Hardware Components in Action

Executing any machine-level instruction involves two phases: instruction and execution. During the instruction phase, a computer performs the following steps:

- **Step 1: Fetch instruction.** The computer reads the next program instruction to be executed and any necessary data into the processor.

- **Step 2: Decode instruction.** The instruction is decoded and passed to the appropriate Processor execution unit. Each execution unit plays a different role: The arithmetic/logic Unit performs all arithmetic operations, the floating-point unit deals with non-integer operations, the load/store unit manages the instructions that read or write to memory, and the branch processing unit predicts the outcome of a branch instruction in an attempt to reduce disruptions in the flow of instructions and data into the processor, the memory management unit translates an application's addresses into physical memory addresses, and the vector-processing unit handles vector-based instructions that accelerate graphics operations.
  The time it takes to perform the instruction phase (Steps 1 and 2) is called the **instruction time (I-time)**.
  The second phase is execution. During the execution phase, a computer performs the following steps:

- **Step 3: Execute instruction.** The hardware element, now freshly fed with an instruction and data, carries out the instruction. This could involve making arithmetic Computation, logical comparison, bit shift, or vector operation.

- **Step 4: Store results.** The results are stored in registers or memory. The time it takes to complete the execution phase (Steps 3 and 4) is called the **execution time (E-time)**.

After both phases have been completed for one instruction, they are performed again for the second instruction and so on. Completing the instruction phase followed by the execution phase is called a **machine cycle** (see Figure 3.2). Some processing units can speed processing by using **pipelining**, whereby the processing unit gets one instruction, decodes another, and executes a third at the same time. The Pentium 4 processor, for example, uses two execution unit pipelines. This means the processing unit can execute two instructions in a single machine cycle.

Enterprise Storage Options

Businesses increasingly need to store large amounts of data created throughout the organization. Such large secondary storage is called *enterprise storage* and comes in three forms: attached storage, network-attached storage (NAS), and storage area networks (SANs).

Attached Storage

Attached storage methods include the tape, hard disks, and optical devices discussed previously, which are connected directly to a single computer. Attached storage methods, though simple and cost-effective for single users and small groups, do not allow systems to share storage, and they make it difficult to back up data. Because of the limitations of attached storage, firms are turning to network-attached storage (NAS) and storage area networks (SANs). These alternative forms of enterprise data storage enable an organization to share data-storage resources among a much larger number of computers and users, resulting in improved storage efficiency and greater cost- effectiveness. In addition, they simplify data backup and reduce the risk of downtime. Nearly one-third of system downtime is a direct result of data-storage failures, so eliminating storage problems as a cause of downtime is a major advantage.

Network-Attached Storage

Network-attached storage (NAS) employs storage devices that attach to a network instead of to a single computer. NAS includes software to manage storage access and file management and relieve the users' computers of those tasks. The result is that both application software and files can be served faster because they are not competing for the same processor resources.

Computer users can share and access the same information, even if they are using different types of computers. Common applications for NAS include consolidated storage, Internet and e-commerce applications, and digital media. The University of North Carolina (UNC) Hospital employs 2,000 physicians, over 5,000 staff members, and operates on a $600 million budget. It uses a state-of-the-art Picture

Archiving and Communications System (PACS) to manage x-rays, CAT scans, and MRIs in a digital form instead of more traditional x-ray film. The system improves patient care and facilitates teaching by streamlining access to critical information. However, the sheer volume of data was causing UNC to struggle with its inefficient local storage devices. Data from over 200,000 radiology procedures each year requiring 4–5 TB of data storage was overwhelming the existing system. UNC recently converted to a centralized NAS data solution that now allows it to consolidate data onto fewer servers and storage devices and reduce the effort required to manage data. More importantly, the NAS solution enables rapid retrieval of patient information, saving doctor's time, which can mean the difference between life and death in the operating room.

Storage Area Network

A **storage area network (SAN)** is a special-purpose, high-speed network that provides direct connections between data-storage devices and computers across the enterprise. A SAN also integrates different types of storage subsystems, such as multiple RAID

storage devices and magnetic tape backup systems, into a single storage system. Use of a SAN loads the network traffic associated with storage onto a separate network. The data can then be copied to a remote location, making it easier for companies to create backups and implement disaster recovery policies.
Using a SAN, an organization can centralize the people, policies, procedures, and practices for managing storage, and a data-storage manager can apply the data consistently across an enterprise. This centralization eliminates inconsistent treatment of data by different system administrators and users, providing efficient and cost-effective data-storage practices.

Software

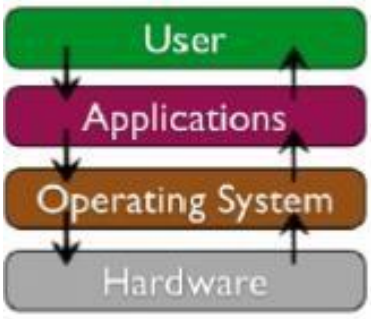
Why Learn About Software?

Software is indispensable for any computer system and the people using it. In this section, you will learn about systems and application software. Without systems software, computers would not be able to input data from a keyboard, make calculations, or print results. Application software is the key to helping you achieve your career goals. Sales representatives use software to enter sales orders and help their customers get what they want. Stock and bond traders use software to make split second decisions involving millions of dollars. Scientists use software to analyze the threat of global warming. Regardless of your job, you most likely will use software to help you advance in your career and earn higher wages. Today, most organizations could not function without accounting software to print payroll checks, enter sales orders, and send out bills. You can also use software to help you prepare your personal income taxes, keep a budget, and play entertaining games. Software can truly advance your career and enrich your life. We begin with an overview of software.

The second component of an information system is software. Simply put: Software is the set of instructions that tell the hardware what to do. Software is created through the process of programming. Without software, the hardware would not be functional.

Types of Software

Software can be broadly divided into two categories: system and application software. *Operating systems* manage the hardware and create the interface between the hardware and the user. *Application software* is the category of programs that do something useful for the user.



System Software
Systems software is the set of programs that coordinates the activities and functions of the hardware and other programs throughout the computer system. Each type of systems software is designed for a specific CPU and class of hardware. The combination of a hardware configuration and systems software is known as a computer system platform.

Application Software
The second major category of software is application software. Application software consists of programs that help users solve particular computing problems. In most cases, application software resides on the computer's hard disk before it is brought into the computer's memory and run. Application software can also be stored on CDs, DVDs, and even flash or keychain storage devices that plug into a USB port. Before a person, group, or enterprise decides on the best approach for acquiring application software, they should analyze their goals and needs carefully. For example, if you have to write a paper, you might use the application-software program Microsoft Word. If you want to listen to music, you might use iTunes. To surf the web, you might use Internet Explorer or Firefox. Even a computer game could be considered application software.

Productivity Software
Along with the spreadsheet, several other software applications have become standard tools for the workplace. These applications, called productivity software, allow office employees to complete their daily work. Many times, these applications come packaged together, such as in Microsoft's Office suite.

Applications for the Enterprise
As the personal computer proliferated inside organizations, control over the information generated by the organization began splintering. Say the customer service department creates a customer database to keep track of calls and problem reports, and the sales department also creates a database to keep track of customer information. Which one should be used as the master list of customers? As another example, someone in sales might create a spreadsheet to calculate sales revenue, while someone in finance creates a different one that meets the needs of their department. However, it is likely that the two spreadsheets will come up with different totals for revenue. Which one is correct? And who is managing all of this information?

Enterprise Resource Planning
In the 1990s, the need to bring the organization's information back under centralized control became more apparent. The enterprise resource planning (ERP) system (sometimes just called enterprise software) was developed to bring together an entire organization in one software application. Simply put, an ERP system is a software application utilizing a central database that is implemented throughout the entire organization.

Customer Relationship Management
A customer relationship management (CRM) system is a software application designed to manage an organization's customers. In today's environment, it is important to develop relationships with your customers, and the use of a well-designed CRM can allow a business to personalize its relationship with each of its customers. Some ERP software systems include CRM modules. An example of a well-known CRM package is Sales force.

Supply Chain Management

Many organizations must deal with the complex task of managing their supply chains. At its simplest, a supply chain is the linkage between an organization's suppliers, its manufacturing facilities, and the distributors of its products. Each link in the chain has a multiplying effect on the complexity of the process: if there are two suppliers, one manufacturing facility, and two distributors, for example, then there are 2 x 1 x 2 = 4 links to handle. However, if you add two more suppliers, another manufacturing facility, and two more distributors, then you have 4 x 2 x 4 = 32 links to manage.

A supply chain management (SCM) system manages the interconnection between these links, as well as the inventory of the products in their various stages of development. A full definition of a supply chain management system is provided by the Association for Operations Management: "The design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally."

Mobile Applications

Just as with the personal computer, mobile devices such as tablet computers and smartphones also have operating systems and application software. In fact, these mobile devices are in many ways just smaller versions of personal computers. A mobile app is a software application programmed to run specifically on a mobile device.

As organizations consider making their digital presence compatible with mobile devices, they will have to decide whether to build a mobile app. A mobile app is an expensive proposition, and it will only run on one type of mobile device at a time. For example, if an organization creates an iPhone app, those with Android phones cannot run the application. Each app takes several thousand dollars to create, so this is not a trivial decision for many companies.

One option many companies have is to create a website that is mobile-friendly. A mobile website works on all mobile devices and costs about the same as creating an app.

Cloud Computing

Historically, for software to run on a computer, an individual copy of the software had to be installed on the computer, either from a disk or, more recently, after being downloaded from the Internet. The concept of "cloud" computing changes this, however. To understand cloud computing, we first have to understand what the cloud is. "The cloud" refers to applications, services, and data storage on the Internet. These service providers rely on giant server farms and massive storage devices that are connected via Internet protocols. Cloud computing is the use of these services by individuals and organizations.

You probably already use cloud computing in some forms. For example, if you access your e-mail via your web browser, you are using a form of cloud computing. If you use Google Drive's applications, you are using cloud computing. While these are free versions of cloud computing, there is big business in providing applications and data storage over the web. Sales force (see above) is a good example of cloud computing – their entire suite of CRM applications are offered via the cloud. Cloud computing is not limited to web applications: it can also be used for services such as phone or video streaming.

Advantages of Cloud Computing

- No software to install or upgrades to maintain.
- Available from any computer that has access to the Internet.
- Can scale to a large number of users easily.
- New applications can be up and running very quickly.
- Services can be leased for a limited time on an as-needed basis.
- Your information is not lost if your hard disk crashes or your laptop is stolen.
- You are not limited by the available memory or disk space on your computer.

Disadvantages of Cloud Computing

- Your information is stored on someone else's computer – how safe is it?
- You must have Internet access to use it. If you do not have access, you're out of luck.
- You are relying on a third-party to provide these services.

Using a Private Cloud

Many organizations are understandably nervous about giving up control of their data and some of their applications by using cloud computing. But they also see the value in reducing the need for installing software and adding disk storage to local computers. A solution to this problem lies in the concept of a *private cloud*. While there are various models of a private cloud, the basic idea is for the cloud service provider to section off web server space for a specific organization. The organization has full control over that server space while still gaining some of the benefits of cloud computing.

Virtualization

One technology that is utilized extensively as part of cloud computing is virtualization." Virtualization is the process of using software to simulate a computer or some other device. For example, using virtualization, a single computer can perform the functions of several computers. Companies such as EMC provide virtualization software that allows cloud service providers to provision web servers to their clients quickly and efficiently. Organizations are also implementing virtualization in order to reduce the number of servers needed to provide the necessary services.

Software Creation

How is software created? If software is the set of instructions that tells the hardware what to do, how are these instructions written? If a computer reads everything as ones and zeroes, do we have to learn how to write software that way?

Modern software applications are written using a programming language. A programming language consists of a set of commands and syntax that can be organized logically to execute specific functions. This language generally consists of a set of readable words combined with symbols. Using this language, a programmer writes a program (called the source code) that can then be compiled into machine-readable form, the ones and zeroes necessary to be executed by the CPU. Examples of well-known programming languages today include Java, PHP, and various flavors of C (Visual C, C++, C#). Languages such as HTML and JavaScript are used to develop web pages. Most of the time, programming is done inside a programming environment; when you purchase a copy of Visual Studio from Microsoft, it provides you with an editor, compiler, and help for many of Microsoft's programming languages.

Software programming was originally an individual process, with each programmer working on an entire program, or several programmers each working on a portion of a larger program. However, newer methods of software development include a more collaborative approach, with teams of programmers working on code together.

Databases

Why Learn About Database Systems and Business Intelligence?

A huge amount of data is entered into computer systems every day. Where does all this data go and how is it used? How can it help you on the job? If you become a **marketing manager**, you can access a vast store of data on existing and potential customers from surveys, their Web habits, and their past purchases. This information can help you sell products and services. If you become a **corporate lawyer**, you will have access to past cases and legal opinions from sophisticated legal databases. This information can help you win cases and protect your organization legally. If you become a **human resource manager**, you will be able to use databases and business intelligence tools to analyze the impact of raises, employee insurance benefits, and retirement contributions on long- term costs to your company. Regardless of your field of study in school, using database systems and business intelligence tools will likely be a critical part of your job.

The goal of many information systems is to transform data into information in order to generate knowledge that can be used for decision making. In order to do this, the system must be able to take data, put the data into context, and provide tools for aggregation and analysis. A database is designed for just such a purpose. A **database** is an organized collection of related information. It is an *organized* collection, because in a database, all data is described and associated with other data. All information in a database should be *related* as well; separate databases should be created to manage unrelated information. For example, a database that contains information about students should not also hold information about company stock prices. Databases are not always digital – a filing cabinet, for instance, might be considered a form of database. For the purposes of this text, we will only consider digital databases.

Because data is so critical to an organization's success, many firms develop databases to help them access data more efficiently and use it more effectively. This typically requires a well-designed database management system and a knowledgeable database administrator.
A **database management system (DBMS)** consists of a group of programs that manipulate the database and provide an interface between the database and its users and other application programs. Usually purchased from a database company, a DBMS provides a single point of management and control over data resources, which can be critical to maintaining the integrity and security of the data. A database, a DBMS, and the application programs that use the data make up a database environment. A **database administrator (DBA)** is a skilled and trained IS professional who directs all activities related to an organization's database, including providing security from intruders.