project managers find the use of the project manager's power the easiest and quickest way to resolve problems. "Do it because I said to" is the mantra for project managers who use forcing as the default approach to resolve conflict. Some project managers find accommodating with the client the most effective approach to dealing with client conflict.

The effectiveness of a conflict resolution approach will depend on the situation. The forcing approach often succeeds in a situation where a quick resolution is needed, and the investment in the decision by the parties involved is low.

Example: Resolving an Office Space Conflict

Two senior managers both want the office with the window. The project manager intercedes with little discussion and assigns the window office to the manager with the most seniority. The situation was a low-level conflict with no long-range consequences for the project and a solution all parties could accept.

Sometimes office size and location is culturally important, and this situation would take more investment to resolve.

Example: Conflict Over a Change Order

In another example, the client rejected a request for a change order because she thought the change should have been foreseen by the project team and incorporated into the original scope of work. The project controls manager believed the client was using her power to avoid an expensive change order and suggested the project team refuse to do the work without a change order from the client.

This is a more complex situation, with personal commitments to each side of the conflict and consequences for the project. The project manager needs a conflict resolution approach that increases the likelihood of a mutually acceptable solution for the project. One conflict resolution approach involves evaluating the situation, developing a common understanding of the problem, developing alternative solutions, and mutually selecting a solution. Evaluating the situation typically includes gathering data. In our example of a change order conflict, gathering data would include a review of the original scope of work and possibly of people's understandings, which might go beyond the written scope.The second step in developing a resolution to the conflict is to restate, paraphrase, and reframe the problem behind the conflict to develop a common understanding of the problem. In our example, the common understanding may explore the change management process and determine that the current change management process may not achieve the client's goal of minimizing project changes. This phase is often the most difficult and may take an investment of time and energy to develop a common understanding of the problem.

After the problem has been restated and agreed on, alternative approaches are developed. This is a creative process that often means developing a new approach or changing the project plan. The result is a resolution to the conflict that is mutually agreeable to all team members. If all team members believe every effort was made to find a solution that achieved the project charter and met as many of the team member's goals as possible, there will be a greater commitment to the agreed-on solution.

Delegation

Delegating responsibility and work to others is a critical project management skill. The responsibility for executing the project belongs to the project manager. Often other team members on the project will have a functional responsibility on the project and report to a functional manager in the parent organization. For example, the procurement leader for a major project may also report to the organization's vice-president for procurement. Although the procurement plan for the project must meet the organization's procurement policies, the procurement leader on the project will take day-to-day direction from the project manager. The amount of direction given to the procurement leader, or others on the project, is the decision of the project manager.

If the project manager delegates too little authority to others to make decisions and take action, the lack of a timely decision or lack of action will cause delays on the project. Delegating too much authority to others who do not have the knowledge, skills, or information will typically cause problems that result in delay or increased cost to the project. Finding the right balance of delegation is a critical project management skill.

When developing the project team, the project manager selects team members with the knowledge, skills, and abilities to accomplish the work required for the project to be successful. Typically, the more knowledge, skills, abilities, and experience a project team member brings to the project, the more that team member will be paid. To keep the project personnel costs lower, the project manager will develop a project team with the level of experience and the knowledge, skills, and abilities to accomplish the work.

On smaller, less complex projects, the project manager can provide daily guidance to project team members and be consulted on all major decisions. On larger, more complex projects, there are too many important decisions made every day for the project manager to be involved at the same level, and project team leaders are delegated decision-making authority. Larger projects, with a more complex profile will typically pay more because of the need for the knowledge and experience. On larger, more complex projects, the project manager will develop a more experienced and knowledgeable team that will enable the project manager to delegate more responsibility to these team members.

> Example Learning Project in Peru

An instructional design project in Peru was falling behind schedule, and a new manager was assigned to the design team, which was the one most behind schedule. He was an experienced project manager from the United States with a reputation for meeting aggressive schedules. However, he failed to see that as a culture, Peruvians do a great deal more socializing than teams in the U.S. The project manager's communication with the team was then limited because he did not go out and spend time with them, and his team did not develop trust or respect for him. Due to these cultural differences, the project fell further behind, and another personnel change had to be made at a significant cost of time, trust, and money.

The project manager must have the skills to evaluate the knowledge, skills, and abilities of project team members and evaluate the complexity and difficulty of the project assignment. Often project managers want project team members they have worked with in the past. Because the project manager knows the skill level of the team member, project assignments can be made quickly with less supervision than with a new team member with whom the project manager has little or no experience.

Delegation is the art of creating a project organizational structure with the work organized into units that can be managed. Delegation is the process of understanding the knowledge, skills, and abilities needed to manage that work and then matching the team members with the right skills to do that work. Good project managers are good delegators.

Adjusting Leadership Styles

Remember that personality traits reflect an individual's preferences, not their limitations. It is important to understand that individuals can still function in situations for which they are not best suited. It is also important to realize that you can change your leadership style according to the needs of your team and the particular project's attributes and scope.

For example, a project leader who is more thinking (T) than feeling (F) (according to the Myers-Briggs model) would need to work harder to be considerate of how team members who are more feeling (F) might react if they were singled out in a meeting because they were behind schedule. If individuals knows their own preferences and which personality types are most successful in each type of project or project phase, they can set goals for improvement in their ability to perform in those areas that are not their natural preference.

Another individual goal is to examine which conflict resolution styles you are least comfortable and work to improve those styles so that they can be used when they are more appropriate than your default style.

Working with Groups and Teams

A team is a collaboration of people with different personalities that is led by a person with a favoured leadership style. Managing the interactions of these personalities and styles as a group is an important aspect of project management.

Trust

Trust is the foundation for all relationships within a project. Without a minimum level of trust, communication breaks down, and eventually the project suffers in the form of costs increasing and schedules slipping. Often, when reviewing a project where the performance problems have captured the attention of upper management, the evidence of problems is the increase in project costs and the slippage in the project schedule. The underlying cause is usually blamed on communication breakdown. With deeper investigation, the communication breakdown is associated with a breakdown in trust.

On projects, trust is the filter through which we screen information that is shared and the filter we use to screen information we receive. The more trust that exists, the easier it is for information to flow through the filters. As trust diminishes, the filters become stronger and information has a harder time getting through, and projects that are highly dependent on an information-rich environment will suffer from information deprivation.

Contracts and Trust Relationships

A project typically begins with a charter or contract. A contract is a legal agreement that includes penalties for any behaviour or results not achieved. Contracts are based on an adversarial paradigm and do not lend themselves to creating an environment of trust. Contracts and charters are necessary to clearly establish the scope of the project, among other things, but they are not conducive to establishing a trusting project culture.

A relationship of mutual trust is less formal but vitally important. When a person or team enters into a relationship of mutual trust, each person's reputation and self-respect are the drivers in meeting the intent of the relationship. A relationship of mutual trust within the context of a project is a commitment to an open and honest relationship. There is nothing that enforces the commitments in the relationship except the integrity of the people involved. Smaller, less complex projects can operate within the boundaries of a legal contract, but larger, more complex projects must develop a relationship of mutual trust to be successful.

Types of Trust

Svenn Lindskold describes four kinds of trust (1978):

- *Objective credibility.* A personal characteristic that reflects the truthfulness of an individual that can be checked against observable facts.
- *Attribution of benevolence*. A form of trust that is built on the examination of the person's motives and the conclusion that they are not hostile.
- *Non-manipulative trust*. A form of trust that correlates to a person's self-interest and the predictability of a person's behaviour in acting consistent in that self-interest.
- *High cost of lying*. The type of trust that emerges when persons in authority raise the cost of lying so high that people will not lie because the penalty will be too high.

Creating Trust

Building trust on a project begins with the project manager. On complex projects, the assignment of a project manager with a high trust reputation can help establish the trust level needed. The project manager can also establish the cost of lying in a way that communicates an expectation and a value for trust on the project. Project managers can also assure that the official goals (stated goals) and operational goals (goals that are reinforced) are aligned. The project manager can create an atmosphere where informal communication is expected and reinforced.

The informal communication is important to establishing personal trust among team members and with the client. Allotting time during project start-up meetings to allow team members to develop a personal relationship is important to establishing the team trust. The informal discussion allows for a deeper understanding of the whole person and creates an atmosphere where trust can emerge.

> Example: High Cost of Lying in a Charleston Project

On a project in Charleston, South Carolina, the client was asking for more and more backup to information from the project. The project manager visited the client to better understand the reporting requirements and discovered the client did not trust the reports coming from the project and wanted validating material for each report. After some candid discussion, the project manager discovered that one of the project team members had provided information to the client that was inaccurate. The team member had made a mistake but had not corrected it with the client, hoping that the information would get lost in the stream of information from the project. The project manager removed the team member from the project for two main reasons. The project manager established that the cost of lying was high. The removal communicated to the project team an expectation of honesty. The project manager also reinforced a covenant with the client that reinforced the trust in the information the project provided. The requests for additional information declined, and the trust relationship between project personnel and the client remained high.

Small events that reduce trust often take place on a project without anyone remembering what happened to create the environment of distrust. Taking fast and decisive action to establish a high cost of lying, communicating the expectation of honesty, and creating an atmosphere of trust are critical steps a project manager can take to ensure the success of complex projects.

Project managers can also establish expectations of team members to respect individual differences and skills, look and react to the positives, recognize each other’s accomplishments, and value people’s self-esteem to increase a sense of the benevolent intent.

Managing Team Meetings

Team meetings are conducted differently depending on the purpose of the meeting, the leadership style that is appropriate for the meeting, and the personality types of the members of the team.

Action Item Meetings

Action item meetings are short meetings to develop a common understanding of what the short-term priorities are for the project, individual roles, and expectations for specific activities. This type of meeting is for sharing, not problem solving. Any problems that emerge from the discussion are assigned to a person, and another meeting is established to address the issue. Action item meetings focus on short-term activities, usually less than a week in duration.

The action item meeting is fact based and information oriented. It is a left-brain-type focus. The action item meeting has very little dialogue except to ask clarification questions. If discussion is needed or disagreement is not easily resolved, another problem-solving meeting is established to deal with that issue. On smaller topics, that meeting might take place immediately after the action item meeting and only include those people with an interest in the outcome of the discussion.

The project manager keeps the successful action item meeting short in duration and focused on only those items of information needed for the short-term project plan. The project manager will restate the common understandings of what activities are priorities and who will be responsible for the activities. Often these meetings can include a review of safety procedures or security procedures when these issues are important to the project. The leadership approach to action item meetings focuses on data, actions, and commitments. Although the project manager may observe stresses between project team members or other issues, they are not addressed in this meeting. These are fact-based meetings. If issues begin to arise between people, the project manager will develop other opportunities to address these issues in another forum. Using the Myers-Briggs descriptions, team members who favour thinking more than feeling and judging more than perceiving are more comfortable with this type of meeting.

Management Meetings

Management meetings are longer in duration and are focused on planning. They are oriented toward developing plans, tracking progress of existing plans, and making adjustments to plans in response to new information.

These meetings include focused discussion on generating a common understanding of the progress of the existing plan. This discussion is based on quantitative information provided on the progress of the schedule and other data, but the discussion is qualitative in evaluating the data to develop a more complete understanding of the data. The experience and opinions of the project leaders are solicited, and disagreement about meaning of the data is even encouraged to develop a deeper understanding of the data. Through this discussion, a common understanding of the status of the project should emerge, and the project manager invites discussion, invites people to offer their thoughts, and assures that disagreements are positive discussions about interpretation of the information and that disagreements do not become personal.

Management meetings also focus on developing mid-term goals. For larger, more complex projects, the goals may be monthly or even quarterly. For smaller or less complex projects, weekly goals will provide the focus. The project manager focuses the discussion on the broad priorities for the next period and includes all the functional leaders in the discussion. The goals that emerge from the discussion should represent a common understanding of the priorities of the project for the next term.

For example, during the early phases of a project, the team is focused on developing a conceptual understanding of the project. A major milestone on complex projects is typically the completion of the conceptual plan. The project manager would lead a discussion on what needs to be accomplished to meet the project milestone and asks what potential barriers exist and what key resources are needed. From the discussion, the project team develops a few key goals that integrate the various functions of the project team and focus the team on priorities.

The following are some examples of goals during the conceptual phase:

- Developing a list of the procurement long-lead items and defining critical dates
- Developing a human resources plan that identifies critical positions
- Developing and building agreement with the client on the project scope of work

Each of these goals is measurable and has a time frame specified. They can be developed as positive motivators and will take the project leaders and most of the project team to accomplish. They develop a general understanding of the priorities and are easy to remember.

Management meetings are a combination of left-brain thinking, which is fact based, and right-brain thinking, which is creative and innovative. Using the Myers-Briggs terminology, team members who prefer feeling over thinking and perceiving over judging can contribute ideas and perspectives on the project that the more fact-oriented members might miss.

The project manager allows and encourages conversation in developing and evaluating the goals but focuses the discussion on the goals and obstacles. Management meetings take on a different focus during the month. Meetings at the beginning of the month spend time addressing the progress and potential barriers to the goals developed the previous month. During the middle of the month, the project manager leads the team to develop next month’s goals as the team also works on the current month’s goals. Toward the end of the month as the goals for the month are accomplished, the meeting focuses more on the next month, enabling the team to remain goal focused during the life of the project.

Management meetings are also an opportunity to discover obstacles to goal achievement. The project team reallocates resources or develops alternative methods for accomplishing the goals. As the project team discusses the progress of project goals, the project manager explores possible obstacles and encourages exposing potential problems in achieving goals. The project manager focuses the team on finding solutions and avoids searching for blame.

The project manager uses a facilitative leadership approach, encouraging the management team to contribute their ideas, and builds consensus on what goals will bring the appropriate focus. The project manager keeps the focus on developing the goals, tracking progress, identifying barriers, and making adjustments to accomplish the management goals. Although there are typically meetings for scheduling and procurement and other meetings where goals are established and problems solved, the management meeting and the goal development process create alignment among the project leadership on the items critical to the project's success.

Leadership Meetings

Leadership meetings are held less frequently and are longer in length. These meetings are used by the project manager to reflect on the project, explore the larger issues of the project, and back away from the day-to-day problem solving. The project manager will create a safe environment for sharing thoughts and evaluations of issues that are less data oriented. This is a right-brained, creative meeting that focuses on the people issues of the project: the relationship with the client, vendors, and project team. Team members who favour feeling, perceiving, and intuition often contribute valuable insights in this type of meeting. The team might also share perceptions by upper management and perceptions of the community in which the project is being executed. Where the time frame for action item meetings is in weeks and management meetings is in months, the time frame for leadership meetings is longer and takes in the entire length and impact of the project.

The project manager's meeting management skill includes creating the right meeting atmosphere for the team discussion that is needed. For discussions based on data and facts, the project manager creates the action item type meeting. The conversation is focused on sharing information and clarification. The conversation for leadership meetings is the opposite. Discussion is more open ended and focused on creativity and innovation. Because each type of meeting requires a different meeting atmosphere, mixing the purposes of a meeting will make it difficult for the project manager to develop and maintain the appropriate kind of conversation.

Skilled project managers know what type of meeting is needed and how to develop an atmosphere to support the meeting type. Meetings of the action item type are focused on information sharing with little discussion. They require efficient communication of plans, progress, and other information team members need to plan and execute daily work. Management type meetings are focused on developing and progressing goals. Leadership meetings are more reflective and focused on the project mission and culture.

These three types of meetings do not cover all the types of project meetings. Specific problem-solving, vendor evaluation, and scheduling meetings are examples of typical project meetings. Understanding what kinds of meetings are needed on the project and creating the right focus for each meeting type is a critical project management skill.

Types of Teams

Teams can outperform individual team members in several situations. The effort and time invested in developing a team and the work of the team are large investments of project resources, and the payback is critical to project success. Determining when a team is needed and then chartering and supporting the development and work of the team are other critical project management abilities.

Teams are effective in several project situations:

- When no one person has the knowledge, skills, and abilities to either understand or solve the problem
- When a commitment to the solution is needed by large portions of the project team
- When the problem and solution cross project functions
- When innovation is required

Individuals can outperform teams on some occasions. An individual tackling a problem consumes fewer resources than a team and can operate more efficiently—as long as the solution meets the project's needs. A person is most appropriate in the following situations:

- When speed is important
- When one person has the knowledge, skills, and resources to solve the problem
- When the activities involved in solving the problem are very detailed
- When the actual document needs to be written (Teams can provide input, but writing is a solitary task.)

In addition to knowing when a team is appropriate, the project manager must also understand what type of team will function best.

Functional Teams

A functional team refers to the team approach related to the project functions. The engineering team, the procurement team, and the project controls team are examples of functional teams within the project. On a project with a low complexity profile that includes low technological challenges, good team member experience, and a clear scope of work, the project manager can utilize well-defined functional teams with clear expectations, direction, and strong vertical communication.

Cross-Functional Teams

Cross-functional teams address issues and work processes that include two or more of the functional teams. The team members are selected to bring their functional expertise to addressing project opportunities.

> Example: Cross-Functional Teamwork

A cross-functional project team in Tennessee was assigned to develop a project approach to drafting, shooting, and editing educational videos without storing the videos on the school server. Although the complexity of this goal is primarily related to creating the videos and procuring editing equipment, the planning involved coordination of the script drafting, procurement of equipment and talent, and establishment of project controls. Team members from each of these functions developed and tracked a plan to meet the project goal. Because they communicated so frequently and clearly, the cross-functional team was successful in designing a process and executing the plan in a way that saved three weeks on the video schedule and several thousand dollars in cost by hosting off-site.

Problem-Solving Teams

Problem-solving teams are assigned to address specific issues that arise during the life of the project. The project leadership includes members that have the expertise to address the problem. The team is chartered to address that problem and then disband.

Qualitative Assessment of Project Performance

Project managers should provide an opportunity to ask such questions as “What is your gut feeling about how the project going?” and “How do you think our client perceives the project?” This creates the opportunity for reflection and dialogue around larger issues on the project. The project manager creates an atmosphere for the team to go beyond the data and search for meaning. This type of discussion and reflection is very difficult in the stress of day-to-day problem solving.

The project manager has several tools for developing good quantitative information—based on numbers and measurements—such as the project schedules, budgets and budget reports, risk analysis, and goal tracking. This quantitative information is essential to understanding the current status and trends on the project. Just as important is the development of qualitative information—comparisons of qualities—such as judgments made by expert team members that go beyond the quantitative data provided in a report. Some would label this the “gut feeling” or intuition of experienced project managers.

The Humm Factor is a survey tool developed by Russ Darnall to capture the thoughts of project participants. It derived its name from a project manager who always claimed he could tell you more by listening to the hum of the project than reading all the project reports. “Do you feel the project is doing the things it needs to do to stay on schedule?” and “Is the project team focused on project goals?” are the types of questions that can be included in the Humm Factor. It is distributed on a weekly or less frequent basis depending on the complexity profile of the project. A project with a high level of complexity due to team-based and cultural issues will be surveyed more frequently.

The qualitative responses are converted to a quantitative value as a score from 1 to 10. Responses are tracked by individuals and the total project, resulting in qualitative comparisons over time. The project team reviews the ratings regularly, looking for trends that indicate an issue may be emerging on the project that might need exploring.

> Example: Humm Survey Uncovers Concerns

On a project in South Carolina, the project surveyed the project leadership with a Humm Survey each week. The Humm Factor indicated an increasing worry about the schedule beginning to slip when the schedule reports indicated that everything was according to plan. When the project manager began trying to understand why the Humm Factor was showing concerns about the schedule, he discovered an apprehension about the performance of a critical project supplier. When he asked team members, they responded, “It was the way they answered the phone or the hesitation when providing information—something didn’t feel right.”

The procurement manager visited the supplier and discovered the company was experiencing financial problems and had serious cash flow problems. The project manager was able to develop a plan to help the supplier through the period, and the supplier eventually recovered. The project was able to meet performance goals. The Humm Factor survey provided a tool for members of the project team to express concerns that were based on very soft data, and the project team was able to discover a potential problem.

Another project team used the Humm Factor to survey the client monthly. The completed surveys went to a person who was not on the project team to provide anonymity to the responses. The responses were discussed at the monthly project review meetings, and the project manager summarized the results and addressed all the concerns expressed in the report. “I don’t feel my concerns are being heard” was one response that began increasing during the project, and the project manager spent a significant portion of the next project review meeting attempting to understand what this meant. The team discovered that as the project progressed toward major milestones, the project team became more focused on solving daily problems, spent more time in meetings, and their workday was becoming longer. The result was fewer contacts with the clients, slower responses in returning phone calls, and much fewer coffee breaks where team members could casually discuss the project with the client.

The result of the conversation led to better understanding by both the project team and client team of the change in behaviour based on the current phase of the project and the commitment to developing more frequent informal discussion about the project.

Creating a Project Culture

Project managers have a unique opportunity during the start-up of a project. They create a project culture, something organizational managers seldom have a chance to do. In most organizations, the corporate or organizational culture has developed over the life of the organization, and people associated with the organization understand what is valued, what has status, and what behaviours are expected. Edgar Schein identified three distinct levels in organizational culture.

1. Artifacts and behaviours
2. Espoused values
3. Assumptions

Artifacts are the visible elements in a culture and they can be recognized by people not part of the culture. Espoused values are the organization’s stated values and rules of behaviour. Shared basic assumptions are the deeply embedded, taken-for-granted behaviours that are usually unconscious, but constitute the essence of culture.

Characteristics of Project Culture

A project culture represents the shared norms, beliefs, values, and assumptions of the project team. Understanding the unique aspects of a project culture and developing an appropriate culture to match the complexity profile of the project are important project management abilities.

Culture is developed through the communication of:

- The priority
- The given status
- The alignment of official and operational rules

Official rules are the rules that are stated, and operational rules are the rules that are enforced. Project managers who align official and operational rules are more effective in developing a clear and strong project culture because the project rules are among the first aspects of the project culture to which team members are exposed when assigned to the project.

> Example: Operational Rules on a Multi-site Project

During an instructional design project that required individuals to collaborate remotely, an official rule had been established that individuals would back up their work in a location other than the shared folders they were using every week. It did not take long, however, for everyone involved to see that one member was actively backing up all work. Believing that was sufficient, the operational rule became simply leaving the backing up to a single individual. They assumed that official rules could be ignored if they were difficult to obey.

When this individual fell ill, however, no one picked up the slack and followed the official rule. When some files were corrupted, the team found that their most recent backups were weeks old, resulting in redoing a lot of work. The difference between the official rules and the operational rules of the project created a culture that made communication of the priorities more difficult.

In addition to official and operational rules, the project leadership communicates what is important by the use of symbols, storytelling, rituals, rewards or punishments, and taboos.

> Example: Creating a Culture of Collaboration

A project manager met with his team prior to the beginning of an instructional design project. The team was excited about the prestigious project and the potential for career advancement involved. With this increased competitive aspect came the danger of selfishness and backstabbing. The project leadership team told stories of previous projects where people were fired for breaking down the team efforts and often shared inspirational examples of how teamwork created unprecedented successes—an example of storytelling. Every project meeting started with team-building exercises—a ritual—and any display of hostility or separatism was forbidden—taboo—and was quickly and strongly cut off by the project leadership if it occurred.

Culture guides behaviour and communicates what is important and is useful for establishing priorities. On projects that have a strong culture of trust, team members feel free to challenge anyone who breaks a confidence, even managers. The culture of integrity is stronger than the cultural aspects of the power of management.

Innovation on Projects

The requirement of innovation on projects is influenced by the nature of the project. Some projects are chartered to develop a solution to a problem, and innovation is a central ingredient of project success. The lack of availability of education to the world at large prompted the open education movement, a highly innovative endeavor, which resulted in the textbook you are now reading. Innovation is also important to developing methods of lowering costs or shortening the schedule. Traditional project management thinking provides a trade-off between cost, quality, and schedule. A project sponsor can typically shorten the project schedule with an investment of more money or a lowering of quality. Finding innovative solutions can sometimes lower costs while also saving time and maintaining the quality.

Innovation is a creative process that requires both fun and focus. Stress is a biological reaction to perceived threats. Stress, at appropriate levels, can make the work environment interesting and even challenging. Many people working on projects enjoy a high-stress, exciting environment. When the stress level is too high, the biological reaction increases blood flow to the emotional parts of the brain and decreases the blood flow to the creative parts of the brain, making creative problem solving more difficult. Fun reduces the amount of stress on the project. Project managers recognize the benefits of balancing the stress level on the project with the need to create an atmosphere that enables creative thought.

> Example: Stress Managed on a Website Design Project

When a project manager visited the team tasked with designing the website for a project, she found that most of the members were feeling a great deal of stress. As she probed to find the reason behind the stress, she found that in addition to designing, the team was increasingly facing the need to build the website as well. As few of them had the necessary skills, they were wasting time that could be spent designing trying to learn building skills. Once the project manager was able to identify the stress as well as its cause, she was able to provide the team with the support it needed to be successful.

Exploring opportunities to create savings takes an investment of time and energy, and on a time-sensitive project, the project manager must create the motivation and the opportunity for creative thinking.

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9.2.7: Budget Planning

Every project boils down to money. If you had a bigger budget, you could probably get more people to do your project more quickly and deliver more. That's why no project plan is complete until you come up with a budget. But no matter whether your project is big or small, and no matter how many resources and activities are in it, the process for figuring out the bottom line is always the same.

It is important to come up with detailed estimates for all the project costs. Once this is compiled, you add up the cost estimates into a budget plan. It is now possible to track the project according to that budget while the work is ongoing.

Often, when you come into a project, there is already an expectation of how much it will cost or how much time it will take. When you make an estimate early in the project without knowing much about it, that estimate is called a rough order-of-magnitude estimate (or a ballpark estimate). This estimate will become more refined as time goes on and you learn more about the project. Here are some tools and techniques for estimating cost:

- **Determination of resource cost rates**: People who will be working on the project all work at a specific rate. Any materials you use to build the project (e.g., wood or wiring) will be charged at a rate too. Determining resource costs means figuring out what the rate for labour and materials will be.
- **Vendor bid analysis:** Sometimes you will need to work with an external contractor to get your project done. You might even have more than one contractor bid on the job. This tool is about evaluating those bids and choosing the one you will accept.
- **Reserve analysis**: You need to set aside some money for cost overruns. If you know that your project has a risk of something expensive happening, it is better to have some cash available to deal with it. Reserve analysis means putting some cash away in case of overruns.
- **Cost of quality**: You will need to figure the cost of all your quality-related activities into the overall budget. Since it's cheaper to find bugs earlier in the project than later, there are always quality costs associated with everything your project produces. Cost of quality is just a way of tracking the cost of those activities. It is the amount of money it takes to do the project right.

Once you apply all the tools in this process, you will arrive at an estimate for how much your project will cost. It's important to keep all of your supporting estimate information. That way, you know the assumptions made when you were coming up with the numbers. Now you are ready to build your budget plan.

Estimating Costs to Compare and Select Projects

During the conceptual phase when project selection occurs, economic factors are an important consideration in choosing between competing projects. To compare the simple paybacks or internal rates of return between projects, an estimate of the cost of each project is made. The estimates must be accurate enough so that the comparisons are meaningful, but the amount of time and resources used to make the estimates should be appropriate to the size and complexity of the project. The methods used to estimate the cost of the project during the selection phase are generally faster and consume fewer resources than those used to create detailed estimates in later phases. They rely more on the expert judgment of experienced managers who can make accurate estimates with less detailed information. Estimates in the earliest stages of project selection are usually based on information from previous projects that can be adjusted—**scaled**—to match the size and complexity of the current project or developed using standardized formulas.

Analogous Estimate

An estimate that is based on other project estimates is an **analogous estimate**. If a similar project cost a certain amount, then it is reasonable to assume that the current project will cost about the same. Few projects are exactly the same size and complexity, so the estimate must be adjusted upward or downward to account for the differences. The selection of projects that are similar and the amount of adjustment needed is up to the judgment of the person who makes the estimate. Normally, this judgment is based on many years of experience estimating projects, including incorrect estimates that were learning experiences for the expert.

Less-experienced managers who are required to make analogous estimates can look through the documentation that is available from previous projects. If projects were evaluated using the Darnall-Preston Complexity Index (DPCI), the manager can quickly identify projects that have profiles similar to the project under consideration, even if those projects were managed by other people.

The DPCI assesses project attributes, enabling better-informed decisions in creating the project profile. This index assesses the complexity level of key components of a project and produces a unique project profile. The profile indicates the project complexity level, which provides a benchmark for comparing projects and information about the characteristics of a project that can then be addressed in the project execution plan. It achieves this objective by grouping 11 attributes into four broad categories: internal, external, technological complexity, and environmental.

Comparing the original estimates with the final project costs on several previous projects with the same DPCI ratings gives a less-experienced manager the perspective that it would take many years to acquire by trial and error. It also provides references the manager can use to justify the estimate.

Example: Analogous Estimate for John's Move

John sold his apartment and purchased another one. It is now time to plan for the move. John asked a friend for advice about the cost of his move. His friend replied, "I moved from an apartment a little smaller than yours last year and the distance was about the same. I did it with a 14-foot truck. It cost about $575 for the truck rental, pads, hand truck, rope, boxes, and gas." Because of the similarity of the projects, John's initial estimate of the cost of the move was less than $700 so he decided that the cost would be affordable and the project could go forward.

Parametric Estimate

If the project consists of activities that are common to many other projects, average costs are available per unit. For example, if you ask a construction company how much it would cost to build a standard office building, the estimator will ask for the size of the building in square feet and the city in which the building will be built. From these two factors—size and location—the company's estimator can predict the cost of the building. Factors like size and location are **parameters**—measurable factors that can be used in an equation to calculate a result. The estimator knows the average cost per square foot of a typical office building and adjustments for local labour costs. Other parameters such as quality of finishes are used to further refine the estimate. Estimates that are calculated by multiplying measured parameters by cost-per-unit values are **parametric estimates**.

Example: Parametric Estimate for John's Move

To estimate the size of the truck needed for John's move, the parameter used by a truck rental company is the number of bedrooms (Figure 12.1). The company assumes that the number of bedrooms is the important parameter in determining how big a truck is needed for a move. John has a one-bedroom apartment, so he chooses the 14-foot truck. Once the size is determined, other parameters, such as distance and days, are used to estimate the cost of the truck rental.

Figure 12.1 Parametric Cost Estimate

Bottom-Up Estimating

The most accurate and time-consuming estimating method is to identify the cost of each item in each activity of the schedule, including labour and materials. If you view the project schedule as a hierarchy where the general descriptions of tasks are at the top and the lower levels become more detailed, finding the price of each item at the lowest level and then summing them to determine the cost of higher levels is called **bottom-up estimating**.

Example: Bottom-Up Estimate for John's Move

Table 12.1 Detailed Cost Estimate

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Category	Description	Activity	Quantity	Unit Price	Cost
Packing Materials	Small Boxes	2.1	10	$1.70	$17.00
Packing Materials	Medium Boxes	2.1	15	$2.35	$35.25
Packing Materials	Large Boxes	2.1	7	$3.00	$21.00
Packing Materials	Extra-Large Boxes	2.1	7	$3.75	$26.25
Packing Materials	Short-Hanger Boxes	2.1	3	$7.95	$23.85
Packing Materials	Box Tape	2.1	2	$3.85	$7.70
Packing Materials	Markers	2.1	2	$1.50	$3.00
Packing Materials	Mattress/Spring Bags	2.1	2	$2.95	$5.90
Packing Materials	Life Straps per Pair	2.1	1	$24.95	$24.95
Packing Materials	Bubble Wrap	2.1	1	$19.95	$19.95
Packing Materials	Furniture Pads	2.1	4	$7.95	$31.80
Truck	Rental	2.2	–	–	$400.00
Truck	Gas at 10mpg	2.2	200	$2.25	$45.00

After evaluating the bids by the moving companies, John decides the savings are worth his time if he can get the packing done with the help of his friends. He decides to prepare a detailed estimate of costs (Table 12.1) for packing materials and use of a rental truck. He looks up the prices for packing materials and truck rental costs on company websites and prepares a detailed list of items, quantities, and costs.

This type of estimate is typically more accurate than an analogous or parametric estimate. In this example, the sum of packing materials and truck expenses is estimated to be $661.25.

The estimate can be rolled up—subtotaled—to display less detail. This process is made easier using computer software. On projects with low complexity, the cost estimates can be done on spreadsheet software. On larger projects, software that manages schedules can also manage costs and display them by activity and category. For example, the subtotal feature could be used in Excel and collapsed to show the subtotals for the two categories of costs (Figure 12.2).

	A	B	C	D	E
1	Type	Description	Quantity	Unit Price	Cost
13	**Packing Materials Total**				$216.65
16	**Truck Total**				$445.00
17	**Grand Total**				$661.65
18					

Figure 12.2 Sum of detailed costs by type

Activity-Based Estimates

An activity can have costs from multiple vendors in addition to internal costs for labour and materials. Detailed estimates from all sources can be reorganized so those costs associated with a particular activity can be grouped by adding the activity code to the detailed estimate (Table 12.2).

Table 12.2 Costs Associated with Activities

Category	Activity	Cost
Packing Materials	2.1	$216.65
Truck	2.2	$445.00

The detailed cost estimates can be sorted and then subtotaled by activity to determine the cost for each activity.

Managing the Budget

Projects seldom go according to plan in every detail. It is necessary for the project manager to be able to identify when costs are varying from the budget and manage those variations.

Managing Cash Flow

If the total amount spent on a project is equal to or less than the amount budgeted, the project can still be in trouble if the funding for the project is not available when it is needed. There is a natural tension between the financial people in an organization, who do not want to pay for the use of money that is just sitting in a checking account, and the project manager, who wants to be sure that there is enough money available to pay for project expenses. The financial people prefer to keep the company's money working in other investments until the last moment before transferring it to the project account. The contractors and vendors have similar concerns, and they want to get paid as soon as possible so they can put the money to work in their own organizations. The project manager would like to have as much cash available as possible to use if activities exceed budget expectations.

Contingency Reserves

Most projects have something unexpected occur that increases costs above the original estimates. If estimates are rarely exceeded, the estimating method should be reviewed because the estimates are too high. It is impossible to predict which activities will cost more than expected, but it is reasonable to assume that some of them will. Estimating the likelihood of such events is part of risk analysis, which is discussed in more detail in a later chapter.

Instead of overestimating each cost, money is budgeted for dealing with unplanned but statistically predictable cost increases. Funds allocated for this purpose are called **contingency reserves**. Because it is likely that this money will be spent, it is part of the total budget for the project. If this fund is adequate to meet the unplanned expenses, then the project will complete within the budget.

Management Reserves

If something occurs during the project that requires a change in the project scope, money may be needed to deal with the situation before a change in scope can be negotiated with the project sponsor or client. It could be an opportunity as well as a challenge. For example, if a new technology were invented that would greatly enhance your completed project, there would be additional cost and a change to the scope, but it would be worth it. Money can be made available at the manager's discretion to meet needs that would change the scope of the project. These funds are called **management reserves**. Unlike contingency reserves, they are not likely to be spent and are not part of the project's budget baseline, but they can be included in the total project budget.

Evaluating the Budget During the Project

A project manager must regularly compare the amount of money spent with the budgeted amount and report this information to managers and stakeholders. It is necessary to establish an understanding of how this progress will be measured and reported.

> Example: Reporting Budget Progress on John's Move

In the John's move example, he estimated that the move would cost about $1,500 and take about 16 days. Eight days into the project, John has spent $300. John tells his friends that the project is going well because he is halfway through the project but has only spent a fifth of his budget. John's friend Carlita points out that his report is not sufficient because he did not compare the amount spent to the budgeted amount for the activities that should be done by the eighth day.

As John's friend pointed out, a budget report must compare the amount spent with the amount that is expected to be spent by that point in the project. Basic measures such as percentage of activities completed, percentage of measurement units completed, and percentage of budget spent are adequate for less complex projects, but more sophisticated techniques are used for projects with higher complexity.

Earned Value Analysis

A method that is widely used for medium- and high-complexity projects is the **earned value management (EVM)** method. EVM is a method of periodically comparing the budgeted costs with the actual costs during the project. It combines the scheduled activities with detailed cost estimates of each activity. It allows for partial completion of an activity if some of the detailed costs associated with the activity have been paid but others have not.

The **budgeted cost of work scheduled (BCWS)** comprises the detailed cost estimates for each activity in the project. The amount of work that should have been done by a particular date is the **planned value (PV)**. These terms are used interchangeably by some sources, but the planned value term is used in formulas to refer to the sum of the budgeted cost of work up to a particular point in the project, so we will make that distinction in the definitions in this text for clarity.

Example: Planned Value on Day Six of John's Move

On day six of the project, John should have taken his friends to lunch and purchased the packing materials. The portion of the BCWS that should have been done by that date (the planned value) is shown in Table 12.3. This is the planned value for day six of the project.

Table 12.3 Planned Value for Lunch and Packing Materials

Description	Quantity	Cost
Lunch	3	$45.00
Small Boxes	10	$17.00
Medium Boxes	15	$35.25
Large Boxes	7	$21.00
Extra Large Boxes	7	$26.25
Short Hanger Boxes	3	$23.85
Box Tape	2	$7.70
Markers	2	$3.00
Mattress/Spring Bags	2	$5.90
Life Straps per Pair	1	$24.95
Bubble Wrap	1	$19.95
Furniture Pads	4	$31.80

Total: $261.65

The **budgeted cost of work performed (BCWP)** is the budgeted cost of work scheduled that has been done. If you sum the BCWP values up to that point in the project schedule, you have the **earned value (EV)**. The amount spent on an item is often more or less than the estimated amount that was budgeted for that item. The **actual cost (AC)** is the sum of the amounts actually spent on the items.

Example: Comparing PV, EV, and AC in John's Move on Day Six

Dion and Carlita were both trying to lose weight and just wanted a nice salad. Consequently, the lunch cost less than expected. John makes a stop at a store that sells moving supplies at discount rates. They do not have all the items he needs, but the prices are lower than those quoted by the moving company. They have a very good price on lifting straps so he decides to buy an extra pair. He returns with some of the items on his list, but this phase of the job is not complete by the end of day six. John bought half of the small boxes, all of five other items, twice as many lifting straps, and none of four other items. John is only six days into his project, and his costs and performance are starting to vary from the plan. Earned value analysis gives us a method for reporting that progress (Table 12.4).

Table 12.4 Planned Value, Earned Value, and Actual Cost

	Budgeted Cost of Work Scheduled (BCWS)		Budgeted Cost of Work Performed (BCWP)		Actual Cost (AC)	
Description	Quantity	Cost	Quantity	Cost	Quantity	Cost
Lunch	3	$45.00	3	$45.00	3	$35.00
Small Boxes	10	$7.00	5	$8.50	5	$9.50
Medium Boxes	15	$35.25	15	$35.25	15	$28.00
Large Boxes	7	$21.00				
Extra-Large Boxes	7	$26.25				
Short-Hanger Boxes	3	$23.85				
Box Tape	2	$7.70	2	$7.70	2	$5.50
Markers	2	$3.00	2	$3.00	2	$2.00
Mattress/Spring Bags	2	$5.90	2	$5.90	2	$7.50
Life Straps per Pair	1	$24.95	1	$24.95	2	38.50
Bubble Wrap	1	$19.95				
Furniture Pads	4	$31.80	4	$31.80	4	28.50

The original schedule called for spending $261.65 (PV) by day six. The amount of work done was worth $162.10 (EV) according to the estimates, but the actual cost was only $154.50 (AC).

Schedule Variance

The project manager must know if the project is on schedule and within the budget. The difference between planned and actual progress is the **variance**. The **schedule variance (SV)** is the difference between the earned value (EV) and the planned value (PV). Expressed as a formula, SV = EV − PV. If less value has been earned than was planned, the schedule variance is negative, which means the project is behind schedule.

Example: Schedule Variance on John's Move

Planning for John's move calls for spending $261.65 by day six, which is the planned value (PV). The difference between the planned value and the earned value is the scheduled variance (SV). The formula is SV = EV − PV. In this example, SV = $162.10 − $261.65 = ($99.55) A negative SV indicates the project is behind schedule.

The difference between the earned value (EV) and the actual cost (AC) is the **cost variance (CV)**. Expressed as a formula, CV = EV −AC. A positive CV indicates the project is under budget.

Example: Cost Variance on John's Move

The difference between the earned value of $162.10 and the actual cost of $154.50 is the cost variance (CV). The formula is CV = EV − AC. In this example, CV = $162.10 − $154.50 = $7.60.

Variance Indexes for Schedule and Cost

The schedule variance and the cost variance provide the amount by which the spending is behind (or ahead of) schedule and the amount by which a project is exceeding (or not fully using) its budget. They do not give an idea of how these amounts compare with the total budget.

The ratio of earned value to planned value gives an indication of how much of the project is completed. This ratio is the **schedule performance index (SPI)**. The formula is SPI = EV ÷ PV. In the John's move example, the SPI equals 0.62 (SPI = $162.10 ÷

$261.65 = 0.62) An SPI value less than 1 indicates the project is behind schedule.

The ratio of the earned value to the actual cost is the **cost performance index (CPI)**. The formula is CPI = EV ÷ AC.

> Example: Cost Performance Index of John's Move

In the John's move example, CPI = $162.10 ÷ $154.50 = 1.05. A value greater than 1 indicates that the project is under budget.

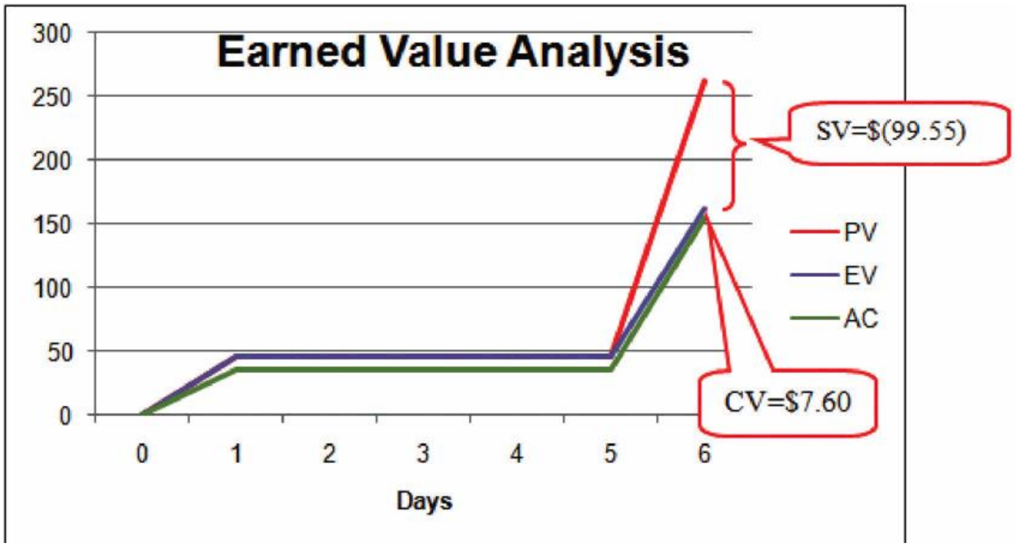

Figure 12.3 Schedule variance and cost variance.

The cost variance of positive $7.60 and the CPI value of 1.05 tell John that he is getting more value for his money than planned for the tasks scheduled by day six. The schedule variance (SV) of negative $99.55 and the schedule performance index (SPI) of 0.62 tell him that he is behind schedule in adding value to the project (Figure 12.3).

During the project, the manager can evaluate the schedule using the schedule variance (SV) and the schedule performance index (SPI), and the budget using the cost variance (CV) and the cost performance index (CPI).

Estimated Cost to Complete the Project

Part way through the project, the manager evaluates the accuracy of the cost estimates for the activities that have taken place and uses that experience to predict how much money it will take to complete the unfinished activities—**the estimate to complete (ETC)**.

To calculate the ETC, the manager must decide if the cost variance observed in the estimates to that point are representative of the future. For example, if unusually bad weather causes increased cost during the first part of the project, it is not likely to have the same effect on the rest of the project. If the manager decides that the cost variance up to this point in the project is atypical—not typical—then the estimate to complete is the difference between the original budget for the entire project—the **budget at completion (BAC)**—and the earned value (EV) up to that point. Expressed as a formula, ETC = BAC − EV.

> Example: Estimate to Complete John's Move

For his move, John was able to buy most of the items at a discount house that did not have a complete inventory, and he chose to buy an extra pair of lift straps. He knows that the planned values for packing materials were obtained from the price list at the moving company where he will have to buy the rest of the items, so those two factors are not likely to be typical of the remaining purchases. The reduced cost of lunch is unrelated to the future costs of packing materials, truck rentals, and hotel fees. John decides that the factors that caused the variances are atypical. He calculates that the estimate to complete (ETC) is the budget at completion ($1,534) minus the earned value at that point ($162.10), which equals $1,371.90. Expressed as a formula, ETC = $1,534 − $162.10 = $1,371.90.

If the manager decides that the cost variance is caused by factors that will affect the remaining activities, such as higher labour and material costs, then the estimate to complete (ETC) needs to be adjusted by dividing it by the cost performance index (CPI). For example, if labour costs on the first part of a project are estimated at $80,000 (EV) and they actually cost $85,000 (AC), the cost performance (CPI) will be 0.94. (Recall that the CPI = EV ÷ AC.)

To calculate the estimate to complete (ETC), assuming the cost variance on known activities is typical of future cost, the formula is ETC = (BAC − EV) ÷ CPI. If the budget at completion (BAC) of the project is $800,000, the estimate to complete is ($800,000 − $80,000) ÷ 0.94 = $766,000.

Estimate Final Project Cost

If the costs of the activities up to the present vary from the original estimates, this will affect the total estimate of the project cost. The new estimate of the project cost is the estimate at completion (EAC). To calculate the EAC, the **estimate to complete (ETC)** is added to the actual cost (AC) of the activities already performed. Expressed as a formula, EAC = AC + ETC.

> Example: Estimate at Completion for John's Move

The revised estimate at completion (EAC) for John's move at this point in the process is EAC = $154.50 + $1,371.90 = $1,526.40.

Table 12.5 Summary of Terms and Formulas for Earned Value Analysis

Term	Acronym	Description	Formula	John's Move
Actual Cost	AC	The money actually spent on projects up to the present.	–	$154.50
Budget at Completion	BAC	Original budget for the project (same sa BCWS)	–	$1,534.00
Cost Performance Index	CPI	Ratio of earned value to actual cost	CPI = EV ÷ AC	1.05
Cost Variance	CV	Difference between earned value and actual cost	CV = EV − AC	$7.60
Earned Value	EV	Sum of estimates for work actually done up to the present	–	$162.10
Estimate at Completion	EAC	Revised estimate of total project cost	EAC = AC + ETC	$1,526.40
Estimate to Complete	ETC	Money to complete the project if early cost variance is atypical	ETC = (BAC − EV) ÷ CPI	n/a
Planned Vale	PV	Sum of the estimates for work done up to the present	–	$261.65
Schedule Performnce Index	SPI	Ratio of earned value to planned value	SPI = EV ÷ PV	0.62
Schedule Variance	SV	Difference between earned value and planned value	SV = EV − PV	$99.55

To summarize (Table 12.5):

- Extra money is allocated in a contingency fund to deal with activities where costs exceed estimates. Funds are allocated in a management reserve in case a significant opportunity or challenge occurs that requires change of scope but funds are needed immediately before a scope change can typically be negotiated.
- Schedule variance is the difference between the part of the budget that has been spent so far (EV) versus the part that was planned to be spent by now (PV). Similarly, the cost variance is the difference between the EV and the actual cost (AC).
- The schedule performance index (SPI) is the ratio of the earned value and the planned value. The cost performance index (CPI) is the ratio of the earned value (EV) to the actual cost (AC).
- The formula used to calculate the amount of money needed to complete the project (ETC) depends on whether or not the cost variance to this point is expected to continue (typical) or not (atypical). If the cost variance is atypical, the ETC is simply the original total budget (BAC) minus the earned value (EV). If they are typical of future cost variances, the ETC is adjusted by dividing the difference between BAC and EV by the CPI.
- The final budget is the actual cost (AC) to this point plus the estimate to complete (ETC).

Establishing a Budget

Once you have broken your project down into activities, you will be able to calculate your overall project costs by estimating and totaling the individual activity costs.

This process of subtotaling costs by category or activity is called **cost aggregation**.

Budget Timeline

Costs are associated with activities, and since each activity has a start date and a duration period, it is possible to calculate how much money will be spent by any particular date during the project. The money needed to pay for a project is usually transferred to the project account shortly before it is needed. These transfers must be timed so that the money is there to pay for each activity without causing a delay in the start of the activity. If the money is transferred too far in advance, the organization will lose the opportunity to use the money somewhere else, or they will have to pay unnecessary interest charges if the money is borrowed. A schedule of money transfers is created that should match the need to pay for the activities. The process of matching the schedule of transfers with the schedule of activity payments is called **reconciliation**. Refer to Figure 12.4, which shows the costs of 10 major activities in a project. Funds are transferred into the project account four times. Notice that during most of the project, there were more funds available than were spent except at activity 6 when all the available funds were spent.

Activity	1	2	3	4	5	6	7	8	9	10
Cost	50	200	50	300	500	200	100	400	300	500
Total Spent	50	250	300	600	1,100	1,300	1,400	1,800	2,100	2,600
Transfers	400			900			700		600	
Total Funding	400	400	400	1,300	1,300	1,300	2,000	2,000	2,600	2,600
Cash in Account	350	150	100	700	200	-	600	200	500	-

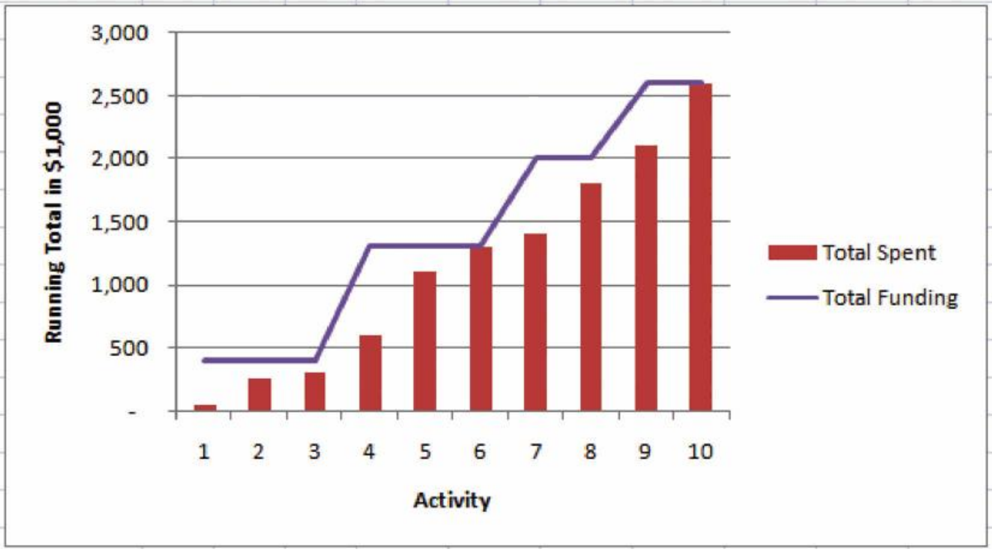

Figure 12.4: Fund transfers and expenditures.

In the project budget profile shown in Figure 12.4, there is no margin for error if the total of the first six activities exceeds the amount of funding at that point in the project.

Contractual agreements with vendors often require partial payment of their costs during the project. Those contracts can be managed more conveniently if the unit of measure for partial completion is the same as that used for cost budgeting. For example, if a graphic designer is putting together several pieces of artwork for a textbook, their contract may call for partial payment after 25% of their total number of drawings is complete.

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9.2.8: Procurement Management

Procurement management follows a logical order. First, you plan what you need to contract; then you plan how you'll do it. Next, you send out your contract requirements to sellers. They bid for the chance to work with you. You pick the best one, and then you sign the contract with them. Once the work begins, you monitor it to make sure that the contract is being followed. When the work is done, you close out the contract and fill out all the paperwork.

You need to start with a plan for the whole project. Before doing anything else, you need to think about all of the work that you will contract out for your project. You will want to plan for any purchases and acquisitions. Here's where you take a close look at your needs to be sure that contracting is necessary. You figure out what kinds of contracts make sense for your project, and you try to define all of the parts of the project that will be contracted out.

Contract planning is where you plan out each individual contract for the project work. You work out how you'll manage the contract, what metrics it will need to meet to be considered successful, how you'll pick a seller, and how you'll administer the contract once the work is happening.

The procurement management plan details how the procurement process will be managed. It includes the following information:

- The types of contracts you plan to use and any metrics that will be used to measure the contractors' performance
- The planned delivery dates for the work or products you are contracting
- The company's standard documents you will use
- The number of vendors or contractors involved and how they will be managed
- How purchasing may impact the constraints and assumptions of the project plan
- The coordination of purchasing lead times with the development of the project schedule
- The identification of prequalified sellers (if known)

The procurement management plan, like all other management plans, becomes a subsidiary of the project management plan. Some tools and techniques you may use during the procurement planning stage include make-or-buy analysis and definition of the contract type.

Make-or-Buy Analysis

This means figuring out whether or not you should be contracting the work or doing it yourself. It could also mean deciding whether to build a solution to your problem or buy one that is already available. Most of the same factors that help you make every other major project decision will help you with this one. How much does it cost to build it as opposed to buying it? How will this decision affect the scope of your project? How will it affect the project schedule? Do you have time to do the work and still meet your commitments? As you plan out what you will and won't contract, you need to think through your reasoning very carefully.

There are some resources (like heavy equipment) that your company can buy, rent, or lease depending on the situation. You'll need to examine leasing-versus-buying costs and determine the best way to go forward.

Contract Types

You should know a little bit about the major kinds of contracts available to you (the client) so that you choose the one that creates the most fair and workable deal for you and the contractor. Some contracts are fixed price: no matter how much time or effort goes into them, the client always pay the same. In Figure 13.1 the cost to the client stays the same, but as more effort is exerted the profit to the contractor goes down. Some are cost reimbursable also called cost plus. This is where the seller charges you for the cost of doing the work plus some fee or rate. Table 13.1 illustrates this by showing that as efforts increase, costs to the client go up but the contractor's profits stay the same. The third major kind of contract is time and materials. That's where the client pays a rate for the time spent working on the project and also pays for all the materials used to do the work. Figure 13.2 shows that as costs to the client go up, so does the profit for the contractor.

Fixed-Price Contracts

The **fixed-price contract** is a legal agreement between the project organization and an entity (person or company) to provide goods or services to the project at an agreed-on price. The contract usually details the quality of the goods or services, the timing needed to support the project, and the price for delivering goods or services. There are several variations of the fixed-price contract. For commodities and goods and services where the scope of work is very clear and not likely to change, the fixed-price contract offers a predictable cost. The responsibility for managing the work to meet the needs of the project is focused on the contractor. The project team tracks the quality and schedule progress to ensure the contractors will meet the project needs. The risks associated with fixed-price contracts are the costs associated with project change. If a change occurs on the project that requires a change order from the contractor, the price of the change is typically very high. Even when the price for changes is included in the original contract, changes on a fixed-price contract will create higher total project costs than other forms of contracts because the majority of the cost risk is transferred to the contractor, and most contractors will add a contingency to the contract to cover their additional risk.

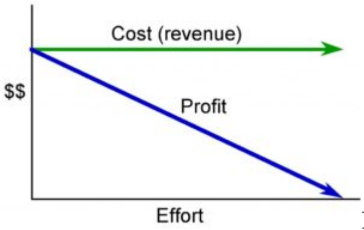

Figure 13.1: In a fixed-price contract, the cost to the client is constant regardless of effort applied or delivery date.

Fixed-price contracts require the availability of at least two or more suppliers that have the qualifications and performance histories that ensure the needs of the project can be met. The other requirement is a scope of work that is most likely not going to change. Developing a clear scope of work based on good information, creating a list of highly qualified bidders, and developing a clear contract that reflects that scope of work are critical aspects of a good fixed-priced contract.

If the service provider is responsible for incorporating all costs, including profit, into the agreed-on price, it is a **fixed-total-cost contract**. The contractor assumes the risks for unexpected increases in labour and materials that are needed to provide the service or materials and in the materials and timeliness needed.

The **fixed-price contract with price adjustmen**t is used for unusually long projects that span years. The most common use of this type of contract is the inflation-adjusted price. In some countries, the value of its local currency can vary greatly in a few months, which affects the cost of local materials and labour. In periods of high inflation, the client assumes the risk of higher costs due to inflation, and the contract price is adjusted based on an inflation index. The volatility of certain commodities can also be accounted for in a price-adjustment contract. For example, if the price of oil significantly affects the costs of the project, the client can accept the oil price volatility risk and include a provision in the contract that would allow the contract price adjustment based on a change in the price of oil.

The **fixed-price contract with incentive fee** provides an incentive for performing on the project above the established baseline in the contract. The contract might include an incentive for completing the work on an important milestone for the project. Often contracts have a penalty clause if the work is not performed according to the contract. For example, if the new software is not completed in time to support the implementation of the training, the contract might penalize the software company a daily amount of money for every day the software is late. This type of penalty is often used when the software is critical to the project and the delay will cost the project significant money.

If the service or materials can be measured in standard units, but the amount needed is not known accurately, the price per unit can be fixed—a **fixed-unit-price contract**. The project team assumes the responsibility of estimating the number of units used. If the estimate is not accurate, the contract does not need to be changed, but the project will exceed the budgeted cost.

Table 13.1 Fixed price contracts and characteristics

Type	Known Scope	Share of Risk	Incentive for Meeting Milestones	Predictability of Cost
Fixed total cost	Very High	All contractor	Low	Very high
Fixed unit price	High	Mostly project	Low	High
Fixed price with incentive fee	High	Mostly project	High	Medium-high
Fixed fee with price adjustment	High	Mostly project	Low	Medium

Cost-Reimbursable Contracts

In a **cost-reimbursable contract**, the organization agrees to pay the contractor for the cost of performing the service or providing the goods. Cost-reimbursable contracts are also known as **cost-plus contracts**. Cost-reimbursable contracts are most often used when the scope of work or the costs for performing the work are not well known. The project uses a cost-reimbursable contract to pay the contractor for allowable expenses related to performing the work. Since the cost of the project is reimbursable, the contractor has much less risk associated with cost increases. When the costs of the work are not well known, a cost-reimbursable contract reduces the amount of money the bidders place in the bid to account for the risk associated with potential increases in costs. The contractor is also less motivated to find ways to reduce the cost of the project unless there are incentives for supporting the accomplishment of project goals.

Figure 13.2: In a cost-reimbursable or cost-plus contract, the contractor is guaranteed a fee, but the client's costs can increase based on effort.

Cost-reimbursable contracts require good documentation of the costs that occurred on the project to ensure that the contractor gets paid for all the work performed and to ensure that the organization is not paying for something that was not completed. The contractor is also paid an additional amount above the costs. There are several ways to compensate the contractor.

- A **cost-reimbursable contract with a fixed fee** provides the contractor with a fee, or profit amount, that is determined at the beginning of the contract and does not change.
- A **cost-reimbursable contract with a percentage fee** pays the contractor for costs plus a percentage of the costs, such as 5% of total allowable costs. The contractor is reimbursed for allowable costs and is paid a fee.
- A **cost-reimbursable contract with an incentive fee** is used to encourage performance in areas critical to the project. Often the contract attempts to motivate contractors to save or reduce project costs. The use of the cost reimbursable contract with an incentive fee is one way to motivate cost-reduction behaviours.
- A **cost-reimbursable contract with award fee** reimburses the contractor for all allowable costs plus a fee that is based on performance criteria. The fee is typically based on goals or objectives that are more subjective. An amount of money is set aside for the contractor to earn through excellent performance, and the decision on how much to pay the contractor is left to the judgment of the project team. The amount is sufficient to motivate excellent performance.

On small activities that have a high uncertainty, the contractor might charge an hourly rate for labour, plus the cost of materials, plus a percentage of the total costs. This type of contract is called **time and materials (T&M)**. Time is usually contracted on an hourly rate basis and the contractor usually submits time sheets and receipts for items purchased on the project. The project reimburses the contractor for the time spent based on the agreed-on rate and the actual cost of the materials. The fee is typically a percentage of the total cost.

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Figure 13.3: In a time-and-materials contract, the profit to the contractor increases with increased effort, as does the costs to the client.

T&M contracts are used on projects for work that is smaller in scope and has uncertainty or risk. The project, rather than the contractor, assumes the risk. Since the contractor will most likely include contingency in the price of other types of contracts to cover the high risk, T&M contracts provide lower total cost to the project.

Table 13.2 Cost-reimbursable contracts

Cost Reimbursable (CR)	Known Scope	Share of Risk	Incentive for Meeting Milestones	Predictability of Cost
CR with fixed fee	Medium	Mostly project	Low	Medium-high
CR with percentage fee	Medium	Mostly project	Low	Medium-high
CR with incentive fee	Medium	Mostly project	High	Medium
CR with award fee	Medium	Mostly project	High	Medium
Time and Materials	Low	All project	Low	Low

To minimize the risk to the project, the contractor typically includes a not-to-exceed amount, which means the contract can only charge up to the agreed amount. The T&M contract allows the project to make adjustments as more information is available. The final cost of the work is not known until sufficient information is available to complete a more accurate estimate.

Progress Payments and Change Management

Vendors and suppliers usually require payments during the life of the contract. On contracts that last several months, the contractor will incur significant cost and will want the project to pay for these costs as early as possible. Rather than wait until the end of the contract, a schedule of payments is typically developed as part of the contract and is connected to the completion of a defined amount of work or project milestones. These payments made before the end of the project and based on the progress of the work are called *progress payments*. For example, the contract might develop a payment schedule that pays for the design of the curriculum, then the development of the curriculum, and then a final payment is made when the curriculum is completed and accepted. In this case there would be three payments made. There is a defined amount of work to be accomplished, a time frame for accomplishing that work, and a quality standard the work must achieve before the contractor is paid for the work.

Just as the project has a scope of work that defines what is included in the project and what work is outside the project, vendors and suppliers have a scope of work that defines what they will produce or supply to the company. (Partners typically share the project scope of work and may not have a separate scope of work.) Often changes occur on the project that require changes in the contractor's scope of work. How these changes will be managed during the life of the project is typically documented in the contract. Capturing these changes early, documenting what changed and how the change impacted the contract, and developing a change order (a change to the contract) are important to maintaining the progress of the project. Conflict among team members may arise when changes are not documented or when the team cannot agree on the change. Developing and implementing an effective change management process for contractors and key suppliers will minimize this conflict and the potential negative effect on the project.

Procurement Process

The project procurement cycle reflects the procurement activities from the decision to purchase the material or service through to the payment of bills and closing of procurement contracts.

Procurement Plan

After the decision has been made to purchase goods or outsource services, the procurement team develops a plan that includes the following:

- Selecting the appropriate relationships and contract approaches for each type of purchased goods or outsourced service
- Preparing requests for quotes (RFQs) and requests for proposals (RFPs) and evaluating partnership opportunities
- Evaluating RFQs, RFPs, and partnerships
- Awarding and signing contracts
- Managing quality and timely performance
- Managing contract changes
- Closing contracts

Depending on the complexity level of the project, each of these steps can take either hours or sometimes weeks of work to complete. Each of these steps is also included in the project master schedule. The time involved in the procurement cycle can influence the scheduling of critical activities, including the decision to self-perform the work or contract the work to others. The delivery dates for equipment and materials and the work completion dates for contracted works are placed on the project schedule. Any procurement activities that create a project delay or fall on the project critical path may require special attention.

Selecting the Contract Approach

The technical teams typically develop a description of the work that will be outsourced. From this information, the project management team answers the following questions:

- Is the required work or materials a commodity, customized product or service, or unique skill or relationship?
- What type of relationship is needed: supplier, vendor, or partnership?
- How should the supplier, vendor, or potential partner be approached: RFQ, RFP, or personal contact?
- How well known is the scope of work?
- What are the risks and which party should assume which types of risk?
- Does the procurement of the service or goods affect activities on the project schedule's critical path and how much float is there on those activities?
- How important is it to be sure of the cost in advance?

The procurement team uses the answers to the first three questions listed above to determine the approach to obtaining the goods or services and the remaining questions to determine what type of contract is most appropriate.

A key factor in selecting the contract approach is determining which party will take the most risk. The team determines the level of risk that will be managed by the project and what risks will be transferred to the contractor. Typically, the project management team wants to manage the project risk, but in some cases, contractors have more expertise or control that enable them to better manage the risk associated with the contracted work.

Soliciting Bids

A **solicitation**is the process of requesting a price and supporting information from bidders. The solicitation usually takes the form of either an RFQ or an RFP. Partnerships are pursued and established differently on a case-by-case basis by senior management.

Qualifying Bidders

Potential bidders are people or organizations capable of providing the materials or performing the work required for the project. On smaller, less complex projects, the parent company typically has a list of suppliers and vendors that have successfully provided goods and services in the past, and the project has access to the performance record of companies on that list. On unique projects, where no supplier lists exist, the project team develops a list of potential suppliers and then qualifies them to become eligible to bid on project work. Eligible bidders are placed on the bidders list and provided with a schedule of when work on the project will be put out for bid.

The eligibility of a supplier is determined by the ability to perform the work in a way that meets project requirements and demonstrates financial stability. Ability to perform the work includes the ability to meet quality specifications and the project schedule. During times when economic activity is high in a region, many suppliers become busy and stretch their resources. The project team investigates the potential suppliers, before they are included on the bidder's list, to ensure that they have the capacity and track record to meet deadlines.

The potential supplier must also be financially stable to be included on the bidders list. A credit check or a financial report from Dun and Bradstreet (D&B)—a well-known provider of financial information about individual companies—will provide the project with information about the potential bidder's financial status. D&B services include the following:

- D&B proprietary rankings and predictive creditworthiness scores
- Public filings, including suits, liens, judgments, and UCC (uniform commercial code) filings—standardized financial disclosure documents that conform to the uniform commercial code
- Company financial statements and history

Request for Quote

An RFQ focuses on price. The type of materials or service is well defined and can be obtained from several sources. The bidder that can meet the project quality and schedule requirements usually wins the contract by quoting the lowest price.

Request for Proposal

An RFP accounts for price but focuses on meeting the project quality or schedule requirements. The process of developing a proposal in response to an RFP can be very expensive for the bidder, and the project team should not issue an RFP to a company that is not eligible to win the bid.

Evaluating Bids

Evaluation of bids in response to RFQs for commodity items and services is heavily graded for price. In most cases, the lowest total price will win the contract. The total price will include the costs of the goods or services, any shipping or delivery costs, the value of any warranties, and any additional service that adds value to the project.

The evaluation of bids based on RFPs is more complex. The evaluation of proposals includes the price and also an evaluation of the technical approach chosen by the bidder. The project team evaluating the proposal must include people with the expertise to understand the technical aspects of the various proposal options and the value of each proposal to the project. On more complex projects, the administrative part of the proposal is evaluated and scored by one team, and the technical aspect of the proposal is evaluated by another team. The project team combines the two scores to determine the best proposal for the project.

Awarding the Contract

After the project team has selected the bidder that provides the best value for the project, a project representative validates all conditions of the bid and the contract with the potential contractor. Less complex awards, like contracts for printed materials, require a reading and signing of the contract to ensure that the supplier understands the contract terms and requirements of the project schedule. More complex projects require a detailed discussion of the goals, the potential barriers to accomplishing those goals, the project schedule and critical dates, and the processes for resolving conflicts and improving work processes.

Managing the Contracts

The contract type determines the level of effort and the skills needed to manage the contract. The manager of supplier contracts develops detailed specifications and ensures compliance with these specifications. The manager of vendor contracts ensures that the contractors bidding on the work have the skills and capacity to accomplish the work according to the project schedule and tracks the vendor's performance against the project needs, supplying support and direction when needed. The manager of partnering arrangements develops alignment around common goals and work processes. Each of these approaches requires different skills and various degrees of effort.

Items that take a long time to acquire—**long-lead items**—receive early attention by the project leadership. Examples of long-lead items are equipment that is designed and built specifically for the project, curriculum that is created for training a new workforce, and a customized bioreactor for a biotech project. These items might require weeks, months, or years to develop and complete. The project team identifies long-lead items early to begin the procurement activities as soon as possible because those procured through the normal procurement cycle may cause delays in the project.

After the contract is awarded, the project team tracks the performance of the contractor against performance criteria in the contract and his or her contribution to the performance of the project. Usually, contractors deliver the product or service that meets the quality expectations and supports the project schedule. Typically, there are also one or two contractors that do not perform to project expectations. Some project managers will refer to the contract and use it to attempt to persuade the contractor to improve performance or be penalized. Other project managers will explore with the contractor creative ways to improve performance and meet project requirements. The contract management allows for both approaches to deal with non`-performing contractors, and the project team must assess what method is most likely to work in each situation.

Managing contractor performance on a project is as important to the overall project outcomes as the work performed by the project team.

Logistics and Expediting

Equipment and materials that are purchased for use on the project must be transported, inventoried, warehoused, and often secured. This area of expertise is called *logistics*. The logistics for the project can be managed by the project team or can be included in the RFP or RFQ. On international projects, materials may be imported, and the procurement team manages the customs process. On smaller projects, the logistical function is often provided by the parent company. On larger projects, these activities are typically contracted to companies that specialize in logistical services. On larger, more complex projects, the procurement team will include logistical expertise.

The project work often depends on materials procured for the project. The delivery of these materials influences the scheduling of the project, and often some materials are needed earlier than normal procurement practices would deliver. On long-lead items, the project schedule is included in the contracting plans and contractors must explain how they will support the project schedule.

On large, complex projects, critical items might be scheduled for delivery after they are needed on the project. The procurement team then explores ideas with the contractor to expedite the manufacturing or transportation of the equipment or materials. The contract can often place a priority on the fabrication of the equipment and delivery of the equipment to meet the project schedule. The project logistics team can also explore ways of shortening the transportation time. For example, a project in Argentina flew some critical equipment from Sweden rather than transport the equipment by ship to save several weeks in transit. The logistics costs were higher, but the overall value to the project was greater.

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9.2.9: Quality Planning

It's not enough to make sure you get a project done on time and under budget. You need to be sure you make the right product to suit your stakeholders' needs. Quality means making sure that you build what you said you would and that you do it as efficiently as you can. And that means trying not to make too many mistakes and always keeping your project working toward the goal of creating the right product.

Everybody "knows" what quality is. But the way the word is used in everyday life is a little different from how it is used in project management. Just like the triple constraint (scope, cost, and schedule), you manage quality on a project by setting goals and taking measurements. That's why you must understand the quality levels your stakeholders believe are acceptable, and ensure that your project meets those targets, just like it needs to meet their budget and schedule goals.

Customer satisfaction is about making sure that the people who are paying for the end product are happy with what they get. When the team gathers requirements for the specification, they try to write down all of the things that the customers want in the product so that you know how to make them happy. Some requirements can be left unstated. Those are the ones that are implied by the customer's explicit needs. For example, some requirements are just common sense (e.g., a product that people hold can't be made from toxic chemicals that may kill them). It might not be stated, but it's definitely a requirement.

"Fitness to use" is about making sure that the product you build has the best design possible to fit the customer's needs. Which would you choose: a product that's beautifully designed, well constructed, solidly built, and all around pleasant to look at but does not do what you need, or a product that does what you want despite being ugly and hard to use? You'll always choose the product that fits your needs, even if it's seriously limited. That's why it's important that the product both does what it is supposed to do and does it well. For example, you could pound in a nail with a screwdriver, but a hammer is a better fit for the job.

Conformance to requirements is the core of both customer satisfaction and fitness to use, and is a measure of how well your product does what you intend. Above all, your product needs to do what you wrote down in your requirements document. Your requirements should take into account what will satisfy your customer and the best design possible for the job. That means conforming to both stated and implied requirements.

In the end, your product's quality is judged by whether you built what you said you would build.

Quality planning focuses on taking all of the information available to you at the beginning of the project and figuring out how you will measure quality and prevent defects. Your company should have a quality policy that states how it measures quality across the organization. You should make sure your project follows the company policy and any government rules or regulations on how to plan quality for your project.

You need to plan which activities you will use to measure the quality of the project's product. And you'll need to think about the cost of all the quality-related activities you want to do. Then you'll need to set some guidelines for what you will measure against. Finally, you'll need to design the tests you will run when the product is ready to be tested.

Quality and Grade

According to the International Organization for Standardization (ISO), **quality**is "the degree to which a set of inherent characteristics fulfill requirements." The requirements of a product or process can be categorized or given a grade that will provide a basis for comparison. The quality is determined by how well something meets the requirements of its grade.

For most people, the term *quality* also implies good value—getting your money's worth. For example, even low-grade products should still work as expected, be safe to use, and last a reasonable amount of time. Consider the following examples.

> Example: Quality of Gasoline Grades

Petroleum refiners provide gasoline in several different grades based on the octane rating because higher octane ratings are suitable for higher compression engines. Gasoline must not be contaminated with dirt or water, and the actual performance of the fuel must be close to its octane rating. A shipment of low-grade gasoline graded as 87 octane that is free of water or other contaminants would be of high quality, while a shipment of high-grade 93 octane gas that is contaminated with dirt would be of low quality.

Example: Quality of Furniture Packing

John has antique furniture in excellent condition that was left to him by his grandmother. The pieces are important to John for sentimental reasons, and they are valuable. John decides to hire movers (high-grade professionals) to load his furniture into the truck using appropriate padding and restraints to prevent dents and scratches during the move. John's standard for high quality is that no observable damage occurs to his large pieces of furniture, especially the antiques. If the furniture arrives in his new apartment without a single dent, scratch, or other damage, the activity will be of high quality. John's standard for packing his kitchen is lower. His dishes are old and cheap, so he decides to trust his inexperienced friends (low-grade amateurs) to help him pack his kitchen. If a few of the dishes or glassware are chipped or broken in the process, the savings in labour cost will more than make up for the loss and will be a good value.

Statistics

Determining how well products meet grade requirements is done by taking measurements and then interpreting those measurements. **Statistics**—the mathematical interpretation of numerical data—are useful when interpreting large numbers of measurements and are used to determine how well the product meets a specification when the same product is made repeatedly. Measurements made on samples of the product must be within **control limits**—the upper and lower extremes of allowable variation—and it is up to management to design a process that will consistently produce products between those limits.

Instructional designers often use statistics to determine the quality of their course designs. Student assessments are one way in which instructional designers are able to tell whether learning occurs within the control limits.

Example: Setting Control Limits

A petroleum refinery produces large quantities of fuel in several grades. Samples of the fuels are extracted and measured at regular intervals. If a fuel is supposed to have an 87 octane performance, samples of the fuel should produce test results that are close to that value. Many of the samples will have scores that are different from 87. The differences are due to random factors that are difficult or expensive to control. Most of the samples should be close to the 87 rating and none of them should be too far off. The manufacturer has grades of 85 and 89, so they decide that none of the samples of the 87 octane fuel should be less than 86 or higher than 88.

If a process is designed to produce a product of a certain size or other measured characteristic, it is impossible to control all the small factors that can cause the product to differ slightly from the desired measurement. Some of these factors will produce products that have measurements that are larger than desired and some will have the opposite effect. If several random factors are affecting the process, they tend to offset each other, and the most common results are near the middle of the range; this phenomenon is called the **central limit theorem**.

If the range of possible measurement values is divided equally into subdivisions called **bins**, the measurements can be sorted, and the number of measurements that fall into each bin can be counted. The result is a **frequency distribution** that shows how many measurements fall into each bin. If the effects that are causing the differences are random and tend to offset each other, the frequency distribution is called a **normal distribution**, which resembles the shape of a bell with edges that flare out. The edges of a theoretical normal distribution curve get very close to zero but do not reach zero.

Example: Normal Distribution

A refinery's quality control manager measures many samples of 87 octane gasoline, sorts the measurements by their octane rating into bins that are 0.1 octane wide, and then counts the number of measurements in each bin. Then she creates a frequency distribution chart of the data, as shown in Figure 14.1.

It is common to take **samples—**randomly selected subsets from the total population—and measure and compare their qualities, since measuring the entire population would be cumbersome, if not impossible. If the sample measurements are distributed equally above and below the centre of the distribution as they are in Figure 14.1, the average of those measurements is also the centre value that is called the *mean*, and is represented in formulas by the lowercase Greek letter μ (pronounced mu). The amount of difference of the measurements from the central value is called the *sample standard deviation* or just the *standard deviation*.

The first step in calculating the standard deviation is subtracting each measurement from the central value (mean) and then squaring that difference. (Recall from your mathematics courses that squaring a number is multiplying it by itself and that the result is always positive.) The next step is to sum these squared values and divide by the number of values minus one. The last step is to take the square root. The result can be thought of as an average difference. (If you had used the usual method of taking an average, the positive and negative numbers would have summed to zero.) Mathematicians represent the standard deviation with the lowercase Greek letter σ (pronounced sigma). If all the elements of a group are measured, instead of just a sample, it is called the standard deviation of the population and in the second step, the sum of the squared values is divided by the total number of values.

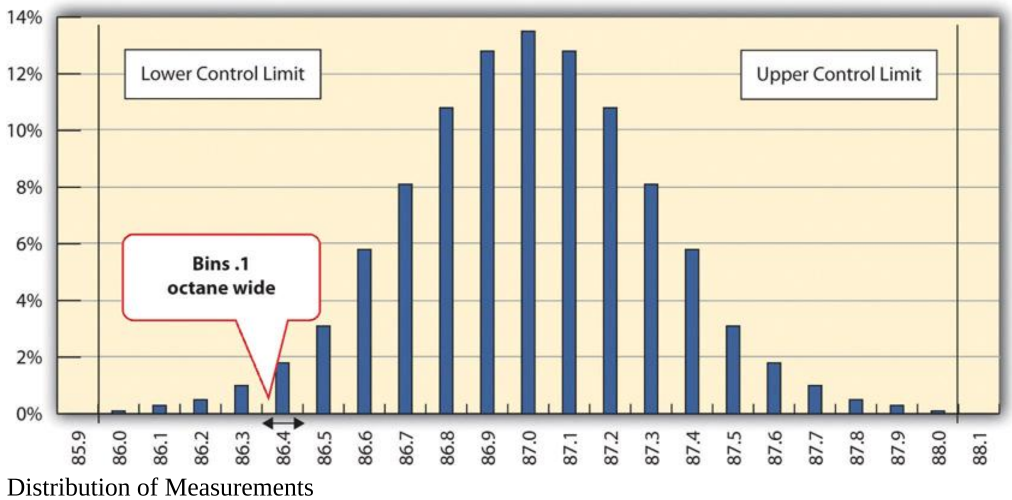

Figure 14.1 Normal Distribution of Measurements

Figure 14.1 shows that the most common measurements of octane rating are close to 87 and that the other measurements are distributed equally above and below 87. The shape of the distribution chart supports the central limit theorem's assumption that the factors that are affecting the octane rating are random and tend to offset each other, which is indicated by the symmetric shape. This distribution is a classic example of a *normal distribution*. The quality control manager notices that none of the measurements are above 88 or below 86 so they are within control limits, and she concludes that the process is working satisfactorily.

Example: Standard Deviation of Gasoline Samples

The refinery's quality control manager uses the standard deviation function in her spreadsheet program to find the standard deviation of the sample measurements and finds that for her data, the standard deviation is 0.3 octane. She marks the range on the frequency distribution chart to show the values that fall within one sigma (standard deviation) on either side of the mean (Figure 14.2).

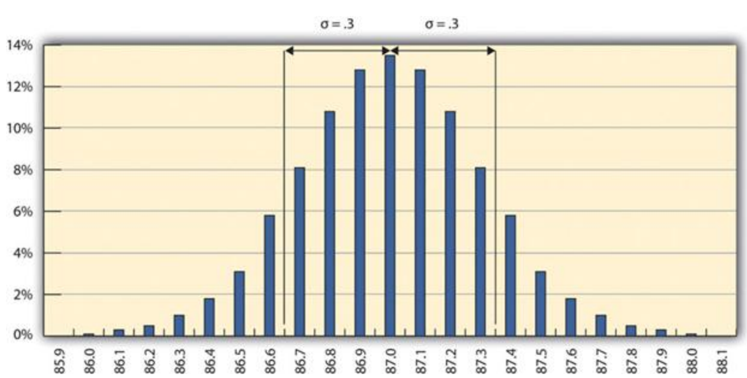

Figure 14.2: One Sigma Range. Most of the measurements are within 0.3 octane of 87.

For normal distributions, about 68.3% of the measurements fall within one standard deviation on either side of the mean. This is a useful rule of thumb for analyzing some types of data. If the variation between measurements is caused by random factors that result in a normal distribution, and someone tells you the mean and the standard deviation, you know that a little over two-thirds of the measurements are within a standard deviation on either side of the mean. Because of the shape of the curve, the number of measurements within two standard deviations is 95.4%, and the number of measurements within three standard deviations is 99.7%. For example, if someone said the average (mean) height for adult men in the United States is 178 cm (70 inches) and the standard deviation is about 8 cm (3 inches), you would know that 68% of the men in the United States are between 170 cm (67 inches) and 186 cm (73 inches) in height. You would also know that about 95% of the adult men in the United States were between 162 cm (64 inches) and 194 cm (76 inches) tall, and that almost all of them (99.7%) are between 154 cm (61 inches) and 202 cm (79 inches) tall. These figures are referred to as the **68-95-99.7** rule.

Example: Gasoline within Three Standard Deviations

The refinery's quality control manager marks the ranges included within two and three standard deviations, as shown in Figure 14.3. Some products must have less variability than others to meet their purpose. For example, if training designed to operate highly specialized and potentially dangerous machinery was assessed for quality, most participants would be expected to exceed the acceptable pass rate. Three standard deviations from the control limits might be fine for some products but not for others. In general, if the mean is six standard deviations from both control limits, the likelihood of a part exceeding the control limits from random variation is practically zero (2 in 1,000,000,000).

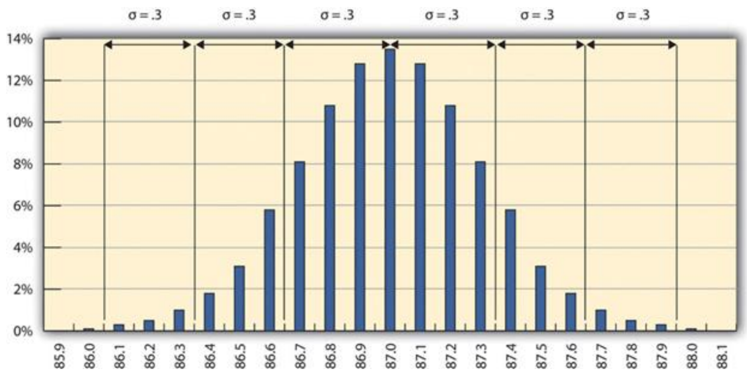

Figure 14.3 The 68-95-99.7 Rule

Example: A Step Project Improves Quality of Gasoline

A new refinery process is installed that produces fuels with less variability. The refinery's quality control manager takes a new set of samples and charts a new frequency distribution diagram, as shown in Figure 14.4. The refinery's quality control manager calculates that the new standard deviation is 0.2 octane. From this, she can use the 68-95-99.7 rule to estimate that 68.3% of the fuel produced will be between 86.8 and 87.2 and that 99.7% will be between 86.4 and 87.6 octane. A shorthand way of describing this amount of control is to say that it is a five-sigma production system, which refers to the five standard deviations between the mean and the control limit on each side.

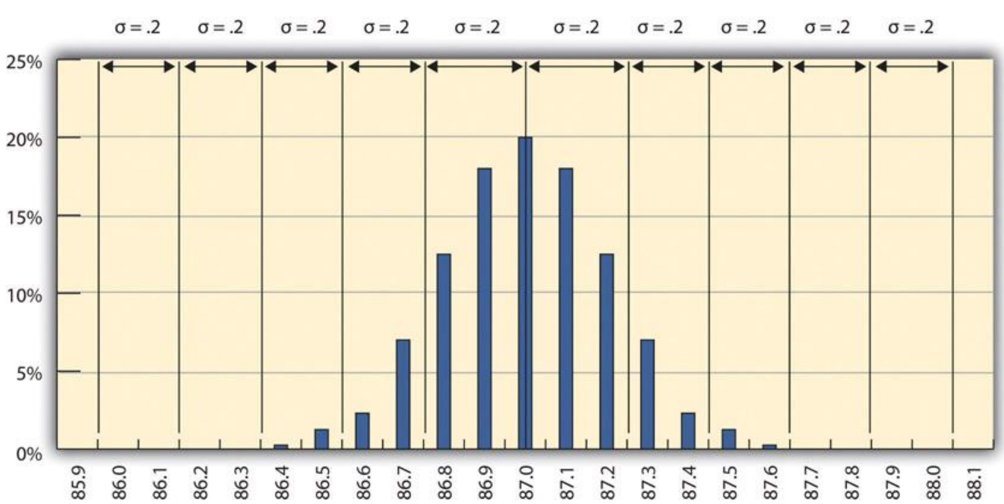

Figure 14.4 Smaller Standard Deviation

Quality planning tools

High quality is achieved by planning for it rather than by reacting to problems after they are identified. Standards are chosen and processes are put in place to achieve those standards.

Measurement Terminology

During the execution phase of the project, services and products are sampled and measured to determine if the quality is within control limits for the requirements and to analyze causes for variations. This evaluation is often done by a separate quality control group, and knowledge of a few process measurement terms is necessary to understand their reports. Several of these terms are similar, and it is valuable to know the distinction between them.

The quality plan specifies the control limits of the product or process; the size of the range between those limits is the tolerance. **Tolerances**are often written as the mean value, plus or minus the tolerance. The plus and minus signs are written together, ±.

> Example: Tolerance in Gasoline Production

The petroleum refinery chose to set its control limits for 87 octane gasoline at 86 and 88 octane. The tolerance is 87 ± 1.

Tools are selected that can measure the samples closely enough to determine if the measurements are within control limits and if they are showing a trend. Each measurement tool has its own tolerances.

The choice of tolerance directly affects the cost of quality (COQ). In general, it costs more to produce and measure products that have small tolerances. The costs associated with making products with small tolerances for variation can be very high and not proportional to the gains. For example, if the cost of evaluating each screen as it is created in an online tutorial is greater than delivering the product and fixing any issues after the fact, then the COQ may be too high and the instructional designer will tolerate more defects in the design.

Defining and Meeting Client Expectations

Clients provide specifications for the project that must be met for the project to be successful. Recall that meeting project specifications is one definition of project success. Clients often have expectations that are more difficult to capture in a written specification. For example, one client will want to be invited to every meeting of the project and will then select the ones that seem most relevant. Another client will want to be invited only to project meetings that need client input. Inviting this client to every meeting will cause unnecessary frustration. Listening to the client and developing an understanding of the expectations that are not easily captured in specifications is important to meeting those expectations.

Project surveys can capture how the client perceives the project performance and provide the project team with data that are useful in meeting client expectations. If the results of the surveys indicate that the client is not pleased with some aspect of the project, the project team has the opportunity to explore the reasons for this perception with the client and develop recovery plans. The survey can also help define what is going well and what needs improvement.

Sources of Planning Information

Planning for quality is part of the initial planning process. The early scope, budget, and schedule estimates are used to identify processes, services, or products where the expected grade and quality should be specified. Risk analysis is used to determine which of the risks to the project could affect quality.

Techniques

Several different tools and techniques are available for planning and controlling the quality of a project. The extent to which these tools are used is determined by the project complexity and the quality management program in use by the client.

The following represents the quality planning tools available to the project manager.

- **Cost-benefit analysis** is looking at how much your quality activities will cost versus how much you will gain from doing them. The costs are easy to measure; the effort and resources it takes to do them are just like any other task on your schedule. Since quality activities don't actually produce a product, it is sometimes harder for people to measure the benefit. The main benefits are less reworking, higher productivity and efficiency, and more satisfaction from both the team and the customer.

- **Benchmarking** means using the results of quality planning on other projects to set goals for your own. You might find that the last project in your company had 20% fewer defects than the one before it. You should want to learn from a project like that and put in practice any of the ideas they used to make such a great improvement. Benchmarks can give you some reference points for judging your own project before you even start the work.
- **Design of experiments** is the list of all the kinds of tests you are going to run on your product. It might list all the kinds of test procedures you'll do, the approaches you'll take, and even the tests themselves. (In the software world, this is called *test planning*.)
- **Cost of quality** is what you get when you add up the cost of all the prevention and inspection activities you are going to do on your project. It doesn't just include the testing. It includes any time spent writing standards, reviewing documents, meeting to analyze the root causes of defects, reworking to fix the defects once they're found by the team: in other words, absolutely everything you do to ensure quality on the project. Cost of quality can be a good number to check to determine whether your project is doing well or having trouble. Say your company tracks the cost of quality on all of its projects; then you could tell if you are spending more or less than has been spent on other projects to get your project up to quality standards.
- **Control charts** can be used to define acceptable limits. If some of the functions of a project are repetitive, statistical process controls can be used to identify trends and keep the processes within control limits. Part of the planning for controlling the quality of repetitive processes is to determine what the control limits are and how the process will be sampled.
- **Cause-and-effect diagrams** can help in discovering problems. When control charts indicate an assignable cause for a variation, it is not always easy to identify the cause of a problem. Discussions that are intended to discover the cause can be facilitated using a cause-and-effect or **fishbone diagram** where participants are encouraged to identify possible causes of a defect.

Example: Diagramming Quality Problems

A small manufacturing firm tries to identify the assignable causes to variations in its manufacturing line. They assemble a team that identifies six possibilities:

- Low-quality raw materials
- Power fluctuation
- Ambient temperature
- Worker absenteeism
- Poor training
- Old equipment

Each of these possibilities are organized into a fishbone diagram in Figure 14.5:

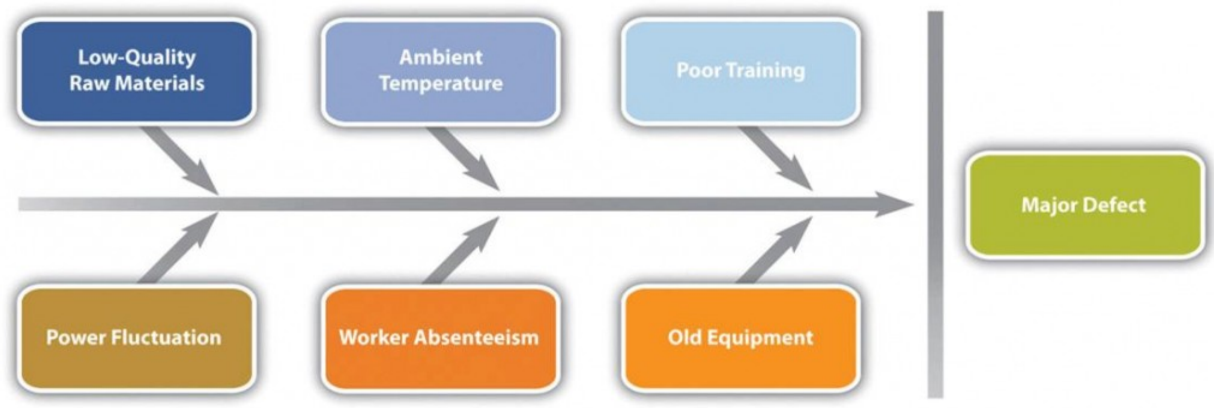

Figure 14.5

Cause-and-Effect (Fishbone) Diagram

Each branch of the diagram can be expanded to break down a category into more specific items. An engineer and an electrician work on one of the branches to consider possible causes of power fluctuation. They identify:

- Utility reliability
- Personal space heaters and large motor start up leading to over loaded circuits
- Lighting

Those items are added to their part of the fishbone diagram, as shown in Figure 14.6.

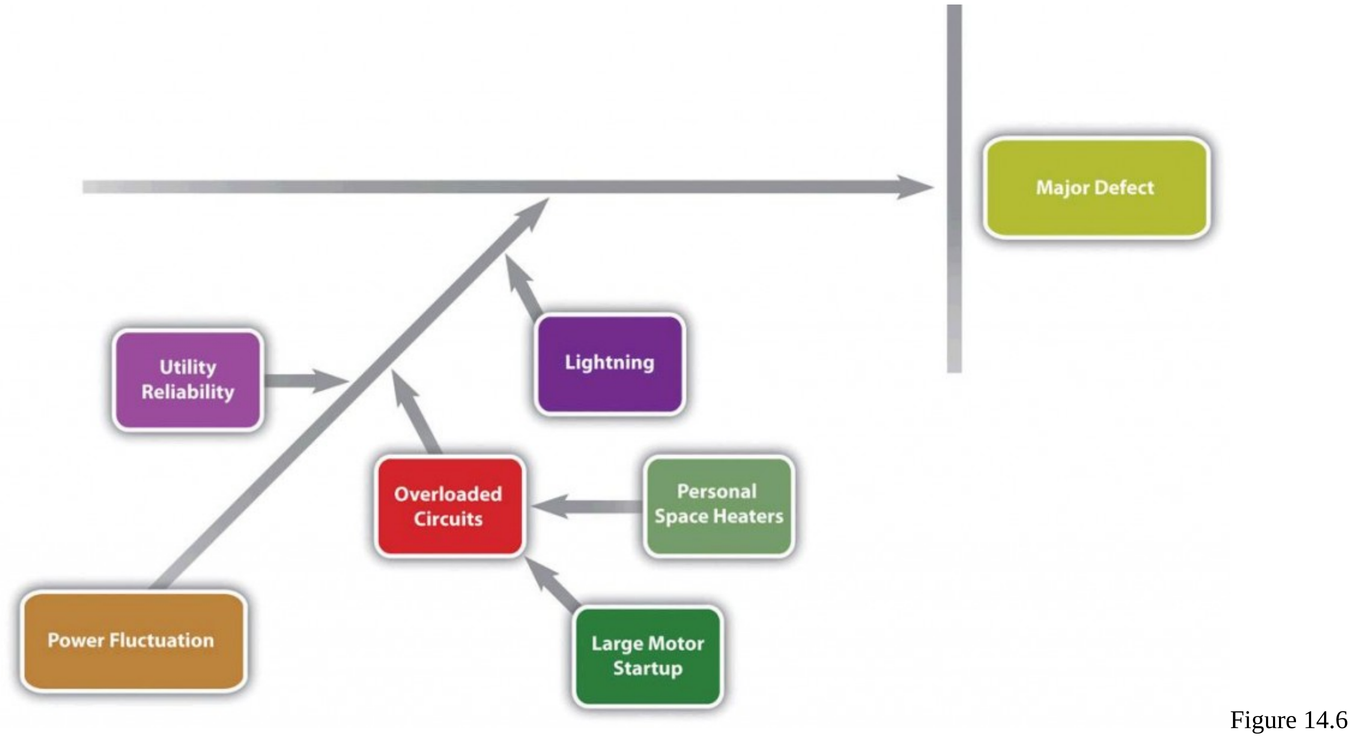

Figure 14.6

Possible Causes of Power Fluctuation

Check sheets, histograms, and Pareto charts are used to solve several quality problems. When a quality-control issue occurs, a project manager must choose which problem to address first. One way to prioritize quality problems is to determine which ones occur most frequently. These data can be collected using a **check sheet**, which is a basic form on which the user can make a check in the appropriate box each time a problem occurs or by automating the data collection process using the appropriate technology. Once the data are collected, they can be analyzed by creating a type of frequency distribution chart called a **histogram**. A true histogram is a column chart where the widths of the columns fill the available space on the *x*-axis axis and are proportional to the category values displayed on that axis, while the height of the columns is proportional to the frequency of occurrences. Most histograms use one width of column to represent a category, while the vertical axis represents the frequency of occurrences.

A variation on the histogram is a frequency distribution chart invented by economist Vilfredo Pareto known as a **Pareto chart**, in which the columns are arranged in decreasing order with the most common on the left and a line added that shows the cumulative total. The combination of columns and a line allows the user to tell at a glance which problems are most frequent and what fraction of the total they represent.

Once you have your quality plan, you know your guidelines for managing quality on the project. Your strategies for monitoring project quality should be included in the plan, as well as the reasons for all the steps you are taking. It's important that everyone on the team understand the rationale behind the metrics being used to judge success or failure of the project.

Quality Assurance

The purpose of quality assurance is to create confidence that the quality plan and controls are working properly. Time must be allocated to review the original quality plan and compare that plan to how quality is being ensured during the implementation of the project.

Process Analysis

The flowcharts of quality processes are compared to the processes followed during actual operations. If the plan was not followed, the process is analyzed and corrective action taken. The corrective action could be to educate the people involved on how to follow the quality plan, or it could be to revise the plan.

The experiments that sample products and processes and collect data are examined to see if they are following statistically valid sampling techniques and that the measurement methods have small enough tolerances to detect variation within control limits.

Because projects are temporary, there are fewer opportunities to learn and improve within a project, especially if it has a short duration. But even in short projects, the quality manager should have a way to learn from experience and change the process for the next project of a similar complexity profile.

Example: Analyzing Quality Processes in Safety Training

A technical college responsible for training employees in safe plant practices evaluates its instructor selection process at the end of the training to see if it had the best criteria for selection. For example, it required the instructors to have master's degrees in manufacturing to qualify as college instructors. The college used an exit survey of the students to ask what they thought would improve the instruction of future classes on this topic. Some students felt that it would be more important to require that the instructors have more years of training experience, while others recommended that instructors seek certification at a training centre. The college considered these suggestions and decided to retain its requirement of a master's degree but add a requirement that instructors be certified in plant safety.

The purpose of quality assurance is to build confidence in the client that quality standards and procedures are being followed. This is done by an internal review of the plan, testing, and revisions policies or by an audit of the same items performed by an external group or agency.

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9.2.10: Project Implementation Overview

After you have carefully planned your project, you will be ready to start the project implementation phase, the third phase of the project management life cycle. The implementation phase involves putting the project plan into action. It's here that the project manager will coordinate and direct project resources to meet the objectives of the project plan. As the project unfolds, it's the project manager's job to direct and manage each activity, every step of the way. That's what happens in the implementation phase of the project life cycle: you follow the plan you've put together and handle any problems that come up.

The implementation phase is where you and your project team actually do the project work to produce the deliverables. The word "deliverable" means anything your project delivers. The deliverables for your project include all of the products or services that you and your team are performing for the client, customer, or sponsor, including all the project management documents that you put together.

The steps undertaken to build each deliverable will vary depending on the type of project you are undertaking, and cannot therefore be described here in any real detail. For instance engineering and telecommunications projects will focus on using equipment, resources, and materials to construct each project deliverable, whereas computer software projects may require the development and implementation of software code routines to produce each project deliverable. The activities required to build each deliverable will be clearly specified within the project requirements document and project plan.

Your job as project manager is to direct the work, but you need to do more than deliver the results. You also need to keep track of how well your team performs. The implementation phase keeps the project plan on track with careful monitoring and control processes to ensure the final deliverable meets the acceptance criteria set by the customer. This phase is typically where approved changes are implemented.

Most often, changes are identified by looking at performance and quality control data. Routine performance and quality control measurements should be evaluated on a regular basis throughout the implementation phase. Gathering reports on those measurements will help you determine where the problem is and recommend changes to fix it.

Change Control

When you find a problem, you can't just make a change, because it may be too expensive or take too long to do. You will need to look at how it affects the triple constraint (time, cost, scope) and how it impacts project quality. You will then have to figure out if it is worth making the change. If you evaluate the impact of the change and find that it won't have an impact on the project triple constraint, then you can make the change without going through change control. Change control is a set of procedures that lets you make changes in an organized way.

Any time you need to make a change to your plan, you must start with a change request. This is a document that either you or the person making the request must complete. Any change to your project must be documented so you can figure out what needs to be done, by when, and by whom.

Once the change request is documented, it is submitted to a change control board. A change control board is a group of people who consider changes for approval. Not every change control system has a board but most do. The change request could also be submitted to the project sponsor or management for review and approval. Putting the recommended changes through change control will help you evaluate the impact and update all the necessary documents. Not all changes are approved, but if the changes are approved, you send them back to the team to put them in place.

The implementation phase uses the most project time and resources, and as a result, costs are usually the highest during this phase. Project managers also experience the greatest conflicts over schedules in this phase. You may find as you are monitoring your project that the actual time it is taking to do the scheduled work is longer than the amount of time planned.

When you absolutely have to meet the date and you are running behind, you can sometimes find ways to do activities more quickly by adding more resources to critical path tasks. That's called *crashing*. Crashing the schedule means adding resources or moving them around to to bring the project back into line with the schedule. Crashing **always** costs more and doesn't always work. There's no way to crash a schedule without raising the overall cost of the project. So, if the budget is fixed and you don't have any extra money to spend, you can't use this technique.

Sometimes you've got two activities planned to occur in sequence, but you can actually do them at the same time. This is called *fast tracking* the project. On a software project, you might do both your user acceptance testing (UAT) and your functional testing at the same time, for example. This is pretty risky. There's a good chance you might need to redo some of the work you have done concurrently. Crashing and fast tracking are schedule compression tools. Managing a schedule change means keeping all of your schedule documents up to date. That way, you will always be comparing your results to the correct plan.

After the deliverables have been physically constructed and accepted by the customer, a phase review is carried out to determine whether the project is complete and ready for closure.

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9.2.11: Project Completion

Every project needs to end and that's what project completion is all about in the last phase of the project life cycle. The whole point of the project is to deliver what you promised. By delivering everything you said you would, you make sure that all stakeholders are satisfied and all acceptance criteria have been met. Once that happens, your project can end.

Project completion is often the most neglected phase of the project life cycle. Once the project is over, it's easy to pack things up, throw some files in a drawer, and start moving right into the initiation phase of the next project. Hold on. You're not done yet.

The key activities in project completion are gathering project records; disseminating information to formalize acceptance of the product, service, or project; and performing project closure. As the project manager, you will need to review project documents to make certain they are up-to-date. For example, perhaps some scope change requests were implemented that changed some of the characteristics of the final product. The project information you are collecting during this phase should reflect the characteristics and specifications of the final product. Don't forget to update your resource assignments as well. Some team members will have come and gone over the course of the project. You need to double-check that all the resources and their roles and responsibilities are noted.

Once the project outcomes are documented, you'll request formal acceptance from the stakeholders or customer. They're interested in knowing if the product or service of the project meets the objectives the project set out to accomplish. If your documentation is up-to-date, you'll have the project results at hand to share with them.

Contract Closure

Contracts come to a close just as projects come to a close. Contract closure is concerned with completing and settling the terms of the contracts let for the project. It supports the project completion process because the contract closure process determines if the work described in the contracts was completed accurately and satisfactorily. Keep in mind that not all projects are performed under contract so not all projects require the contract closure process. Obviously, this process applies only to those phases, deliverables, or portions of the project that were performed under contract.

Contract closure updates the project records, detailing the final results of the work on the project. Contracts may have specific terms or conditions for completion. You should be aware of these terms or conditions so that project completion isn't held up because you missed an important detail. If you are administering the contract yourself, be sure to ask your procurement department if there are any special conditions that you should be aware of so that your project team doesn't inadvertently delay contract project closure.

One of the purposes of the contract closure process is to provide formal notice to the seller, usually in written form, that the deliverables are acceptable and satisfactory or have been rejected. If the product or service does not meet the expectations, the vendor will need to correct the problems before you issue a formal acceptance notice. Before the contract is closed, any minor items that need to be repaired or completed are placed on a *punch list*, which is a list of all the items found by the client or team or manager that still remain to be done. Hopefully, quality audits have been performed during the course of the project, and the vendor was given the opportunity to make corrections earlier in the process than the closing phase. It's not a good idea to wait until the very end of the project and then spring all the problems and issues on the vendor at once. It's much more efficient to discuss problems with your vendor as the project progresses because it provides the opportunity for correction when the problems occur.

The project team will then work on all of the items on the punch list, building a small schedule to complete the remaining work. If the number of items on the punch list is too large or the amount of work is significant, the project team continues to work on the project. Once the punch list becomes smaller, the project manager begins closing down the project, maintaining only enough staff and equipment to support the team that is working on the punch list.

If the product or service does meet the project's expectations and is acceptable, formal written notice to the seller is required, indicating that the contract is complete. This is the formal acceptance and closure of the contract. It's your responsibility as the project manager to document the formal acceptance of the contract. Many times the provisions for formalizing acceptance and closing the contract are spelled out in the contract itself.

If you have a procurement department handling the contract administration, they will expect you to inform them when the contract is complete and will in turn follow the formal procedures to let the seller know the contract is complete. However, you will still note the contract completion in your copy of the project records.

Releasing the Project Team

Releasing project team members is not an official process. However, it should be noted that at the conclusion of the project, you will release your project team members, and they will go back to their functional managers or get assigned to a new project. You will want to keep their managers, or other project managers, informed as you get closer to project completion, so that they have time to adequately plan for the return of their employees. Let them know a few months ahead of time what the schedule looks like and how soon they can plan on using their employees on new projects. This gives the other managers the ability to start planning activities and scheduling activity dates.

Final Payments

The final payment is usually more than a simple percentage of the work that remains to be completed. Completing the project might involve fixing the most difficult problems that are disproportionately expensive to solve, so the final payment should be large enough to motivate the vendor to give the project a high priority so that the project can be completed on time.

If the supplier has met all the contractual obligations, including fixing problems and making repairs as noted on a punch list, the project team signs off on the contract and submits it to the accounting department for final payment. The supplier is notified that the last payment is final and completes the contractual agreement with the project.

Post-Project Evaluations

Before the team is dissolved and begins to focus on the next project, a review is conducted to capture the lessons that can be learned from this project, often called a **lessons-learned meeting** or document. The team explores what went well and captures the processes to understand why they went well. The team asks if the process is transferable to other projects. The team also explores what did not go well and what people learned from the experience. The process is not to find blame, but to learn.

Quality management is a process of continual improvement that includes learning from past projects and making changes to improve the next project. This process is documented as evidence that quality management practices are in use. Some organizations have formal processes for changing work processes and integrating the lessons learned from the project so other projects can benefit. Some organizations are less formal in the approach and expect individuals to learn from the experience and take the experience to their next project and share what they learned with others in an informal way. Whatever type of approach is used, the following elements should be evaluated and the results summarized in reports for external and internal use.

Trust and Alignment Effectiveness

The project leadership reviews the effect of trust—or lack of trust—on the project and the effectiveness of alignment meetings at building trust. The team determines which problems might have been foreseen and mitigated and which ones could not have been reasonably predicted. What were the cues that were missed by the team that indicated a problem was emerging? What could the team have done to better predict and prevent trust issues?

Schedule and Budget Management

The original schedule of activities and the network diagram are compared to the actual schedule of events. Events that caused changes to the schedule are reviewed to see how the use of contingency reserves and float mitigated the disruption caused by those events. The original estimates of contingency time are reviewed to determine if they were adequate and if the estimates of duration and float were accurate. These activities are necessary for the project team to develop expertise in estimating schedule elements in future projects—they are not used to place blame.

A review of budget estimates for the cost of work scheduled is compared to the actual costs. If the estimates are frequently different from the actual costs, the choice of estimating method is reviewed.

Risk Mitigation

After the project is finished, the estimates of risk can be reviewed and compared to the events that actually took place. Did events occur that were unforeseen? What cues existed that may have allowed the team to predict these events? Was the project contingency sufficient to cover unforeseen risks? Even if nothing went wrong on this project, it is not proof that risk mitigation was a waste of money, but it is useful to compare the cost of avoiding risk versus the cost of unexpected events to understand how much it cost to avoid risk.

Procurement Contracts

The performance of suppliers and vendors is reviewed to determine if they should still be included in the list of qualified suppliers or vendors. The choice of contract for each is reviewed to determine if the decision to share risk was justified and if the choice of incentives worked.

Customer Satisfaction

Relationships with the client are reviewed and decisions about including the client in project decisions and alignment meetings are discussed. The client is given the opportunity to express satisfaction and identify areas in which project communication and other factors could be improved. Often a senior manager from the organization interviews the client to develop feedback on the project team performance.

A general report that provides an overview of the project is created to provide stakeholders with a summary of the project. The report includes the original goals and objectives and statements that show how the project met those goals and objectives. Performance on the schedule and budget are summarized and an assessment of client satisfaction is provided. A version of this report can be provided to the client as a stakeholder and as another means for deriving feedback.

Senior Management

The report to senior management contains all the information provided to the stakeholders in a short executive summary. The report identifies practices and processes that could be improved or lessons that were learned that could be useful on future projects.

Archiving of Document

The documents associated with the project must be stored in a safe location where they can be retrieved for future reference. Signed contracts or other documents that might be used in tax reviews or lawsuits must be stored. Organizations will have legal document storage and retrieval policies that apply to project documents and must be followed. Some project documents can be stored electronically.

Care should be taken to store documents in a form that can be recovered easily. If the documents are stored electronically, standard naming conventions should be used so documents can be sorted and grouped by name. If documents are stored in paper form, the expiration date of the documents should be determined so they can be destroyed at some point in the future. The following are documents that are typically archived:

- Charter documents
- Scope statement
- Original budget
- Change documents
- DPCI ratings
- Manager's summary—lessons learned
- Final DPCI rating

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