CHAPTER

6

HIT ARCHITECTURE AND INFRASTRUCTURE

Learning Objectives

1. Define and use in context the technical terms related to information technology architecture.
2. Distinguish between the hardware and software elements of an information system, and provide illustrative examples.
3. Identify the elements of a computer network, and give examples of various network structures.
4. Distinguish among operating systems, utility programs, and application software.
5. Discuss basic telecommunication concepts.

Overview

As many healthcare executives will happily attest, managing information resources and using information effectively do not require an in-depth knowledge of computer technology. However, managers and leaders in information-intensive organizations do need a basic understanding of the physical and logical structures of information systems and their various components. Such an understanding is of particular importance when the manager is part of a cross-disciplinary team—along with physicians and other clinicians, financial experts, and technology specialists—charged with the responsibility for defining the health enterprise information system needs, negotiating system contracts, or implementing new applications to support patient care and business operations. To be an effective member of this team, the manager must not be intimidated by technical computing concepts or technology jargon. At a minimum, broad-based knowledge about the various hardware and software elements of an information system as well as system design and configuration principles is needed. As done for any other investment decision, thoughtful, knowledge-based consideration must be given to selecting the physical components of the enterprise information system.

The physical components and devices configured into an information system are known collectively as *hardware*. Computer hardware spans incredibly broad spectrums of size and function. Some devices are small enough to be held in and manipulated with one hand and may be used for data capture or for data processing. A large segment of the general population enjoys personal computing with such devices as notebook or desktop computers and even multifunction telephones, and these products have applications in healthcare organizations as well. Many diagnostic machines are computers that analyze clinical samples, process data, and produce reports. At the upper extreme of the spectra are large and powerful supercomputers. Size, function, and sophistication of data-storage devices vary—from thumb drives (which can be smaller than an adult's thumb) to high-resolution, high-volume storage for diagnostic images. In addition to the plethora of products and devices currently available, computer hardware technology changes at such a rapid pace that keeping up with cutting-edge technology is difficult even for the information systems specialist, let alone the healthcare manager.

Computer hardware is useless without programming or application software, which provides the device's functionality. Applications to support healthcare enterprise computing are addressed later in the chapter. A key point for this chapter is that software and hardware decisions must be made in tandem; one cannot be considered independently of the other. Healthcare managers need an understanding of basic software concepts to be knowledgeable participants in the complex processes of selecting, implementing, and testing software to maximize the value of their healthcare information technology (HIT) investments. Knowledge needs include an understanding of the functionality of clinical, business, and communication application software; an awareness of the distinction between integrated and interfaced systems; a recognition of the role of system management software; and a general comprehension about programming languages and language translators.

This chapter discusses the devices, programs, and communication networks that combine to form a computer-based information system. This is not an exhaustive treatment comparable with that found in computer science texts. Rather, this is an overview that provides the healthcare manager with appropriate background knowledge to understand the various elements of an information system and how they may be configured to achieve desired functionality to support the enterprise's clinical service delivery and associated business processes. The fundamentals discussed in this chapter are designed to make the manager feel comfortable participating in the selection, implementation, and evaluation of HIT systems.

Computer Hardware

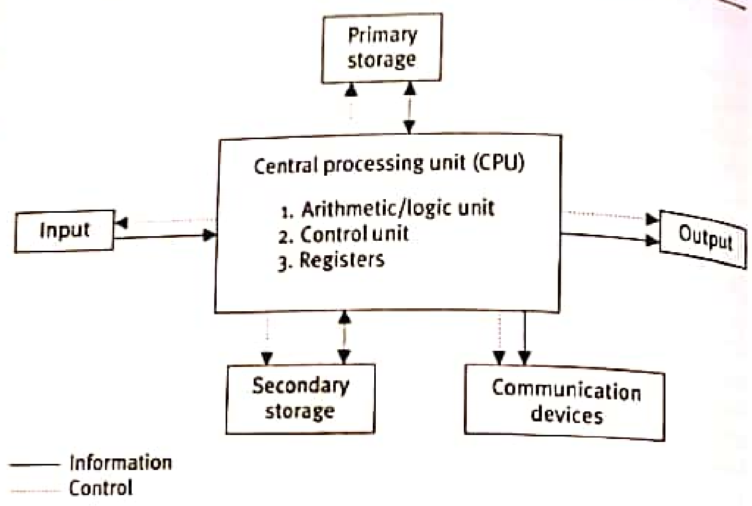
A *computer* is an electronic, digital device characterized by its ability to store a set of instructions—known as a *program*, and the data on which the instructions will operate. The Electronic Numerical Integrator and Calculator (ENIAC), completed in 1946 at the University of Pennsylvania, Philadelphia, was the first computing device built in the United States (Rosen 1969). ENIAC launched what has since become known as the first generation of computer hardware, consisting of devices that used vacuum tubes. Today, the computer world has evolved to the fourth generation of hardware, which employs microprocessor technology, and is exploring the fifth generation of parallel processing and artificial intelligence. One impressive facet of this evolution has been that, as technical capacity has increased, the size of the processor has decreased. Fortunately, mass production has reduced the cost of personal computing devices for public purchase. In a span of about 30 years, ENIAC's enormous vacuum tubes gave way to the second and third computer generations' transistors and integrated circuitry and then to the presently employed microprocessor (microchip). A user can now hold in one hand a device that has more computing power than did early computers that required a large, controlled-environment room. Further, that small device is so easy to use, children as young as four or five quickly learn to manipulate the device and use it as a toy or as a tool. Since the advent of microprocessing technology in the early 1970s, computers have become omnipresent in society, enjoyed both for entertainment and work. In fact, a large segment of the current workforce has no memory of life or work without computers.

Although this hardware evolution has been impressive in terms of design and functionality, the basic schematic of a computer remains the same. Exhibit 6.1 depicts the six major components of a computer system. Simplistically, a computing system comprises the central processing unit, primary storage, secondary storage, input devices, output devices, and communications devices. The communications devices create connections that enable the computer to interact with other computers, either within or outside the organization. The ability to connect multiple devices that work collaboratively to complete a work process gives rise to the concepts of networking and telecommunications.

Central Processing Unit

The central processing unit (CPU), where the actual "computing" takes place, consists of three major subcomponents: the arithmetic/logic unit (ALU), the control unit, and the registers. The speed and power of the CPU greatly influence the computer's capabilities. As noted previously, each generation of computer technology has increased the processing capability but

EXHIBIT 6.1
Major Components of a Computer System



reduced the size of the processing component. An important by-product of processor evolution has been the increased speed of processing.

The basic computational and comparison capabilities of the computer lie in the ALU, which has the ability to perform arithmetic functions at high speeds. The ALU also can perform the logical operation of comparison of both numeric and character (nonnumeric) data. The ALU's speed is an important performance characteristic, particularly in applications that involve a large number of arithmetic operations. Examples of such applications include image processing, interpretation of electrocardiogram (EKG) data, and statistical analysis of very large sets of data.

Processing instructions are communicated to the CPU in a structured language, which has evolved over time from binary code (0, 1) to instructions resembling spoken language. However, no matter what programming language is used to communicate a problem to the computer, the problem description ultimately is converted to a series of binary machine instructions stored in primary storage. The control unit orchestrates the sequential processing of these machine instructions by coordinating retrieval of the data to be manipulated, retrieval and application of processing instructions, and storage and/or output of the results.

When program instructions or data are transferred from primary storage to the CPU for processing, they are held in a high-speed memory area within the CPU known as *registers*. Enhancing the computer's performance is

possible by increasing the number of operations performed within the CPU's registers and minimizing the number of accesses to data stored in memory.

Primary Storage

Primary storage refers to "internal" memory, where data to be processed are stored for access by the CPU. The capacity and speed of the primary storage greatly affect the computer system's performance, and, fortunately, the cost of this component has lessened greatly since the early designs. Read-only memory (ROM) is used to store sets of instructions for special tasks such as the computer start-up process. Data cannot be written to this storage area by the user, but the existing readable data are retained even when the machine is turned off.

Random access memory (RAM), the largest volume of the types of primary data storage, houses data and processing instructions in specified locations that can be accessed in any order (i.e., random access). The contents of RAM are volatile, meaning the data are deleted when the computer is powered off. Cache memory stores selected redundant data to be quickly accessible for high-speed processing. Although most cache storage is cleared when the computer is powered off, some data stored in cache for specific applications, or for data access tracking, may be retained. Users of personal computing devices may associate the need to "clear their cache" periodically with this concept.

Secondary Storage

It is not possible for a computer system to have sufficient primary storage to accommodate all the information maintained and used in the many healthcare information system applications required. In fact, few individuals are able to manage their personal computing needs with primary storage alone. Secondary storage devices include a variety of devices and media designed to maintain small or large quantities of data. The speed with which data are entered into and retrieved from secondary storage devices is an important specification within the overall system. However, the ability to ensure the security of these devices and media is of paramount importance.

Healthcare enterprises, and even individuals, need large capacity, nonvolatile storage media from which desired information can be obtained as necessary. Most personal computer (PC) users, as well as large information systems managers, employ a variety of storage media. The "best" medium is the one that meets the users' needs for access efficiency, data integrity, and security. Exhibit 6.2 provides a summary of commonly used secondary storage media and some key attributes of each.

Data and information storage poses several extremely important issues in healthcare information systems. Key among these issues are storage

EXHIBIT 6.2 Examples of Secondary Storage Media

Medium	Description	Advantage(s)	Disadvantage(s)
Magnetic tape	Data are recorded as magnetized "spots" on tape.	Large amounts of data can be stored at low cost; relatively stable medium	Older medium; slow speed; sequential access only
Magnetic disk	Data are recorded as magnetized spots on rigid (hard) or flexible (floppy) disks. Hard disks consist of stacks of "platters" sealed in dustproof cases and may be internal to the CPU or an external peripheral device. Floppy disks are small (3.5"), removable, and may zip files to increase storage capacity.	Hard disks can store large amount of data in small physical space; floppy disks are very inexpensive	Floppy disk storage volume is relatively small; disks are insecure and easily damaged or lost; medium is essentially obsolete
Optical disk	Data are burned onto a rigid plastic disk with a laser device. Examples include compact disk (CD) and digital versatile (or video) disk (DVD), both of which may be read-only recordable or rewritable.	Can store large amount of data on small disk; disks are inexpensive and convenient to use	Disks are easily damaged or lost; portable media pose security issues
Optical or laser card	This resembles a plastic credit card. Data are permanently written to card with laser, and data can be added, but not erased. It could be useful for personal health record.	Large memory capacity; permanent data storage	Requires special reader; easily lost; portable media pose security issues
Smart card	This resembles a plastic credit card but has embedded computer chip to store and process information.	Convenient; good memory capacity	Requires special reader; easily lost; portable media pose security issues
Portable hard drive	This is an external (peripheral) hard drive often used to back up data in other storage or to store digital photographs, music, or movies.	Available in many physical sizes and storage capacities; relatively inexpensive	Portable media pose security issues
USB flash drive (thumb drive)	This is a small circuit board encased in metal or plastic that interfaces with the computer via the USB port.	Very small, highly portable storage; inexpensive	Memory cells eventually fail; easily lost; portable media pose security issues

volume, physical security, disaster recovery, and expansion planning. These points are discussed briefly here, but the savvy manager will use a just-in-time approach to explore these issues in further detail when the need to apply these concepts is job-relevant.

Storage Volume

The actual secondary storage required for captured and archived data in a healthcare enterprise is massive, and the associated costs are a significant component of the total HIT cost equation. How much literal storage is required for a given application is dependent on the type(s) of data captured, access and retrieval requirements, retention requirements, and volume of data captured. For example, are data in text or nontext format? The size of image and other nontext files is a significant contributor to the total volume of archival storage space required, as nontext data require significantly more storage space than text data do (*Journal of AHIMA* 2011).

Many other questions must be posed to inform decisions about storage needs. For diagnostic images, how many procedures are performed in a year? How many years must original images be maintained? Must the diagnostic image and the clinical interpretation be maintained in the same "file"? Must previous diagnostic data be accessible for comparison with current diagnostic tests? Must the data be accessible in real time for an extended period, or can the data be archived quickly with minimal access requirements? These and other questions are paramount to establishing system data storage requirements.

In addition to nonvolatile storage options, cache storage requirements for components that store certain types of data, such as diagnostic images for viewing and interpretation, must be extensive to enable rapid retrieval of the stored files. When evaluating certain types of systems, cache capacity can become the determining factor in selecting one vendor product over another. For application-specific parameters, such as cache requirements for image viewing, including clinician users on the product evaluation and selection team is extremely important. If a technology solution does not produce quality data that can support clinical decision making, the solution is insufficient. With issues of clinical adequacy, patient safety, and patient satisfaction, product cost is rarely the deciding criterion.

Physical Security

The physical security of data and information storage is essential for compliance with regulatory and legal requirements. One of the most significant legal protections for health information generally, and electronic information specifically, is the Health Insurance Portability and Accountability Act (HIPAA) of 1996 (CMS n.d.[b]), and the modifications to HIPAA made via the Health Information Technology for Economic and Clinical Health

(HITECH) Act of 2009 (HHS n.d.[a]). The HIPAA Privacy Rule references personal health information (PHI), sometimes described as "protected health information" or "individually identifiable health information." PHI is defined as "individually identifiable health information held or transmitted . . . in any form or media, whether electronic, paper, or oral" (HHS n.d.[b]). Because a significant proportion of the data maintained by a healthcare enterprise is classed as PHI, compliance with these security regulations is not a trivial matter.

Disaster Recovery

Not only are healthcare enterprises accountable for protecting all medical and patient identification data maintained and used in the facility, they also must maintain a secure but accessible copy of these data in an off-site location in anticipation that information resources could be damaged or destroyed by a natural or man-made disaster. This obligation effectively doubles the secondary storage requirements mandated by the clinical and administrative operations of the enterprise. Disaster recovery plans and procedures for information resources are discussed in more detail in Chapter 3.

Expansion Planning

It is a certainty, equally as profound as death and taxes, that the required volume of data to be stored by healthcare enterprises will only increase. The corollary of that certainty is that data integrity and security requirements for archived PHI will not lessen. Technology capabilities will continue to evolve, the types of data that can be captured will expand, and the storage media employed will change. All of these changes will occur rapidly. A continuing challenge for information resource managers will be to ensure that previously archived data and information can be migrated to emerging storage media with no loss of data integrity.

Input Devices

The power of an information system can be realized only when data and programs have been entered for processing and information is generated for the user. A number of peripheral devices are available to facilitate the process of entering data into the computer in a variety of formats, including keyboard or touch-screen entry, optical scanning, and voice input. The field has progressed tremendously since the early days of computing, in which keypunched cards served as the exclusive input medium. System designers now select from multiple input options to meet the organization's needs for speed, accuracy, and cost-effectiveness for a given application. A selection of currently employed devices and techniques used to input data are reviewed in Exhibit 6.3.

EXHIBIT 6.3 Input Devices

Device	Description	Advantage(s)	Disadvantage(s)
Keyboard	This contains a panel of "keys," including alphabetic and numeric characters and special function keys.	Familiar, similar to typewriter; inexpensive	Poor keying skills result in data-entry errors; smaller boards on handheld devices may be difficult to use
Pointing device (mouse, rollerball, touch screen)	This is a device that controls the screen cursor; the "pointer" may be a finger or a special device. Functions are activated at cursor location.	Easy to use; rapid data-entry method	Precision in pointing required to avoid data-entry errors
Scanning device (bar-code readers, optical mark readers	Data are captured by reading differences in light reflection between the mark and the white space.	Rapid data entry; good error control; useful in tracking systems	Limited amount of data captured; fairly limited application
Handwriting recognition device	This is a stylus or other device used to write data on touch-sensitive screen, or it is optical scanning of writing on paper.	Familiar skill, no training required	Handwriting must be intelligible
Voice input technology	User enters data and instructions via a microphone; software program converts spoken language to machine language by digitizing sound waves.	Technical skills not required	Expensive, not widely used; machine must "learn" user's voice pattern and pronunciation; vocabulary must be built

Although the keyboard remains a frequently used input device, healthcare organizations have found that other input devices are especially suitable for specific applications. For example, scanning devices provide an efficient and accurate means for tracking many types of inventory items, locating paper documents, and even identifying patients. Medical supplies, pharmaceuticals, and patient identification bands may be tagged with bar codes or graphical markings that perform several functions when scanned and recognized by the computer software. For example, a medical supply item or drug may be removed from current inventory, charged to a patient's account, and scheduled for inventory replacement with one simple scanning process. Paper documents converted to images for inclusion in an electronic health record typically are indexed for retrieval using a bar code (Dunn 2006). Additionally, the computing skills and time constraints of the staff members who will enter the data may be a consideration in choosing the input approach. Busy clinicians often respond better to data-entry devices that are highly automated rather than to keyboard entry, which requires some skill and perhaps more time than is desirable.

Physicians may order diagnostic tests or medications simply by touching the monitor screen where a list of options is displayed. Scanning handwritten documents may make the information available to more users much sooner than if the document is audio-recorded and transcribed through keyboard entry. Scanned graphical material, such as EKG reports, can be accessed online by users in multiple locations, unlike hard copies stored in a single location, which requires users to travel to the storage location or the document to travel to the user.

Selection of the best input device for a given application should consider both efficiency and accuracy criteria. While speed of input provides user convenience, which is important to time-pressured clinicians, speed should not be gained at the expense of data quality, patient safety, and information confidentiality. Clinicians must be able to trust the accuracy of electronic data, and the quality and resolution of captured images must be adequate for visual recognition and interpretation of clinical data.

In the early phases of healthcare computing (pre-networked systems), data entry typically occurred at centralized locations, such as nursing stations or dictation rooms. Today, information systems are designed to facilitate data capture at the point of care, such as the patient's bedside or in other diagnostic or treatment areas. Often, data are captured concurrently with patient examination and treatment (point of care), through voice recorders or digitally enhanced diagnostic devices. Data also may be entered using computer workstations in or near the patient's room or by using a portable or handheld device. Thin client (dumb terminal) devices often are used in point-of-care locations to reduce initial hardware costs and the costs of continuing support and maintenance. A thin client device essentially serves the user as an access portal to the computer or storage device that houses the needed data or serves as the data processor. The user can input new data through the thin client and access existing data from the thin client's archived location, but any actual data processing or archiving is performed on a remote system. The thin client has no computing capability of its own.

Output Devices

The actual work performed by the computer system is of little value until it is produced (output) in a usable format accessible to the user, such as in print or as a screen image, digitally for additional processing, or in audio or spoken form. An important goal of the information technology industry is to make both entry and retrieval as simple as possible. Accurate, comprehensive data are required to produce the information that clinical and administrative decision makers need, and the ability to access the information at the time it is needed is crucial.

Types of output of particular value to healthcare managers include visual displays, printed documents, and audio (including voice) output. The oldest and still most widely used form of displaying output from an information system is a *video display terminal* (VDT). Typically called a monitor, the VDT has evolved from small monochrome screens into large, high-resolution liquid crystal displays (LCDs). These sophisticated monitors can display images at resolutions high enough to support clinical diagnosis and treatment. Where processing devices have evolved to smaller sizes, monitors have moved in the opposite direction. LCD monitors come in more than a dozen sizes and vary in resolution and pixel density. Two or more monitors can be connected to a single computer to allow simultaneous viewing of data from multiple applications. Although most users prefer larger, higher-resolution monitors, purchasing decisions should be based in part on the applications to be used on the system and the data to be displayed on the monitor. For example, monitors to be used for image display need higher resolution than do monitors used for text processing. Individuals who are coding medical diagnoses and procedures may need multiple monitors, or very large split-screen monitors, to access multiple applications simultaneously. If the processing output is intended to meet the needs of a mobile user, the built-in monitor in a smart phone or other handheld device serves that purpose.

Printers, too, have developed extensively from the early impact devices that were similar to typewriters, except they printed on track-fed continuous paper rolls. Today's color laser printers are capable of reproducing artwork, photographs, and detailed diagnostic images. These machines can print on a variety of sizes and multiple grades of paper and cardstock. Photocopying machines now multitask, given that printers and high-resolution printers are available for lease or purchase at acceptable costs. In fact, for many low-end printers, the cost of color ink cartridges compared with printer cost may cause a user to question whether the printer is the disposable item. Key printer characteristics to consider in lease/purchase decisions include memory capacity, print resolution, and print speed. Networking and wireless technology enable a single printer to service multiple computers and the many users who may share access to those computers. Thus, as with monitors, decisions about printer selection can be based on users and applications served rather than on cost alone.

As technology has enabled digitization of sound with good quality, audio output has become a more viable option in clinical technology applications. When digital text is converted to understandable speech by voice synthesis, an ordinary telephone can be used to access healthcare information. For example, a physician needing a patient's diagnostic test results could use a telephone to call the laboratory or radiology system and hear the results read by a voice synthesizer. Clinicians also can listen to body sounds, such as breathing or heartbeat, from distant locations. This capability allows expert consultation without patient travel or monitoring of home-bound patients with chronic conditions.

Computer Software

The hardware components of even the most powerful supercomputer cannot by themselves produce output that is of value to the healthcare manager because they need a detailed set of instructions that describe, step by step, the tasks that must be performed to achieve a desired objective. This detailed set of instructions is known as a *program*, and programs are collectively referred to as *software*.

Although for many people software is equated with applications—either general purpose or function specific—computer software also includes operating systems, utilities, programming languages, software development tools, and language translators. The healthcare manager must consider many factors in choosing computer software. Among them are the number of existing and potential users, required hardware configurations, security considerations, anticipated future growth in computer applications, and functional requirements for individual applications.

Software issues are important for healthcare managers to understand for a number of reasons. First, although most healthcare organizations do little in-house development of software, the manager must be a knowledgeable participant in software acquisition. Managers must acknowledge that the quality of available software is variable, and in some cases software purchased at significant expense fails to meet expectations. Perhaps knowledgeable and informed managers participating in the evaluation, acquisition, and implementation of software will help ensure that installed systems meet their organizations' needs.

Second, all software must be appropriately licensed. It is relatively easy for someone to copy software for personal use or to load a single-license program on multiple machines without any thought of impropriety. Users may want to install personal applications on facility computers. While these issues can be controlled to a large degree by system security configurations, policies should be in place that emphasize the organization's strong stance on exclusive use of legally licensed software and facility ownership.

Third, managers should be aware of the rapid evolution of software versions. Operating systems and application software are constantly being revised. Sometimes, users will campaign to upgrade a software package solely to have the most current version, even when the current version meets their needs. In other cases, the vendor might actually cease to support a given version, thereby forcing the user to upgrade. Again, knowledgeable participation by the manager is valuable in making upgrade decisions.

Finally, and perhaps most important in the current technology environment, the manager must understand the challenges created by the need for interfaces that link disparate software packages and system components. Upgrading one module of an interfaced system may require extensive modification of the interface as well. Increasingly, there is a need to connect facility applications with those hosted by other providers in the continuum of care or with enterprise partners. A simple example is the electronic transfer of a patient prescription to an external pharmacy, a procedure that may contribute to patient satisfaction.

Application Software

From the users' perspective, the most important category of software is application software. After all, this is the software that accomplishes the useful tasks that justify the purchase of the information system. A general overview of application software is provided here, and the topic is covered in greater detail in chapters 8 and 9.

Application software can be further classified as general purpose or application specific. Many computer programs provide an environment in which a user can solve a particular *class* of problems rather than a single, narrowly defined problem. Examples include word processors, desktop publishing software, spreadsheet software, statistical packages, database management/break software, presentation graphics software, and web browsers. These types of programs are known as *general purpose* application software, and it is generally purchased as a suite of integrated, menu-driven module programs. Microsoft Office is a common example of this type of software and is used for personal computing and in business and healthcare organizations.

Application-specific software ~~is a computer program designed to~~ solve a single, specifically defined problem. A good example is a payroll program, which is developed to accumulate labor hours, compute deductions, process payroll disbursements, post summaries to the general ledger, and complete forms required by federal and state governments. In the current environment, these programs frequently include electronic transfer of funds from the enterprise's operating bank account to the employees' personal accounts.

Numerous vendors offer an array of application-specific software aimed at the healthcare industry. *Healthcare Informatics*, a print and online technology journal, publishes a resource guide of information technology companies, products, services, and associations. The online database (www.healthcare-informatics.com) may be searched by product category or by vendor.

Healthcare organizations have the option of developing application-specific software in-house or purchasing (or leasing) a vendor-designed application and installing it on their computer system. However, the process is not as simple as it might sound. Each approach has its advantages and disadvantages. With in-house development, the software can be tailored specifically to the organization's needs, and changes are generally easier to make when necessary. Purchased or leased software, by comparison, is generally less expensive, takes less time to get running, and requires fewer in-house computer personnel. However, any changes to the program must be negotiated with the vendor. A third approach—modifying an existing package—attempts to integrate the advantages of the first two alternatives, but it is not without its own set of problems.

In the early years of healthcare computing, in-house development of application software was a favorite choice of many healthcare organizations. Today, most software is purchased or leased. The high cost of specialized software has led some organizations to contract with application service providers (ASPs) that provide needed computing services via a network connection. The ASP may provide a single application, such as billing, or a full range of computing services. This second option might be particularly attractive for a small physician practice. Outsourced computing is not without risks, however, and managers must be savvy when negotiating contracts. Two key issues to include in contract negotiations are (1) data ownership and (2) return of data should the relationship be terminated (Dolan 2006).

Most healthcare managers have concluded that they are in the business of providing healthcare services, not developing software. However, they must still be knowledgeable participants in the process of purchasing or leasing software. In addition, involving key users in software purchasing decisions is very important, especially when major systems are being acquired. Other factors that must be considered when choosing application software are the required staffing and equipment resources, the cost of maintenance, the complexity of the operations being automated, the number of potential users, and data security issues.

Integrated System Versus Interfaced System

Two general approaches are available for acquiring and implementing application software in a healthcare organization. In the first approach, all modules required to satisfy the organization's computing needs are identified and purchased from a single vendor. Typically, these modules will have been designed to work with one another so that data transfer among modules proceeds smoothly. This type of system is known as an *integrated information system*. Epic (www.epic.com), Cerner (www.cerner.com), and Siemens Healthcare (www.medical.siemens.com) are well-known vendors of integrated healthcare system solutions for all types of organizations. Some vendors of integrated products offer solutions for specific facility types, such as the ICHS DiagnoSYS product for behavioral health (www.ihealthcs.com).

By contrast, each of the required modules could be purchased from the vendor thought to be the leader in that particular application area—or one that offers a unique feature valued by the enterprise. In some cases, the decision might reflect the personal bias of influential members of a particular department in the organization. In any event, although a given module might work well for its particular application area, connecting the module to other modules for data sharing could be problematic. For example, the data contained in one module could be incompatible with the data format of other modules. The data formats or the vocabulary used could differ between the two systems. Something as simple as the way a date is recorded (e.g., 01-31-13 versus 2013-01-31) can prevent data from transferring or being matched correctly. Often, the solution is the development of an *interface*, which acts as a bridge between the two modules and which, for example, translates the data format into one that the receiving module can handle.

The use of an interfaced approach is made simpler if the modules composing the interfaced system have all been developed in accordance with a standard that makes data formats compatible. The American National Standards Institute, the National Information Standards Organization, and the Organization for the Advancement of Structured Information Standards are examples of organizations and consortia working toward consensus standards for information products and services. Compliance with accepted industry standards is an important criterion to apply when evaluating vendors' products.

Advantages of an integrated system include compatibility among the modules and the need to have only a single source for system support and maintenance. On the other hand, interfaced systems that allow users to choose the leading system for a given module can sometimes result in lower costs by leveraging one vendor against another, which obviates the need to replace all existing modules when updates are considered.

System Management Software

System management software is the group of programs that manage the resources of a computer system and perform a variety of routine processing tasks. Unlike the role of application software, the function of system management software typically is not obvious to the user. Thus, many computer users are unaware of the important functions being performed by the operating system and by utility programs.

Operating System

Operating system serves as the interface between the human user and the computer, managing the functioning of the software and hardware. The operating system incorporates a graphical user interface (GUI), which uses icons (graphical symbols on the monitor screen) to represent available operating system commands. The user simply clicks on a given icon with the computer's mouse or other pointing device to invoke the desired command. The advent of GUI made computing accessible to the general public, as a user did not have to be skilled in delivering text commands to the processor in a structured language.

The complexity of the operating system and the scope of services that it must provide depend on the complexity of the computing environment in which the operating system is installed. An environment that allows only one user to run one program at a time possesses the least complexity and places the fewest demands on the operating system. Examples include the early mainframe computers and the early PCs, which could not support multiple applications simultaneously.

The computing power of a device is more effectively exercised when multiple tasks can be run by either a single user or by multiple users. In such an environment, known as *multitasking*, the operating system plays a more essential role in assigning processing priorities, memory access, and file management tasks. Multiple users must be able to perform a variety of tasks with no perceptible slowing of processing time. Today's typical computer user could be preparing a report with a word processor, basing the report on data being extracted from a spreadsheet, copying key points into a presentation format, researching concepts on the Internet, and monitoring e-mail all at the same time. All these applications can run simultaneously and produce data in real time. As noted previously, much of the current workforce has no memory of a computing environment where such multitasking could not occur.

Utility Program

Utility program is software, often incorporated into the operating system, that performs generalized data processing, computational functions, or system maintenance functions. These functions are not specific to any particular computer application. They offer general utility and support to a variety of information processing tasks, including functions of the operating system as well as application programs. Examples of utility programs include virus scan programs, screen savers, and encryption programs. Many of these programs may be set to operate routinely, such as scanning all incoming e-mail files for a virus before placing the message in the user's inbox, or automatic shift to a screensaver following a specified period of inactivity. Some utility programs require the user to initiate the program's action, such as a disk defragmentation operation that reconnects file components that have become scattered in multiple disk locations.

Programming Language

All software—application, system, or utility—consists of a detailed set of instructions describing the specific steps the computer is to perform. These instructions must be communicated to the computer in a specific *programming language*. When a spreadsheet user enters a formula for an arithmetic computation in a particular cell on the spreadsheet, that user is actually writing a program statement.

Although the typical healthcare manager will make limited use of programming languages as little in-house program development is done, a few brief comments can illustrate some key points. Despite the number and type of programming languages in existence, the objective of all languages from the user's perspective is simple. The overarching goal is to communicate with the computer in some prescribed format so that useful output can be generated. Whereas skilled programmers may find reward in creating complex code, for the nonprogrammer user, the satisfaction of this communication process lies in the output created, not in the communication process itself.

When computers were first developed, instructions were specified in *machine language*—strings of zeros and ones that a computer is capable of understanding. The progression of programming languages can be tracked through successive *generations*, with each generation improving the computer–human interface. The evolutionary goal is to achieve *natural language* input, whereby the user is able to give commands to a computer as easily as communicating with another person. A translator program would convert natural language statements into the binary number commands intelligible to the computer. The technology necessary to recognize the spoken words, interpret their content, transform them into a set of procedures, and translate this sequence into machine commands is complex and has not been perfected. Voice-recognition applications are available for business or personal use, but acceptance for medical applications is not widespread. TopTenReviews (n.d.; see www.toptenreviews.com), which conducted a review of several voice recognition products available to consumers, lists the following factors as most important in evaluating a voice-recognition program:

- Features—such as voice training, customizable commands, and accent support
- Commands—specifically the ability to engage other applications by voice command
- Dictation—transcription of spoken language using a text editor
- Accuracy—ability of the program to transcribe all kinds of words accurately
- Ease of use—intuitive commands and menus

Networking and Communications

Today's clinicians and managers require information from a variety of sources outside of, as well as within, their organizations. When geographically separated healthcare delivery units are combined to form a healthcare enterprise or an integrated delivery system, sharing information among the system's components becomes increasingly challenging. Communicating electronically with organizations and strategic partners that are not a legal component of the enterprise organization adds further complexity to the issue. The implementation of computer networks and the use of communication channels and protocols help these organizations manage their information flow.

The technology associated with data communication systems and computer networks is relatively complex, involving the expertise of communications engineers, computer hardware specialists, and software professionals. While these functional experts assume responsibility for the design and installation of this technology, the healthcare manager must assume responsibility for overseeing these activities and making sure that the organization's information needs are met.

As is true in the areas of hardware and software, the manager will need sufficient understanding (working knowledge) of networking and communications concepts to work intelligently with the functional experts in these fields. The following discussion is meant neither to be exhaustive nor to make the healthcare manager a networking or communications expert but to present an introductory overview of these subjects. Again, more comprehensive study at the time this knowledge is needed should be a priority.

Computer Network

Early applications of computers in hospitals, as in many other industries, began with financial applications such as billing, payroll, and general accounting. These programs typically were run on a large mainframe computer located in the organization's data-processing department. In some cases, the organization might have chosen to have its computing performed by an outside vendor of data-processing services. The input data for these early programs were contained in handwritten documents or simplistic paper forms such as charge slips, invoices, or time and attendance sheets. Most of the time, the data had to be ***keypunched*** or manually entered for processing. The output consisted of standardized printed reports that were distributed to the appropriate users.

The demise of the mainframe approach to healthcare computing can be attributed to two key developments in the computing industry: (1) the introduction of software systems designed to perform specific functions and (2) the introduction of the microprocessors and the PC. Special function applications for departments such as pharmacy, radiology, and laboratory systems frequently were run on minicomputers (mid-range computers smaller than mainframes) that could be located within close proximity of the department using the system. Using a PC, managers were able to analyze a variety of operational and financial data themselves. They were no longer dependent on the data-processing department to run special reports, which often had an unacceptable time delay, as special reports were generated after routine processing had been completed. Without the ability of the computer to multitask, processing priority had to be established for individual job orders.

As department managers purchased minicomputer-based systems and other managers became increasingly dependent on personal computing, they soon realized the utility of the various programs was not optimal if they operated as independent, stand-alone modules. In fact, a high level of interdependence needed to exist among these programs. For example, the laboratory, pharmacy, and radiology systems all needed information captured by the admitting system. Similarly, many of the management reports generated on PCs were derived from data abstracted from a printed report generated by a mainframe financial application. From perspectives of efficiency and data quality, the ideal situation is to capture data once and then distribute the data to every application that uses the data to perform its assigned processing tasks.

Stand-alone systems are particularly problematic in a healthcare system because data on a given patient might be found in a number of locations, and a single diagnostic service might serve widely separated patient care locations. Data must flow across a large area, and managers often require input from many sources to arrive at a solution to a problem. Clearly, disparate systems throughout the organization (and even beyond) need to be connected to facilitate the exchange of data and the sharing of information resources. ***Interoperability*** is the term typically applied to the capability of elements of an information system or network to communicate and exchange information (Heubusch 2006). Full interoperability cannot be achieved without industry standards. Most healthcare organizations, particularly larger ones, purchase HIT products from more than one vendor that must serve users in locations throughout the organization. Without extensive standardization, particularly in communication media and protocols, connecting the system elements is a difficult and expensive venture.

The linkages needed to facilitate data exchange and sharing of resources are accomplished through the construction of a network. When all components of the network are located within relatively close proximity to one another—perhaps within a single facility—generally the network is referred to as a *local area network* (LAN). A network that extends into a broad geographic area is referred to as a *wide area network* (WAN). The actual connections between the network components may be constructed through physical wires or cables, or achieved without "hard wiring" (i.e., wireless) by transmitting data using radio wave or microwave technologies and communication satellites. In addition to public access media, communication lines for an extended network may be leased from a private network provider. When the provider offers services beyond allowing traffic on the leased line, it may be referred to as a *value added network*. In effect, wireless computing has extended possible network area to global. Global area network capability is extremely important to corporate enterprises with service locations distributed nationally or internationally, and it also serves well the individuals in our mobile society. An illness or injury that occurs during travel may be better managed clinically if the treating provider has access to previous medical information.

Ways of Distributing the Processing Function

One basis for classifying networks is the way in which the processing functions are distributed among the devices composing the network. Four configurations are in common use, ranging from a *centralized* computing environment, in which the processing functions are concentrated in a single device, to a *decentralized* environment, in which these functions are split, or distributed, among all of the users on the network. Decentralized networks typically create greater managerial challenges, a fact that is particularly relevant for the healthcare manager.

Terminal–Host System

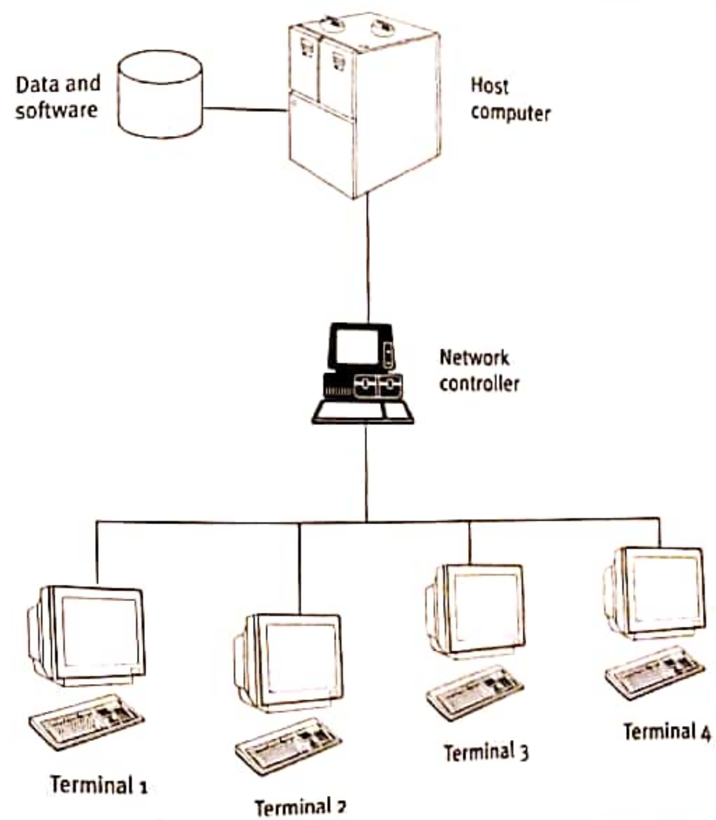
In the most centralized computing environment, dating back to the 1960s, users work at devices known as *terminals*. Early terminals had no processing capability and were often known as *dumb terminals*. Today, a PC is used to mimic, or emulate, a terminal. The terminal is connected to a large central

host computer, typically a mainframe. The important feature of this computing environment is that all computing takes place on the host system. A more current descriptive term is *thin client*, which continues to mean that little computing work is done at the workstation. This terminal-host configuration is depicted in Exhibit 6.4.

Depending on the level of sophistication of the program running on the host machine, the terminals allow users to perform a variety of functions, including the following:

- Entering a set of data for a program to be run at some later time in batch mode—that is, as part of a sequential stream of programs from several users. For example, staff at patient care units may enter select

EXHIBIT 6.4
Terminal–Host Configuration



data about the patients in their unit that are aggregated with patient data from all other care units for end-of-shift or daily reporting.

- Real time processing of a program immediately after entering data and/or programming commands. Staff may enter current patient vital signs and immediately receive an updated graphical display that shows the patient's vital signs as a trend over a specified period of time.
- Responding to a query in real time. As a patient is processed for inpatient admission or current outpatient service, the patient's outstanding account balance can be determined.

The terminal-host configuration enables *remote job entry* (RJE), where terminals might be located at considerable distance from the host machine. Thus, an organization that outsources a processing function can transmit the source data to the vendor's processing center. Several major companies have specialized in providing computing services to healthcare organizations on an RJE basis. Alternatively, remote data entry into the enterprise system is an option. One example of remote entry is diagnostic coding. Professional coders may work in remote locations, even in their homes, and transmit coded data to the enterprise system for inclusion in the electronic health record system.

The terminal-host configuration provides strong data security when the data flow is unidirectional (i.e., users can enter raw data but cannot access processed information). The ability to restrict data and information access on a need-to-know basis is crucial but faces complexities in implementation. While the technical element is fairly straightforward, managing the human element is more challenging. Well-defined administrative policies must be established and consistently enforced.

Client/Server Computing

Users of dumb terminals connected to a host computer easily recognized the advantage that would result from their terminals having computing capability. Data could be edited, preliminary computations could be made, and other processing could be done that did not require the power of the host machine. This early conceptualization was predictive of today's client/server computing configuration, which is characterized by less centralization than is possible with a terminal-host installation (see Exhibit 6.5).

Client/server architecture divides applications into two components: (1) client, or *front-end* functions, which include the user interface, decision support, and data processing, and (2) server, or *back-end* functions, such as database management, printing, communication, and applications program execution. Special-purpose machines or PCs, minicomputers, or mainframe computers can function as servers, and multiple servers can be used in a

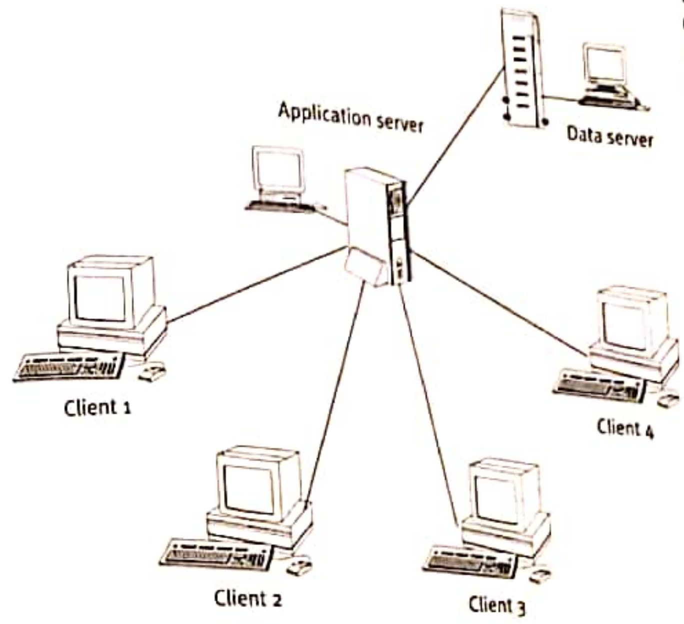


EXHIBIT 6.5
Client/Server Computing Configuration

client/server network. In fact, information technology staff sometimes refer to their network management activities as "working the server farm." Servers often are described internally by the applications they process for clients, such as databases, e-mail, or printing.

The user hardware in this type of network may be thin clients with little processing capability, but in many instances the hardware are PCs that have general purpose software such as Microsoft Office. PCs cost more than thin-client hardware, but they may be more cost-effective because PCs can be used as both server access and independent computing devices. The decision between thin clients and PCs should be based on how the workstation will be used and whether the users need PC capability to perform their jobs. Because access to servers can be granted to users as needed, this configuration offers some data security benefits even when PCs are used as the interface.

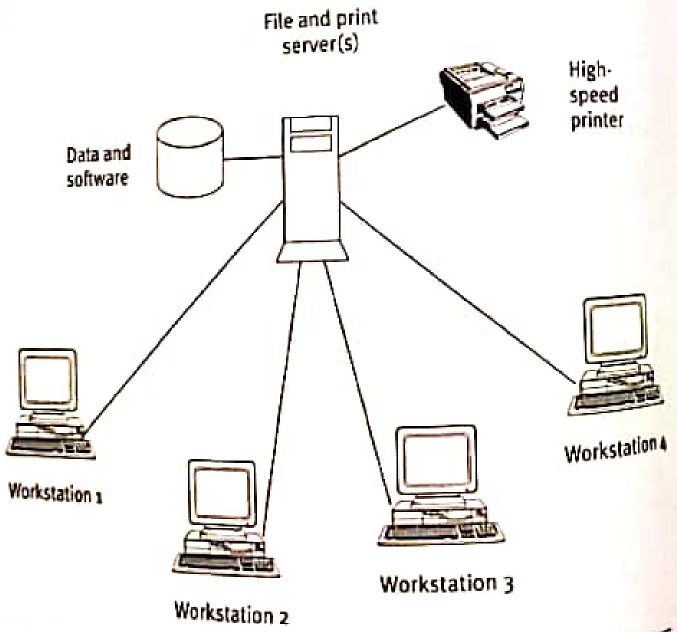
The most simplistic configuration is to have all clients connected to a single server that performs all back-end functions. A single server may be functional for very small healthcare organizations, such as a community service organization or an adult daycare center, or for a restricted application in larger organizations that have relatively few users. The next level is to use two servers or more, separating application programs from data storage. This configuration supports faster processing and distribution than does housing both applications and storage on a single server.

File/Server Architecture

Even less centralized than client/server installations is file/server architecture. In a file/server network, a relatively large number of network processors are able to share the data contained in files on the server (see Exhibit 6.6). The actual processing of data, however, is distributed across the network machines. The file server does not perform computing tasks; it stores data and manages rapid retrieval by the workstations where the computing occurs.

Many small LANs are configured with file/server architecture. The file server typically has a large fixed-disk drive with fast disk-access time. The other computers on the network have much more modest fixed-disk drive requirements, but they benefit from fast processors to support their execution of application software.

EXHIBIT 6.6
File/Server Architecture



Peer Network

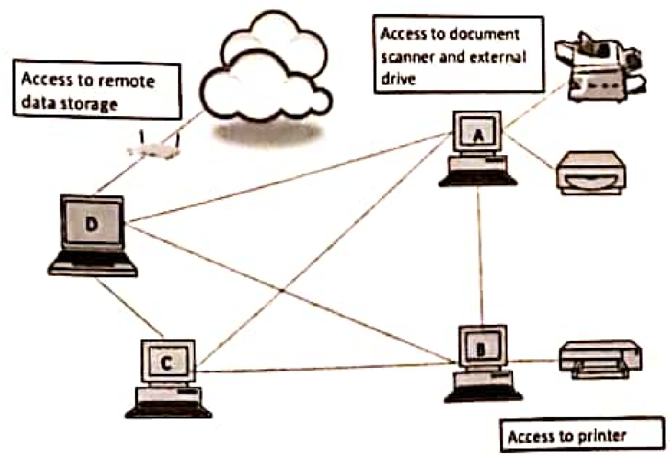
Peer networks represent a decentralized computing environment, in which each computer on the network has either data or some hardware resource that it can make available to the other users on the network. The key distinguishing feature of peer networks is the fact that there is no server, and all of the computers on the network can be used as workstations (see Exhibit 6.7). Key advantages of a peer network are the ease of installation and configuration and the relative low expense compared with those associated with client/server networks. However, peer networks are generally considered suitable only for small installations, as large peer networks may not be secure and are unreliable (Hayden 2001, 93).

Grid and Cloud Computing

Grid computing emerged in the late 1990s as a form of distributed computing. In this model, a "grid," or large number of Internet-connected computers, is used to emulate a supercomputer, capable of managing complex computing and data storage needs for users within an organization, whether real or virtual. Grid computing is deemed most effective for organizations with large amounts of data but few users (Schiff 2010), and it has not received widespread acceptance in healthcare.

The grid concept enabled the cloud computing model, a system that allows users to access computing services and data storage via the Internet

EXHIBIT 6.7
Peer Network Configuration



without concern for the actual physical location of the hardware where the processing or storage occurs. Data transmission using this model is wireless (transmitted over air waves) or "in the clouds." For example, a Google gmail account is accessed via the Internet, but the location of the server holding the e-mail is unknown to the user. An enticing element of cloud computing is that users pay only for the services or storage space actually used, not a monthly or annual service fee, and no capital investment is required for additional computing resources (Mitchell 2009). However, while a student may not particularly care where a term paper is stored, healthcare organizations are accountable for protecting the security and integrity of patient and business data. Cloud computing for healthcare applications requires due diligence in selecting a vendor and ensuring that data are managed in compliance with all applicable regulations.

In addition to using a cloud host for primary storage and computing, healthcare organizations may use the cloud as redundant secondary data storage as part of a disaster plan. If the organization's physical plant is damaged or destroyed through a natural or man-made disaster, information resources are secure for recovery from the cloud host.

Management Issues

As healthcare managers participate with their functional specialists in selecting the appropriate networking configurations for their organization, they must consider several issues. First, while distributing computing capability down to the user level is desirable from an efficiency perspective, in a highly complex and interrelated field such as healthcare, some degree of centralization of the computing and information storage functions is necessary. In addition, the need to support integrated healthcare systems and managed care makes information system integration even more vital.

Second, the network configuration can affect the choice and maintenance of application software. For example, a single "network version" of an application package can be installed on a server accessible to the users on the network, or individual licensed copies of the software can be placed on each user machine. Careful evaluation of the purchase price of the software, software licensing fees, and software maintenance costs as well as hardware costs is of paramount importance.

Healthcare managers are well advised to monitor closely the architecture being designed by their functional specialists to ensure that the information systems function is moving in a direction that appropriately supports the organization's strategic direction. Specification of the overall systems architecture and infrastructure is one step in the strategic development of information systems plans (see Chapter 3).

Network Components

Creating an information network requires the assembly of a variety of hardware and software components. This section presents an overview of these components.

Transmission Media

Early in the process of designing a network, a decision must be made regarding the transmission media to be used. Transmission media, which carry the signal being transmitted from one location to another, include metal wires, which carry electrical signals; fiber-optic cables, which carry optical signals; or air, through which radio waves or microwaves travel. Each transmission medium is discussed in this section.

Wired Media

Wired media consist of one or more strands of metal—frequently copper, which is an excellent conductor of electricity. Data are transmitted along these conductors in the form of changing electrical voltages and may be represented as either a ***digital*** or ***analog*** waveform. Digital transmission involves the representation of data with binary digits or bits. Analog transmission represents data by varying the amplitude (height), frequency, and/or phase of a waveform. A key distinction is that analog transmits across a continuous range of values, whereas digital transmissions are discrete. Traditional telephone lines carry signals in an analog format, while integrated services digital network lines, digital subscriber lines (DSL), and the cable in a LAN carry signals digitally. Wired connections are physical, meaning the scope of the network connections is limited to the distance the wiring is extended. Network elements connected by wire cables internal to a building can be extended by connecting a computer in the network through a telephone line to a geographically distant computer. While hardwiring has important positive characteristics in network designs, the physical element severely constrains the scope of the network and imposes significant cost.

Fiber-Optic Media

An optical fiber is made of glass, a much less expensive medium than copper, and can be made in a diameter about the size of a human hair. Data are carried in the fiber-optic medium in the form of light pulses that shine inside the shaft of the fiber to the receiving end. The electrical data signal is used to turn a light source on and off very rapidly. At the receiving end of the cable, an optical detector converts the light signal back to an electrical signal. Fiber-optic cable is thinner and more durable than copper wiring, provides higher bandwidth, and is not subject to electronic eavesdropping.

Radio Media

Unlike copper wire and fiber glass media, radio media use radio waves of different frequencies to transmit data through the air. *Broadcast radio* is used to support some paging devices and cellular technology. *Microwave radio* is capable of higher data rates than broadcast radio and is used in WANs and wireless LANs. However, microwave signals travel only in a straight line, so microwave transmission over long distances requires the use of repeaters or satellites. Microwave transmissions are subject to interference from adverse weather conditions as well as any objects that might interfere with the transmissions' travel from transmitter to receiver. All communication using radio waves is subject to electronic eavesdropping, thus resulting in special security issues that must be addressed.

Transmitter/Receiver

The general process of communication consists of a transmitter sending information (or in some cases raw data) through a transmission medium to a receiver. When two people have a conversation, at a specific point in time the person speaking plays the role of the transmitter and the person listening has the role of the receiver. During the course of the conversation, these roles alternate many times. Similarly, in an information systems network, at any given time one network component acts as a transmitter while a second component acts as a receiver. As with personal conversations, the roles of these components can change frequently. The devices used to connect transmitters and receivers to the transmission media depend on the media type and data format.

Network Interface Controller

A network interface controller (NIC) is a piece of hardware that serves as an adapter to allow a personal computer to connect to a network. The device is sometimes referred to as a *card*, which is a general term for a printed circuit board that can be inserted to add functionality not originally programmed into a computer. The specific interface device required depends on the architecture of the computer and the network communication protocol, such as Ethernet or wi-fi wireless technology. When an NIC is installed, it is also necessary to install appropriate software, known as the *device driver*, which allows the computer to "talk" to the NIC. Finally, note that every NIC is assigned a unique 48-bit number—called *media access control*—that identifies the computer to the network (Hayden 2001).

Modem

A modem (modulator/demodulator) is a device capable of changing signals from one format to another and then back again. Two types are available: copper based and fiber optic. The copper-based modem converts a device's digital signals to analog signals appropriate for copper media. It can take the form of a card (circuit board) located inside the computer (internal modem) or a separate component connected to, but physically located outside, the computer (external modem). Fiber-optic modems convert a device's digital signals to optical digital signals, which can then be carried over a fiber-optic network. Modems are classified by data transmission speed as bits per second (bps) or baud rate, the frequency of sending a new signal.

Multiplexer

A multiplexer increases the speed of data that can be transmitted over a given bandwidth line by efficiently distributing multiple input signals to available output lines. Several devices (i.e., computer, printer, and scanner) can be connected to a multiplexer. The output of the multiplexer serves as the input to the transmission medium. A multiplexer at the receiving end of the transmission medium separates the signals. Thus, the devices appear to have their own transmission channel when in fact they are sharing the transmission medium. Exhibit 6.8 graphically represents the function of a multiplexer.

Bridge, Gateway, and Router

Data are transmitted across networks as formatted "packets," unlike one-to-one links that send straightforward user data. Packets include addressing information and other instructions as well as user data. Moving the information packets from one network component to another requires the components to employ communication protocols (rules or conventions governing the communication process) and some specific hardware devices and

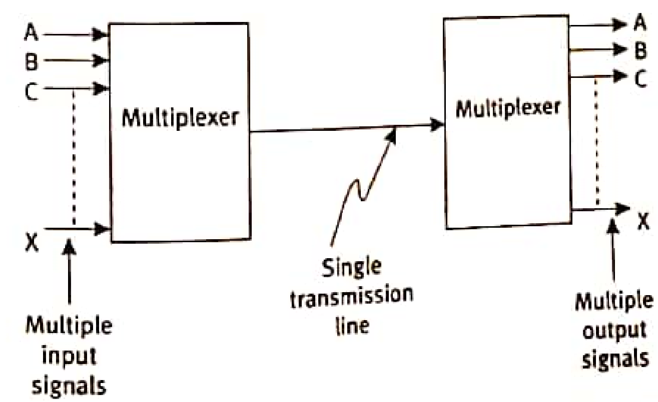


EXHIBIT 6.8
Function of a Multiplexer

programming. A ***bridge*** is an interface that connects two or more networks that use similar communication protocols. A ***gateway*** represents the interface that must be created between two networks that use dissimilar protocols to communicate. A gateway allows users to access data and programs outside of their own defined network. Gateways are network entrances and play an important role in the interconnection of the many disparate networks that compose the Internet.

A ***router*** is a device located at any gateway to manage the data flow between the networks. The router decides, on the basis of its current understanding of the activity state of the networks, which way to send each packet of information flowing on the network for greatest efficiency. The addressing information on the information packet shows the ultimate destination of the packet. The router determines the most efficient path to the ultimate destination by sending the packet through the available networks that have the least activity. Conceptually, this is very similar to driving to a destination using low-traffic secondary roads rather than a busy interstate route. Although the actual mileage may be somewhat higher on the secondary roads, travel time to the destination may be shorter than the more direct route with heavier traffic.

Network Controller/Server

A network controller is used in terminal–host networks consisting of a number of terminals connected to one or more mainframe host computers. The function of this controller is to direct the communications traffic between the host and the terminals and peripheral devices.

LANs do not have a network controller. Rather, communication traffic is directed by a defined protocol that depends on the network topology. The network may have one or more ***servers,*** which provide network users with a variety of services such as access to files (file servers), help with passing files over the transmission medium (database servers), and a connection to network printers (printer servers).

Network Control Software/Network Operating System

Like a network controller, network control software is also associated with mainframe-based telecommunications networks. The software resides on the host (mainframe), on a small computer (front-end processor) connected to the host and dedicated to communications management, and on other processors in the network. Functions of this software include controlling access to resources, regulating data transmission to and from terminals, improving network efficiency, and detecting and correcting errors.

LANs and WANs employ network operating systems to coordinate and support the operation of the network, such as user access, data traffic, and security. Some network operating systems serve as supplements to the computer's existing operating system. Others, like Windows XP, constitute comprehensive computer operating systems where the networking capabilities have been integrated into the operating system.

The information systems manager, when choosing network software, must consider several factors, such as the number of existing or potential users, the type of network hardware available, the type of applications software programs needed, available resources (human and equipment), and network configuration costs.

Network Topologies

The configuration used to connect the computers and peripheral devices in a LAN is known as the network's ***physical topology.*** Common alternative configurations available to network designers are bus, ring, and star topologies. These topologies can be used singly or used in combination with one another to form a hybrid network.

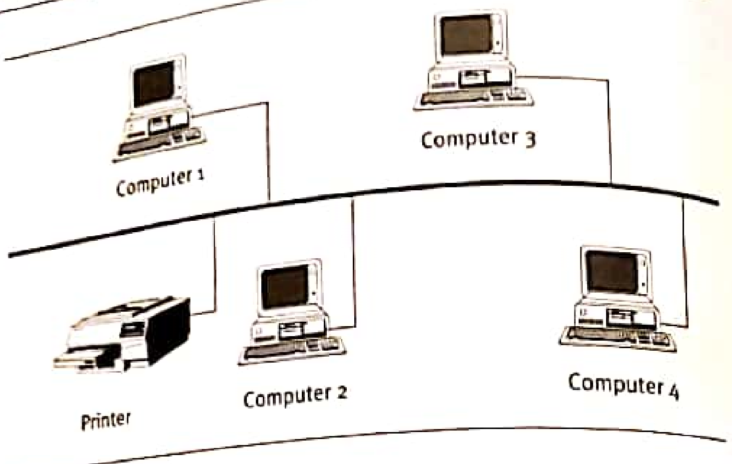
Closely related to these physical topologies are ***logical topologies,*** which "lay out the rules of the road for data transmission" (Hayden 2001, 36). These topologies are largely abstract and not as easily visualized as the physical topologies. This section presents an overview of four physical topologies (bus, ring, star, and hybrid) and four common logical topologies (Ethernet, including fast and switched Ethernet; token ring; fiber-distributed data interface; and asynchronous transfer mode).

Bus Network

In a bus network, a single circuit, or bus, is used to link the computers and other devices composing the network (see Exhibit 6.9). All devices are connected along the bus, or backbone, which may be composed of twisted wire, coaxial cable, or fiber-optic cable. A hardware device known as a ***terminator*** is used at either end of the bus. Advantages of a bus network are the relative ease of wiring the network and the relatively fast communication rate. Disadvantages are limitations of length of the bus because of signal attenuation, or loss of signal strength, and the fact that if a break in the bus occurs, then all of the devices beyond the break are disconnected from the network. A configuration is called a ***line network*** if the devices on a single circuit are connected in this manner: Computer A is connected to computer B, computer B is connected to computer C, computer C is connected to computer D, and so on.

A device instructed to send a message listens first to see if the bus is busy. The message is then sent out and received by every other device. Only the intended recipient, however, pays attention to the message. If, by chance,

EXHIBIT 6.9
Bus Network Topology



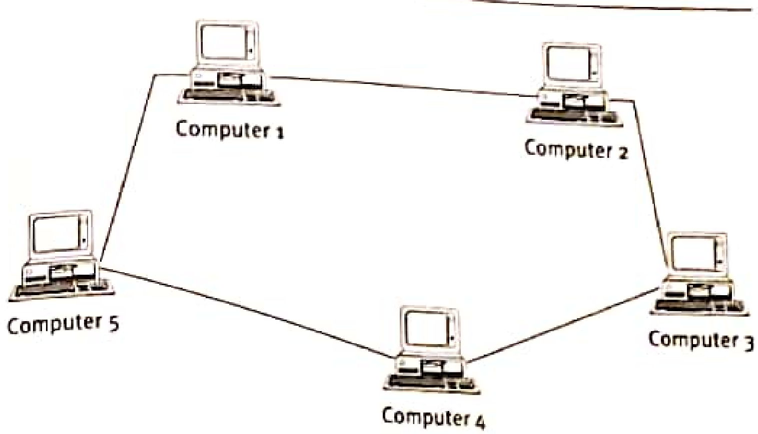
two devices send out messages at the same time, a collision will occur, which will be detected and the messages will be lost. This problem is resolved by having the two devices involved wait for a random time interval and then resend the message. This protocol is known as *carrier sense multiple access with collision detection* (CSMA/CD), and the trade name for this protocol is *Ethernet*. When a large number of users are attempting to use an Ethernet network, a bottleneck can occur. Fast Ethernet and switched Ethernet represent two possible solutions for this bottleneck. *Fast Ethernet* simply uses a higher-quality line and operates at ten times the speed of traditional Ethernet. *Switched Ethernet* dedicates bandwidth space to segments of users.

Ring Network

A ring network can be conceptualized as a group of devices (nodes) arranged in a circle with a connection between adjacent devices to form a closed loop (see Exhibit 6.10). Data travel in a single direction around the ring, and each device on the network retransmits the signal it receives from the previous device to the next device in the ring. Ring networks offer the advantage of facilitating the construction of high-speed networks that operate over large distances. This is accomplished through the use of a fiber-optic transmission medium for the connection between adjacent nodes along with the use of an amplification device (repeater) at each node. In addition, the operation of the network is not affected by the removal of a node from the ring. Disadvantages include difficulty in troubleshooting the network and adding new nodes to the ring.

A protocol often used with ring networks—the *token-ring* protocol—passes an electronic token (an instruction in computer language) along the

EXHIBIT 6.10
Ring Network Topology



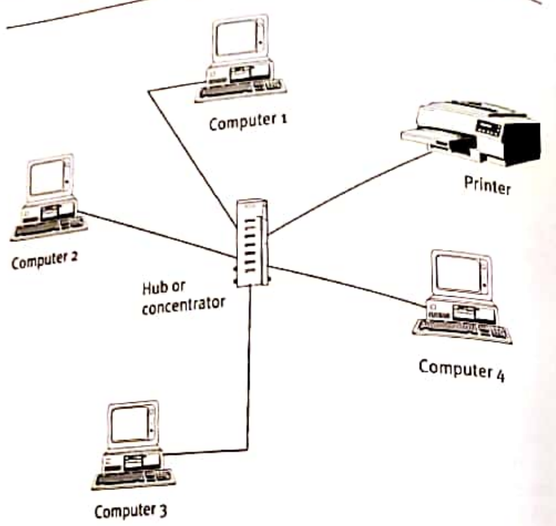
loop. Only the node computer that holds the token at a given time can place a message on the network. The token is then passed on to the next node. The message passes from node to node until it reaches its destination. Because only one node can access the network at a time, the collisions that are possible with the CSMA/CD protocol (Ethernet) cannot occur here. A fiber-distributed data interface (FDDI) uses a backup token ring that becomes operational in the event that the primary ring fails. If the second ring is not needed for backup and can be used to carry data, the network can operate at rates up to 200 million bps.

Star Network

In a star network, each node has a single point-to-point connection to a center node, called a *hub* or *concentrator* (see Exhibit 6.11). When a given node wants to send a message to a second node, the message must first travel through the central hub. A *passive hub* simply serves as a connector for the wires coming from the various nodes. A message sent from a given node goes to every other node, and the intended recipient node is responsible for claiming its own messages. An *active hub* not only serves as a connector but also regenerates message signals before sending them on to the other nodes. The message signal still goes to all of the nodes, and the appropriate node claims its own messages. Finally, *intelligent hubs* are able to determine the destination address for a particular message and to route the message to that address only.

Advantages of a star network include the ease with which it can be initially wired and repaired and the relative ease with which nodes can be

EXHIBIT 6.11
Star Network Topology



added to an existing network. One disadvantage of a star network is the fact that a malfunctioning hub can bring the entire network down. The use of backup hubs can help to address this difficulty. Additionally, star networks can require more cabling than networks using other topologies. Nevertheless, this topology is in wide use in many network installations.

Hybrid Network

Two or more of these basic network topologies are often combined into a single network known as a *hybrid network*. One example is a WAN formed by linking several LANs that have different topologies. A tree topology connects multiple star networks along a linear bus circuit. Mesh topologies are constructed of multiple connections among network devices, either partially or to the extent that every device is connected to all other devices in the network (full mesh). Possibly the ultimate hybrid network is the Internet, which is a massive interconnection of the full spectrum of network types.

Asynchronous Transfer Mode

Asynchronous transfer mode (ATM) refers to a logical network topology that segments data to be transmitted into small packets of a fixed size, called *cells*. The cells are directed through switches to the appropriate destination node and then reassembled into the original data format. The cells are a fixed size and relatively small; this allows voice, data, and video to be mixed over a network. ATM can run at speeds of up to 1.5 billion bps (Hayden 2001, 40). Understanding the type of data and the speed with which it must be transferred is an important factor when purchasing ATM services. Data may be transferred at a constant or variable bit rate, both of which have guaranteed throughput capacity. Alternatively, transferring at available bit rate allows higher-capacity transfer during nonpeak network time. If time delay is not an issue, ATM service at an unspecified bit rate may be acceptable. These options will differ in price.

Electronic Data Interchange

The networks described in this chapter can serve as the medium for transferring structured information from one computer to another without human intervention. This process, known as *electronic data interchange* (EDI), must incorporate standards and procedures so that the receiving computer will be able to interpret the output of the sending computer. The American National Standards Institute (ANSI) is a primary standard-setting organization for the computer industry. The ANSI X12 standards apply to EDI and are used by HIT product vendors and network communications providers to ensure interoperability across and between networks.

Early applications of EDI in the healthcare field involved the electronic processing of health insurance claims, and claims processing remains an important role for EDI. However, with the connectivity available via the Internet, EDI has become a primary business tool, as data are routinely transferred to various components of the healthcare enterprise and to its strategic partners as well as to fulfill accrediting and regulatory requirements.

Wireless Communication

In each of the computing configurations described earlier, users interact with the information system at a fixed location, often called a *workstation*. However, healthcare professionals deliver their expertise at the site of the patient. While interacting with the patient, they must be able to retrieve needed information and record newly acquired patient data. Mobile computing and wireless communication make this flow of data at the point of care possible.

Mobile Computing Versus Wireless Communication

Mobile computing and wireless communication are in fact two separate concepts. *Mobile computing* refers to the use of a portable computing device such as a laptop, notebook, or palmtop computer. For example, nurses and other caregivers providing healthcare services in patients' homes can download the records of their patients for a given day from a central database into their laptop's hard disk, enter new data and notes into their laptop over the course of the day, and then upload the newly acquired information back to the central system at the end of the day.

Although this procedure is workable, it recreates the very difficulty that led hospitals to adopt networking technology. Because the laptops function as stand-alone computers, the information in the central database is not current until data collected by the portable devices are uploaded back to the central system. If a second provider—say, a physical therapist—calls on the patient later in the day, the nurse's notes, collected earlier but not yet uploaded, will not be available to the therapist.

Even within an inpatient setting, similar problems result when independent mobile computers are used. Until newly acquired information within the hard disk of the mobile computer is transmitted back to the central database or until information from the central computer is sent to the mobile computer, a discrepancy about a given patient remains between two or more databases. This mismatch is not always considered to be a serious problem. For some applications, merely updating the wireless device on a periodic basis is sufficient. For example, physicians may use personal digital assistants (PDAs) at the bedside that contain clinical data, including basic patient data, lab results, and medications prescribed and administered. Updated data are available for download from syncing stations (Briggs 2002, 46). A *syncing station* is a cradle that is wired to a PC. When the PDA is placed in the cradle, data and systems are updated on the PDA and the PC. Mobile devices also need to be recharged from a fixed power source at regular intervals. During the syncing and recharging processes, the mobile device is not accessible for use. Thus, these procedures are usually completed between work shifts or at the end of a workday.

On the other hand, the combination of mobile computing and wireless communication enables portable computers to be connected to an established information systems network without being physically connected. Wireless technology allows computing activities performed on the portable devices in real time, and the central database, as well as the mobile device, always stays current.

Installing a wireless network is considerably less costly than installing additional cabling to create a hardwired system (Sislo 2002), and typically clinicians are supportive of wireless technology (Gillespie 2001, 27).

Despite the obvious benefits of data accessibility, mobile devices are not without drawbacks. Portability, the feature that is a prime benefit, makes the devices physically insecure. Devices may be lost or stolen, creating problems of data security. Due to their size, devices may be easily damaged or need frequent replacement. Special attention must be paid to removing or destroying data on devices that are taken out of service or reissued to new users (Southerton 2007).

Wireless Topologies

Expansion of radio frequency and microwave technologies has enabled broadband wireless options with various ranges, many of which are well suited for use in healthcare facilities. The expectation is that ultimately availability of low-cost, open-standard wireless technology will lead to cable replacement (Ng et al. 2006). With wireless communication networks, even patients and visitors can use their personal communication devices while inside the facility. This capability can reduce some of the frustration associated with patient waiting time in some areas of the enterprise and improve patient satisfaction ratings.

The advent of wireless networks has expanded the traditional classification of networks as LANs or WANs into five classes: (1) wireless global area networks, (2) wireless regional area networks, (3) wireless metropolitan area networks, (4) wireless local area networks, and (5) wireless personal area networks (Siep 2007). As indicated by the labels, the network range may be as extensive as nationwide or limited to a single room.

The conceptual aspect of wired network topologies is applicable in wireless networks in that they can be described in terms of connection structure. Wireless connections may be point-to-point, or linear, which is a direct connection between two clients, such as connecting a personal computing device to a desktop computer to share e-mail and calendar applications. Wireless connections may also be point-to-multipoint, a star configuration. A good example of this structure is a wi-fi hotspot such as you might find in your neighborhood coffee shop where customers can access the Internet and play games or complete work assignments while they enjoy a cup of coffee. When redundancy is important, mesh topologies are useful. Generally speaking, however, wireless networks employ more than one of these configurations.

Three wireless communication topologies are commonly used in networks. Two are typically associated with LANs, while the third is used in a WAN. Each is briefly described in this section.

Spread Spectrum

Spread spectrum is a type of radio frequency technology widely used in healthcare today for wireless communication between devices on a LAN. Benefits of this transmission approach include improved privacy and decreased signal interference. Of the four basic techniques—frequency-hopping spread spectrum (FHSS), direct-sequence spread spectrum (DSSS), time-hopping spread spectrum, and chirp spread spectrum—only FHSS and DSSS are widely used.

Decisions to use this technology in wireless LAN installations should be informed by range of the transmitted signal (to determine network access points), signal frequency (to avoid interference with other systems), and aggregate throughput (data transfer rate).

Infrared Technology

Infrared radiation is a wavelength between visible light and radio waves. Because infrared technology is "line of sight" and cannot pass through walls, it can only be used in a single room. It has found common use in wireless keyboards and mouse devices, remote control units, and cordless modems.

Cellular Digital Packet Data

Cellular digital packet data (CDPD) is a WAN architecture used in cellular networks, like those of cellular telephones, for voice and data transmission. The CDPD transmits and receives packets of data at high speed. An important factor is that using existing cellular data carriers and frequencies offers significant cost savings over capital investment in new cellular media. From a healthcare perspective, CDPD allows remote users to connect to a network without directly connecting to a telephone jack.

Communicating via the Internet

The LANs described in this chapter can be connected to form larger networks, known as *internets* (note the use of a lowercase *i*). For example, each institution's LANs that compose an integrated delivery system can be linked to form an internet known as an ***enterprise computer network***.

The largest interconnection of networks in the world today is known as the *Internet* (note the uppercase *I*). The Internet began in 1969 as a US Department of Defense project designed to connect various government laboratories and contractors. However, as the "net" began to be used, it was soon recognized as an indispensable data link between researchers. By the 1990s, the Internet had entered the domain of the general public.

The Internet has become a ubiquitous business and personal tool, bringing instant access to information on almost any topic imaginable, not

the least of which is healthcare. According to Internet World Stats (2011), North America boasts 272 million Internet users, about 78 percent of the population. The number of users in North America has increased by about 40 million since 2007. This figure represents more than 151 percent growth in the number of users since 2000. The United States is where 13 percent of all Internet users in the world reside. The continent with the largest percentage of all Internet users is Asia, with an amazing 44 percent.

In 1991 the first web page was launched on the World Wide Web, an environment of multimedia websites and myriad other web pages that are linked electronically and are accessible through the Internet. Individuals have found the Internet and the web to be valuable, and so have businesses, including healthcare organizations; together, they have developed numerous applications to harness these resources. This section provides an overview of the technology issues associated with communication on the Internet, including Internet connection, website hosting, the role of an intranet, and thin client network computer.

Internet Connection

Except for the very few institutions with a staff of in-house engineers, computer specialists, and networking experts who are capable of connecting directly to the Internet, the majority of healthcare organizations obtain their Internet services through an intermediate provider. This provider can be an ***online service connection*** such as Verizon or AT&T, which provides an array of information services, or an *Internet service provider* (ISP), which provides users with a link to the Internet. A list of ISPs serving a given geographic region can be obtained on www.internetserviceproviders.org. Although Internet connection still can be made using a dial-up or telephone line, most connections are achieved through high-speed cable, fiber optics, or DSL, which are termed ***direct network connections***.

A direct network connection uses dedicated digital telephone lines that go directly from the computer to the ISP. They can be fractional T1 lines (about 1 megabit per second) or T3 lines (45 megabits per second). Telephone companies now offer DSL service, which runs over standard telephone wire. It is priced affordably and is found in many home-computing environments. Many cable companies offer direct connections between a computer and the cable television network. The cable company then provides a connection between its cable network and an ISP, or the company might serve as the ISP. A cable modem must be added to the computer to facilitate making a connection into the cable network.

Once a connection has been made between a computer and the Internet, a program is needed to manage the assembly and routing of the messages being transmitted. The ***transmission control protocol/Internet protocol***

(TCP/IP) is such a program. According to the Mac OS X Server manual (version 10.4), although the "IP takes care of handling the actual delivery of the data, the TCP takes care of keeping track of the individual units of data (called packets) into which a message is divided for efficient routing through the Internet."

Website Hosting

Most healthcare organizations sponsor a facility website or link to the parent corporation or enterprise website. These websites serve several purposes, including marketing the organization's service lines and providing users with access to an array of e-health applications.

Websites typically consist of multiple "pages" or screen images that a user accesses with the use of software known as a *browser*. The user then interacts with the website using a keyboard and a point-and-click device to input information and navigate through the site's various sections. Common functions of healthcare organization websites include delivering static information such as locations and operating hours, interactive elements such as appointment scheduling, and database capability such as searchable professional staff listings.

Each sponsored website is identified by a unique *Uniform Resource Locator* (URL) or "address." The first part of the URL—www.—indicates a connection to the World Wide Web. The second part of the URL often is an abbreviated version of the organization's name, such as the "ache" in the American College of Healthcare Executives's URL of www.ache.org. The third part of the URL is after the dot (.) and identifies the organization type or domain, such as ".org" (which means the website sponsor is a nonprofit organization). Other common domains include ".gov" for a government entity, ".edu" for an educational institution, and ".com" for a commercial enterprise. This naming convention has become so ubiquitous in our social language that companies with primarily Internet-based transactions are lumped under the term *dot-com industry*.

An organization's website content is stored on a host computer or a server, either in the facility or at a remote location. As websites have become more integrated with business processes, the data storage requirements have increased tremendously. Websites typically function both as an intranet and as a connection to the Internet, thus security issues are extremely important. The need for restricted access to various sections of the website requires assigning and managing multiple access levels as well as monitoring security protocols. Website content must remain current to ensure repeated access by clients, so site maintenance is imperative. A website with incorrect or outdated information creates a negative image for the organization and is quickly ignored by users, which could threaten the organization's market share. In addition, the usual hardware and software updates required by any computer installation must be addressed. For these reasons and others, managing a website is a dynamic process that requires a significant financial investment, close management attention, and skilled technicians.

In today's high tech social media environment, few organizations design and maintain their own websites. Creating an attractive, highly functional, and dynamic multimedia website requires the talents of skilled graphic designers and programmers who are as efficient in their work as they are artistic. These individuals are mostly employed by companies that offer this specialized technical service to the corporate market on a contractual basis.

The Role of an Intranet

The same Internet infrastructure technology can support communication inside the organization; this structure is referred to as an *intranet* or private network. When an organization shares part of its intranet with customers, strategic partners, and other stakeholders, the intranet becomes an *extranet*. An intranet or extranet uses the same protocols as the Internet and in general looks no different.

A *firewall* is a security protocol to protect the intranet from outside access while permitting organizational access to the Internet. The firewall can also contain software that establishes a *virtual private network* that allows organizations to maintain privacy while sharing public networks for transmission of their data. Data are encrypted before they are sent through the public network and then decrypted at the receiving end. This methodology makes customers feel more comfortable about providing personal information, such as a credit card number, online. Transmission of sensitive patient information can use this same protocol.

As developments in intranet and Internet applications continue, healthcare managers should monitor how their organizations are using this technology. Special attention should be directed toward the security and confidentiality issues created by electronic data access and transmission. Chapter 3 addresses security and confidentiality of healthcare information.

Thin Client Network Computer

Thin client computers are minimally configured PCs that are, as described earlier in the chapter, suitable for a client/server network. Similar machines can also serve as user workstations on the Internet. The healthcare manager will encounter a variety of terminology associated with this type of installation, including *network computer* and *diskless computer*. The Google Chrome OS (operating system) is designed specifically for Internet access and consists of a browser, media player, and file manager (Epipheo Studios n.d.).

Two major advantages result from the use of thin clients or diskless computers rather than fully configured PCs. The first, and most obvious, advantage is cost. Thin clients carry a lower purchase price that can become significant as the number of computers connected to the Internet in typical healthcare settings continues to increase. A second, and somewhat related, advantage relates to the maintenance of these machines. The hard drive of a typical PC contains a number of application packages. As software changes, the information technology department has the formidable task of updating all of the machines. In an environment where thin clients are used, however, the software resides on the web server and thus can be updated relatively easily.

A disadvantage that the manager will face in moving toward the use of thin clients is a cultural one. Users have become accustomed to the power of a fully configured PC on their desk. Making a change to thin clients could face opposition from these users. Another disadvantage, as in all networking situations, is when the server is "down" the user of a thin client is also down.

In this area, as in all decisions concerning information systems acquisition and installation, the healthcare manager is well advised to be aware of all alternatives and select the one best suited for his or her organization.

Summary

The trend toward the creation of integrated health systems and other industry environmental changes has made the information needs of healthcare organizations increasingly complex. Among the strategies necessary to respond to these changes are the development of interoperable computer networks and the use of telecommunications. These technologies are necessary for EDI between and among organizations.

Networks also can be classified according to the manner in which the processing function is distributed among the devices that make up the network: (1) terminal-host system, (2) client/server computing, (3) file/server architecture, and (4) peer network. Each alternative has its own strengths and weaknesses, and the appropriate configuration is dependent on the organization's strategic direction.

A variety of components compose an information network. Transmission media include wired media, fiber-optic media, and radio media. Transmission and receiving components include NICs, modems, multiplexers, bridges, gateways, and routers. Network controllers and protocols associated with the network servers help to direct the communication traffic on the network. Finally, network control software and network operating systems control the accessing and use of network resources and help improve network efficiency.

The configuration with which devices are connected to form a network is known as the network physical topology. Three alternative configurations, each with pros and cons, are bus, ring, and star topologies; two or more topologies can be combined to form a hybrid network. Networks also have logical topologies that guide data transmission. Four logical topologies are Ethernet (including fast and switched), token ring, FDDI, and ATM.

Mobile computing makes information available at the point of care. The addition of wireless communication to the mobile computing device allows the transfer of information between the device and central database to occur in real time. Spread spectrum technology serves as the basis for wireless LANs. CDPD is a WAN architecture that makes data transmission across cellular networks possible.

The Internet is an important resource for healthcare organizations. It provides access to a wide range of information, allows the organization to achieve a presence on a worldwide information network, and provides an infrastructure for communication within the organization and with external entities. Internet technology enables a global network and remote computing as well as novel technology solutions such as cloud computing.

Networking and telecommunications are highly technical and rapidly changing areas. Gaining a basic understanding of these areas, staying abreast of the changes, and knowledgeably interacting with the technical specialists in the field are ongoing challenges for the healthcare manager.

Web Resources

A number of organizations (through their websites) provide more information on the topics discussed in this chapter:

- *Healthcare Informatics* magazine (www.healthcare-informatics.com) publishes a resource guide of information technology companies, products, services, and associations.
- McKesson (www.mckesson.com) provides extensive information about its technology products.
- Microsoft (www.microsoft.com) offers user tips and guides as well as product information.

Discussion Questions

1. Name each of the six components of a computer system and indicate the function of each.
2. Give a brief description of three secondary storage media, including their advantages and disadvantages.
3. Discuss the relative advantage of using a pointing device to enter a patient's vital signs compared with simply typing in the values using a keyboard.
4. Suggest how the use of a patient ID bracelet containing a bar code representation of the patient's ID and a bar code scanner can lead to improved quality of care in a hospital.
5. Explain the difference between devices capable of voice input and voice-recognition technology.
6. Explain what is meant by the resolution of a VDT, and indicate applications where high resolution is important.
7. List the four generations of programming languages, and briefly describe the characteristics of each.
8. Why are users doing so little in-house development of software today?
9. Distinguish between an interfaced system and an integrated system. Provide some examples where one model would provide an advantage over the other.
10. List three specific functions of an operating system.
11. How did the integration of healthcare systems affect the development of computer networks in healthcare organizations?
12. What is the difference between digital and analog waveforms?
13. What are the advantages of fiber-optic media compared with copper media?
14. How do the three physical network topologies differ?
15. Describe some important applications of electronic data interchange in the healthcare field.
16. How does mobile computing differ from wireless communication?
17. Explain the difference between an internet and the Internet.
18. What is the purpose of a firewall?
19. What are the benefits of using a thin client for Internet connection?

CHAPTER 7

HIT SERVICE MANAGEMENT

Learning Objectives

1. Articulate the impact that unplanned work has on the healthcare information technology (HIT) department.
2. Identify a number of different process-improvement frameworks that could be applied to the management of the HIT department and the advantages and disadvantages of each approach.
3. Describe the Information Technology Infrastructure Library (ITIL) service support components and their interrelationships.
4. Articulate why the configuration management database is critical to the service support processes.
5. Describe the ITIL service delivery components and their interrelationships.
6. Describe what service-level agreements are and why they are important to the HIT department.
7. Describe some of the reasons given for HIT service continuity plan failures.

Overview

A consistent area of focus throughout a healthcare manager's career, regardless of responsibility, is the constant effort to achieve efficient, cost-effective operations. While it is certainly true that all healthcare managers will continually be asked to think more strategically, a focus on the strategic aspects of the job at the expense of the operational aspects is a sure recipe for failure as a manager. Debra Walker, former chief information officer (CIO) of Goodyear Tire & Rubber Company, provides a framework for how to think about the effective management of a healthcare information technology (HIT) department for both operational effectiveness and strategic impact. She suggests that the HIT department must master three levels of services. The base level provides a robust and reliable infrastructure for the organization, which is covered in Chapter 6. The second level, which builds on the base level, provides excellent HIT services, which is the focus of this chapter. Walker characterizes the third level by noting that "if [the HIT department] achieves those two things, then [it] gets the credibility that allows [it and the CIO] to play in the third level: partnering with the business to do the very high value-added activities and create competitive advantage" (Field 1998).

Why HIT Service Management Matters

The assertion that the more tactical or operational elements of HIT services are critical to strategic HIT value delivery is consistently reinforced in a number of academic studies (Agarwal and Sambamurthy 2002; Kaplan and Harris-Salamone 2009; Singleton, McLean, and Altman 1988; Smaltz, Sambamurthy, and Agarwal 2006; Watson, Pitt, and Kavan 1998). Much in the same way that Maslow's (1970) hierarchy of needs works in the field of psychology, if lower-level operational HIT needs (e.g., reliable infrastructure, consistent and effective HIT support services) are not being met, the CEO may wonder if the CIO and the organization can be effective in delivering the higher-level strategic HIT needs of the institution.

Ironically, only the most progressive organizations are adopting best practices in HIT service management, while many HIT departments continue to rely on informal, "seat of the pants," error-prone processes (Hoerbst et al. 2011; Schick 2001). This leads to reactive "fire fighting" operating norms within HIT departments, when formal, proactive approaches would be more effective. Recent studies suggest that one of the most accurate indicators of HIT departmental effectiveness in delivering quality services is the percentage of unplanned work in which the department is engaged. *Unplanned work* is any activity in the HIT organization that cannot be mapped to an authorized project, procedure, or change request. While unplanned work can never be entirely eliminated from the HIT department, Kim (2006) suggests that the nature of the unplanned work is very different for high- and low-performing HIT departments. In Kim's study, low-performing HIT departments' unplanned work includes the following:

- *Failed change.* The production environment is used as a test environment, and the customer is the quality assurance team.
- *Unauthorized change.* Engineers do not follow the change management process, making mistakes harder to track and fix.
- *No preventive work.* Failing to conduct preventive work makes repeated failures inevitable. Mean time to repair may be improving, but without root-cause analysis, the organization is doomed to fix the same problems over and over.

- *Configuration inconsistency.* Inconsistencies in user applications, platforms, and configurations make appropriate training and configuration mastery difficult.
- *Security-related patching and updating.* Inadequate understanding and inconsistency of configurations make applying security patches extremely dangerous.
- *Too much access.* Too many people have too much access to too many HIT assets, causing preventable issues and incidents.

In contrast, Kim (2006) found that high-performing HIT departments have very different types of unplanned work, which include the following:

- Product failures
- Release failures
- Human/user errors

The key difference between low- and high-performing HIT departments is that high-performing HIT departments put in place holistic controls and processes that cut horizontally across the HIT department, whereas low-performing HIT departments often operate in vertical function-based silos with little to no formal cross-functional controls or processes. Interestingly, the Sarbanes-Oxley Act, passed by Congress in 2002, now mandates that holistic and formal controls be established for all for-profit organizations (Library of Congress 2002). However, these controls are not mandated for not-for-profit organizations, which make up the majority of the healthcare delivery field. As such, many HIT departments will continue to have high levels of costly, unplanned work as a result of poor adoption rates of leading organizations' process frameworks that include but are not limited to the HIT process improvement frameworks outlined in Exhibit 7.1.

Sundaresan (2005) notes that "while transforming a typical IT organization into an efficient service delivery organization is difficult, companies that don't make the transition face loss of competitiveness, while the IT organization faces loss of credibility, influence and most importantly impact." Kim (2006) illustrates this sentiment via the following scenario, adapted for our healthcare purpose:

> Suppose someone changes an IT asset (such as releasing a seemingly small software patch to a major enterprise application such as an EHR), but the change fails catastrophically due to lack of preproduction testing and change management authorization. The failed change results in an "all hands on deck" situation for the IT operational staff; IT drops planned work to remedy the results of the changes. The service

EXHIBIT 7.1
HIT Process Improvement Frameworks

Information Technology (IT) Process Improvement Framework	Description
Capability Maturity Model (CMM)	An IT process improvement framework best suited to process improvements surrounding the application development and maintenance domain. The model is based on five levels of maturity (Gartner, Inc. 2001): Level 1: Initial—no repeatable processes Level 2: Repeatable—requirements-identification process in place, policy compliance in place, and basic project management in place Level 3: Defined—application-development processes are well defined, as are applications training and coordination processes Level 4: Quantitatively managed—precise measurement, forecasting, and predictability are added; seeks to reduce special cause–process variation Level 5: Optimizing—continual process improvement efforts at reducing common cause–process variation are added; describes what characterizes an organization at each level but does not describe how to get there
Control Objects for Information Technology (CoBiT)	An IT governance, oversight, and process audit framework recently linked to Sarbanes-Oxley Act of 2002 corporate financial reporting compliance law. CoBiT is made up of four main areas of control objects along with two supporting areas of focus (IT Governance Institute 2005): 1. Planning and organization—assess strategic plan creation, how projects are managed, communications and messaging, and human resources 2. Acquisition and implementation—assess how the organization acquires IT assets, how it implements IT, and how changes are inserted into existing IT assets 3. Delivery and support—assess how end users are supported and served 4. Monitoring—ensure that regular audits of IT controls are accomplished and that reporting is available on internal financial controls 5. Information—assess the degree to which information about the IT operations and internal controls is available for proactive management action 6. IT resources—assess the degree to which adequate IT resources are in place to ensure effective internal controls are in place

(continued)

EXHIBIT 7.1
HIT Process Improvement Frameworks *(continued)*

Information Technology (IT) Process Improvement Framework	Description
CoBiT (continued)	Like the CMM, CoBiT tends to describe what characterizes an organization that has solid internal control mechanisms in place but falls short of how-to descriptions.
International Standards Organization (ISO) 9000	Also from manufacturing, ISO 9000 requires that organizations become accredited or registered, thereby assuring customers that the organization adheres to the ISO quality assurance standards. One criticism of ISO 9000 is that it requires a great deal of administrative overhead to employ ISO 9000 standards and become registered.
Information Technology Infrastructure Library (ITIL®)	An IT process improvement framework centered around seven main IT management domains (itSMF 2004): 1. The business perspective—processes focused on aligning IT investments and activities with business, strategic, and operational needs 2. IT service management (service delivery)—processes focused on ensuring the long-term availability and capacity of IT assets 3. IT service management (service support)—processes focused on holistic approaches to change, release, incident, problem, and configuration management 4. Information communication technology infrastructure management—processes associated with the full lifecycle of IT assets from requests for proposals to acquisition, testing, implementation, and retirement of the IT infrastructure asset 5. Planning to implement service management—planning framework for implementing an IT service management improvement program to include the cultural and organizational change issues associated with it 6. Application management—processes focused on all stages of an application's lifecycle 7. Security management—processes focused on information security to include assessment of information security risks and mitigation strategies Well suited to organizations whose CIO or IT leader is championing IT process improvements. As opposed to some of the other process improvement models, ITIL provides high-level how-to guidance via its many generic ITIL process flow diagrams and descriptions.

disruption causes an incident that takes four hours to repair and involves 25 IT staffers from all functional roles: application developers, QA [quality assurance] workers, database administrators, network and systems administrators, and security. Lost IT staff productivity is the first cost of this episode of unplanned work.

Unplanned work also comes at the cost of planned project work. In this case, the application developers and QA staffers are taken from the critical path of an important patient satisfaction project, and the project completion date slips one week. In addition, to address this project delay, IT has to employ a team of contractors longer.

The costs continue to mount. While the IT staff works to restore service, [physicians and nurses] call the service desk to find out why they can't access their [patient's information in the electronic health record (EHR)]. Because of the large [EHR user] base, [hundreds of users] call the service center. The excess calls require the service center to activate the overflow call center, which costs tens of thousands of dollars. Revenue is also disrupted because [the delay in EHR related workflows causes delays in admitting, transfer and discharging patients in a timely manner].

Downtime and IT project resource costs run in the thousands of dollars; service center costs, lost revenue and the delayed IT project costs are in the tens of thousands. . . . Now that this single rogue change affects [the revenue cycle], costs increase almost exponentially. . . . [The impact on the revenue cycle for a large hospital can easily run into the hundreds of thousands of dollars in either lost revenue (workflow disruptions cause a bed to not be available to admit a new patient when needed) or delayed revenue or decreased margins (patient discharged beyond normal length of stay).]

And, there is one more extremely high cost of unplanned work. Any of those late projects, which are getting even further delayed, had some ROI that the [organization] attached to it. So, every moment of unplanned work delaying that project has a quantifiable opportunity cost. . . .

The scenario is all too common in most hospital and healthcare delivery organizations. As such, doing nothing to improve these broken HIT processes will make it increasingly difficult for the CIO and the HIT department to take on the even more challenging strategic HIT issues facing the healthcare field. It is beyond the scope of this text to expand on each of the various HIT process improvement frameworks listed in Exhibit 7.1. While each has its own advantages and disadvantages, the Information Technology Infrastructure Library® (ITIL) is an HIT process improvement framework that is well suited to improvement efforts led by the CIO or HIT leader and department (Young and Mingay 2003). As opposed to some of the other process improvement models, ITIL provides high-level "how to" guidance via its many generic ITIL process flow diagrams and descriptions.

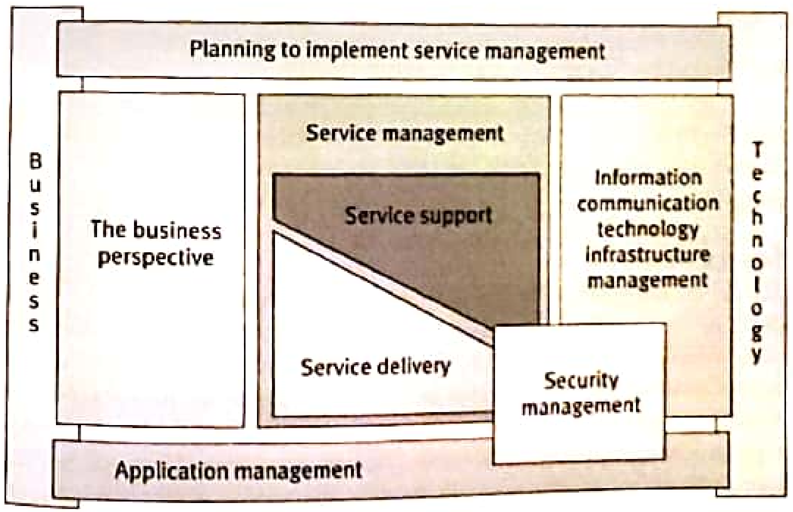
The Information Technology Infrastructure Library

While Control Objects for Information Technology (CobiT) (see Exhibit 7.1) can be thought of as a framework for *what* sorts of things an HIT department

should consider having in place, ITIL can be thought of as a framework of *how* HIT department processes should be interlinked to gain optimum proactive HIT service management. The ITIL was originally created by the Office of Government Commerce (OGC) in the United Kingdom. It is intended to be a holistic framework for providing both the lower-level and higher-level HIT needs of an organization (see Exhibit 7.2). Arguably, current HIT operating budget levels—which typically average 2 percent of operating expenses in community hospitals (Ciotti and Birch 2005) and nearly 4 percent across all health delivery organizations (McGitten et al. 2013)—may make full adoption of the entire ITIL framework challenging. By this we mean that ITIL requires organizations to dedicate some of their resources toward putting in place the more proactive ITIL processes. However, the low-operating HIT budget levels that exist within the healthcare industry mean that most HIT departments do not perceive that they have the excess resources needed to break out of their reactive, fire-fighting mode. By comparison, the financial services industry expends 5 percent to 7 percent on HIT operating budgets (Baschab and Piot 2003; McGitten et al. 2013) and, not coincidentally, is a robust adopter of both the CobiT and ITIL frameworks.

HIT services in most healthcare organizations will, out of necessity, most likely require more proactive approaches with the increasing use of

EXHIBIT 7.2
The Information Technology Infrastructure Library



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mission-critical automation, such as EHR with clinical decision support (CDS) and computerized physician order entry (CPOE). The service man- agement (service support and service delivery) components of the ITIL framework (the middle box in Exhibit 7.2) are particularly well suited to HIT departments that seek to improve their service delivery and support via more proactive, holistic, and integrated HIT service workflows (Grajek and Cunningham 2007).

The IT Service Management Forum (2004) notes that "ITIL . . . provides a framework of 'best practice' guidance for IT service management and is the most widely used and accepted approach to IT service management in the world." HIT service management is composed of two main domains: service support and service delivery (see Exhibit 7.3).

The ITIL processes outlined in Exhibit 7.3, along with project man- agement concepts and practices discussed in Chapter 11, can be thought of as the fundamental HIT services in which every HIT department must excel to be successful, particularly as hospitals and healthcare delivery organiza- tions become even more automated. While informal, seat-of-the-pants HIT service management processes may have been adequate for organizations with largely paper-based records and manual processes, these informal ser- vice management processes will no longer be adequate for organizations that increasingly rely on digitally enabled workflows such as EHRs with CDS and CPOE. HIT service support processes are discussed in more detail in the next section.

HIT Service Support

All of the HIT service support processes identified in Exhibit 7.3 are heavily interrelated and should be put in place with forethought. Exhibit 7.4, for example, provides some insight into how these processes are related.

Service Desk

Almost all hospitals or healthcare delivery organizations provide a "help desk" or "service desk," which users call or access online to obtain assistance with computer-related problems. This is likely the most misunderstood and underappreciated service provided by the HIT department. Best practices in providing services for incidents (when malfunctions occur that require HIT support services to repair) are discussed later in the chapter. Here, the health- care manager must recognize that because the service desk provides such wide exposure into the customer interfacing operations of the HIT depart- ment, it becomes—for better or worse—one of the main ways that healthcare executives and managers throughout the organization gauge the effectiveness

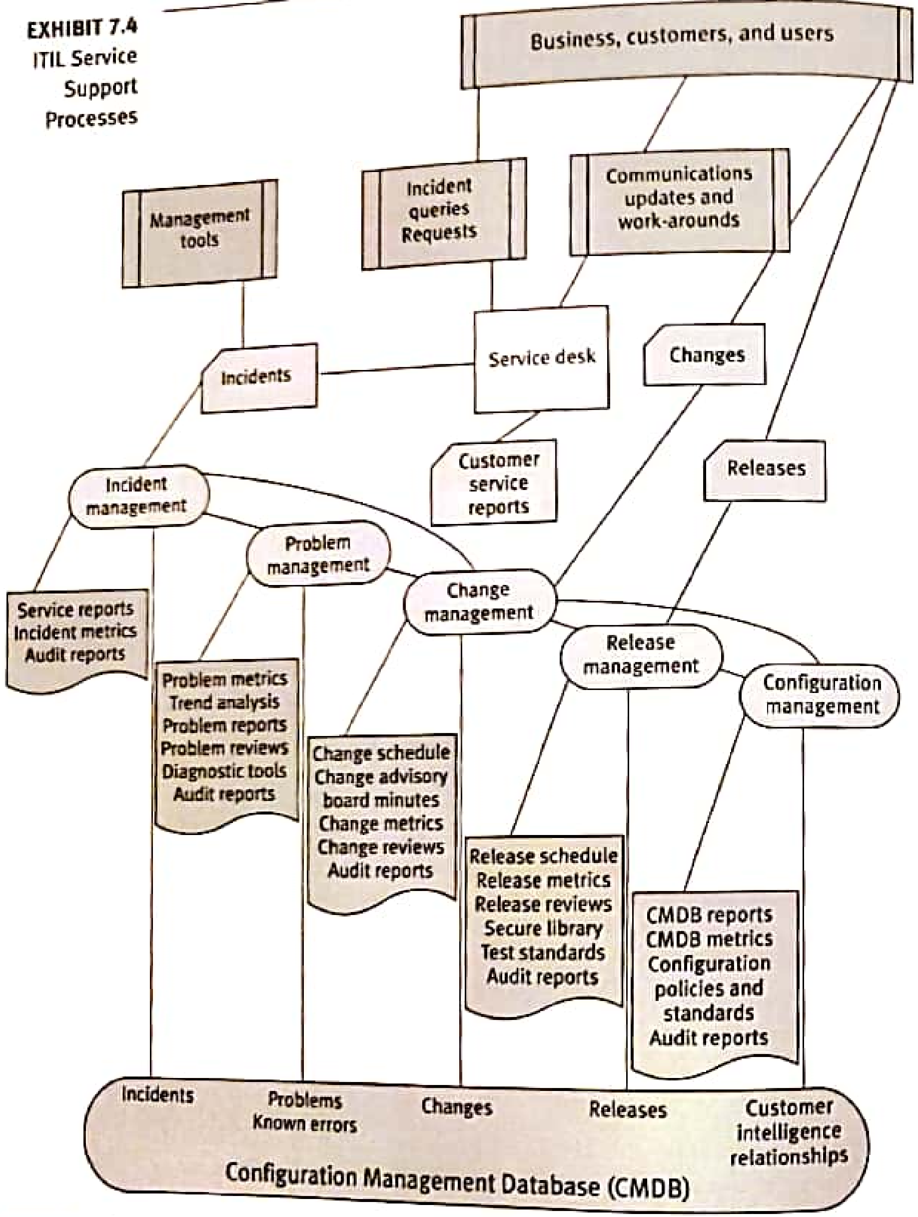
EXHIBIT 7.3
Elements of HIT Service Management

IT Service Support	Service desk	The single point of contact for users to report incidents and seek troubleshooting resolution
	Incident management	The process by which trouble calls or incidents are managed to resolution
	Problem management	The process by which recurring incidents are analyzed to determine and provide permanent solutions for root causes
	Change management	The process by which changes are introduced into the computing environment of an organization
	Release management	The process by which major new releases of application or operating system software is implemented
	Configuration management	Closely tied to all of the above IT service support processes, configuration management is the process by which the computing environment is documented—typically in a configuration management database
IT Service Delivery	Service-level management	The process by which service levels are negotiated with end users and tracked for performance adherence
	Availability management	The process focused on ensuring that the IT infrastructure and support services are available to the business functions
	Capacity management	The process focused on ensuring that the IT infrastructure has the processing capacity needed by the business functions
	Financial management	The process of accounting for the complex nature of IT services, understanding cost by unit of service, and assisting management with decisions related to IT services
	Service continuity management	Formerly known as the "disaster recovery" or "business continuity planning" function, this is the process by which organizations identify their most critical applications and design, test, and maintain alternatives for providing IT services in the event of a major service interruption

SOURCE: Adapted from itSMF (2004).

of the HIT services delivered. Therefore, it behooves CIOs and HIT depart- ment managers to ensure that the leading customer service practices are in place. The IT Service Management Forum (2001) notes that the service desk is "often a stressful place for staff to work, [and] underestimating its importance, high profile, and the skills required to perform the duties well, can severely hinder an organization's ability to deliver quality IT services."

EXHIBIT 7.4
ITIL Service Support Processes



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For most of the users of computer resources, the help desk represents the face of the HIT department. While some of the employees of the hospital or healthcare delivery organization have the opportunity to interact with the other service delivery teams within the HIT department, statistically almost *all* employees, at some point in their tenure, will have a need to contact and use the services of the help desk. Gartner Research suggests that, on average, users will place between 1 and 2 calls per month to the help desk (Guevara, Hall, and Stegman 2011). This does not necessarily mean that each and every user will call the help desk at least once a month (e.g., a single user may place six calls in one month and six more the next month to the help desk, while another may not place a call for a year or more). Because many help desks address not only malfunctions or incidents but also how-to questions, over time a user can average 1.1 to 1.6 calls per month. Additionally, as Exhibit 7.4 indicates, a second source of incidents comes from HIT operational management tools that can monitor the HIT infrastructure. When certain thresholds are met (e.g., central processing unit [CPU] capacity on a critical server reaches 75 percent, disk space in the storage area network reaches 85 percent capacity), these management tools will automatically trigger an incident that initially gets sent to the service desk for action.

Hospital or healthcare delivery organizations typically have one of three different types of HIT service desks:

1. *Decentralized.* This is typical of many academic medical centers, where often a central service desk exists, but historically many departments retain their own HIT staff to deal with incidents within their department.
2. *Virtual.* This is a new form of service desk whereby a single contact phone number or website is provided for initiating incidents; however, the actual services may be delivered by a number of different service providers, including internal staff and a third-party provider.
3. *Centralized.* A central pool of resources typically within the HIT department provides centralized service-desk support.

While there are pros and cons for each type of HIT service desk, the key feature that all three must put in place to optimize service support is an integrated view of all incoming incidents. This view not only facilitates a coordinated resolution of the incident but also ensures that trends across the enterprise can be spotted and more proactive approaches can be applied to prevent incidents in the first place (as opposed to simply reacting to them each time they recur).

Incident Management

The goal of incident management is "to restore normal service operation as quickly as possible with minimum disruption to the business [or clinical workflows], thus ensuring that the best achievable levels of availability and service are maintained" (itSMF 2001). In most organizations with a central service desk function, all incidents are channeled through the service desk. Typically, central HIT service desks are organized to provide three levels of support.

1. *First-level support services.* All incidents initially come to the individuals that staff the first-level support services. These individuals typically log the call or request into a "trouble ticket" or "incident management" database so that incidents can be tracked from start to finish. Additionally, the first-level support staff are typically trained to handle most routine, recurring incidents such as resetting a user's password, assisting with routine office-automation software, and answering how-to questions. When HIT service desk technicians are armed with service desk tools that allow remote control of a user's desktop device, organizations can expect 65 percent resolution on the first call into the first-level support technicians. With increased training and access to a knowledge base of symptoms/resolutions, first-call resolution rates above 80 percent can be obtained (Anton 2001).
2. *Second-level support services.* Incidents that cannot be addressed by the first-level support technicians because they require greater expertise and training or require that a technician physically go to the user's location are handed off to dedicated desktop or field-support technicians for resolution.
3. *Third-level support services.* Incidents that are routed to third-level support are typically the most difficult and unique problems and often require deep root-cause analysis and reengineering of the application or system affected.

Exhibit 7.5 depicts a sample workflow diagram showing how incidents may flow through the various levels within a service desk.

In this example of a typical organizational central HIT service desk, the end user can either call in an incident, a request, a problem, or a question (IRPQ) or, for nonurgent IRPQ, simply open an incident report via the service desk's web-based incident portal application. In either case, first-level service desk technicians will initially address the IRPQ and attempt to resolve it on the spot. In this example, the service desk technicians also have access to an ITIL best practice—configuration management database (CMDB), which is covered later in this chapter. In short, this is essentially a knowledge store

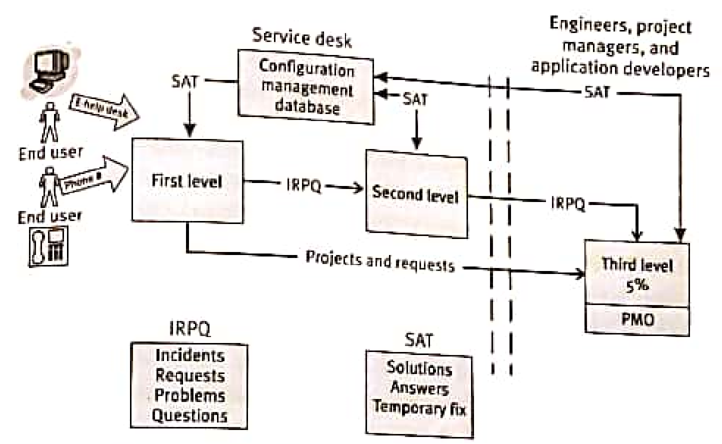


EXHIBIT 7.5
Sample IT Service Desk Workflow

of solutions, answers, and temporary fixes (SATs) as well as a knowledge store for system configuration settings that first-level technicians can use to potentially expedite the resolution of an end user's incident. However, if the first-level service desk technician cannot immediately resolve it, the IRPQ gets escalated to a second-level service desk technician. Finally, for organizations that have implemented a portfolio or program management office (PMO) as outlined in Chapter 11, often the service desk becomes the "front door" for requesting new HIT projects, which, as Exhibit 7.5 suggests, get escalated immediately to the PMO.

Second-level HIT service desk technicians make use of the CMDB and may create new knowledge within it when they discover a permanent solution or find a reliable temporary workaround or fix to a recurring problem. As the exhibit indicates, when second-level service desk technicians cannot resolve the issue, the IRPQ is then moved to the third-level service desk technicians, who typically are members of the organization's HIT network engineering, server administration, or applications development group where root-cause analysis occurs along with efforts to engineer a permanent solution to the IRPQ. Ideally, first- and second-level service desk technicians should be able to find SATs 95 percent of the time, while third-level service desk technicians should be needed for only 5 percent of IRPQs.

Without a disciplined, effective front-door approach to all trouble calls and requests for services, the HIT department can quickly become swamped with requests that circumvent the service desk process. Additionally, without the integration with some of the other ITIL processes (e.g., change management, release management, configuration management, which are discussed later in this chapter) the service desk can be seen as largely ineffective. Ciccolini and McDermott (2005, 1) suggest that

> in many cases, the front-line service desk acts as little more than an answering service, logging incidents and forwarding them to a more senior IT person [second- or third-level support technicians] for resolution. Further, service desks often lack the information needed to address end-user incidents—particularly those that involve proprietary applications. The under-utilization of front-line service desks poses both cost and credibility problems for IT organizations. Incident resolution costs (and indirect opportunity costs) increase as cases are passed on to more senior IT specialists. Business users suffer from productivity declines and perceptions of IT often sour as customers fail to see their issues being addressed in a timely fashion.

Best practices in incident management to overcome these costs and productivity declines include the following:

- Insisting that all users employ the service desk as the front door for submitting all IRPQs
- Using effective automated service desk tools, such as telephony to track phone metrics (e.g., average time a customer is on hold), and service desk management software to log and track all incidents through to resolutions
- Ensuring that service desk technicians have access to an effective CMDB, which serves as an effective knowledge base of system configuration settings, upcoming changes to the infrastructure, upcoming new releases, known problems and errors, resolutions, and workarounds
- Ensuring that service desk technicians have access to service-level management data (covered later in this chapter)

One of the most important functions of the service desk—in addition to quickly finding a resolution to an incident and returning users to productive use—is providing data to spot trends that require a root-cause analysis and a more permanent resolution. For instance, in tracking monthly incident metrics, the HIT manager spots the same incidents recurring each month. As Exhibit 7.4 indicates, these recurring incidents become the input to the next HIT service support process—problem management.

Problem Management

The goal of problem management is "to minimize the adverse effect on the business of incidents and problems caused by errors in (any of the components of) the infrastructure and to proactively prevent the occurrence of incidents, problems, and errors. . . . A problem is the unknown underlying cause of one or more incidents. It will become a known error when the root cause is known and a temporary workaround or a permanent [solution] has been identified" (itSMF 2001).

With incident management, the primary goal is to restore service to end users as quickly as possible. This often results in temporary workarounds or Band-Aid solutions being implemented to allow the end user to use whatever HIT asset is needed to perform his or her job. Problem management, on the other hand, is focused on determining the underlying root cause(s) of incidents. Root-cause analysis should not be a foreign concept, as The Joint Commission (2003) requires root-cause analysis to be conducted to get to the underlying causes of sentinel events that occur in healthcare settings. Furthermore, the National Aeronautics and Space Administration or NASA uses root-cause analysis routinely to determine underlying causes of spacecraft system malfunctions. These same root-cause analysis processes are applied by leading HIT departments as a means of providing world class HIT support services. Root-cause analysis is composed of the following four elements (Rooney and Vanden Heuvel 2004):

1. *Data collection.* HIT department analysts collect all known information about a particular problem from myriad sources, which include but are not limited to the incident management database, the configuration management database, and change control logs.
2. *Causal factor charting.* Analysts create a flowchart of events, configuration settings, and other known facts that created the problem. This charting process often identifies gaps in knowledge that require more data collection to investigate the problem. Therefore, the data collection and causal factor charting should be viewed as iterative processes that work in tandem. Additionally, it is not uncommon for multiple contributing causes to problems to exist.
3. *Root-cause identification.* After all of the potential contributing causes have been identified in a flowchart, analysts identify the underlying root causes for the problem.
4. *Recommendation generation and implementation.* Based on the particular root causes, people from the HIT department with the relevant skill sets are gathered to generate ideas about resolving the identified root causes, select the "best" recommended solution(s), and develop and implement the plan (this typically involves the change management process discussed next).

Healthcare organizations with formal problem management processes in place can expect to see a reduction in the number of overall incidents that are generated, a decrease in average time to resolve incidents, and an increase in customer satisfaction over time.

Change Management

To effectively administer needed changes to the *HIT infrastructure*—broadly defined as any HIT application or architecture component—organizations generally defer to a change review committee or change advisory committee. This committee is made up primarily of HIT personnel from all of the various teams within the HIT department along with key users from the business and clinical areas. Typical representation of such a group includes but is not limited to the following:

- Network engineer or architect
- Server/hardware engineer or architect
- Key application analyst
- Support center manager
- Nurse manager
- Business office manager
- Physician (as needed for changes that involve physician workflow)
- Vendor representative (as needed when changes affect a vendor-supplied application or hardware device)
- Third-party consultant and other technical expert (as needed)

This group meets as often as necessary to proactively manage upcoming changes. Typically, organizations have a means of dealing with both urgent and routine changes. Urgent changes follow a fast-track approach, such as quickly rolling out the latest virus-protection signature files to all end-user devices after an organization is hit with a new virus. Routine changes include those for which lead times are known and can be planned in a less hurried manner, such as adding disk-encryption software to all end-user devices, which can be planned far in advance and rolled out in a measured way.

As Exhibit 7.4 indicates, requests for changes can come from the business or clinical units (e.g., request to interface two preexisting applications that have not previously been interfaced), can come from incidents, or can stem from a problem management process that has recommended changes to alleviate root causes to identified problems. Additionally, change management process must ensure that ongoing changes are documented in the organization's CMDB.

Release Management

The purpose of release management processes is to ensure that either a new software or a new hardware being added to a live environment has been built and tested in such a way that it is put into service without causing negative effects (described earlier in this chapter). For instance, as part of the healthcare organization's testing of a new version of a mission-critical application, an HIT manager discovers that the software will run only on hardware with an upgraded operating system and upgraded hardware memory. In this case, the decision is made to release this new version of software as part of a package that includes an upgrade of its associated hardware. Organizations without rigorous release management practices suffer from disruptions in service due to unplanned work as described by Kim (2006).

The full release management process as outlined by the IT Service Management Forum (2001) includes the following processes, all of which are tied to the CMDB at a minimum (as it is the definitive knowledge source for documenting changes to all HIT resources):

- Release policy (clarify roles and responsibilities within the HIT department, and establish business rules or operating norms associated with how releases will be managed)
- Release planning (develop a succinct but comprehensive plan for each specific release to include a contingency plan to remove the release and return to a preexisting version should the release fail)
- Development or purchase of software/hardware (determine if the release requires the purchase of hardware/software components)
- Building and configuration of the release (include the development of detailed instructions for implementing the release)
- Release testing (conduct a performance test of the release, ideally with the end users of the product, to ensure it operates as expected)
- Release acceptance (the end users and the HIT manager[s] responsible for the release formally accept the release)
- Roll-out planning (essentially extend the release plan that was initially developed at the beginning of the project to add specific details of the exact installation process)
- Communication preparation and training (plan and develop the communications targeted at the end users as well as the training that end users and system administrators may need prior to the release implementation)
- Distribution and installation (distribute the release and install it as appropriate)

In essence, the release management process requires explicit and deliberate coordination and communication mechanisms to be evident within and beyond the HIT department. Release management processes are closely tied to both change management and configuration management. In fact, leading organizations are advised, when putting in place these ITIL processes, to centralize oversight of the change, configuration, and release management processes (Farah 2004; OGC 2005) and to closely tie this centralized oversight into the project management process identified in Chapter 4 (Moreira 2004).

Configuration Management

A common feature of almost all hardware and software is the ability to manipulate its configurations. Examples of configuration settings can be simple (such as the screen saver that can be selected on a personal computer) or complex (such as the fail-over settings for adding CPU capacity to a virtual server environment). Most hospitals and integrated hospital delivery networks use a hundred or more different applications and dozens of different hardware platforms. Thus, maintaining comprehensive knowledge of the configuration settings on each becomes an important task for HIT departments that want to avoid all of the reactive, unplanned work that results when new changes or releases are introduced without knowledge of their impact on preexisting configurations (Kim 2006). Configuration management processes focus on the identification, recording, and reporting of HIT components to include software versions and the interrelationships between the components (itSMF 2000, 2001).

Configuration management includes the following five subprocesses:

1. *Planning*. This entails high-level outline planning and detailed three- to six-month planning that address envisioned additions to the hardware or software environment that likely will have an impact on configuration settings of one or more of the HIT assets within the healthcare organization.
2. *Identification*. This explicitly identifies configurable components of the HIT infrastructure and documents their ownership and the interrelationships between them. Examples include but are not limited to servers, network components, software licenses, desktops, and computer facilities.
3. *Control*. This ensures that no change is enacted within the HIT infrastructure without appropriate documentation validating that the envisioned affected configuration items have been adequately tested prior to implementation.

4. *Status accounting*. This ensures accurate reporting of the configuration setting of all of the items that make up an organization's HIT infrastructure throughout their lifecycle.
5. *Verification and audit*. This involves routinely auditing the documentation that exists on configuration items to ensure accuracy.

One tool that can facilitate the configuration management process is the CMDB. As noted in Exhibit 7.4, all of the HIT service support processes (incident management, problem management, change management, and release management) can have an effect on HIT asset configuration settings. As such, a single CMDB that is used by the entire HIT department can provide a powerful means of dynamically documenting change states in asset configurations as well as serving as an up-to-date tool to plan changes and releases.

HIT Service Delivery

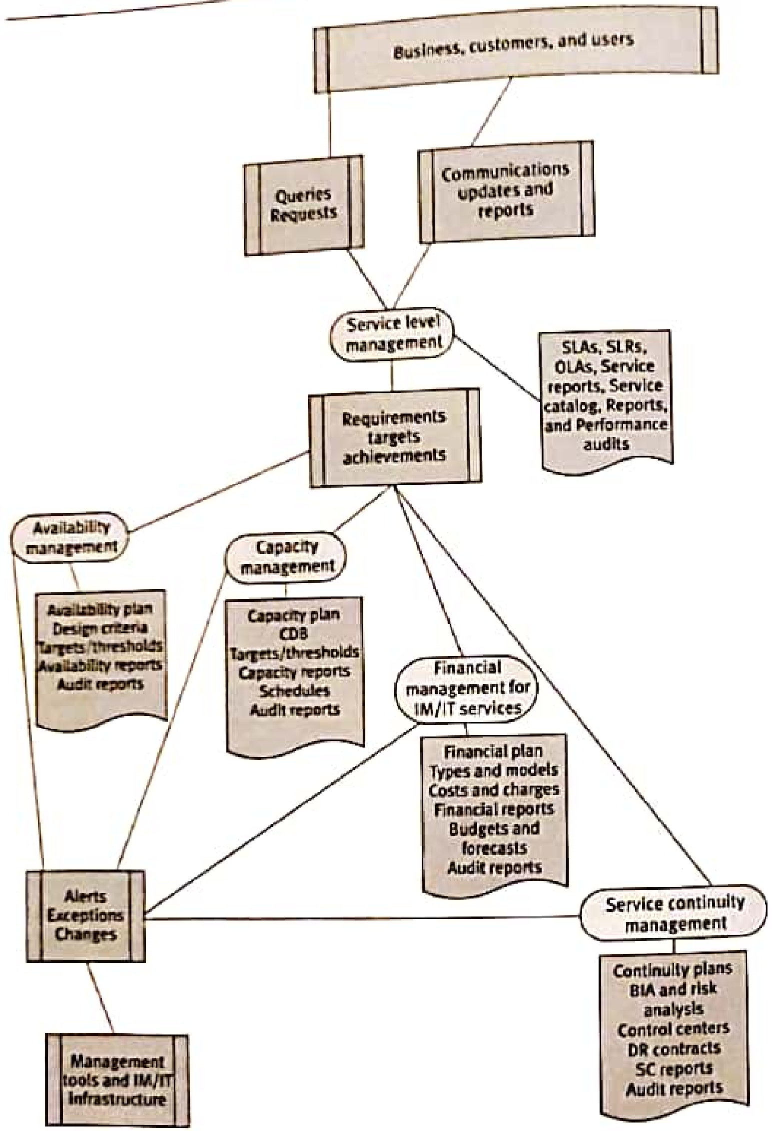
The previous section of key HIT departmental processes was largely focused on establishing a rigorous, interconnected set of operational methodologies. This section, on HIT service delivery, focuses on tactical methodologies that focus on ensuring that services are delivered as expected by the HIT department's customers. Exhibit 7.6 depicts how the HIT service delivery processes work together. (For definitions of HIT service delivery processes, please refer to Exhibit 7.3.)

Service-Level Management

The purpose of service-level management is to proactively review, with the HIT department's customers, the value of the services being delivered. Service-level management is typically operationalized via the establishment of service-level agreements (SLAs) between the HIT department and specific sets of customers. The contents of a typical SLA include the following (itSMF 2004):

- Description of the services to be provided or a particular deliverable (e.g., provide dual power and redundant server hosting services in the hospital's central computer room)
- Agreed-on service hours (e.g., help desk services from 7:00 am to 7:00 pm)
- Description of the response times and resolution times for various scenarios (e.g., resolve within two hours all PC support incidents categorized as urgent)

EXHIBIT 7.6
ITIL Service Delivery Processes



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- Description of service availability, security, and business continuity expectations (e.g., in the event of catastrophic loss of the hospital's central computer room, inpatient electronic medical record application will be available via the disaster recovery remote site within 72 hours)
- Explicit articulation of customer responsibilities and HIT department responsibilities (e.g., customer is required to initiate all requests for service via the HIT central service desk)
- Explicit articulation of critical business periods (e.g., end-of-year financial closeout may require heightened service levels and responsiveness) and exceptions (e.g., holidays)

Some HIT departments do not enter into SLAs at all; hospital users simply get whatever service the HIT department is able to provide. Others enter into SLAs whereby the HIT department specifies the terms or conditions of the services it is able to provide within specified time periods without any input from its customers. Both of these examples (no SLAs and SLAs dictated by the HIT department) are suboptimal practices that do not align HIT service delivery expectations with the drivers of the hospital's business. High-functioning HIT departments, on the other hand, take the time with all of their major customers to negotiate and agree on specific service-level expectations at a given cost. Typically, HIT departments with more resources can be more responsive. Often, however, hospital budgets limit the amount of dollars available for the delivery of HIT services. For this very reason, it becomes paramount that HIT managers put in place SLAs with their customers. The purpose of these agreements are not only to set realistic expectations (in the case of the budget-constrained hospital) but also to continually work together to assess performance against the SLA and make adjustments (perhaps by increasing the HIT budget to attain higher service levels).

Another important component of service-level management is the development of a service catalog, which describes all of the HIT services that the healthcare organization's customers can expect to receive from the HIT department. These service catalogs can range from simple brochures detailing the services and means of accessing the services to fully web-enabled dynamic service catalogs that link to various applications that serve as entry points to numerous HIT services.

Capacity Management

The Information Systems Audit and Control Association, considered the definitive professional society for certifying and educating information systems audit professionals, defines *capacity management* as "the process of monitoring, analyzing and planning the effective use of computer resources"

(Anderson and Peris 2007). Specifically, first, capacity management is an explicit process to create a better understanding of the business and clinical needs for computer resources (such as the impact that adding a patient portal to a preexisting EHR system will have on existing computer resources). This is largely an outward-looking analysis of the organization's changes in business goals and approaches. Changes in goals and approaches might necessitate changes in the hardware or software environment that supports the business and clinical processes. The second focus of capacity management is more inwardly focused, whereby CPU performance, disk space utilization, growth of applications running on computer resources, growth of users accessing computer resources, and network traffic patterns are constantly monitored so that HIT managers can proactively address potential problems that can be forecasted as a result of rigorous monitoring. As such, the definitive goal of capacity management is to consistently and accurately predict and implement needed changes in the computer resources of an organization to ensure that sufficient capacity exists within the computing resources for unimpeded business and clinical operations. Organizations that do not have capacity management processes in place experience high amounts of unscheduled downtime and high costs associated with mitigating the impact of unforeseen computer resource upgrades needed to restore capacity (Schess 2002).

Availability Management

Availability management is closely related to capacity management in its focus on ensuring that computer resources are available when users need them. Availability management consists of the following five components (itSMF 2001):

1. *Availability*—the percentage of agreed-on service hours that a particular computer resource or service is available for use (e.g., the service center is available for taking trouble calls from 7:00 am to 7:00 pm)
2. *Reliability*—the prevention of malfunctions and the ability to keep services and computer resources operational (e.g., by using backup power distribution units, power-related failures are mitigated)
3. *Maintainability*—the ability to quickly restore services or computer resources back to normal operations (e.g., an effective service center that can quickly resolve incidents and restore computer resources to an operational state)
4. *Serviceability*—the ability of external contractors to augment internal HIT department resources to service parts of the HIT infrastructure (e.g., an effective escalation process whereby vendor specialists can be called in to help resolve vendor-specific hardware or software issues)

5. *Security*—the implementation of appropriate access controls to ensure continued services (e.g., the ability to accurately restore user passwords for bona fide employees when such a need arises)

The availability management process focuses on measuring system downtime, network downtime, average time it takes to resolve an incident, and other metrics that describe when systems and services are not available to users. These metrics then become the internal benchmarks with which HIT managers assess improvements in availability of computer resources.

Financial Management for HIT Services

Many small HIT departments do not set up a distinct function to holistically manage the finances associated with providing HIT services. As healthcare institutions continue to automate an increasing number of their operational processes and as the complexity of managing computer resources increases as a result of this significant growth in automation, the need to effectively manage HIT as a business in and of itself will also continue to grow (Lutchen 2004). In fact, Ferranti (2007) suggests that organizations with more than 100 HIT employees will typically have a senior manager who oversees the HIT department finances and reports directly to the CIO. Typical functions associated with the financial management of HIT services include but are not limited to the following:

- Creation of the annual HIT budget and management of that budget to ensure annual expenditures do not exceed the budgeted amounts
- HIT asset procurement management to ensure purchased items are within the budget and to seek maximum volume discounting on purchases
- Creation of the schedule of costs and oversight of charge-back processes and receipt of funds from customers
- Vendor management to continually seek vendor discounts and manage relations with vendors
- Oversight of anti-fraud policies and procedures, such as Sarbanes-Oxley Act compliance (particularly true for for-profit healthcare organizations)

As noted in Exhibit 7.6, the finances required to provide a given level of HIT services are driven by the clinical and business needs of the healthcare organization. As the need for responsiveness goes up, so does the need for additional finances to support these higher service-level targets. Likewise, organizations' attempt to increase the number of HIT development initiatives they wish to undertake within a budget cycle typically will also drive up the funding levels needed to support increased simultaneous development efforts. Thus, it is critical to negotiate definitive SLAs with all of the customers of the HIT department to ensure that adequate funding needs can be identified that align with the desired service-level needs. Often, cutting back on HIT budgets forces organizations to remove resources that had previously been assigned to providing HIT services. In these situations, it is paramount that HIT leaders renegotiate SLAs to ensure that misunderstandings about service-level expectations can be avoided. The old adage "you get what you pay for" holds particularly true in providing HIT services to healthcare organizations. To avoid a mismatch in customer expectations, fully understanding the service-level constraints of given levels of funding is important to the effective financial management of HIT services.

Service Continuity Management

While service interruptions due to unforeseen downtime of healthcare HIT assets are fairly well understood, expected, and largely routinized, major service interruptions due to natural disasters such as earthquakes, hurricanes, or fires typically require a much different response. HIT ***service continuity management*** is the process for restoring the healthcare organization's HIT services as quickly as possible after a service interruption (itSMF 2001). Examples of devastating impacts on healthcare operations were plentiful in the New Orleans area following Hurricane Katrina in 2005. Some healthcare operations, such as Charity Hospital, simply ceased to exist as a result (Rowland 2007). As noted earlier, healthcare delivery organizations' poor financial health often makes it difficult to invest adequately in HIT services such as continuity plans. While it is not uncommon for organizations to have continuity plans, in the event of a real disaster or major disruption in service, the executions of these plans often fail. Clarke (2004) refers to these types of plans as "symbolic plans" or "fantasy plans." He notes, "symbolic [continuity] plans are the ones that are charade. They're touted as workable but, in fact, they're not based on actual expertise or experience and, by definition, they over promise. . . . [Furthermore,] symbolic plans can create a dangerous false sense of security" (Clarke 2004, 21–22).

To ensure that the HIT department has workable HIT service continuity plans in place, the United Kingdom's Office of Government Commerce (2005) suggests that the organization undertake a business impact analysis whereby the senior leadership team identifies the business and clinical processes that are absolutely critical to the functioning of the enterprise. For instance, a balanced scorecard-performance reporting application may not be essential, but the admissions, discharges, and transfers and billing applications

will likely be considered critical. The business impact analysis also assesses the following for each critical process (OGC 2005):

- Lost revenue or costs associated with a disruption that may accrue
- Likelihood that the degree of damage or loss will escalate after a disruption
- The staffing, skills, facilities, and services necessary to enable critical and essential business processes to continue operating at a minimum acceptable level
- Realistic estimates of the time required to restore minimum service levels
- Realistic estimates of the time required to fully recover service levels

After the business impact analysis is completed, a risk assessment is conducted to assess the extent to which a healthcare organization is vulnerable to different potential threats. For instance, a hospital in Lubbock, Texas, has a higher likelihood of sustaining damage from a tornado than a hospital in Vancouver, British Columbia. After assessing the business impacts as well as the potential risks and their likelihood of occurrence, an HIT service continuity strategy is developed. The key elements of this strategy should describe the following:

- Implementation of the strategy
- Arrangements made for standby recovery locations, either via contracts with third-party vendors specializing in disaster recovery hosting services or via reciprocal support agreements with other organizations
- Risk-reduction measures (While the organization cannot do much about being located in a tornado alley, for example, identifying a need to move the computer room from the basement of the building because it is within the 100-year flood zone to a higher floor is certainly something that can be accomplished to reduce risk.)
- Detailed step-by-step procedural checklists to restore service levels (These should "be action oriented—simple checklists for teams to follow, supported by supplements containing more detailed information on each action required" [Hiles 1992].)
- Timeline for testing the plan in a realistic manner (e.g., periodically simulating a disaster and invoking the standby contracts to bring up one or more of the critical applications at an alternate location. This is an important element of service continuity planning, as it overcomes Clarke's [2004] criticism of symbolic plans and ensures that

the organization has a tried-and-tested approach to restore critical HIT-dependent business processes.)

The Continued Evolution of the ITIL Service Management Practices

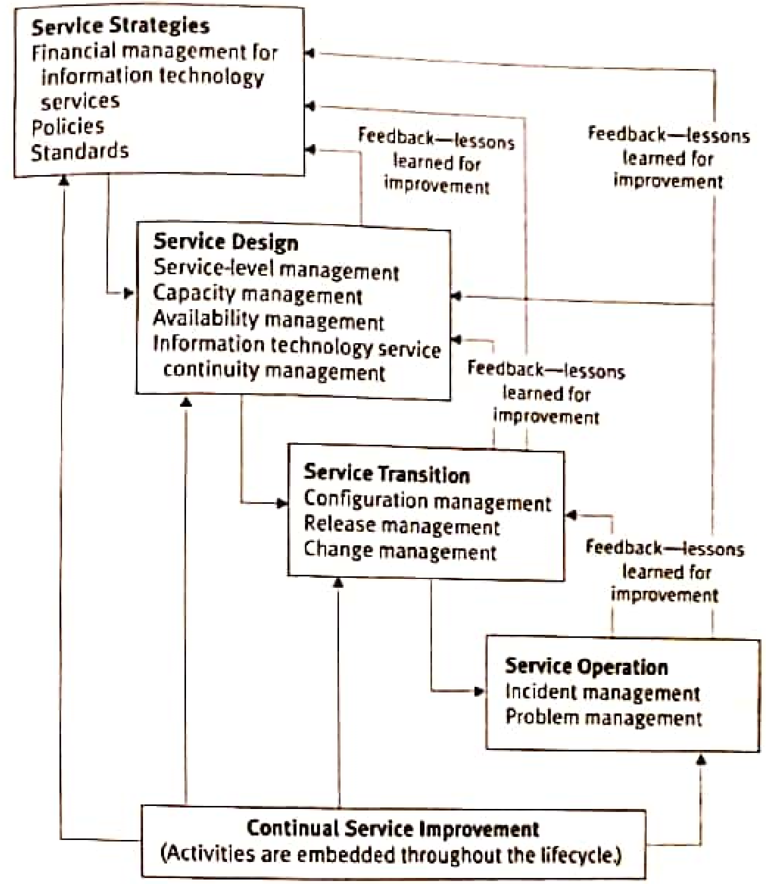
As a framework of information technology service management practices, ITIL continues to evolve and be refined. The ITIL framework was reconceptualized as the ITIL Service Management Lifecycle (TSO 2007). The individual information technology operational service support management processes (i.e., incident management, problem management, release management, change management, and configuration management) continue to be recognized as important best practices in managing HIT departments. In addition, they remain core to current conceptualizations of ITIL (Whittleston 2012). These individual information technology service support management practices are now part of a lifecycle framework that emphasizes the need to view information technology services as a continual service improvement process. Exhibit 7.7 provides an overview of the ITIL service management lifecycle and shows how the individual ITIL processes discussed in this chapter are related to the latest evolution of service management.

This new conceptualization of ITIL suggests that the delivery of services should begin with a strategy for how those services might be provided to the various businesses, customers, and users of the services. Most important, it highlights the importance of establishing policies and standards that will help in effectively delivering information technology services. The financial management for information technology services, discussed in this chapter, falls into this ITIL service management lifecycle category.

The output of the service strategy lifecycle element becomes the input for the service design element, where plans to create and modify services as well as tactical service delivery management processes (i.e., service-level management, capacity management, availability management, financial management, and service continuity management) are addressed. In turn, the output of the service design element becomes the input to the service transition element, in which the proactive management of the transition of a new or changed service and/or service management process is placed into production. The output of the service transition element becomes the input for the service operation element, which involves the day-to-day operations of services and service management processes.

Finally, the latest evolution of the ITIL service management practices is the conceptualization of a continual service improvement element, which is to be embedded throughout all of the ITIL practices, creating feedback loops

EXHIBIT 7.7 Service Management Lifecycle



SOURCE: Adapted from TSO (2007).

of lessons learned throughout the lifecycle that should be used to continually improve services.

Summary

Healthcare administrators have long recognized the need for efficient and effective operations throughout the healthcare enterprises that they lead. However, because few senior executives have come from HIT backgrounds, the internal workings of the HIT department have often been a "black box" to senior leadership. In this chapter, we open the HIT department black box and present ten operational and tactical key processes that, when managed in a loose, informal manner, will create costly unplanned work that limits the resources available for new strategic initiatives. To maximize efficiencies and effectiveness, many healthcare enterprises are adopting frameworks to enhance their internal operations.

A number of frameworks are presented here, including the ITIL framework, which Young and Mingay (2003) suggest is the framework best suited for HIT department-led process improvement efforts. ITIL categorizes the ten key HIT department processes into two: (1) service support management, which includes incident management, problem management, change management, release management, and configuration management, and (2) service delivery management, which includes service-level management, capacity management, availability management, financial management, and services continuity management. As more and more healthcare enterprises are becoming automated, demands on professional HIT department services will continue to increase. HIT departments that have implemented, or are implementing, formal process improvement frameworks like ITIL will create greater efficiencies and thereby leverage HIT resources toward more strategic initiatives.

Web Resources

A number of organizations (through their websites) provide more information on the topics discussed in this chapter:

- Information Technology Infrastructure Library (ITIL; www.itil-officialsite.com). This is the official ITIL website.
- ITIL Open Guide (www.itlibrary.org/index.php?page=ITIL). This website is maintained by the ITIL practitioner community for sharing information about ITIL.
- IT Service Management Forum International (www.itsmfi.org). This is an international forum that promotes best practices in information technology service management.
- IT Service Management Forum US (www.itsmfusa.org). This is the US chapter of the IT Service Management Forum International.

Discussion Questions

1. Why does unplanned HIT work increase costs?
2. Identify some process improvement frameworks that are applicable to an HIT department. What are the advantages and disadvantages of each?
3. Describe the five HIT service support processes and how they are interrelated.
4. What is a CMDB, and why is it an important component of HIT service support?
5. Describe the five HIT service delivery processes and how they are interrelated.
6. What is an SLA, and why is it an important component of HIT service delivery?
7. List some of the reasons given for HIT service continuity plan failures.

CHAPTER

8

SYSTEMS SELECTION AND CONTRACT MANAGEMENT

Learning Objectives

1. Describe the steps in the healthcare information technology (HIT) system selection process.
2. Articulate why it is important to clarify objectives prior to engaging in system selection.
3. Describe vital features that an organization should include when negotiating and crafting contract terms and conditions.
4. Articulate the purpose of an HIT total-cost-of-ownership analysis.
5. Articulate the purpose of a benefits realization assessment.

Overview

When he saw a large wooden horse at the gates of Troy, presumably left as a peace offering by the Greek army, the Trojan priest Laocoön gave birth to the now famous phrase, "beware of Greeks bearing gifts." As the mythology tells us, the Trojans ignored Laocoön's warning and accepted the gift horse, which resulted in the fall of Troy (Phrase Finder 2011). Clearly, this Trojan Horse analogy is entirely too strong for healthcare information technology (HIT) vendors; however, it is nevertheless prudent for healthcare managers to play modern-day Laocoön when working with any outsider whose interests and risk profile may not be aligned with those of the organization. To be sure, failed IT implementations can sometimes be attributed to poor execution on the part of the hospital or health system project team. Although this chapter is not about failure to execute scenarios, it does focus attention on how to establish productive relationships with potential HIT vendors.

Mike Murphy, president and CEO of Sharp Healthcare in San Diego, once commented, "I have been disappointed that many of the products are not really ready for prime time when they are sold" (Smaltz et al. 2005b). Similarly, David Hoidal, while CEO of the University of Alabama at Birmingham Health System, noted that "it's disappointing that the lack of functionality that cuts across multiple applications leaves healthcare system like ours to bear the cost and the burden of making everything work together" (Smaltz et al. 2005b). These anecdotal insights from leading CEOs suggest that having a sound system selection process with contract management is instrumental in making informed HIT investment decisions. This chapter[1] focuses on the crucial system selection process and contract management function.

The System Selection Process

For many healthcare providers, selecting and implementing a new enterprise information system can be one of the most costly and high-risk investments they will make over the course of many years. Especially in the case of an enterprise electronic health record (EHR), revenue cycle, or enterprise resource planning (ERP) solution, the capital and ongoing operational investment can run into hundreds of millions of dollars, and the system itself will have a direct impact on the daily lives of staff, clinicians, administrators, and (most important) patients and their families. These core systems are long-term investments, so a lot of fear and uncertainty are associated with the selection process because it is an activity that occurs infrequently but has far-reaching consequences.

The good news is that system selection is relatively straightforward, and the guidelines and principles of a well-managed system selection process apply equally well to the process of selecting a departmental solution (such as a pharmacy information system) and an enterprise EHR.

The primary activities in a system selection process are as follows:

- Clarification of the objectives
- Formation of the system selection governance structure and processes
- Establishment of a system selection plan
- Education: Understanding the marketplace
- Down selection: Narrowing the field
- Documentation of the requirements: Developing the request for proposal
- Conducting detailed product demonstrations
- Completion of other due diligence activities
- Final selection
- Contract negotiations
- Benefits realization

Clarification of the Objectives

As with any organizational management decision, the first step is to document the problems that the organization is trying to solve with the new system or define the opportunities that the organization will be able to pursue because of the investment in a new system. This step addresses what the great philosopher and baseball legend Yogi Berra once said, "If you don't know where you are going, you will wind up somewhere else" (Things People Said 2011).

For instance, the organization can develop a set of requirements that address known problem areas with current applications or processes. Even more important, once the organization has created this initial list of needs, it must vet these requirements to understand which ones truly are must-have capabilities and which ones are less important. Too often, the organization becomes enamored by a new technology or popular product without knowing the clear purpose for that system. Technology should always be implemented to support the achievement of a desired process or outcome. Key questions for which an organization should have clear answers include the following:

- Is the system required to meet a regulatory mandate?
- What aspects of the organization's strategic business plan will it support?
- Will it help to drive business growth or support service-line development?
- Will it enhance patient safety and quality outcomes?
- Will it improve the flow of clinical, financial, or operational information across the enterprise?

Ideally, the objectives for the system must be clearly identified and agreed on before any products are reviewed. A project charter that lists these objectives, the expected benefits, the main project participants, the participants' roles and responsibilities, and the process for monitoring project progress is an excellent tool to support communication and buy-in. The project charter's objectives can be the basis for a return-on-investment analysis, which is required for the approval of capital investment in many organizations.

Formation of the System Selection Governance Structure and Functions

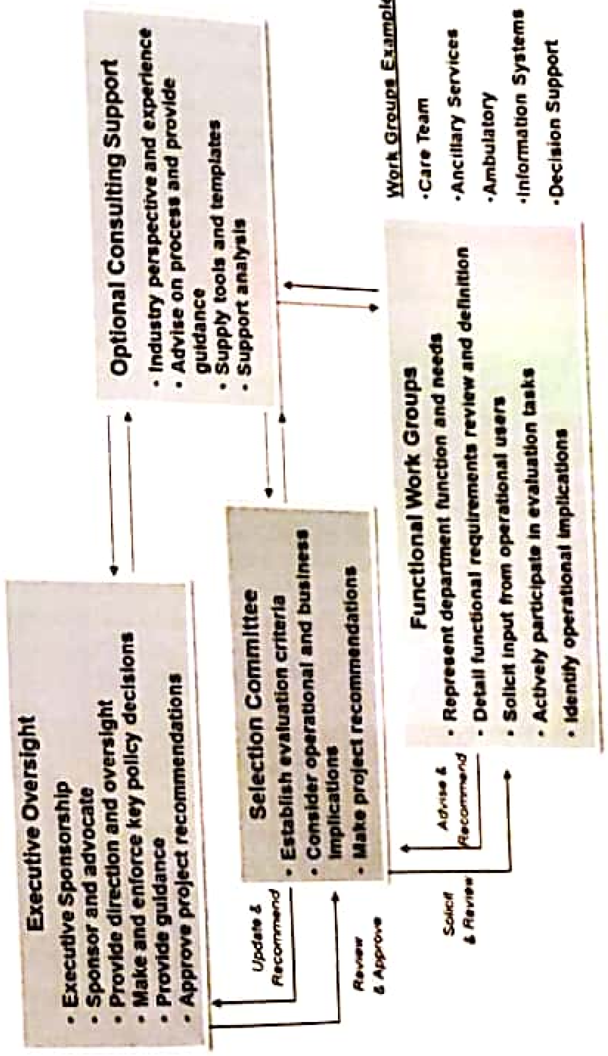
One of the most difficult tasks in systems implementation is achieving the desired level of adoption in the organization. An excellent way to lay the foundation for enthusiastic adoption is to bring all the stakeholders to the table as early as possible, obtain their endorsement of the objectives, and then ensure their active participation in the selection process. This leads to a shared sense of ownership in the result as well as a better-educated and better-prepared user population. Note here that the HIT department should almost never be seen as the main driver of the system selection. Having executive-level sponsorship for the project and highly visible leadership by members of the intended user population (be they physicians, nurses, pharmacists, or others), with the information technology (IT) department providing support to the process in the background, is ideal. Also important is to establish a project organizational governance structure that ensures strong and ongoing sponsorship, effective management and oversight, and sufficient involvement of operational staff so that all requirements are properly defined and evaluated. A hierarchical structure works well, where operational work groups perform the bulk of the analysis, feeding the information up to a selection committee for decision making. In some cases, it may be appropriate to seek the assistance of an external consultant with expertise in the specific technology and vendor marketplace to help guide the process and provide subject matter expertise on the marketplace. An example organizational governance structure is provided in Exhibit 8.1.

Most organizations have a preexisting executive committee that can serve in the executive oversight role. Under that committee, typically a system selection committee composed of representative stakeholders is formed. For instance, if the technology is a pharmacy system, the committee membership could comprise the pharmacy director/vice president (VP), the finance director/VP, the chief nurse, the chief medical information officer, one or two representatives from the medical staff, the IT applications director, and other key stakeholders of the potentially affected workflow areas. On the other hand, if the system is an enterprise EHR, then the system selection committee must have much broader stakeholder representation. For efficiency, establishing functional work groups for focused activities is often useful. For example, the system selection committee may form an ancillary services work group to develop requirements for the ancillary modules of the EHR, while a decision support work group might work on developing requirements and evaluating vendor responses for order set development, alerts and reminders, and so on. Finally, external consultants sometimes augment the process in organizations that prefer to have a consultant that has broad experience in running a system selection process.

Establishment of a System Selection Plan

Another best practice is to develop a system selection plan and timeline that are not only efficient but also realistic. If the process is rushed to meet an

EXHIBIT 8.1
Sample HIT Project Organization: Roles and Responsibilities

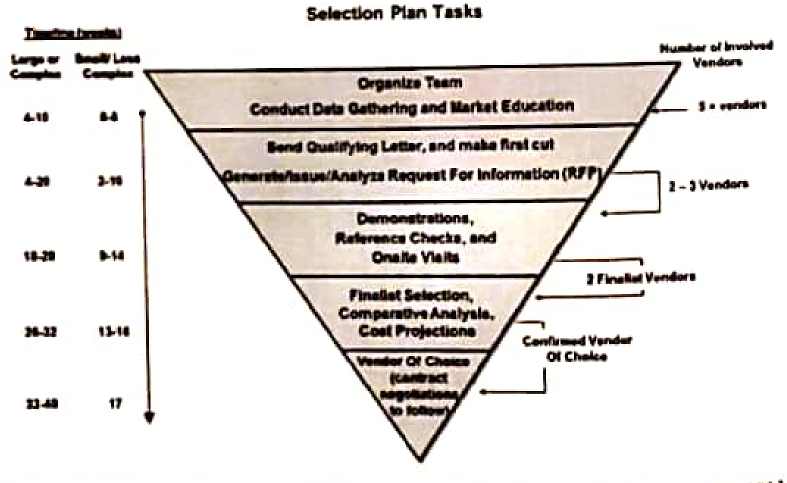


SOURCE: Reprinted from material in "The Vendor Selection Process" by Paul Murphy, 2011, Encore Health Resources White Paper, Houston, Texas, pp. 1-12.
Used with permission.

aggressive deadline, decisions may need to be made too quickly—and this can result in errors or omissions and in members of the selection team feeling left out of the process or forced into a solution they were not ready to accept. Some tasks in the selection process can be very time intensive, so it is important to ensure that selection team members understand or are conscious of the time commitment required of them, the time impact of competing projects and responsibilities, and specific calendar events (such as public holidays and summer vacations). Equally important is to match the selection project timeline to the complexity of the systems being evaluated and the committed availability of the selection team members, both at the functional work group level and the system selection committee level. Organizations should anticipate activities that will require extra time to coordinate and plan (such as product demonstrations), and prepare early. An example of a system selection work plan is provided in Exhibit 8.2.

The system selection plan depicted in the exhibit outlines a 17-week intended process for the steps leading up to, but not including, the contract negotiation and beyond. This assumes that the organization has no delays in forming the system selection governance structure and functions, the stakeholders are available and can participate on schedule, and so forth. In large, complex organizations with many stakeholders undertaking a complex enterprise EHR system selection, selecting a vendor of choice could easily take twice as long. The important point is to have an explicit system selection plan with a timeline that the organization thoughtfully develops and attempts to follow.

EXHIBIT 8.2
Sample System Selection Work Plan



SOURCE: Adapted from material in "The Vendor Selection Process," by Paul Murphy, 2011, Encore Health Resources White Paper, Houston, Texas, pp. 1-12. Used with permission.

Education: Understanding the Marketplace

In highly competitive markets with many quality products, the vendors' reputation and services may represent the biggest differentiator between one system and another. System selection committee members typically conduct some initial data gathering on the leading vendors in the marketplace to find out details such as the following:

- How long has the vendor been in business?
- What is the vendor's reputation for providing customer support during implementation and ongoing maintenance?
- How much effort will the vendor put into product development and enhancement?
- What is the vendor's business plan?
- How has the vendor performed financially over the past several years?

If the vendor is financially or organizationally unstable, it may not be able to adequately support an organization or continue to invest in the quality of the product. In the HIT marketplace, vendor acquisitions are common, and the new owner may not provide the same level of service as given by the original vendor.

A number of subscription-based sources are available for assessing HIT functionality and the extent of a vendor's installed base for its products. The first is Gartner (www.gartner.com), a consulting firm that specializes in providing market research in the IT industry. Many healthcare organizations' IT departments maintain subscription services to Gartner, which also tracks the HIT industry specifically. For instance, for EHR applications, Gartner tracks by vendor the level of sophistication of various EHR capabilities such as the following:

- Clinical data repository
- Privacy
- Interoperability
- Controlled medical vocabulary
- Workflow
- Clinical decision support
- Clinical documentation
- Display
- Order management (computerized physician order entry)
- Knowledge management
- Continuum of care

Furthermore, Gartner tracks the number of implementations of various vendors' EHR components (Handler 2004, 2005, 2006).

Another source for assessing the extent of installed base of various vendors' EHR offerings is the HIMSS Analytics database (www.himssanalytics.com). This information is generally free to healthcare organizations that are willing to submit their own data regarding their particular installed base of various products. Furthermore, because the HIMSS Analytics database tracks organizational demographic information (e.g., number of beds, adjusted patient days), it can create peer-comparison reports that can be used to benchmark peers running similar financial or clinical application suites.

Finally, KLAS Enterprises (www.klasresearch.com) provides another source for doing research on HIT products. Regardless of a healthcare manager's tolerance for risk, the acquisition of most HIT is an expensive endeavor—one that requires particular due diligence with respect to narrowing the field, negotiation, and contracting.

Down Selection: Narrowing the Field

Down selection is the term for taking an initial set of vendors that are in the marketplace and narrowing down the field to just a few finalists. Often, there are many potential suppliers of a product; some may be industry veterans with tried-and-tested solutions, while others may be newcomers with exciting new technologies but a short track record. It is usually not possible or even desirable to do a full and detailed evaluation of every potential vendor and product. To use time and resources efficiently, it is best to narrow the field of vendors as quickly as possible to the top two or three candidates before engaging in very detailed, time-consuming analysis. Think of this initially as a process of elimination rather than a process of selection. Weed out the obvious misfits so that the system selection committee can focus on the leaders. An effective way to narrow the field is to establish a list of selection criteria that match closely the organization's objectives. Following are some criteria that are often used:

- Essential product functionality
- Existing client base for the system
- Ability to integrate with other systems
- Technology platform
- Vendor reputation and financial health
- Cost to acquire and implement
- System usability

The selection team may apply a percentage weighting to each of the selection criteria so that everyone understands the relative importance of functionality

versus cost versus technology and so on. This weighting will prove highly valuable in the final selection as it provides an objective way to score the finalist vendors.

If a very large number of vendors exist in the marketplace, what can be useful sometimes is to write a short *qualifying letter* that requires each vendor to indicate its ability to comply with basic, objective selection criteria, such as the vendor must have existing clients that are similar to the organization or the vendor must hold desired certifications such as the Centers for Medicare & Medicaid Services' Meaningful Use certification for EHRs. This qualifying letter helps to quickly eliminate outliers with the minimum of effort.

Documentation of the Requirements: Developing the Request for Proposal

During the initial stages of the system selection process, high-level objectives and knowledge gained by the system selection committee members during the marketplace education stage are used to down select to a few key vendors. Some organizations spend a great deal of time developing lists with hundreds or even thousands of functional requirements for the system to which the vendors are then required to respond. This is very time-consuming for both the selection team and the vendors and can provide limited value (the vendor responses also take a lot of work to review). Often, it is better to think "bigger picture" and then create a request for proposal (RFP) or alternatively a request for information (RFI) that contains fewer than 100 questions addressing the primary functions and features desired by the organization. The RFP or RFI is a formal notice—often issued by an organization's purchasing department—that the organization is interested in purchasing a particular type of HIT product. If the selection team is unsure of the features available in the current market, the team may invite one or two vendors to provide a high-level demonstration of their products as a form of education before creating the RFP.

The RFP should be divided into sections addressing different aspects of the system and vendor. It should begin with a few paragraphs that inform the vendors about the organization and its objectives for the system selection, followed by a series of questions about the vendor, the product it is proposing, the functionality offered, underlying technology, associated services, comprehensive costs, and any other relevant information that will help the selection team in decision making. The work groups should participate in drafting questions in their area of expertise. The RFP questions should require the vendor to explain key aspects of the proposed solution rather than merely give a simple yes/no response. For example, instead of "Does your system include medication ordering?", the question should be "Describe medication orders functionality, including related decision support and any features designed to enhance patient safety." Typical RFP sections include the following (see also Exhibit 8.3).

According to mThink (2003), system selection committee members should ensure "vendors account for all costs, such as implementation and maintenance, and don't overlook hidden costs for items such as training and infrastructure costs (wireless, mobile devices, etc.). Here is a list of common expenses:

- Hardware
- System software (e.g., operating system, database licensing, etc.)
- Vendor software
- Interfaces
- Conversions
- Ongoing licensing [and] maintenance
- Increased staff needs
- Networking

EXHIBIT 8.3 Sections in a Typical Request for Proposal

Information Category	Details Sought
Corporate overview	Vendor corporate history, size, organization, financials
Client base	Current client base using relevant products, geographic spread, clients similar to the organization
Healthcare reform and regulatory compliance	Meaningful use compliance plan, support of quality measures reporting, interoperability support for medical home, etc.
Product availability	Products matching required functions (e.g., inpatient, ambulatory, clinical, administrative, technical, reporting), date released, Office of the National Coordinator for Health Information Technology certification status, delivery and support models
Interface availability	Interfacing approach, relevant experience
Technology platform	Use of current, industry-standard technologies
Preliminary and ongoing costs	One-time and ongoing costs, including hardware, software licensing, implementation, training, support, and subscriptions
Implementation and support approach	Phasing, resource requirements (vendor and organization), ongoing support services
Development direction, unique attributes	Future product and technology plans, alignment with organizational vision, market differentiators

- Peripherals (printers, PCs, bar-code readers, handheld devices)
- Training
- Facility renovation to accommodate hardware and training."

Some organizations provide a separate spreadsheet form in which the vendors are required to list costs by category. This helps to ensure that all the costs are identified and can be compared across the vendors' price quotes. Comparing vendor costs should be "apples to apples," carefully separating one-time costs (e.g., licenses, implementation services, training services) from ongoing costs (e.g., annual maintenance, subscriptions) and ensuring that the functionality being included matches across the quotes.

In addition, the RFP should include detailed instructions for vendor responses, including the format for response, dates of submission, and rules for communication. It is important to limit vendor communications to a small number of people on the selection team so that the process can be properly managed and to ensure that all vendors receive the same information. It is a best practice in the selection process to inform the responding vendors that the responses documented in their RFP and quotes will be attached to the final contract as a commitment. This helps to set the vendors' expectations that they will be held accountable to their RFP promises and prevents rework during the negotiation. Analysis of the RFP responses and how well they match the system selection criteria helps to determine which vendors are asked to continue to the next step—conducting detailed product demonstrations.

Conducting Detailed Product Demonstrations

Detailed product demonstrations are usually one of the most time-consuming steps in the selection process. Demonstrations for an enterprise EHR can take more than a full day per vendor and require the attendance of many key personnel. For this reason, it is best to use the information from the qualifying letter and RFP to eliminate all but the top two or three vendors before inviting them for demonstrations. A formal agenda for the product demonstrations is helpful as it sets the expectation that all vendors follow the same approximate sequence and show equivalent functions and features. Paul Murphy of Encore Health Resources, a firm that specializes in assisting hospitals with system selection processes, suggests that organizations should avoid very detailed scripts as these may force the vendor into a workflow that does not match the design of their system and will confuse the audience. Scripted demonstrations tend to take much longer to prepare for and conduct. A simple evaluation document that outlines the major requirements outlined in the RFP will allow system selection committee members to easily record their observations. This is vital to performing an objective comparative analysis.

Completion of Other Due Diligence Activities

The term *due diligence* in the context of this chapter means the effort to educate oneself when evaluating options available for purchase. To round out the selection process, talking to existing users of the finalist vendors' products is always valuable to hear about their experience with the system and the vendor. Using an evaluation form for these reference calls is also recommended. If the organization can afford it, it should conduct site visits with a select group of representatives from the selection team. Many selection committees create a clear agenda for the site visit and share it with the host before traveling to the site. Site visits are also an opportunity to forge relationships with other organizations that can become great sources of advice and assistance during the implementation process and beyond.

Finally, ensure that any questions left unanswered from the RFP, demonstrations, and reference checks are addressed through additional meetings with the finalist vendors. Often valuable is for the technical team at the provider organization to meet directly with technical representatives from the vendors to more fully understand the details of the system infrastructure and technical support requirements.

If the vendors were asked to supply cost quotes during the RFP, the selection team should review these proposed prices again and ask the vendor to confirm the total quoted costs. Frequently, new costs are introduced during due diligence. As a result, creating a total-cost-of-ownership (TCO) analysis prior to final system selection is often helpful in understanding the total costs an organization is likely to incur. A sample TCO for an EHR project appears in Exhibit 8.4.

The intent of the TCO analysis is to uncover not only the fees payable to the HIT vendor but also any additional third-party software fees. Equally important is that a TCO analysis allows the organization to gain an understanding of its own staff costs, as knowledgeable subject matter experts (SMEs) from the current staff often are assigned full-time to the project and will need to be back-filled with new hires or temporary hires; these are often significant costs that are historically underestimated in large HIT projects. Many organizations build in a budgetary reserve of 5 to 15 percent of the anticipated TCO to cover any unforeseen costs (e.g., a hospital acquisition midway through HIT implementation, which would increase licensing and implementation costs).

Final Selection

It is helpful to return to the original selection criteria and rate each of the finalist vendors against each of these weighted criteria based on all the findings from the activities performed by the selection committee. Much of the scoring is subjective, but the selection criteria help the selection team to

make decisions regarding the pros and cons of each solution and weigh those decisions in an objective way. Once the final vendors are ranked (e.g., first preference, second preference), identify the top-ranked vendor as "Vendor of Choice," pending contract negotiations. In this way, the first-place vendor is aware that the organization has a second option, and thus the vendor may be more willing to negotiate the terms more favorably to close the deal.

Contract Negotiations

A well-conducted selection process should set the stage for a streamlined negotiation. By clearly identifying the expectations for the products being purchased or licensed and working through the pricing and implementation support elements of the RFP response, the selection team will already have laid out many of the terms that are of highest priority in the contract negotiations prior to the actual formal discussions.

As a general guideline, the most productive contract negotiations are those in which all parties are committed to developing an agreement that is fair, clearly sets out expectations for the implementation project and subsequent support relationship, provides legal and financial protection to the purchaser, and establishes a relationship based on mutual respect and collaboration. Organizations that take a combative stance or adopt an aggressive, no-compromise attitude during the negotiations must recognize that contract negotiations are the first step in a new business relationship that may continue for many years and thus will find this negative approach unproductive in the long term.

The first step in negotiations is to identify the members of the negotiations team, which include senior executives who have the authority to make financial commitments on behalf of the organization, management-level members of the selection committee who understand the product and its intended functionality, a representative from the organization's purchasing department, and the organization's legal counsel.

Contract negotiations should be treated as a project in itself, with designated negotiation committee members, documented goals and objectives, and a timeline and meeting schedule that includes internal review sessions in between the negotiating meetings. In most cases, including legal counsel, who will take the lead in managing the legal aspects of the contract negotiation, is necessary. Because legal counsel can be expensive, especially for an organization that is not large enough to have an internal legal professional, the legal discussion may be put on hold until all or most of the business terms have been resolved.

Before the first negotiation session with the vendor, the internal negotiating committee should meet to agree on the negotiating strategy, which includes the issues that are most important (e.g., better pricing on software

EXHIBIT 8.4

Sample Ten-Year Total Cost of Ownership for a Typical EHR

Products	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	Total
Capital Based License Fees											
Volume Based Software Licenses											
Chunk 1 (350K Visits)											
25% at Signing	$$$,$$$										$$$,$$$
20 % at Delivery	$$$,$$$										$$$,$$$
5 % on final workflow walkthru		$$,$$$									$$,$$$
5 % on integrated testing kickoff		$$,$$$									$$,$$$
25 % on First Live Use (FLU)		$$$,$$$									$$$,$$$
10% FLU + 90 Days			$$$,$$$								$$$,$$$
10% FLU + 12 months			$$$,$$$								$$$,$$$
Chunk 2 (up to 500K Visits)			$$$,$$$								$$$,$$$
Chunk 3 (up to 750K Visits)			$$$,$$$	$$$,$$$							$$$,$$$
Chunk 4 (up to 850K Visits)				$$,$$$	$$$,$$$						$$$,$$$
Oncology Module	$$$,$$$		$$$,$$$								$$$,$$$
Third Party Database	$$,$$$	$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$						$,$$$,$$$
Addl Vendor One Time Products	$$,$$$	$$,$$$									$$,$$$
Third Party One Time Products		$$,$$$									$$,$$$
Interfaces (Live)											$$,$$$
25% at Signing	$$,$$$										$$,$$$
25% at Delivery		$$,$$$									$$,$$$
25 % at FLU		$$,$$$									$$,$$$
25% at FLU + 90		$$,$$$									$$,$$$
Medication Interfaces (Phase II)			$$,$$$								
Capital Based Implementation Fees											
Implementation (Base)	$$$,$$$	$$$,$$$									$$$,$$$
Implementation (Oncology)		$$,$$$	$$$,$$$								$$$,$$$
Implementation (Interfaces)		$$$,$$$									$$$,$$$
Post-Live Activities	$$,$$$										$$,$$$
Project Team Training	$$$,$$$	$$,$$$									$$$,$$$
Estimated Travel	$$$,$$$	$$$,$$$									$$$,$$$
Rollout			$$$,$$$								$$$,$$$
Capital Based Hardware Fees											
Hardware Environment							$$$,$$$				$,$$$,$$$
AIX Servers		$$$,$$$					$$$,$$$	$$$,$$$	$$,$$$		$$$,$$$
SAN		$$$,$$$	$$$,$$$	$$,$$$							$$,$$$
Test Training Server	$$,$$$					$$,$$$					$,$$$
Clarity RDBMS Server	$,$$$					$,$$$	$$,$$$	$$,$$$			$$,$$$
Crystal Enterprise Server		$$,$$$	$$,$$$				$,$$$				$$,$$$
Print Server		$,$$$					$$,$$$				$$,$$$
Patient Portal Server		$$,$$$				$$,$$$	$$$,$$$	$$$,$$$			$$$,$$$
Citrix Servers	$$,$$$	$$$,$$$	$$$,$$$						$$$,$$$		$$$,$$$
Citrix Server Optional				$$$,$$$			$$,$$$	$$,$$$	$$,$$$		$$$,$$$
Blade Enclosure		$$,$$$	$$,$$$	$$,$$$		$$,$$$	$$,$$$	$$,$$$	$$,$$$		$$$,$$$
Citrix Licenses	$$,$$$	$$,$$$	$$,$$$	$$,$$$							$$$,$$$
Training/Implementation for AIX		$$,$$$					$$,$$$				$$,$$$
SQL Enterprise Licenses	$$,$$$					$$,$$$					$$$,$$$
Citrix Administrator		$$$,$$$					$$$,$$$				$$,$$$
Citrix Technical Training	$$,$$$					$$,$$$	$$,$$$	$$$,$$$			$,$$$,$$$
Network Infrastructure Upgrades	$$,$$$	$$$,$$$	$$$,$$$								
Operating Based Software Fees (Maintenance and Subscription Fees)											
Volume Based PP Chunk 1 (350)		$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Yearly Support - Optional			$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Oncology			$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Third Party dB - Required	$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$$,$$$
Third Party dB - Optional			$$,$$$	$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Third Party Maintenance Fees		$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$$,$$$
Vendor Consulting On Hand		$$,$$$	$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Patient Portal Software		$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$$,$$$
Interface Maintenance		$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$$,$$$
Subscription Applications	$0	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$,$$$	$$$,$$$
Operating Based Additional EMR Staffing											
Clinical Applications IS Team	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Oncology Specific IS Team		$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Other IS Staff		$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Core Trainers	$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
End User Trainers - Initial		$$$,$$$	$$$,$$$	$$$,$$$							$$$,$$$
End User Trainers - Addl			$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$					$,$$$,$$$
Onsite Support Personnel - Initial		$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Onsite Support Personnel - Addl				$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Total Spend	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$$,$$$,$$$
Required and Optional Split of Costs											
Total Required	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$$,$$$,$$$
Total Optional	$0	$0	$$$,$$$	$,$$$,$$$	$,$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$
Capital and Operational Split of Costs											
Total Capital	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$$$,$$$	$$$,$$$	$,$$$,$$$	$$$,$$$	$$$,$$$	$$$,$$$	$$,$$$,$$$
Total Operational	$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$,$$$,$$$	$$,$$$,$$$

Legend

$,$$$	Thousands
$$,$$$	Tens of Thousands
$$$,$$$	Hundreds of Thousands
$,$$$,$$$	Millions
$$,$$$,$$$	Tens of Millions

Notes

1. For confidentiality reasons, real dollar figures could not be used.
2. This 10-year total cost of ownership model is from a 5-hospital, 1,000+ bed academic medical center with 700+ physicians.
3. The total estimated operational spend over the 10-year period is 75% of the total spend, while the capital spend is only 25% of the total spend.

licenses, additional implementation resources, better support services). Naming a primary spokesperson during the negotiating meetings as well as an individual to be responsible for handling communications between meetings creates clarity, prevents confusion about the most current status of issues, and helps prevent conflicts. Another efficient practice is to have the negotiating team prospectively vet and gain agreement on which items are of the highest priority, which items the organization will be unwilling to compromise, and which items are open for compromise and can therefore be used as "bargaining chips." Some items that an organization should pay particular attention to when negotiating and crafting terms and conditions include but are not limited to the following (Chesney 2005; O'Connor 2005):

- *Project scope*, such as levels of effort, resource requirements, timing, costs, and deliverables. Areas that vendors are keenly sensitive to include endless customizations that the organization wants to make to their product. Recognize that vendors will want to minimize their risk as well and will want to limit customizations. Seek to strike a mutually agreeable balance.
- *Consequences of nonperformance*, which might include options to require the vendor to provide additional resources at no additional cost to mitigate the nonperformance, give the organization the right to a set sum of money for liquidated damages, or give the organization the right to withhold payments. Because much of an EHR or ERP implementation, for instance, requires large-scale workflow reengineering, recognize that vendors will not want to take on the risk that the organization cannot make decisions regarding changes in the workflow.
- *Personnel commitments.* Clearly specify the personnel by name, and retain the right to be involved in personnel selection should changes be required during the project. Establish also the expectations regarding on-site work versus off-site work; redesigning workflows using an automated tool typically requires vendor expertise on site for a large portion of the effort.
- *Project management methodology.* This identifies, among other things, governance and decision rights, change processes, escalation processes for problem resolution, testing and acceptance criteria, expectations regarding standard meetings, and regular project-performance reporting expectations.
- *Payment terms.* Most vendors will want to link payment terms to measured time intervals. The healthcare organization should link payment terms to explicit deliverables that involve demonstrated, stable functional use of the product. It should also specify limits in increases in ongoing maintenance and support costs and ensure that those ongoing costs are indexed to the negotiated price and *not* a "book" price—list price of the application, which averages in the range of 18 to 22 percent of the negotiated price.
- *Site of litigation.* This site should be the organization's state. While litigation is clearly something to be avoided, should it become necessary specifying the site up front when the organization's legal counsel is better positioned to address it is ideal.
- *Vendor's accounting cycles.* Attempt to negotiate on price at the end of an accounting quarter—or, even better, an accounting year. Sometimes, particularly for publicly traded vendor organizations, substantial discounts may be offered during these windows of opportunity.

To start the process of contract negotiations, it is customary for the negotiating team to obtain a copy of the vendor's standard contract for the products and services being proposed and to identify any issues in the contract that are important to address, such as some of the items noted in the preceding list. These issues may be entered into an *issues matrix*, which may be sent to the vendor in advance of the first meeting so that the vendor is prepared to discuss alternatives at the outset. Examples of typical categories and items found in an issues matrix include the following:

Scope Definition

- Software, hardware
- Interfaces and conversions
- Professional services
- Custom development items
- Service support levels

Business Terms

- License term, renewal, termination
- Upgrades and enhancements
- Future products and services
- Risk-sharing terms
- Pricing and discounts, payment terms
- Implementation work plan

Legal Terms and Conditions

- Acceptance terms
- System performance and response times
- Regulatory compliance
- Governing law

- Indemnity, warranties, and remedies
- Assignment
- Intellectual property and confidentiality
- Liability

Include space to record negotiating positions, relevant dates, contract identifiers, and status. An example of a one-page negotiations issues matrix is provided in Exhibit 8.5.

Using the issues matrix as the primary tool to track progress, the negotiating team can conduct several rounds of meetings to work through the issues on the list and agree on the terms. During meetings, stay focused and adopt a tone of collaborative problem solving. It is always appropriate to call a short time out to discuss an item in private (e.g., if a new issue is raised and the team needs to agree on the organization's position). It is normal to compromise on certain items in order to "win" on priority issues; this is where the advance discussion and planning will help to keep the selection process moving forward. In negotiating the terms of a system implementation, a best practice is to seek payment terms that tie payments to achievement of milestones (rather than regular calendar payments) as this encourages the vendor to activate the product in the desired timeframe and reduces risk for the purchasing organization. Many organizations seek to establish risk-sharing arrangements, where the vendor may receive higher payments if it accomplishes certain tasks or outcomes ahead of schedule and, conversely, may be penalized financially if it falls behind schedule. Risk-sharing arrangements like this ensure that each party has "skin in the game"; however, note that this also places a burden on the purchasing organization to hold up its end of the agreement to provide resources and make decisions as required to accomplish the desired results.

Because the contract with the vendor will include costs and services to support implementation of the new system, it is usually best to draft a preliminary implementation plan to make sure that both parties have a shared understanding of the resources and timeline, including the achievement of major milestones.

At the conclusion of contract negotiations, the team can create an internal communication document for senior leadership that summarizes the business deal, key terms and conditions, concessions received, and other risk-mitigation agreements.

Monitor Contract Performance

Remember the importance of clearly defining the project scope up front, such as levels of effort, resource requirements, timing, costs, and deliverables.

EXHIBIT 8.5
Sample Negotiations Issues Matrix

Discussion Topic	Our Position	Vendor Response	Cross-Reference to Contract Section	Date Discussed	Current Status (Open, In process, Resolved)
License	The license to use the software should be perpetual.				
Term	Customer will consider entering into a 7–10 year term for support.				
Scope of use	The agreement would include the entire enterprise, as well as future sites. The list of sites is: • [insert list]				
Products	The following products are included in the base deal: *Clinical* • [insert product names] *Revenue cycle* • [insert product names] *Departmental* • [insert product names] The following products should be considered options to be purchased in the future: • [insert product names]				
Pricing	Provide best and final pricing by: • Application				

If the organization has a professional project management office, the HIT project will have built in performance measurements and updates. However, if the organization has not yet made an investment in comprehensive project management methodologies, it should at the very least ensure that someone in the organization (not someone from the vendor's firm) is tracking progress on full-time equivalent resource consumption, project timelines and milestones, and other costs and deliverables. To fully gain the contracting benefit of having specified these items in the terms and conditions of the contract, the organization must demand regular project-performance updates with the members of the vendor team.

Benefits Realization

An often overlooked but incredibly important part of the system selection process is that, at some point after the new HIT goes into productive use, the organization must conduct a formal benefits realization assessment to see if the desired benefits envisioned for the particular HIT investment were actually achieved. The best approach for accomplishing this is to collect baseline *before* performance indicators (e.g., length of stay, readmission rates by diagnosis-related group, overtime hours by staff type) in the areas of performance the organization hoped to improve with HIT; then, about 12 months after the new HIT goes into production, the organization can collect the *after* measures of those same indicators and compare the two sets of data. This is a powerful, "close the loop" step that can provide valuable lessons and validation to the board of directors or senior leadership team—that the HIT investment made is actually reaping the benefits envisioned.

Summary

The selection of information systems by an organization, particularly those systems that affect a large portion of operational functions, is a process that requires rigorous due diligence and systematic, participative decision making. In this chapter, we provide a framework for conducting a system selection process that includes the following activities:

- Clarification of the objectives
- Formation of the system selection governance structure and process
- Establishment of a system selection plan
- Education: Understanding the marketplace
- Down selection: Narrowing the field
- Documentation of the requirements: Developing the request for proposal

- Conducting detailed product demonstrations
- Completion of other due diligence activities
- Final selection
- Contract negotiations
- Benefits realization

The key to increasing the chances of having a successful outcome to a system selection process is to resource it like any other formal process and to include the key stakeholders throughout the organization who will be affected by the system selection decision. The organization must ensure that these stakeholders are active participants in both the due diligence and the decision to move forward with a vendor of choice.

Note

1. Portions of this chapter have been reprinted and/or adapted from *The Executive's Guide to Electronic Health Records* by Detlev H. Smaltz and Eta Berner (Chicago: Health Administration Press, 2007) and from the 2011 unpublished work by Paul Murphy, strategy advisory service leader at Encore Health Resources. Material from Paul Murphy's work—"The Vendor Selection Process" (July 2011) and "Selection Process Exhibits" (July 2011)—is used with permission of Encore Health Resources.

Web Resources

A number of organizations (through their websites) provide more information on the topics discussed in this chapter:

- Gartner (www.gartner.com/technology/research.jsp). Gartner provides subscription-based research notes on information technology that covers a full spectrum—from technical to IT-based business processes.
- HIMSS Analytics (www.himssanalytics.org). HIMSS Analytics provides data and analytic expertise.
- KLAS (www.klasresearch.com). KLAS provides ratings of healthcare technology that help organizations make informed decisions.

Discussion Questions

1. What are the major activities that make up the system selection process?
2. What are some examples of functional work groups and the types of work that they might accomplish in support of a system selection project?
3. Why is it important to create a system selection plan at the outset of a system selection endeavor?
4. What is the down selection activity, and why is it an important step in the system selection process?
5. What is a request for proposal (RFP), and what is its purpose?
6. What are some of the typical sections that make up an RFP?
7. What is a total cost of ownership, and why is it important to estimate prior to making a system selection?
8. What are some of the important items that an organization should consider when going into contract negotiations with a vendor?
9. What is a benefits realization assessment?

CHAPTER 9

APPLICATIONS: ELECTRONIC HEALTH RECORDS

Learning Objectives

1. Define the term *electronic health record* (EHR).
2. Understand the key capabilities of a robust EHR.
3. Articulate the benefits of a robust EHR.
4. Articulate some of the key cost categories associated with the purchase and implementation of an EHR.
5. Describe the EHR Adoption Model.
6. Understand the concept of meaningful use of an EHR, and describe some of the criteria that both individual providers and hospitals need to achieve to earn incentives for meaningfully using an EHR.

Overview

There has been an evolution of the terms used to describe a digital version of a medical record. Currently, *electronic health record* (EHR) is the most commonly used term to describe "a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports. The EHR automates and (with appropriate operations management) can streamline the clinician's workflow. The EHR has the ability to generate a complete record of a clinical patient encounter—as well as supporting other care-related activities directly or indirectly via an interface—including evidence-based decision support, quality management, and outcomes reporting" (HIMSS 2012b). A key component of this definition from the Healthcare Information and Management Systems Society (HIMSS) is the ability to record patient information that is generated in *any* care delivery setting. In other words, the EHR should provide caregivers with the ability to communicate patient information collected from across organizational boundaries. Regardless of where care was delivered, the EHR is designed to gather that information for a full, longitudinal detailed view of a patient's medical history. In the past, terms like the computer-based patient record (CBPR or CPR) or an electronic medical record (EMR) were used and should be viewed as less robust versions of what today has evolved into the EHR.

Components of an EHR

Dick, Steen, and Detmer (1997) published an Institute of Medicine (IOM) report titled *The Computer-Based Patient Record*, which originally articulated the key features of the contemporary EHR. Later, HIMSS Analytics expanded on the original key components/features of an EHR that Dick and his colleagues suggested (Garets and Davis 2006) and developed the seven-stages EMR Adoption Model (EMRAM), depicted in Exhibit 9.1. These seven stages not only have become the de facto standard description of the key components of a complete EHR but also, with the addition of the stages of adoption of these key components/features, have provided a means of tracking the degree of EHR adoption throughout the industry.

We cover the EHR adoption stages in more detail later in this chapter. The rest of this section provides a brief overview of each of the seven key components of an EHR—primarily in the context of the EMRAM.

Stage 1: Ancillary Systems

The ancillary systems component of an EHR includes automated information systems to support workflow in the laboratory, radiology, and pharmacy departments. In the laboratory department, for instance, this includes capturing test results from various laboratory test devices and automatically pulling that into an automated stand-alone laboratory information system or an integrated laboratory EHR module that physicians and other caregivers can access to obtain their patients' test results. Similarly, in the radiology department, this includes providing results of radiological exams to the physicians that ordered them. In the pharmacy department, it provides an automated means of managing the process of dispensing and delivering drugs to patients.

EXHIBIT 9.1 US EMR Adoption Model℠

Stage	Cumulative Capabilities
Stage 7	Complete EMR; CCD transactions to share data; Data warehousing; Data continuity with ED, ambulatory, OP
Stage 6	Physician documentation (structured templates), full CDSS (variance & compliance), full R-PACS
Stage 5	Closed loop medication administration
Stage 4	CPOE, Clinical Decision Support (clinical protocols)
Stage 3	Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology
Stage 2	CDR, Controlled Medical Vocabulary, CDS, may have Document Imaging; HIE capable
Stage 1	Ancillaries—Lab, Rad, Pharmacy—All Installed
Stage 0	All Three Ancillaries Not Installed

SOURCE: Reprinted from "U.S. EMR Adoption Model℠ Trends," www.himssanalytics.org/docs/HA_EMRAM_Overview_Eng%20011812.pdf. Used with permission from HIMSS Analytics.

Stage 2: Clinical Data Repository (CDR)

The CDR collects data from a variety of information systems and makes the data available to physicians and other caregivers in a unified view of each of their respective patients. While CDRs from different EHR vendors may differ slightly, they typically aggregate data from ancillary systems such as lab results, pathology reports, and radiology reports as well as pharmacy data and other data relating to the patient (e.g., demographics; admission dates; transfer dates, if applicable; discharge dates; diagnosis codes). The CDR often also uses a controlled medical vocabulary.

Stage 2: Controlled Medical Vocabulary (CMV)

CMV is "a tool used to standardize information for purposes of capturing, storing, exchanging, searching and analyzing data" (*Health Informatics* 2012). The purpose of a CMV is to address the many needs and limitations of healthcare's information infrastructure; examples are as follows (*Health Informatics* 2012):

- Reducing ambiguity that is inherent in normal human languages (for example, how "heart attack," "myocardial infarction," and "MI" may mean the same thing when describing a patient condition but represent different conditions to a computer coding that information)
- Making the exchange of information consistent between different providers, care settings, researchers, and others even at different points in time
- Overcoming differences in medical information recording from one place to another
- Summarizing medical information (in a consistent manner)
- Allowing symbolic manipulation of data (searches for specific analysis)
- Providing automated reasoning (clinical decision support)

Some common CMVs include the following:

- *Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT)*. "SNOMED CT provides the core general terminology for the electronic health record . . . and [as of 2012] contains more than 311,000 active concepts with unique meanings and formal logic-based definitions organized into hierarchies. When implemented in software applications, SNOMED CT can be used to represent clinically relevant information consistently, reliably and comprehensively as an integral part of producing electronic health records" (IHTSDO 2012).

- *Logical Observation Identifiers Names and Codes (LOINC)*. LOINC is a universal code system for identifying laboratory and clinical observations (Regenstrief Institute 2012).
- *Unified Medical Language System (UMLS)*. "The UMLS integrates and distributes key terminology, classification and coding standards, and associated resources to promote creation of more effective and interoperable biomedical information systems and services, including electronic health records" (NLM 2012).

In short, the main value of a CMV is in providing a means for health-related information systems—particularly, EHRs and EHR component modules—to become semantically interoperable.

Stage 2: Document Imaging

Many healthcare providers make copies of paper records that are either generated within their own setting or that patients bring with them from another care setting (e.g., clinic, hospital). Making these images of paper records available through the EHR is another capability that helps ensure providers have as much information available as possible as they assess and care for patients.

Stage 2: Health Information Exchange (HIE) Capability

The US Department of Health & Human Services's Office of the National Coordinator for Health Information Technology (ONCHIT) believes that HIE capability (exchange of health information electronically) is essential to both providing the best possible care for patients and driving down the overall cost of that kind of high-quality care at a national level (Williams et al. 2012). Contemporary EHRs should have the basic ability to securely and electronically send and receive data about relevant patients to aid patient assessment and care decisions. ONCHIT is working to establish standards for accomplishing this in a more unified, consistent manner. Note that data about a patient should be able to be securely and appropriately exchanged not only intra-organizationally (i.e., across all inpatient, outpatient, ancillary, and complementary care settings within the organization) but also inter-organizationally (i.e., across distinct, legal, organizational entity boundaries).

Stage 3: Clinical Decision Support (CDS) and Clinical Decision Support System (CDSS)

CDSS has been defined in a variety of ways. Garg and colleagues (2005), in a review of CDSS and its effects on practitioner performance and patient outcomes, says, "CDSS are information systems designed to improve clinician decision making. Characteristics of individual patients are matched to a computerized knowledge base, and software algorithms generate patient-specific recommendations."

Most major EHR system vendors have CDSS capabilities; that is, they can generate a variety of alerts and reminders, such as error checking for drug–drug and drug–food adverse effects as well as conflict checking for drug–lab orders. A more advanced CDSS also has the ability to supply evidence-based medicine protocols (e.g., order sets that have been shown in the medical body of literature to have the best statistical outcomes for patients with specific diagnoses or conditions). These advanced CDS capabilities provide easy access to any local and/or remote subscription-based knowledge sources, such as MD Consult, OVID, the Medline medical literature database, and national or local clinical guidelines. The most advanced CDSS also can provide guidance—in the form of variance and compliance alerts—for all clinical activities related to clinical protocols and outcomes (HIMSS Analytics 2012b; Middleton et al. 2004).

Key CDSS implementation considerations that in the past were determined locally with input from the clinical staff include

- the choice of which alerts/reminders to include,
- how alerts/reminders are delivered to the clinician, and
- the circumstances under which clinicians are allowed to override the alerts/reminders.

Too-frequent alerts with only minimal justification result in what has been termed ***alert fatigue***, which not only generates complaints from clinicians but also results in frequent overrides and ignoring of even the most important alerts. For instance, many medication knowledge bases that can be purchased to be integrated with the EHR to provide alerts for drug–allergy interactions, for example, produce an alert for the specific drug as well as for any drugs in that class—even if patients have already taken the related drugs with no ill effects. Furthermore, alerts are triggered by elements in the EHR; that is, if the clinician had originally included, for instance, an allergy to aspirin when the patient said the aspirin upset her stomach but the clinician never changed the entry when he realized this was not a "real" allergy, then the alert will be triggered anyway. Conversely, if the system is set up so that a blank allergy field suggests that the patient is ***not*** allergic to anything, when in fact the empty field only means that allergies have not yet been assessed or the documentation is incomplete, then unsafe medication orders may not generate an alert. For these reasons, determination of how to implement the CDSS functions of the EHR is definitely too important to leave to the health information technology (HIT) staff. There should be significant involvement by providers during the design phase of the CDSS implementation.

ONCHIT has emphasized CDSS, especially in regard to ***e-prescribing*** —the transmission of prescriptions electronically from clinician to pharmacy. As part of the national effort, the American Medical Informatics Association (AMIA) developed what has been called a "road map" for CDS. This road-map suggests that while CDS tools are promising, much has yet to be done to realize their full potential—particularly in the following three areas (Ford, Menachemi, and Phillips 2006):

1. Applying the best clinical knowledge available at the point when it is needed
2. Achieving high adoption of CDS and effective use
3. Continuous improvement of clinical knowledge and CDS methods

Osherhoff and his colleagues (2005) suggest a phased implementation of CDS with physician thought-leader input as the plans are developed as well as a responsive feedback and modification process as the CDS capabilities of the EHR are implemented. Training and support for physicians are considered essential, and including training on what the alerts mean and how to respond to them is also very important.

Stage 3: Nursing/Clinical Documentation

Contemporary EHRs have the ability to document vital signs, flow sheets (time-based trending of particularly relevant clinical data to assess a patient's condition over time), nursing notes, and care plans. They also can keep a comprehensive record of all medications that have been administered to the patient.

Stage 3: Picture Archiving and Communication Systems (PACS)

PACS capture and store medical images such as x-ray images, CT (computerized tomography) scans, MRI (magnetic resonance imaging) scans, and other medical diagnostic images. They also have the ability to allow caregivers from across the organization to electronically access those images. Contemporary EHRs provide a means to make PACS images available to caregivers outside of the radiology department.

Stage 4: Computerized Physician Order Entry (CPOE)

HIMSS (2012c) defines CPOE as "the portion of a clinical information system [or EHR] that enables a patient's care provider to enter an order for a medication, clinical laboratory or radiology test, or procedure directly into the computer. The system then transmits the order to the appropriate department, or individuals, so it can be carried out. The most advanced implementations of such systems also provide real-time clinical decision support such as dosage and alternative medication suggestions, duplicate therapy warnings, and drug-drug and drug-allergy interaction checking." Both the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 and employer advocacy groups, such as the Leapfrog Group (www.leapfroggroup.org), share the goals to improve quality of care and reduce the cost of care via providing incentives to healthcare practitioners who adopt CPOE. The Leapfrog Group is a continually growing coalition of ***Fortune*** 500 companies that promotes CPOE, which research data have shown to have the ability to reduce the possibility of adverse drug events (Reckmann et al. 2009). Hospitals that have CPOE are promoted to the employees of Leapfrog Group companies and advocate for higher reimbursement levels for care. This push from Leapfrog and federal legislation such as the HITECH Act for healthcare delivery organizations and systems to increase patient safety has prompted the growing interest in CPOE adoption. Remember, however, that CPOE alone is unlikely to realize the proposed benefits—unless the technology is coupled with an EHR with the foundational features discussed in this chapter and unless it is linked to at least minimal CDS that provides advice on appropriate drug ordering, such as alerts for drug–drug or drug–allergy interactions.

Stage 5: Closed-Loop Medication Administration

Closed-loop medication administration, also called ***end-to-end medication administration***, includes CPOE with CDS for error checks, bar code or other automated methods for checks during medication administration, and an electronic medication administration record (e-MAR) linked to the pharmacy and the CPOE. Closed-loop medication administration obviously requires that the component parts (CPOE, CDSS, e-MAR) be in place and integrated; thus, the process is clearly a later stage in the EMRAM but is vital for achieving much-higher levels of patient safety (Smaltz and Berner 2007).

Stage 6: Physician Documentation

Physician documentation that was produced and managed as a paper record—such as progress notes, consult notes, discharge summaries, problem lists, and diagnosis list maintenance—can now be entered and maintained electronically within the EHR. Not only should the EHR support direct entry of data by physicians, but it also should support structured data entry, which necessitates a defined vocabulary (as noted previously). This does not mean that physicians need to be taught a new language to use the system, but the database that underlies the record should be structured. There have been some attempts to use mechanisms to process actual spoken or written natural language, but these have not been as successful in gaining full EHR benefits in the way that structured data have. What is needed if unstructured input is going to be allowed is a mechanism to link from the dictated language to the structured language—that is, *natural language processing* (NLP), which continues to make progress as a technology that captures and transcribes physician dictation into text; at this writing, NLP is not yet a fully fail-safe means of leveraging practitioner input for direct patient care decisions, although it is an excellent means of conducting medical research such as the ability to identify, extract, and categorize information found within clinical narrative text such as in dictated physician notes (Al-Haddad et al. 2010; Terry 2012). However, templates for recording patient information have been used with some success. Indeed, using structured templates for routine types of care (e.g., a template for adult-acquired pneumonia) provides the added benefit of being able to do real-time evaluation and management (E&M) coding, which can have a huge impact on expediting billing and consequently reducing accounts receivable days.

Stage 7: Analytics and Reporting

EHRs should have the ability to provide advanced reporting to analyze patterns of clinical data to improve quality of care and patient safety as well as care efficiencies.

Security and Access

In addition to the elements of the seven stages is one of IOM's original recommendations for EHRs that has become absolutely required: protect the confidentiality and integrity of the patient's information. The system must be able to track, in a rigorous way, who has accessed the record. This essential function aligns the evolution of the EHR with the original HIPAA (Health Insurance Portability and Accountability Act) legislation and the HITECH Act extensions to HIPAA (e.g., more rigorous requirements related to protecting personally identifiable patient information). While timely access, both onsite and remotely, by a wide range of providers needs to be unequivocally guaranteed, unauthorized access must be prevented.

Benefits and Goals

An EHR can increase the efficiency of the clinical care processes not only by getting rid of inefficient paper-based documentation but also by reducing the need to search for lost charts, lab data, or other pieces of patient information. An EHR can potentially increase the efficiency of claims processing by using the actual clinical data to provide documentation for claims. Having the data on care processes in electronic form can also help in monitoring what is happening in the patient care settings at the individual level and in using analytical techniques for identifying patterns in that care process. The monitoring can involve both cost-effectiveness and quality.

Many parts of the clinical processes, the claims processes, and monitoring the patient care setting were accomplished primarily with paper medical records. While bills were generated, risk assessments were conducted, and quality assurance and quality improvement activities were performed, they all relied primarily on painstaking *chart abstraction*—the manual process of reviewing paper-based medical records and extracting the pieces of information needed for the particular task at hand. The use of an EHR can introduce possible improvements in both the processes and outcomes of care. These are improvements that are difficult to accomplish with a paper chart. We discuss those aspects in this section, but first let's look at four benefits of an EHR related to improving efficiency and monitoring.

Benefit 1: Access to Information

One of the most obvious benefits of an EHR is access to information—that is, getting the clinical information when and where it is needed. Goals such as 24-hours-a-day, 7-days-a-week accessibility are common expectations for an EHR. Access and communication go hand in hand, because easy access not only makes it convenient for individual clinicians to get the information they need but also improves communication among providers.

Benefit 2: Better Organization of Data

This benefit includes having basic patient data located in a central place so that the data have to be entered only one time. Other efficiency goals include improving the quality of the data in the record by avoiding illegible handwriting and getting an assurance that the data are complete and accurate.

Benefit 3: Claims Processing Efficiency

Even though the record is a clinical record, the clinical data can improve claims processing efficiency if this information drove the billing process. Data that are accessible in electronic form can ease the process of gathering and providing documentation for claims purposes. In addition, linking the clinical indications to laboratory test orders can improve the accuracy and efficiency of that process.

Benefit 4: Improved Monitoring of Performance

An EHR allows for individual provider profiles of performance as well as aggregate profiles of all providers, something most of the insurance carriers and managed care organizations are already doing. These data can be used within the organization to target quality improvement initiatives. As noted, manual chart audits are difficult and labor intensive. One important point to emphasize, however, is that while microfiche, optical scanning, and other document imaging procedures may provide a better means of storage and may make accessing information easier than was possible with the paper-based medical record system, they will not make the profiling and auditing any easier. To do that, the clinical information must be stored in such a computer-readable/searchable manner that the information can be easily retrieved in multiple different ways.

With an EHR, clinical and financial outcomes can be more easily monitored and linked to quality improvement processes; this is extremely difficult to do with traditional paper records. Individual caregivers can also develop their own profiles of behavior so that they can monitor and modify that behavior. Furthermore, individual profiles of behavior can provide insight into needed, targeted continuing education. Educational activities can be more easily targeted to real clinical needs, not just the practitioner's interests. Finally, a robust EHR's ability to aggregate data across patients provides a means for population-based monitoring and specific disease management.

Stages of EHR Adoption

While it is true that some healthcare facilities have focused on CPOE (Stage 4) even before getting the back-end ancillary systems automated and integrated, it is generally recommended that other systems (stages under 4) be in place and working well before the workflow changes needed for CPOE are undertaken. Exhibit 9.2 shows the stages of adoption of EHR capabilities across the United States as of early 2012.

Most hospitals have moved beyond having just automated departmental systems such as pharmacy, radiology, and laboratory (HIMSS Analytics 2012b). In fact, the majority of hospitals are at Stage 3 capabilities or below—at 44.9 percent in 4th quarter 2011 and 43.9 percent in 1st quarter 2012 (see Exhibit 9.2). This degree of integration can provide very useful, accessible information for clinicians and can promote more direct clinician interaction with the computer, which potentially pave the way for easier adoption and attainment of CPOE *meaningful use* (a new federal incentive

EXHIBIT 9.2
US EMR Adoption Model℠: Levels of Adoption, 2012

Stage	Cumulative Capabilities	2011 Q4	2012 Q1
Stage 7	Complete EMR; CCD transactions to share data; Data warehousing; Data continuity with ED, ambulatory, OP	1.2%	1.2%
Stage 6	Physician documentation (structured templates), full CDSS (variance & compliance), full R-PACS	5.2%	6.2%
Stage 5	Closed loop medication administration	8.4%	9.4%
Stage 4	CPOE, Clinical Decision Support (clinical protocols)	13.2%	13.2%
Stage 3	Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology	44.9%	43.9%
Stage 2	CDR, Controlled Medical Vocabulary, CDS, may have Document Imaging; HIE capable	12.4%	12.1%
Stage 1	Ancillaries—Lab, Rad, Pharmacy—All Installed	5.7%	5.5%
Stage 0	All Three Ancillaries Not Installed	9.0%	8.4%
		N=5337	N=5318

SOURCE: Reprinted from "U.S. EMR Adoption Model℠ Trends." www.himssanalytics.org/docs/HA_EMRAM_Overview_Eng%20011812.pdf. Used with permission from HIMSS Analytics.

program discussed later in this chapter). In addition, most research studies have shown that automation of nursing processes (a Stage 3 capability) actually saves time for nurses, which provides a motivation for accepting these automated systems. In contrast, although it is likely to bring other benefits, CPOE may take more of a physician's time at the front end than do current manual ordering processes. This impact on physician time just from CPOE would be compounded if the automated clinical systems offered no other value. This is why most consultants recommend getting to Stage 3 capabilities before tackling the Stage 4 CPOE.

Adoption of CPOE is still seen as a problem today, as many practicing physicians still have a number of objections to it—such as impact on time, the view that the data-entry component is low-level work, and alert fatigue from overly aggressive systems, just to name a few. Despite the fact that EMRs with CPOE have been around for more than 30 years, a study by HIMSS Analytics (2012b) involving more than 5,300 US hospitals found that at the beginning of 2012 only 1.2 percent of the participating organizations had implemented a complete EHR—what HIMSS Analytics refers to as a Stage 7 Hospital (see Exhibit 9.2). To gain the full benefits of meaningfully using an EHR with CPOE, federal legislation has been enacted to enforce EHR adoption throughout the United States. These mandates reward the meaningful use of an EHR and penalize practitioners and organizations that continue to avoid meaningful use.

Federal Initiatives to Promote the Meaningful Use of an EHR

The 1999 landmark report *To Err Is Human*, published by the IOM, suggested that in the United States between 44,000 to 98,000 deaths a year were due to medical errors. This report heightened the concerns about patient safety by many groups, including healthcare executives, clinicians, health policymakers, and the general public; more important, it captured the attention of the legislative and executive branches of the US government. The report advocated for the increased use of EHR, CPOE, and CDSS as means of preventing errors, leading President George W. Bush, in his 2004 State of the Union address, to emphasize the need to computerize patient health records (*Washington Post* 2004).

While it is difficult to make predictions in any fast-changing arena, the momentum for change in HIT has certainly increased. For one thing, a federal-level office (ONCHIT) now exists, headed by an HIT "czar" who is charged with overseeing a variety of government HIT initiatives, including the deployment of national interoperable EHRs (the term ***interoperability*** refers to the ability of systems to talk to each other within and between facilities and organizations). Congress had initially appropriated funding for ONCHIT and for grants through the Agency for Healthcare Research and Quality (AHRQ 2004), focusing on the development of standards, prototype data networks, review of privacy and security practices at a statewide level, and demonstration projects in urban and rural settings of model systems.

In addition to appropriations to AHRQ for targeted HIT projects, an increasing amount of federal legislation is geared toward reducing medical errors, increasing the use of information technology in healthcare, and changing the way healthcare organizations are trying to improve quality. In 2005, the Patient Safety and Quality Improvement Act was signed into law, establishing a voluntary error-reporting database. The Joint Commission (2011) now publishes an annual report called *Improving America's Hospitals*, which publicizes myriad quality and safety measures stratified by US hospitals. Furthermore, the Centers for Medicare & Medicaid Services (CMS n.d.[c]) has several online sources of quality data on hospitals and home health care, such as the Medicare Inpatient Hospital Dashboard, which provides comparative quality and cost data. Websites like Healthgrades (www.healthgrades.com) already provide various quality performance indicators for a growing number of hospitals (Healthgrades 2009).

Other legislation provides grants to hospitals for implementing systems for electronic transmission of prescription orders (e-prescribing) and a variety of proposals to differentially reward high-quality care (pay for performance). The latter will almost certainly require electronic tracking and transmission of outcome data. In addition to these carrots (or sticks, depending on one's perspective), a bill has been proposed to modify the antikickback provisions of the Stark antitrust laws to provide a "safe harbor" for hospitals that work with their referring physicians to develop integrated information systems (Gottlieb 2010).

Finally, the HITECH Act, which is part of the American Recovery and Reinvestment Act (ARRA) of 2009, gives significant incentives both to hospitals and independent physicians that meaningfully use a certified EHR and imposes penalties to providers for not using a certified EHR by 2015 (ONCHIT 2012a). The intent of these incentives goes beyond rewarding the act of implementing an EHR; they are meant to motivate the use of an EHR that results in significant measurable improvements in the quality and affordability of care (Blumenthal and Tavenner 2010).

While these national laws and developments are encouraging the widespread adoption of HIT, several factors have made healthcare executives (and private clinicians) cautious about embracing new technologies. First, executives are confronted by a rich assortment of products, options, and vendors, so making a choice is difficult in an area as rapidly changing and as expensive as HIT. While it may not be too painful (financially and otherwise) to replace a $2,000 laptop for the CEO every few years as technology changes, the same cannot be said for a $30 million system for her hospital. Second, because of the many different EHR vendors, many hospitals have adopted the ***best of breed*** approach to purchasing departmental systems—that is, buy the locally perceived top-of-the-line radiology system from one vendor, the best billing system from another vendor, and the preferred system of the chief of pathology from a third vendor. This approach, while satisfying the individual department's needs, can make interoperability between these departmental applications a challenge within a hospital, much less between institutions. A related purchasing approach is known as ***best of suite***, wherein hospitals adopt the best financial suite of applications from one vendor and the best clinical suite of applications from a different vendor that has similar cross-suite interoperability challenges. A third purchasing approach is buying all or most applications from a single vendor; this may solve the problem of communication within a hospital but does not make it easy to electronically send data to a different hospital with a different proprietary system. In addition, because the healthcare organization has invested so much in a single vendor's product, it becomes difficult to change vendors (Ford et al. 2010).

ONCHIT (2012b), working closely with CMS, oversees the development of the requirements to certify vendor EHR products. Both the standards of meaningful use and an objective certification process are intended to help buyers of EHRs make more informed decisions and essentially assure buyers that the systems they purchase meet established standards and can work seamlessly with other vendors' systems. In fact, ONCHIT maintains a list of the current certified HIT products for both ambulatory practices and hospitals (see www.healthit.gov/policy-researchers-implementers/certified-health-it-product-list-chpl).

The Meaningful Use Standards

The HITECH Act specifies the three key elements of meaningful use as follows (CMS n.d.[c]):

1. The use of certified EHR technology in a meaningful manner, such as e-prescribing (using an automated system to submit prescriptions directly to a retail pharmacy rather than writing a prescription on paper)
2. The use of certified EHR technology for electronic exchange of health information to improve quality of healthcare
3. The use of certified EHR technology to submit clinical quality and other measures to CMS

These high-level criteria for meaningfully using an EHR are broken into three stages, as envisioned to be implemented between 2011 and 2015 and beyond:

- Stage 1 sets the baseline for electronic data capture and basic information sharing and had a 2011–2012 expected implementation goal. As of February 2013, CMS reports that more than 234,000 healthcare providers have received incentive payments for achieving Stage 1 meaningful use (CMS 2013).
- Stage 2 begins in fiscal year 2014 for hospitals and in calendar year 2014 for eligible hospitals with an expectation to demonstrate meaningful use of an EHR across an even larger portion of their respective patient populations. The latest criteria can be found on the ONCHIT website at www.healthit.gov/policy-researchers-implementers/meaningful-use-stage-2.
- Stage 3 continues to expand on the baselines established in Stage 1 and Stage 2.

Both the actual granular criteria that were adopted to represent the final Stage 1 criteria and the criteria that will be finalized over time to represent the detailed Stage 2 and Stage 3 criteria are accomplished through a public process of rulemaking administered by ONCHIT and CMS. For

instance, the Stage 1 meaningful use criteria include specific items for eligible individual physicians and a separate set for hospitals (outlined in Exhibit 9.3). For eligible professionals (physicians), there are a total of 25 objectives of which they must meet 15 core objectives and select 5 additional objectives

EXHIBIT 9.3
Stage 1 Meaningful Use Criteria

Stage 1 Meaningful Use Core Objectives Criteria	
Eligible Professionals	*Hospitals and Critical Access Hospitals*
15 Core Objectives	14 Core Objectives
1. Use CPOE for medication orders directly entered by any licensed healthcare professional who can enter orders into the medical record per state, local, and professional guidelines. 2. Implement drug–drug and drug–allergy interaction checks. 3. Maintain an up-to-date problem list of current and active diagnoses. 4. Generate and transmit permissible prescriptions electronically (e-prescribing). 5. Maintain active medication list. 6. Maintain active medication allergy list.	
7. Record all of the following demographic information: (a) preferred language, (b) gender, (c) race, (d) ethnicity, and (e) date of birth	7. Record all of the following demographic information: (a) preferred language, (b) gender, (c) race, (d) ethnicity, (e) date of birth, and (f) date and preliminary cause of death in the event of mortality in the eligible hospital
8. Record and chart changes in the following vital signs: (a) height, (b) weight, (c) blood pressure; (d) calculate and display body mass index (BMI); (e) plot and display growth charts for children 2–20 years, including BMI. 9. Record smoking status for patients 13 years old or older.	
10. Report ambulatory clinical quality measures to CMS or state Medicaid programs.	N/A
11. Implement one CDS rule relevant to specialty or high clinical priority along with the ability to track compliance with that rule. 12. Provide patients with an electronic copy of their health information (including diagnostics test results, problem list, medication lists, medication allergies) upon request. 13. Provide clinical summaries for patients for each office visit. 14. Have the capability to electronically exchange key clinical information (for example, problem list, medication list, allergies, and diagnostic test results) among providers of care and patient-authorized entities. 15. Protect electronic health information created or maintained by certified EHR technology through the implementation of appropriate technical capabilities.	

(continued)

EXHIBIT 9.3
Stage 1 Meaningful Use Criteria (*continued*)

Stage 1 Meaningful Use Menu Options Criteria	
Eligible Professionals	*Hospitals and Critical Access Hospitals*
5 Menu Options (*Note:* 5 of the following list of 10 objectives must also be met in Stage 1 to qualify for incentives.)	
1. Implement drug formulary checks. 2. Incorporate clinical lab-test results into EHR as structured data. 3. Generate list of patients by specific condition to use for quality improvement, reduction of disparities, research, or outreach. 4. Use certified EHR technology to identify patient-specific education resources, and provide those resources to the patient if appropriate. 5. The provider, hospital, or critical access hospital that receives a patient from another setting of care or provider of care or that believes an encounter is relevant should perform medication reconciliation. 6. The provider, hospital, or critical access hospital that transitions its patient to another setting of care or provider of care or that refers its patient to another provider of care should provide a summary-of-care record for each transition of care or referral. 7. Have the capability to submit electronic data to immunization registries or immunization information systems and actual submission according to applicable law and practice. 8. Have the capability to submit electronic syndromic surveillance data to public health agencies and actual submission according to applicable law and practice.	
9. Send patient reminders per patient preference for preventive/follow-up care.	9. Record advance directives for patient 65 years old or older.
10. Provide patients with timely electronic access to their health information (including lab results, problem list, medication list, and allergies) within 4 business days of the information being available to the provider.	10. Have the capability to submit electronic data on reportable (as required by state or local law) lab results to public health agencies and actual submission according to applicable law and practice.

SOURCE: Adapted from CMS (n.d [c]).

from a menu list of 10 as outlined in the exhibit (20 of the 25). For eligible hospitals and critical access hospitals, there are 24 objectives of which they must meet 14 core objectives and select 5 additional objectives from a menu list of 10 as outlined in the exhibit (19 of the 24). Many of the objectives for physicians and hospitals are similar, with some appropriate differences relevant to each group's use of an EHR. These objectives are then quantified for Stage 1.

Take, for instance, the first objective—use of CPOE. It requires a provider to use CPOE to directly enter at least one medication order for more than 30 percent of all the provider's unique patients who have at least one medication on their medication list. To meet Stage 1 incentives, the provider must show that more than 80 percent of all unique patients he sees have at least one medication entry (or an indication that the patient is not currently prescribed any medication) recorded as structured data. To meet Stage 2 incentives, the provider must enter more than 60 percent of medication orders, more than 30 percent of laboratory orders, and more than 30 percent of radiology orders. For eligible hospitals, the objective to maintain a problem list requires that more than 80 percent of all unique patients admitted to the inpatient or emergency department have at least one problem entry (or an indication that no problems are known for the patient) recorded as structured data. For Stage 2, this objective has been merged into the summary-of-care document at transitions of care and referrals. For a complete list of the EHR incentive measures for eligible professionals and hospitals, see the CMS website (www.cms.gov/EHRIncentivePrograms).

For eligible professionals who achieve meaningful use objectives, incentives are available through either Medicare or Medicaid (but not both; a provider may take advantage of whichever is most advantageous to her assuming she meets minimum patient volume criteria) depending on the first calendar year that they began to meaningfully use certified EHR technology (CMS 2010b). See Exhibit 9.4 for the EHR incentive table. For eligible hospitals and critical access hospitals that achieve meaningful use objectives, the incentives are calculated differently (following a formula that begins with a \$2 million base incentive, increased principally on the basis of Medicare and/or Medicaid patient volumes) and can range from \$2 million to more than \$10 million.

Beyond the incentives, physicians and hospitals that do not successfully demonstrated meaningful use of an EHR by 2015 or later are subject to a negative payment adjustment on their Medicare and/or Medicaid claims. This makes clear that CMS has both incentives and penalties in place to drive meaningful use of EHRs.

Declining Physician Resistance

A lingering obstacle to the use of clinical systems, in particular EHRs with CPOE, has been physician reluctance. Physicians clearly want to do what is in the best interests of their patients' care, but studies have shown that EHRs—particularly CPOE—change work patterns for physicians in significant ways (Morrison and Smith 2000). In addition, while the costs are obviously less for smaller practices, they may still be substantial. Prior to the development of the HITECH Act's meaningful use incentives, some suggested that the financial benefits of the EHR should largely accrue to payers,

EXHIBIT 9.4
EHR Incentive Payment Schedule for Providers

Maximum EHR Incentive Payments by Program Based on the First Calendar Year (CY) for Which the Eligible Professional Receives Payment												
	CY 2011		CY 2012		CY 2013		CY 2014		CY 2015		CY 2016	
CY	Medicare	Medicaid	Medicare	Medicaid	Medicare	Medicaid	Medicare	Medicaid	Medicare	Medicaid	Medicare	Medicaid
2011	$18,000	$21,250										
2012	$12,000	$8,500	$18,000	$21,250								
2013	$8,000	$8,500	$12,000	$8,500	$15,000	$21,250						
2014	$4,000	$8,500	$8,000	$8,500	$12,000	$8,500	$12,000	$21,250				
2015	$2,000	$8,500	$4,000	$8,500	$8,000	$8,500	$8,000	$8,500		$21,250		
2016		$8,500	$2,000	$8,500	$4,000	$8,500	$4,000	$8,500		$8,000		$21,250
2017				$8,500		$8,500		$8,500		$8,500		$8,500
2018						$8,500		$8,500		$8,500		$8,500
2019								$8,500		$8,500		$8,500
2020										$8,500		$8,500
2021												$8,500
Total (if EP does not switch programs)	$44,000	$63,750	$44,000	$63,750	$39,000	$63,750	$24,000	$63,750	$0	$63,750	$0	$63,750

NOTE: Medicare Eligible Professionals may not receive EHR incentive payments under both Medicare and Medicaid.
NOTE: The amount of the annual EHR incentive payment limit for each payment year will be increased by 10 percent for EPs who predominantly furnish services in an area that is designated as a Health Professional Shortage Area.
SOURCE: Reprinted from CMS (2010b).

the hospital/health system, and the patients themselves—as opposed to the individual physician (Berner et al. 2006; Doolan and Bates 2002).

Physician adoption was seen as a problem, but the meaningful use incentives (and penalties by 2015); the growing body of young caregivers and professionals who were raised with computers and have now entered health-care; and the rise of instant messaging, texting, email, social networking, and other mobile computing and communication technologies all suggest that clinician anxiety about using computers is likely to be replaced by excitement and demand for them. The *Journal of the American Medical Informatics Association* published an estimate of the adoption rates for EHRs among physicians (see Ford, Menachemi, and Phillips 2006, 2009) that has largely been corroborated by the National Center for Health Statistics' annual survey of EHR adoption in physician office settings (see Hsaio et al. 2011; Simborg, Detmer, and Berner 2013). Between 2011 and 2015 as physician practice adoption moves above the 50 percent mark (Hsiao et al. 2011), hospitals and healthcare organizations that do not have an EHR in place may begin to see a decline in their ability to attract physicians and inpatient referral patterns, as physicians and empowered patients may begin to favor a transparently safer and more information-integrated environments that EHRs are envisioned to provide. To further track EHR adoption in the ambulatory setting, HIMSS Analytics has created a new Ambulatory EMR Adoption Model, which can be found at www.himssanalytics.org/emram/AEMRAM.aspx.

Costs and Benefits of an EHR

Federal legislation and programs clearly have created monetary incentives to adopt EHRs, but it is important to understand both the scope of the effort to implement a robust EHR and the other benefits that the IOM and HITECH Act advocate. A study by the Rand Corporation published in *Health Affairs* suggested that $81 billion in aggregate could be saved annually as a result of EHR adoption, but some CEOs wondered how much of that actually could accrue to their respective organizations (Hillestad et al. 2005). They certainly were aware of the legislative incentives and penalties associated with adoption of EHRs and were cognizant of consumer and employer empowerment that may increasingly demand healthcare providers to use EHRs, but at the same time they were leery of a number of unknowns, including (but not limited to) the following (Hillestad et al. 2005):

- Will their organization be able to successfully undergo the significant cultural and workflow process changes needed to achieve benefits?
- Are the vendor's product capabilities real or marketing hype?

- What hidden costs are associated with an EHR project?
- Will the physicians adopt the new EHR-enabled processes and workflows?

In this section we address the costs questions of these CEOs along with the envisioned benefits of the EHR.

Costs

Costs for small physician practice EHRs have declined significantly, but hospital-based EHRs continue to be relatively expensive. While we applaud the efforts to release to the public government-developed EHR software, such as the US Department of Veterans Affairs's VistA system, we issue a caution that the actual cost of that software's license is only the tip of the proverbial iceberg. An EHR project, because it affects so many workflows and individuals, is really a large-scale organizational and cultural transformation project. The bulk of the costs of an EHR is spent on workflow-reengineering efforts and ongoing support and maintenance. A particularly useful way to assess the long-term costs of an EHR is to develop a ten-year total cost of ownership (TCO) model for the project. All hospitals and healthcare organizations consider the purchase price of the hardware and software licenses and even the ongoing software maintenance costs and additional staff needed to be added to the HIT department, but few of them accomplish a comprehensive assessment of the total costs of the project (Smaltz and Berner 2007).

Total Cost of Ownership

Exhibit 9.5 provides the one-time and the recurring cost components for assessing the TCO of an EHR project. Most of these cost items likely resonate with CEOs, COOs, CFOs, and CIOs, but we advocate taking the time to cost out each component over a ten-year period to reduce "blind spots" and thus assist the organization in making a well-informed decision about its total investment package over time. Exhibit 9.5 also provides a nice outline of some of the elements that an EHR planning team should take into consideration when estimating the total ten-year spending on the project. These include not only the obvious one-time charges (such as the purchase of the software licenses for the EHR and/or the purchase of the hardware on which the EHR software resides) but also the recurring charges (such as the ongoing operational personnel needed for the care and feeding of the EHR system, the personnel needed to provide ongoing training, and the personnel needed to provide integration with future applications that might need to integrate with the EHR).

Exhibit 9.6 is a sample ten-year TCO of an outpatient EHR with CDS and CPOE capabilities at a 5-hospital, 1,000-plus bed academic medical center with more than 700 physicians. For confidentiality reasons, the exhibit does not include actual dollar figures but uses appropriate orders of

EXHIBIT 9.5 Components of Total Cost of Ownership of an EHR

Scope Element	One-Time	Recurring
Software and intellectual property	Perpetual software license Content licensing	Term, ASP (application service provider) license; support fees
Timing	Project management Post-live/cutover management	Ongoing support Subsequent improvement phases
People	Implementation • Application • Functional • Infrastructural • Integration • Project management • Sponsorship • Education • Backfill • Vendor and third-party support	Support • Application • Functional • Infrastructural • Integration • Project management • Sponsorship • Education
Process/redesign (logical scope)	People and organizational change needs Third-party support Infrastructure changes	Ongoing support
Infrastructure—technology, facilities	Computing/servers/storage Network Third-party system interfaces End-user devices Space-fit-out, moves	Maintenance Refreshment at end of life

magnitude to give you an itemized perspective of the TCO of an EHR for such an organization.

The real value of developing a ten-year TCO of an EHR or any major project is to explicitly and deliberately force an analysis and articulation of all the expenses the organization will incur, not just the initial purchase costs. While not obvious from the example in Exhibit 9.6, given that the actual dollars are masked, do note that in most EHR projects the capital expenditure over the ten-year period is only about 25 percent or less of the total spending. The vast majority—about 75 percent or more—of the expense of an EHR accrues on the operating side of the balance sheet (Smaltz and Berner 2007). For healthcare organizations that are looking to plan beyond the next budget cycle, accomplishing ten-year TCOs for any major investment, let alone an EHR, provides a systematic means of both making an informed decision at the time of purchase and being more able to proactively reduce the project-execution risks of such a complex project.

EXHIBIT 9.6
Sample 10-Year Total Cost of Ownership for an Outpatient EHR

Products	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	Total
Capital Based License fees											
Volume Based Software Licenses											
Chunk 1 (350K Visits)											
25% at Signing	$$$ $$$										$$$ $$$
20% at Delivery	$$$ $$$										$$$ $$$
5% on final workflow walkthru		$$ $$$									$$ $$$
5% on integrated testing kickoff		$$ $$$									$$ $$$
25% on First Live Use (FLU)		$$$ $$$									$$$ $$$
10% FLU + 90 Days			$$$ $$$								$$$ $$$
10% FLU + 12 months			$$$ $$$								$$$ $$$
Chunk 2 (up to 500K Visits)			$$$ $$$								$$$ $$$
Chunk 3 (up to 750K Visits)			$$$ $$$	$$$ $$$							$$$ $$$
Chunk 4 (up to 850K Visits)				$$ $$$	$$ $$$						$$$ $$$
Oncology Module	$$$ $$$		$$$ $$$								$ $$$ $$$
Third Party Database	$$ $$$	$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$						$$ $$$
Addl Vendor One Time Products	$$ $$$	$$ $$$									$$ $$$
Third Party One Time Products		$$ $$$									
Interfaces (Live)											
25% at Signing	$$ $$$										$$ $$$
25% at Delivery		$$ $$$									$$ $$$
25% at FLU		$$ $$$									$$ $$$
25% at FLU + 90		$$ $$$									$$ $$$
Medication Interfaces (Phase II)			$$ $$$								$$ $$$
Capital Based Implementation Fees											
Implementation (Base)	$$$ $$$	$$$ $$$									$$$ $$$
Implementation (Oncology)		$$ $$$	$$$ $$$								$$$ $$$
Implementation (Interfaces)		$$$ $$$									$$$ $$$
Post-Live Activities	$$ $$$										$$ $$$
Project Team Training	$$$ $$$	$$ $$$									$$$ $$$
Estimated Travel	$$$ $$$	$$$ $$$									$$$ $$$
Rollout			$$$ $$$								$$$ $$$
Capital Based Hardware Fees											
Hardware Environment											
AIX Servers		$$$ $$$					$$$ $$$				$ $$$ $$$
SAN		$$$ $$$	$$$ $$$	$$.$$$			$$$ $$$	$$$ $$$	$$ $$$		$$$ $$$
Test/Training Server	$$ $$$					$$ $$$					$$ $$$
Clarity RDBMS Server	$ $$$					$ $$$					$ $$$
Crystal Enterprise Server		$$ $$$	$$ $$$				$$ $$$	$$ $$$			$$ $$$
Print Server		$ $$$					$ $$$				$$ $$$
Patient Portal Server		$$ $$$					$$ $$$				$$ $$$
Citrix Servers	$$ $$$	$$$ $$$	$$$ $$$			$$ $$$	$$$ $$$	$$$ $$$			$$$ $$$
Citrix Server Optional				$$$ $$$					$$$ $$$		$$$ $$$
Blade Enclosure		$$ $$$	$$ $$$	$$ $$$			$$ $$$	$$ $$$	$$ $$$		$$$ $$$
Citrix Licenses	$$ $$$	$$ $$$	$$ $$$	$$ $$$		$$ $$$	$$ $$$	$$ $$$	$$ $$$		$$$ $$$
Training/Implementation for AIX		$$ $$$					$$ $$$				$$$ $$$
SQL Enterprise Licenses	$$ $$$					$$.$$$					$$ $$$
Citrix Administrator		$$$ $$$					$$$ $$$				$$$ $$$
Citrix Technical Training	$$ $$$										$$ $$$

	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	Total
Operating Based Software Fees (Maintenance and Subscription Fees)											
Volume Based PP Chunk 1 (350)		$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Yearly Support - Optional			$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Oncology			$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Third Party dB - Required	$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$$ $$$
Third Party dB - Optional			$$,$$$	$$,$$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$,$$$	$$$ $$$	$ $$$ $$$
Third Party Maintenance Fees		$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$$ $$$
Vendor Consulting On Hand		$$ $$$	$$.$$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Patient Portal Software		$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$$ $$$
Interface Maintenance		$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$$ $$$
Subscription Applications	$0	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$ $$$	$$$ $$$
Operating Based Additional EMR Staffing											
Clinical Applications IS Team	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Oncology Specific IS Team		$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Other IS Staff		$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Core Trainers	$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
End User Trainers - Initial		$$$ $$$	$$$ $$$	$$$ $$$							$$$ $$$
End User Trainers - Add'l			$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$					$ $$$ $$$
Onsite Support Personnel - Initial		$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Onsite Support Personnel - Add'l				$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Total Spend	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$,$$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$$ $$$ $$$
Required and Optional Split of Costs											
Total Required	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$$ $$$ $$$
Total Optional	$0	$0	$$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$
Capital and Operational Split of Costs											
Total Capital	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$$$ $$$	$$$ $$$	$ $$$ $$$	$$$ $$$	$$$ $$$	$$$ $$$	$$ $$$ $$$
Total Operational	$$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$ $$$ $$$	$$ $$$ $$$

Legend

$ $$$	Thousands
$$,$$$	Tens of Thousands
$$$,$$$	Hundreds of Thousands
$ $$$,$$$	Millions
$$ $$$ $$$	Tens of Millions

Notes
1. For confidentiality reasons, real dollar figures could not be used
2. This 10-year total cost of ownership model is from a 5-hospital, 1000+ bed academic medical center with 700+ physicians
3. The total estimated operational spend over the 10-year period is 75% of the total spend, while the capital spend is only 25% of the total spend

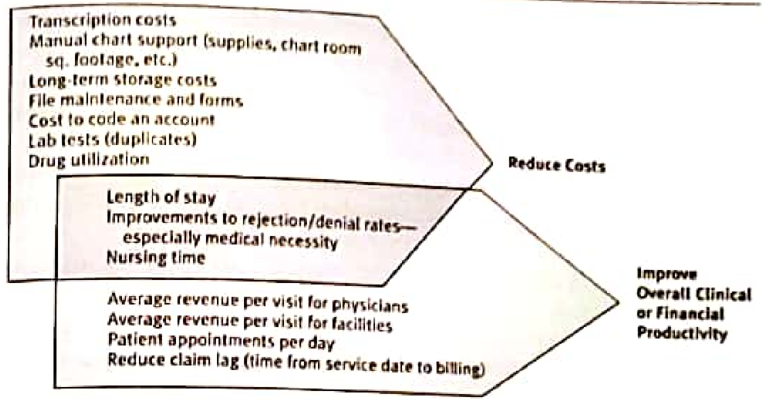
Benefits

A common reaction by most CEO, COO, and CFOs when they become aware of the costs of implementing an EHR is to immediately ask, "Where's the return on investment (ROI)?" Our colleague Dr. John Glaser has a nice analogy that he uses when someone confronts him with that question. He replies with, "What's the ROI of a chainsaw?" After letting his questioner ramble on a bit about the inherent efficiencies of chainsaws over axes or the lower number of full-time equivalents needed when employing a chainsaw versus an ax, he comes to their rescue with an obvious, thought-provoking insight: "What if you are making a dress? You'd be hard pressed to find an ROI for chainsaws if the task at hand were to efficiently make dresses. An equally important question follows that, 'What if the chainsaw is in the hands of a 10-year old child?'" Again, in the hands of a user without the requisite skills or ability to effectively use a chainsaw, the ROI is equally dubious. Glaser's message is clear: Depending on what you want to do with an EHR and who will be using it, the ROI is variable (Glaser and Garets 2005).

First and foremost, EHRs should not be treated as a proverbial silver-bullet technology that one throws at the problem of inefficient patient care processes. Rather, an EHR project is an organizational, cultural transformation that just happens to have a technological component. The benefits of the project will depend on (1) which processes an organization is willing to reengineer to take on the associated long-standing or ingrained status quos; (2) to what extent an organization is willing to invest in ensuring that the process owners and users are fully engaged and committed to reengineering the EHR-enabled processes; and (3) whether users are being fully trained in using the new EHR tools. In other words, as mentioned earlier as well, proper project execution is paramount to achieving the promise and value of the EHR. Assuming the healthcare organization has the leadership and buy-in as well as the project management prowess to effectively implement an EHR, an organization can expect to accrue a number of benefits from an EHR (see exhibits 9.7 and 9.8) beyond the meaningful use incentives.

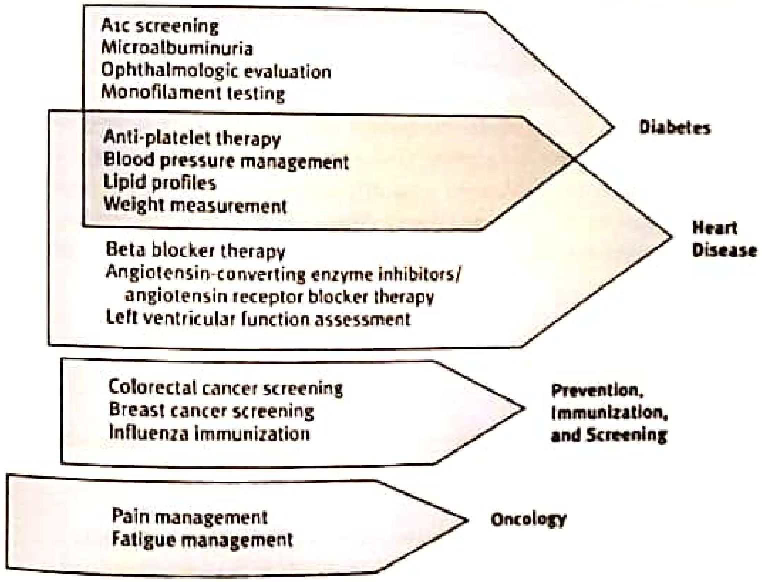
The financial benefits in Exhibit 9.7 are fairly self-explanatory and are those that organizations generally consider when comparing costs with benefits. Not all benefits are strictly financial, although they can be framed in financial terms. The product line benefits in Exhibit 9.8 are often overlooked when assessing the positive impact of an EHR. As legislation and payer models begin to reward health maintenance activities, as opposed to health intervention activities, an EHR can, with pinpoint precision, identify patients that need, for instance, A1C screenings, immunizations, mammograms, prostate screenings, and other proactive or preventive services. EHRs (especially those integrated with CPOE and CDS) have been touted as a key approach to reducing medical errors (Bates et al. 1998; IOM 1999). A number of

EXHIBIT 9.7 Typical Financial Benefits of EHRs



SOURCE: Smaltz and Berner (2007). Reprinted with permission from Health Administration Press, Chicago.

EXHIBIT 9.8 Typical Product Line Benefits of EHRs



SOURCE: Smaltz and Berner (2007). Reprinted with permission from Health Administration Press, Chicago.

research studies have documented that EHRs have the potential to lead to substantial benefits in patient safety, especially in reducing medication errors. Given that the costs of adverse drug events (ADEs) are enormous, avoidance of ADEs can translate into potential cost savings. Evans and colleagues (1998) found significant savings in length of stay, use of anti-infective agents, and total hospital costs when the advice of a CDS system for antibiotic use was followed. Similarly, Kaushal and colleagues (2006) analyzed the ROI on a CPOE system and estimated a cumulative net savings of $16.7 million dollars.

While EHRs can improve efficiency, the efficiencies may not be evenly distributed. An EHR may speed the time between a medication order and the patient receiving the medication, but some parts of that process may take longer than without the EHR. An analysis of multiple studies of time savings with electronic documentation systems showed a decrease in documentation time for nurses, but physician time was more variable; in some cases, the time for electronic documentation meant an increase in physician time at the front end (Poissant et al. 2005), but reduced search time for patient records may compensate for time lost in documentation.

Summary

With federal laws and incentives to meaningfully use an EHR in place for both individual physicians and hospitals, the stage is set for EHR adoption to continue to rise. Both the federal government as well as employer advocacy groups like the Leapfrog Group hope that the meaningful use of an EHR achieves the objectives, originally identified in the IOM report *To Err Is Human*, to prevent unnecessary deaths from healthcare errors, make healthcare demonstrably higher quality, and reduce the overall cost of providing healthcare.

Web Resources

A number of organizations (through their websites) provide more information on the topics discussed in this chapter:

- Centers for Medicare & Medicaid Services (CMS; www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/index.html?redirect=/EHRIncentivePrograms/). This website provides official guidance on CMS EHR incentive programs.

- Healthcare Information and Management Systems Society (HIMSS; www.himss.org/asp/topics_ehr.asp). HIMSS is the largest HIT professional association, and its website provides overview information on EHRs.
- International Health Terminology Standards Development Organisation (IHTSDO; www.ihtsdo.org/snomed-ct/snomed-ct0). IHTSDO's website presents information on standard medical nomenclature.
- Office of the National Coordinator for Healthcare IT (ONCHIT; www.healthit.gov/providers-professionals/ehr-implementation-steps/step-5-achieve-meaningful-use). ONCHIT's website provides guidance on both EHR implementations as well as incentives for meaningful use of an EHR.

Discussion Questions

1. What are some of the key capabilities of a robust EHR?
2. What is CPOE, and why is it seen as vital to achieving the nation's patient safety and healthcare quality goals?
3. What are some of the benefits of a robust EHR?
4. What are some of the main categories of cost associated with purchasing and implementing an EHR?
5. Why did the federal government in the HITECH Act of 2009 create a meaningful use standard for EHRs?

CHAPTER

10

APPLICATIONS: MANAGEMENT/ ADMINISTRATIVE AND FINANCIAL SYSTEMS

Learning Objectives

1. Describe the components typically included in an enterprise resources planning system.
2. Provide examples of transaction processing applications, and discuss how they support financial management.
3. Discuss desirable features of an automated enterprise scheduling system.
4. Distinguish between clinical decision support software and executive information systems.
5. Understand the use of computer applications as tools for research and medical education.

Overview

For many years, the healthcare field lagged other businesses in the design and implementation of robust information systems. Problems have included undercapitalization of the system development process and management failure to oversee system implementation effectively. However, the situation has changed substantially due to heightened competition, increased regulation, and changing payment mechanisms affecting the entire industry. Changes in the delivery and financing of healthcare since the late 1980s have been pivotal to establishing information management as a key strategic resource in most healthcare organizations. Healthcare managers have come to rely on information systems as essential tools for robust growth, effective competition and, in some cases, survival.

Most healthcare organizations began their automated information processing activities with computer systems that supported administrative operations—in particular, financial and accounting systems. While a significant number of current healthcare applications still serve financial purposes, the drive for robust clinical information systems has become a top priority for most healthcare organizations. Note, however, that clinical information systems not only provide direct support to patient care processes but also populate the data repositories essential for performance measurement, external reporting, cost management, and other organizational accountability activities. Thus, the "ideal" clinical and administrative applications integrate into a comprehensive system that supports the continuum of information needs in an enterprise.

Most early information system applications in healthcare organizations were designed as stand-alone systems, and purchase decisions were based on maximizing desired specific functionality at acceptable costs. In the current environment, however, clinical and administrative applications are expected to integrate, sharing functionality and transferring data across various elements of the enterprise information system as well as exchanging information with systems external to the enterprise. Purchase decision criteria now include interoperability, compliance with data transmission standards, and many other complex factors.

Migrating these stand-alone *legacy* systems into an integrated environment proved to be one of the most difficult challenges that healthcare information technology (HIT) teams encountered in building systems to meet the expanding information needs of healthcare enterprises (Gilchrist et al. 2008; Hicken, Thornton, and Rocha 2004; Kraatz, Lyons, and Thompkinson 2010). In fact, some teams concluded that "starting from scratch" would be easier than retrofitting various systems from multiple vintages. As technologies and system configurations continue to evolve, however, repeated "start-overs" usually are not a realistic option for several reasons. Purchase and implementation costs of full-scale systems can be prohibitive, although purchase price has become almost the least important criterion in system selection. Operations and planning are dependent on data and information stored in existing systems, and migrating data archives may be difficult or even impossible. In light of the extent of technology dependence in healthcare organizations, the disruption in service delivery and business operations during a full-system transition could be tremendous. Thus, managers must select system components with forethought for the capability to transition to next-generation products for better interconnectivity and interoperability in both clinical and administrative applications.

Enterprise resources planning (ERP) systems are bundled applications, or "single vendor solutions" (Raths 2006), that integrate operational information derived from financial, human resources, materials management, and other function-based areas into a robust database used to achieve business management objectives (Legnick-Hall and Legnick-Hall 2006). These systems connect inventory and facilities management, resource scheduling, accounting and financial management, and other business events in a real-time environment. As with clinical systems, the market for ERP applications

emerged from the need to update legacy software. However, a large number of vendors continue to develop and market applications that will operate as stand-alones or that can be integrated or interfaced with other applications. The administrative applications typically incorporated in an ERP include the following:

- Financial information systems
- Human resources information systems
- Resource utilization and scheduling systems
- Materials management systems
- Facilities and project management systems
- Office automation systems

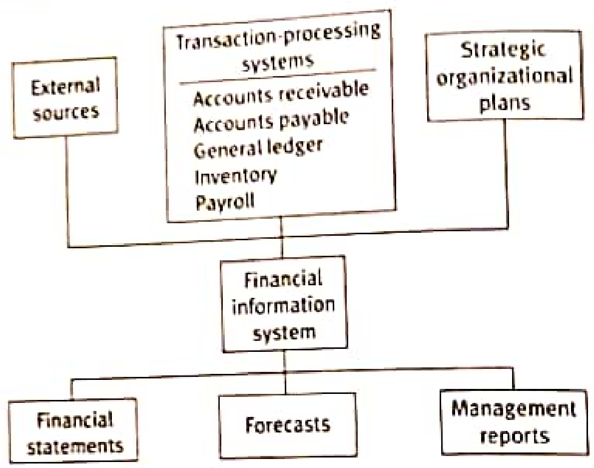
Each of these system components is described in this chapter with illustrative examples. Special features of these types of applications designed to meet the needs of nonhospital healthcare organizations, such as physician practices and home health care, are addressed. Additional uses of information systems in healthcare, such as medical research, education, and decision support, are discussed briefly.

Financial Information Systems

The highly competitive and regulated environments in which healthcare organizations operate require timely and accurate financial information that enables managers to monitor and guide operational performance. In the face of answering demands for accountability and cost containment while still providing high-quality services, managers are acutely aware of the importance of sound financial management in guiding operational performance. Financial information systems support operational activities such as general accounting, patient accounting, payroll, contract management, and investment management. Financial systems also provide information to management for controlling and evaluating organizational performance. Analysis of current and historical information helps in projecting future financial needs of the organization.

Financial information systems require input from transaction-processing systems, external sources, and strategic organizational plans (see Exhibit 10.1). Transaction-processing systems record the organization's routine activities, collecting information from other administrative subsystems, including payroll, accounts payable, accounts receivable, general ledger, and inventory control. These transactions are the basis for many financial reports required by management. To support effective financial decisions, financial

EXHIBIT 10.1 Financial Information System



systems also need external data such as government statistics, inflation rates, and information about the marketplace. An organization's strategic plan should contain financial goals and objectives that help provide the framework for preparation of financial reports.

A fully integrated financial information system brings related information together for planning, monitoring, and control. Individual financial subsystems include the following:

- Payroll preparation and accounting, linked to a human resources information system
- Processing of accounts payable, linked to purchasing and inventory control systems
- Patient accounting, patient and third-party billing, and accounts receivable processing
- Cost accounting and cost allocation of non-revenue-generating activities and general overhead expense
- General ledger accounting
- Budgeting and budget control
- Internal auditing
- Financial forecasting
- Investment monitoring and analysis
- Financial statement preparation

- Financial reporting for operating supervisors, executive management, board members, external regulators, and third-party financing agencies

The development of a financial information system depends on the existence of a good accounting system. Sophisticated cost accounting, essential in a negotiated pricing environment, enables the financial information system to generate accurate information on personnel and other physical resources used to deliver services. For services provided under managed care contracts, providers, managed care organizations, and employers need cost information to help negotiate rates and monitor contract performance. Integrated financial reporting based on a solid cost accounting system provides information for product costing, analysis of labor productivity, inventory control, and examination of the productivity return on capital investments.

Significant proportions of total payments for healthcare services provided are based on either a fixed payment per case (e.g., diagnosis-related groups) or a fixed payment per person per month (i.e., capitation payment systems). For effective management in this environment, a financial information system must have the capability to convert or link cost and net revenue information to multiple units of payment.

A market analysis prepared by the Dorenfest Institute for HIT Research and Education (2006) for the HIMSS Foundation reported that ten suppliers dominate in sales of financial applications software, suggesting a highly concentrated market. This concentration is due in part to two high-profile mergers that produced two powerhouses in the HIT industry: McKesson, which acquired HBOC, Inc., and Siemens, which merged with Shared Medical Systems. These two companies hold significant market share in every type of financial application.

Human Resources Information Systems

Employees of a healthcare organization constitute its most important resource. Most organizations spend more than 60 percent of their operating budget on employee salaries and benefits. Thus, a good human resources information system (HRIS) is a very important tool to assist managers in personnel planning, staffing, and productivity analysis. The common functions of an HRIS include, but certainly are not limited to, the following:

- Maintaining, updating, and retrieving information from a database of employee personnel records
- Providing automatic position control linked to the budget
- Producing labor analysis reports for each operating unit or cost center

- Producing reports used for assessing personnel problems, such as turnover and absenteeism
- Maintaining an inventory of special skills and required certifications of employees
- Producing labor cost allocations with linkage to the payroll system
- Providing information on employee productivity and quality control, assuming that appropriate labor standards have been developed
- Managing employee sick leave, vacation, and other earned time off
- Comparing the organization's compensation and benefit packages with industry norms

Large amounts of data are required to provide these types of reports and others that may be needed. The HRIS information processing and reporting functions are supported by information drawn from various databases that contain individual employee data, wage and salary data, the organization's job-classification structure, benefit packages, employment contracts, and many other related data elements. Actual ownership of the various databases may be distributed among multiple departments. Thus, the structure of the databases is an important factor in data transfer from one element of the system to another.

Although essential for efficient business practices, the availability of computerized employee-record files creates a security issue. Because protecting the employee's right to privacy is essential, organizations need to establish software and hardware security systems and set policies for accessing and updating electronic files containing personnel data and information. (See Chapter 5 for discussion on data security policies.)

In addition to supporting operational work in the human resources department, a well-designed HRIS will produce reports for management planning and control (see Exhibit 10.2). For example, HRIS management reports can be used to monitor turnover rates, unfilled positions, labor costs, employee productivity, and utilization of benefits. Attitudes of employees and physicians can be monitored through periodic satisfaction surveys. This survey data used in conjunction with activity and utilization data can be an important component of planning changes to benefits provided to employees.

Software applications are used to maintain records related to verifying physician credentials and defining practice privileges in the organization as well as for ongoing evaluation of physician clinical performance. Credentials and privileging systems are important for monitoring quality standards and for maintaining documentation required by accrediting and regulatory bodies. The task of verifying academic and training credentials and malpractice exposure is frequently outsourced to a certified *credentials verification organization* (CVO), such as Healthplex (www.Healthplexcvo.com) and Professional

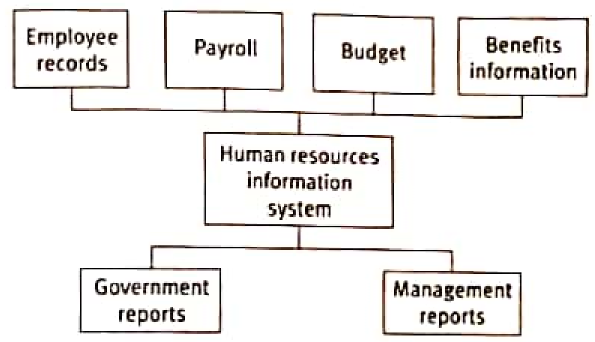


EXHIBIT 10.2
Human Resources Information System

Credentials Verification Service, Inc. (www.pcvs.net). Data transmitted by the CVO must be connected to relevant data from the organization's clinical and administrative systems to develop practice profiles for monitoring physician productivity and conformance to quality standards. Often, there is a need to integrate external benchmark and industry standards for comparison with actual performance data. Because of the sensitive nature of the data in this system and the specificity of facility accreditation requirements for this function, a stand-alone system often is used to achieve the desired functionality and system security. Example applications include MD-Staff (www.mdstaff.com), a cloud-based network that includes background screening, credentialing, and provider management options. In early 2012, MD-Staff reported more than 600 installations.

Resource Utilization and Scheduling Systems

Under fixed-price and capitation payment systems, cost containment and efficient resource utilization are pivotal to success. External mandates for utilization review by regulatory agencies and insurance companies are more than balanced by internal drivers for ensuring that resource utilization is optimized. Managers must ensure that services are available when needed and that personnel and technology are efficiently allocated and scheduled. These efficiency needs are met through computerized monitoring and scheduling systems.

Information systems monitor inpatient occupancy rates, clinic and emergency department activity, and utilization of individual service facilities such as the operating suite or diagnostic units. Patient scheduling systems are used for advance booking and scheduling of facilities—both for patient and physician convenience and for efficient allocation of resources, particularly staffing. Comprehensive and timely data are essential to monitor use of expensive diagnostic and treatment technologies to achieve optimal revenue returns on capital investments.

Advance bed booking and preadmission systems are particularly useful in situations where most of the admissions are elective (e.g., a specialized surgical facility). Advance booking also provides time for necessary precertification for managed care patients and others covered by insurance plans that require review and certification of medical necessity for procedures and inpatient admission. Preadmission information systems can be linked to individual physicians' offices as well. Computer programs can project the average length of stay for each elective admission once historical data (including diagnosis, surgical procedure, age of patient, and gender of patient) have been accumulated. After admissions are scheduled and the data are entered into the computer's master files, the system keeps track of projected occupancy levels for each day.

Admissions monitoring and scheduling systems improve staffing and workflow in healthcare organizations. These systems can reduce daily fluctuations in a hospital's census and improve the effectiveness of flexible staffing systems. Acute care general hospitals must maintain an accurate accounting of bed census and occupancy if they are to survive. Census information helps administrators compare projected income against projected budgets. Administrators can also track demands for specific services and adjust staffing levels and scheduling of facilities as demand patterns change.

Computer programs are also available for scheduling operating rooms in hospitals and ambulatory surgery centers. These systems are designed to improve operating room utilization, contain costs, facilitate planning, and aid in the scheduling of specific surgical procedures. Outpatient clinic appointment and scheduling systems are common in organizations with a large volume of outpatient activity.

Resource utilization and scheduling systems may be designed for use at the department level or for a small entity such as a physician practice, but enterprisewide scheduling systems that meet multiple objectives are becoming common. These robust integrated systems support fiscal objectives such as balanced schedules, optimum staffing, and management of resources across the enterprise. From a patient perspective, the ability to schedule multiple diagnostic procedures in one session, and perhaps schedule all procedures in a single day, contributes to satisfaction with the encounter experience.

The scheduling system can include modules that capture patient insurance and billing information during the registration process, which can be matched against stored contract data to produce appropriate charge records. Most systems can produce automated appointment reminders in a variety of formats, including computer-generated telephone calls, e-mails, or text messages, in addition to mailed documents.

Scheduling systems can be linked with materials management systems to ensure that equipment and supplies are available for scheduled procedures, including initiating the process to transport the supplies to the treatment area. As items are removed from inventory, ordering and restocking procedures are triggered.

Materials Management Systems

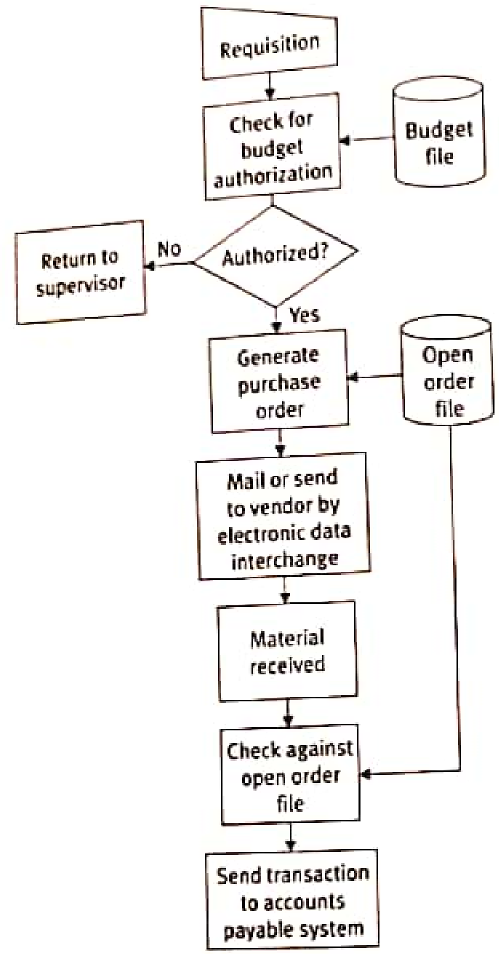
Computer systems are invaluable in effective management of supplies and materials, including data exchange with suppliers, automated purchase orders, inventory control, use of bar-code devices for encoding supplies and materials, and computerized menu planning and food service management.

In a typical materials management system, requisitions for supplies and materials are electronically generated and matched against budgetary authorization for financial control. Reports of overdrafts on supply accounts are transmitted to the appropriate supervisor for follow-up action. Once requisitions are cleared, often using an automated workflow process for sequential authorizations, the system generates purchase orders. Purchase orders can be transmitted electronically to suppliers via established data-exchange protocols. As materials are received, bar-coded products can be scanned and matched against an open order file. Many automated purchasing systems also include direct linkage to the accounts payable system if system integration has been planned. Some systems also provide the capability for automatic reordering of selected items as inventory is depleted (see Exhibit 10.3). Supply chain applications reduce processing costs and obtain materials on a just-in-time basis to minimize the need to carry a large inventory.

Detroit Medical Center divides its materials resource management department into several functional areas: linen services, clinical engineering, contract administration, logistics management, procurement, supplier diversity, and systems development (www.dmc.org/vendor). The department communicates with current and potential business associates via a website, providing information about open requests for proposals, standard contracts and policies, and status on open purchase orders. Some areas of the website are open access, which may generate interest from potential vendors, but areas that store proprietary or contract-related information are protected with a secure login and are accessible only to current business partners.

Coding standards are an important element of automated purchasing and materials management systems. Bar codes for all types of medical supplies and pharmaceuticals have become standard and are essential to efficient purchaser–vendor relationships in healthcare.

EXHIBIT 10.3
Materials Management System



Computerized menu-planning systems store and analyze data on patients' nutritional and dietary requirements, food items in inventory and their costs, and decision rules for selecting from among alternative menus. Decision criteria might include patient preferences or visual appearance of food in addition to nutritional adequacy and cost. (See the sidebar on the next page for an example.)

Healing the Body by Stimulating the Appetite

UAB Hospital in Birmingham, Alabama, has implemented a novel alternative to routine menu plans for inpatients who want more choice in their meal selections. Patients can order "room service" for delivery to their rooms between 6:30 am and 7:00 pm. Meal choices include breakfast foods, soups, salads, hot and cold sandwiches, pizza, meat-based entrees, and desserts. For the adventurous, a seasonal meal planned by a renowned local restaurateur is available.

Patients with dietary restrictions are flagged in the information system to be automatically connected with a dietary representative who will address their meal requests appropriately. Online menus include designations to aid patients in selecting "heart healthy" foods or those allowed on a diabetic diet.

This meal option is supplemented by nutritional education available on the patient education television channel and with telephone access to a registered dietitian.

More information is available at www.uabmedicine.org/patient-and-visitor-guide/patient-information-room-service.

Facilities and Project Management Systems

Computerized systems can help organizations plan, manage, and maintain physical facilities. Examples include preventive maintenance systems, energy management systems, and project scheduling and control systems (particularly useful in new construction and remodeling projects).

Preventive maintenance systems help extend the life of equipment and facilities and reduce costly failures. Routine maintenance can help organizations achieve significant cost savings by preventing repair and replacement costs. Additional benefits accrue, including preventing nonproductive downtime, improving the safety of the workplace, and decreasing the risk of patient or employee injury due to equipment malfunction. Exhibit 10.3 shows the framework for a materials management system.

Energy conservation is an important cost-saving strategy for healthcare organizations as it is in all major industries. Computer applications assist in monitoring routine and peak energy use, providing information to tactics for reducing consumption. Actual utilization figures can be compared against calculated requirements, and a computer model can be developed to find economies and efficiencies. The energy management system also can be employed to implement the selected tactics, such as automatically lowering or raising room temperatures in areas that are unused at night or on the weekend.

Healthcare organizations frequently are involved in capital construction and major remodeling projects, and computer systems are an extremely useful aid in project management. These project scheduling and control systems typically employ a combination of integrated tools to manage personnel and activity scheduling, labor and materials costs, required resources, and periodic progress reporting. As a key component, these tools are used to document (1) all activities required to complete the project; (2) the relationships of these activities to one another, including those that can be carried out simultaneously and those that must follow a time sequence; and (3) time estimates for completing each activity. These data are used to generate a diagram of activities that shows the critical path (longest time required) for project completion and any opportunities for concurrent or fast-tracked activities. As activities are completed, actual completion times can be entered back into the calculation, and more accurate schedules can be prepared for the remaining work. These systems are excellent tools for dynamic scheduling and control of major projects. More detailed coverage of project management related to HIT is provided in Chapter 11.

Office Automation Systems

Office automation helps to coordinate and manage people and workflow, link organizational units and projects, and coordinate work in the organization across levels and functions. Healthcare organizations use a variety of computing tools to carry out general office functions, such as word processing, e-mail, project management, meeting scheduling, and maintenance of personnel calendars for work-related activities. These functions may be conducted using desktop workstations; laptop computers; or a variety of handheld devices, including personal mobile telephones or smart phones. Use of systems for integrated word and graphic processing, scheduling, electronic filing of documents, and message/document transmission can dramatically improve administrative efficiency and reduce the costs of office operations.

Office systems can link parts of the organization together by scheduling meetings using electronic calendars and e-mail or text communication. E-mail systems link offices and individuals, allowing electronic files to be forwarded to others or to be archived in a shared storage area for access by members of a workgroup. Mobile computing using laptops and handheld devices, wireless technology, and the Internet have changed the way people work alone or together. Workgroups and teams can meet and collaborate from anywhere—in the same conference room or in geographically separated offices—with full access to necessary software programs and organizational files.

This work environment is supported by *groupware*—collaborative software that enables sharing of information via an interactive network (e.g., a virtual workspace). This software–hardware combination not only facilitates real-time interaction among members of the group to improve problem solving and project management but also supports independent work tasks.

Audio- and videoconferencing allow real-time interaction among team members. Group members may work asynchronously on project activities while maintaining the integrity of a shared work product. When used effectively, and provided employees are trained to use the electronic tools, the virtual office can be as productive as the traditional office. Typical groupware activities include the following:

- E-mail and discussion forums
- Teleconferencing
- Interactive videoconferencing
- Relational databases (used to search for data and information)
- Document editing and management, including archiving and version tracking
- Group calendars and scheduling

SharePoint, a Microsoft product, is an example of groupware. A description of SharePoint functionality is available at www.sharepoint/microsoft.com. SharePoint can be deployed as an on-premises system or in a hybrid environment that employs cloud computing (Robinson 2011).

Information Systems for Nonhospital Healthcare Organizations

As changes to payment models in the 1980s led to changes in delivery models during the 1990s, nonhospital healthcare organizations began implementing information systems to manage clinical services and business operations. Vendors quickly began designing and marketing software products to meet the special information needs of these organizations. Organization types that fall under the nonhospital category include ambulatory clinics; long-term care (LTC) facilities; home health agencies; physician practices; and many others, including retail clinics. Software applications used in these settings typically include multiple modules that meet the organizations' needs for clinical documentation, operations management, and financial management.

Ambulatory Care Information Systems

Significant components of the healthcare continuum are delivered in outpatient and ambulatory care settings. Information systems that support ambulatory care and assist primary care providers in their practices have become a niche market. The availability of powerful and inexpensive microcomputers and practice management software packages has brought this technology within the reach of even small medical groups and solo practitioners.

A typical practice management system (Slovensky et al. 2006) includes modules to support such business functions as the following:

- Operations management (e.g., scheduling, reminders, billing, authorizations)
- Services (e-mail, groupware)
- Claims processing
- Document processing, spreadsheets, and databases
- Transcription
- Personnel management
- Inventory management
- Waste management
- Energy management

Clinical applications in medical practices and freestanding clinics include electronic health records (EHRs), prescription management, and disease management resources. Patient applications—an emerging software market—include electronic communication, monitoring, educational resources, and telehealth applications. Various vendor products offer full-service suites or selected modules based on the practice's needs.

Automating practice functions increases operational efficiency and reduces errors in information processing, both of which contribute to patient satisfaction and reduced risk and liability exposure. Automating or using web-based patient communication for services—such as callbacks, prescription renewals, and similar activities—can be helpful as well.

Office practice computers can be linked to local hospitals in addition to serving the management needs of the practice. Many hospitals or integrated delivery systems have developed computer linkages with physician offices to enable clinicians to pre-admit patients; order diagnostic tests; and query the patient information system for lab results, progress notes, and other current clinical information. Healthcare organizations use such linkages as incentives to attract physicians to use their facilities in a highly competitive environment. Under some conditions, hospitals may be able to offer financial support to physician practices for the purpose of implementing an EHR that links with the hospital system (Babitch 2009).

An alternative to linking with a hospital system is for two or more clinics or health centers to partner and purchase a shared system. This approach may be an excellent option for a multisite group practice or for affiliated professional groups. One example of this approach is provided by the Metropolitan Collaborative of Health Information Technology (METCHIT), a health center network of four organizations in New York City (Egleson et

al. 2010). This initiative was clinician-led, which contributed to the successful deployment of the system components across the network. An important factor in the success of this EHR application was the ability to modify system templates to accommodate mandatory reporting requirements.

Long-Term Care Information Systems

The LTC industry has been a late adopter in implementing computer systems, in part because software vendors have been slow to develop products tailored to the needs of nursing homes and continuing care communities. This situation is changing as the scope and volume of healthcare delivered in subacute-care and postacute-care facilities increase. Typical requirements for LTC systems include census management, initial and periodic resident assessments, documentation of care services provided, documentation of physician orders, nutritional assessments and menu planning in the dietary department, and pharmacy applications.

The ability to communicate clinical information between caregivers and the admitting physician is especially important, as the physician usually is not physically present on a daily basis. Remote access to clinical documentation facilitates timely intervention in an acute episode and contributes to better health outcomes. As with other HIT applications, remote access can be achieved using various computing devices or telephone systems. System security and controlled system access are extremely important.

As LTC facilities become components of larger integrated delivery systems, electronic sharing of clinical and administrative information with hospitals, clinics, ambulatory care facilities, and other system components becomes a business essential. Once again, data sharing among the enterprise units and IT strategic partners is a key driver in system design. However, insufficiency of data standards and security concerns remain as significant barriers to achieving the desired level of connectivity, along with issues related to proprietary systems (Edwards et al. 2010).

Home Health Care Information Systems

Home health care services have expanded rapidly in recent years as an alternative to more costly institutional care. As service volume has increased and the scope of services expanded, information systems have been developed specifically to meet the needs of home care provider organizations.

Many home health agencies use laptop computers and other remote access devices for on-site documentation of patient care and for access to treatment plans and previous encounter documentation. Home health nurses and other caregivers enter information directly at the treatment sites for uploading to the centralized data repository. Relevant data can be accessed during a service visit by any provider. These systems reduce the amount of administrative work needed to document care, allowing nurses and home health aides to spend more time providing patients the care and services they need to achieve desired clinical outcomes.

Electronic devices also can transmit clinical information via telephone lines or the Internet for the purpose of routine health monitoring between visits. Patients and family members follow the documented treatment plan, take and record measurements as indicated, and submit data for evaluation by the clinical personnel overseeing their care.

Other Information System Applications in Healthcare

Information systems support most processes in healthcare. While many applications can be categorized by their use for a defined function, many serve the needs of multiple providers and managers in disparate service areas. Clinical information may be combined with administrative information or used for an administrative purpose exclusively. Alternatively, administrative information may be applied in the delivery of clinical care.

Clinical Decision-Support Systems

Clinical decision-support (CDS) systems are designed to assist physicians and other providers in diagnosis and treatment planning. CDS systems fall into two categories: (1) passive CDS systems and (2) active CDS systems.

Passive CDS systems use the computer to collect, organize, and communicate clinical data for interpretation and analysis by the physician. They make clinical information, including medical history, physical examinations, and diagnostic tests, more readily available and usable but do not process the information for further analysis. Clinical information systems—such as laboratory, pharmacy, radiology, and other clinical services applications—are examples of passive CDS systems in that they capture clinical data and make them available to caregivers. These applications become more useful to clinicians for decision support when they are fully integrated and can provide complete medical information (both current data and historical information on the patient) through simple, user-friendly access. For example, caregivers could view temperature, heart rate, and blood pressure readings over time to see patterns in relation to medication administration, physical activity, or food ingestion.

Active CDS systems provide direct assistance to the physician in diagnosis and treatment planning. They combine patient-specific data with generalized medical knowledge to reach a conclusion or make a recommendation to the caregiver. These systems may use a branching logic or rule-based structure, or a statistical probability algorithm, to suggest an appropriate diagnostic or treatment response to a clinical condition described by the physician.

These systems incorporate validated clinical guidelines and treatment protocols that represent current best practices in clinical medicine. The National Guideline Clearinghouse (www.guideline.gov) is an excellent resource to learn more about this type of resource available to clinicians.

Types of active CDS systems are as follows:

1. *Expert systems* contain three major components—knowledge base, patient-specific information, and inference engine. A general knowledge base of medical information, obtained from a panel of experts in a given medical specialty, has been rigorously validated through scholarly research, clinical practice, and consensus support from the medical community. This knowledge base is matched against patient-specific information retrieved from the healthcare organization's clinical database and may include subjective information as well as objective clinical findings. A rule-based inference engine generates conclusions for consideration by the physician. The system is dependent on the quality of the expert knowledge base and the "reasoning power" of the rules used by the inference engine.
2. *Probabilistic algorithms* employ statistical probabilities, which include a calculated element of randomness, rather than rely solely on knowledge collected from expert human beings. Expert knowledge is based on a combination of academic preparation and experiential learning, and variation may occur in either component of an expert's knowledge base. Extrapolations outside an expert's existing knowledge contribute to experiential learning. While a consensus viewpoint among experts incorporates nonquantifiable variability, a statistical probability allows the decision maker to control the degree of uncertainty tolerated in the system's output.
3. *Clinical reminders and alerts,* incorporated into clinical computer applications, suggest potential medical conditions or other problems that should be given attention in setting treatment plans. Examples include pharmacy information systems that alert the physician to potentially negative interactions between two drugs prescribed for the same patient as well as systems that suggest certain drugs or treatments should not be employed when specific laboratory results contraindicate their use. This function can also be used to suggest less expensive (but equally effective) alternatives when a high-cost drug has been ordered. Alternative drugs may also be suggested when the prescribed drug has significant risks for certain types of patients.

Computers can aid decision making by simplifying access to data needed to make decisions, providing reminders and prompts, assisting in order entry, assisting in diagnosis, and reviewing new clinical data to issue alerts when important patterns are recognized. Systems are more likely to be successful when they give patient-specific suggestions, save time, and are incorporated into the regular workflow of the organization. Researchers at the University of Alabama at Birmingham found that physicians using a decision-support rule accessed via a handheld device (e.g., personal digital assistant [PDA]) made better prescribing decisions than those who did not have the PDA for CDS access (Berner et al. 2006). The study, a randomized controlled trial, examined ordering practices for nonsteroidal anti-inflammatory drugs (NSAIDs). Physicians accessing the rule were more likely to order NSAIDs that were considered "safer" when considering gastrointestinal risk factors.

CDS systems that are well integrated with the enterprise EHR offer great promise for personalized medicine (Downing et al. 2009). Responding to variability among individual patients and applying the ever-increasing body of medical knowledge require information processing on a scale that cannot be achieved by human means. Well-designed systems can process large volumes of knowledge-based data filtered by personal clinical data and even by personal preferences for options among treatment modalities. Patients can be evaluated for risk factors for specific conditions, be advised about prevention and early detection strategies, and be assessed for probable effectiveness of various treatment options should the condition occur.

Executive Information Systems

The business corollary to CDS systems is the executive information system (EIS). Sometimes referred to collectively as ***business intelligence***, EIS includes systems designed to access and merge internal and external data into meaningful information reports. Executives identify critical environmental trends and facility performance indicators related to strategic objectives to guide their information capture and analysis. Data to support the EIS may be extracted from clinical and administrative databases serving the healthcare enterprise as well as from public and proprietary data repositories. The information needed from an EIS for decision support generally is not met through standard reports. Users must be able to select the variables and data sources needed to answer specific questions, so ad hoc reporting capability is essential. In many analysis scenarios, it is important to begin with general data aggregations and then reduce subsets of the data to increasingly greater detail, a process referred to as ***drilling down***. The EIS must support this type of processing through an easily managed user interface.

Evidence-Based Medicine and Disease-Management Systems

Evidence-based clinical practice guidelines, also referred to in application as ***evidence-based medicine*** (EBM), are intended to assist clinicians and healthcare

organizations in standardizing decisions about the care of individual patients to achieve cost and quality benefits. Accumulated evidence from clinical research is used to formulate statements of the "right" things to do for patients with a given diagnosis or condition. Ideally, guidelines ensure that patients receive appropriate diagnostic tests and treatments in an efficient and cost-effective manner. Guidelines are assumed to lower treatment costs by avoiding unnecessary tests. Hundreds of guidelines have been developed and are archived in the National Guideline Clearinghouse sponsored by the Agency for Healthcare Research and Quality (www.ahrq.gov). Although managed care organizations and health insurers employ such guidelines to make decisions about treatment options, covered services, and other aspects of patient care, practice guidelines are not without significant limitations. Among these limitations are differences in local standards of care, access to recommended technologies, and unique patient characteristics.

While linkages to EBM resources are commonly incorporated in clinical systems for large inpatient facilities or integrated healthcare delivery systems, small clinics or medical practices may rely on independent access to EBM resources via the Internet. In these types of primary care settings, the clinician typically is using some component of the office automation system—desktop computer, laptop, or handheld mobile device—for Internet access. In this type of environment, convenience is an important factor in determining whether the clinician will seek external information. Recent research has shown that primary care providers who report using HIT resources as part of their patient encounter routines are likely to conform to evidence-based standards of care (Davis and Pavur 2011). An important caveat to this finding, however, is that providers who used PDAs as their primary computing device did not have the same level of compliance with these standards. As noted in Chapter 6, the size of the display screen relative to the output being displayed is an important system design characteristic. The small screens on handheld devices and the difficulty of entering precise input data using an ultra-compact keyboard make PDAs a poor choice for this purpose.

Disease management information systems and software products are designed to assist healthcare organizations in designing processes to provide quality care at the most reasonable cost possible. For the most part, they are disease specific and focus on high-volume, high-cost chronic conditions such as asthma, diabetes, and congestive heart failure. The typical approach is to involve patients in self-management of their condition and to create monitoring and feedback processes that encourage compliance with treatment plans. The information system may include capturing blood or urine test data, blood pressure readings, and other clinical information in the patient's home and transmitting it to the healthcare organization via digital telephony or other remote monitoring devices. Communication between patients and providers may be via telephone or the Internet. While routine patient monitoring assists in daily decision making, analyzing aggregated data can guide case managers and physicians in modifying treatment plans for better long-term clinical outcomes.

Computer-Assisted Medical Instrumentation

Virtually every piece of medical equipment used for diagnostic testing and treatment now contains a microprocessor. The processors are used for instrument control, image enhancement, or processing medical data and interpreting the results of the testing or treatment process. Common examples include electrocardiograms, electroencephalograms, and pulmonary function testing. Computer systems interface directly with patient-monitoring devices for continuous surveillance of a patient's vital signs and periodic display of physiological data. These systems are particularly useful in critical care and postsurgical units.

The first step in the process is acquiring data from monitoring equipment attached to the patient and then converting that data for computer processing and display. Data are stored and made available for periodic display or display on demand. Computer programs enhance the measured data through structured analysis of clinical data in accordance with programmed decision rules. Trend data are followed to monitor changes in patient vital signs over time. Patient-monitoring systems can operate at the individual patient bedside, at a central station designed to monitor a small number of intensive care beds, or at a remote location linked back to the critical care unit by telecommunication equipment. For example, output from cardiac monitors may be monitored remotely by trained monitoring personnel, who in turn alert caregivers about aberrant readings. Many of these systems also have electronic linkages for transmission of clinical data to the central EHR.

Coupling automated patient identification with electronic biomedical devices can produce significant efficiency gains in many routine tasks. UAB Hospital in Birmingham, Alabama, for example, uses a bar-code scanner to read codes on the patient's electronic monitor and armband, and then the device transmits recorded vital signs to the EHR. This approach has resulted in a 92 percent efficiency gain in recording vital signs and has decreased the number of errors in documentation significantly (Hicks 2009).

Telemedicine

Telemedicine—now sometimes referred to as telehealth or e-health systems—is the application of computer and communications technologies to support healthcare provided to patients at locations remote from the provider. Telemedicine often involves telephone and online communication between a primary care physician, nurse practitioner, or physician's assistant who is treating

patients in a rural area and specialty physicians located at a distant medical center. Audio communications and videoconferencing equipment are used in conjunction with computer access to patient records to establish primary diagnoses or provide expert consultation and second opinions. The systems often employ teleradiology for transmission of medical images for review by specialty physicians. Telemedicine systems can save patients travel time and costs as well as deliver healthcare cost savings.

The University of Texas Medical Branch's Electronic Health Network, self-described as "the largest telemedicine system in the world" (UTMB 2007), provides medical services to indigent populations and correctional facilities across Texas, in addition to corporate and school programs. One of UTMB's more interesting programs is providing telemedicine services to the National Science Foundation researchers in Antarctica.

Telemedicine applications have increased in recent years, due in part to the advent of mobile computing, which has enabled the deployment of *mHealth*—health-focused applications accessible to the general public. These user-friendly and low-cost applications allow patients to monitor and report health indicators such as blood pressure or blood glucose easily and conveniently. However, for traditional telemedicine applications such as specialist consultation or remote diagnostic procedures, issues remain related to reimbursement for remote services, state licensure of health professionals when the system crosses state borders, patient privacy protection, and government regulations (Thompson 2006). Clinical outcome benefits achieved through various telemedicine applications differ, as do cost savings.

The types of articles published in the ***Journal of Telemedicine and Telecare*** over the past few years suggest that the number and variety of telemedicine applications continue to increase as technology innovations offer more opportunities. Research on patient satisfaction with telemedicine applications appears to be declining. As computer technology pervades business and social environments, individuals may be more accepting of telemedicine and mHealth applications. Although age is sometimes identified as a barrier to technology acceptance, one nine-month study shows that frail elderly subjects are able to use a web-portal telehealth service to reduce their use of facility-based healthcare (Finkelstein et al. 2011). Subjects needed minimal training to use the web portal, and their self-ratings showed improvement in technology acceptance over the course of the study.

Research involving a US Department of Veterans Affairs cohort showed that patients rated service access and educational components of telehealth programs positively, but they reported frustration with equipment problems and slow responses to requests for assistance (Young et al. 2011). Incorporating routine monitoring of these elements of a telehealth service is pivotal to the long-term success of the service.

The ability to meet data-sharing requirements for telemedicine encounters are emerging as key factors in the sustainability of these e-health systems (Ganguly et al. 2009). Telemedicine providers need access not only to clinical data, such as that extracted from an EHR, but also to research findings and other knowledge-based information. Thus, the data-exchange protocol must address both standard format data and free-text formats.

Computer Applications in Medical Research and Education

Information systems and medical databases are used extensively to support biomedical education and research. Computerized patient records serve as the basis for epidemiological studies of a variety of diseases and their potential linkages to social and environmental factors. In addition, computers are used to support medical, dental, nursing, and allied health education, using such techniques as computer-aided instruction and patient-management simulation.

Computers are an integral component of most medical research projects. Effective project design requires close collaboration among clinicians, biostatisticians, and information systems specialists. Some research projects would not be possible without the high-speed computational capabilities and data-storage capacity of large computer systems. An excellent example is the Human Genome Project, which mapped all the genes of the *Homo sapiens* species. One element of the map detailed all sequences of DNA chemical bases—an astounding three billion pairs. Analytical work of this magnitude is inconceivable without supercomputing capabilities.

Hospitals, medical libraries, and individual clinicians use personal computers to access references to the medical literature and full-text online documents. The most widely used bibliographic databases are available through the National Library of Medicine (www.nlm.nih.gov). Articles from thousands of biomedical journals are indexed, stored in computer files, and available for searching and retrieval using standard medical subject headings and keyword searches. The Internet is used extensively to retrieve clinical information from a wide variety of specialty databases and sponsored websites.

Computers are an important tool for the education of clinicians. Computer-based education for physicians and other health professionals engages the students actively in the learning process and builds foundational skills in preparation for clinical training. Learning activities range from presentation of information to students via the Internet or course management systems to sophisticated simulations of clinical problems. Students are presented initial cues and additional information on request as they proceed through a diagnostic process. Final diagnosis, patient management, and follow-up plans selected by the students are entered, and the system responds with a comparison to the "ideal" solution and critiques the process followed.

Increasingly, computerized mannequins are used to teach clinical skills in a laboratory environment before health professions students are assigned to healthcare organizations for clinical practice. These mannequins also can be used in continuing medical education as a tool for testing new technologies or exploring procedure innovations.

Summary

Most healthcare organizations began using electronic data processing by developing or purchasing financial information systems. Financial applications remain essential, but from a broader perspective, healthcare organizations use computers and information systems to support not only financial activities but also all administrative operations, including human resources management, resource utilization and scheduling, materials management, facilities and project management, and office automation.

As healthcare is delivered more frequently in outpatient and nonhospital settings, development of information systems specific to these delivery sites has accelerated. Typical functions for ambulatory settings include patient scheduling and appointments, electronic medical records and medical management, patient and third-party billing, managed care contract management, and electronic communication with other providers in a network of care. LTC systems support census management, residential care documentation, pharmacy, and other areas of operation in skilled nursing facilities. Home health providers use laptop computers or other remote-access devices to document care at the location where it is provided and to access clinical data from previous encounters.

Applications developed to assist physicians and other providers in the delivery of high-quality care include CDS systems and evidence-based medicine programs. These tools aid in diagnosis and treatment planning and comparing treatment plans with established "best practices" using large databases.

Computers have become an integral component of medical equipment for instrument control, image enhancement, and medical data processing. These foundation applications evolved into sophisticated integration of computer and communications technology in telemedicine applications that support patient care at remote locations.

Information systems are used extensively to support biomedical education and research. Automated databases of patient records support epidemiological studies of disease linkage to social and environmental factors. Computer-assisted instruction and patient-management simulation programs support the education of physicians and other health professionals.

Simply stated, no aspect of healthcare delivery or health services management is untouched by computers and information systems. The computer, in its various forms, has become a ubiquitous tool used by clinicians and managers alike. Technological evolution has brought forth powerful machines whose functional capabilities are optimized through the judicious selection of application software to meet business and care delivery needs.

Web Resources

A number of organizations (through their websites) provide more information on the topics discussed in this chapter:

- *Healthcare Informatics* (www.healthcare-informatics.com) is a magazine that provides information about vendors of information technology products and information systems management services.
- Health Level Seven (HL7) (www.hl7.org) is a leading healthcare standard-developing organization. HL7 is working as a coordinating agent for various active standard-setting groups.
- KLAS Enterprises (www.healthcomputing.com/VendorDirectory) offers information about vendors of software, services, and medical equipment.

Discussion Questions

1. Why are administrative systems more evolved than clinical systems?
2. Why do features of handheld devices make them inappropriate for some medical computing applications?
3. What are the key components of groupware as a resource to the management team?
4. What aspects of clinical applications support quality-management and cost-control programs?
5. Describe various functionalities of a pharmacy information system that can aid in reducing medication errors.
6. Distinguish between the logic used in an expert CDS system and systems that employ probabilistic algorithms.
7. What are some ways that HIT contributes to patient satisfaction?
8. Why has HIT development in some segments of the healthcare industry, such as long-term care, lagged other segments?

9. What challenges do legacy systems pose for enterprise system integration?
10. How are transaction-processing systems employed in financial information systems?
11. What are the key functions of a human resources information system?
12. How can centralized scheduling systems contribute to the financial bottom line?
13. List some of the key drivers and some of the challenges of employing telemedicine applications in a healthcare organization.
14. What are the typical elements of a physician practice management system?
15. Describe the basic documentation requirements for an LTC information system. How do these requirements differ from those for the information system used in an inpatient facility?