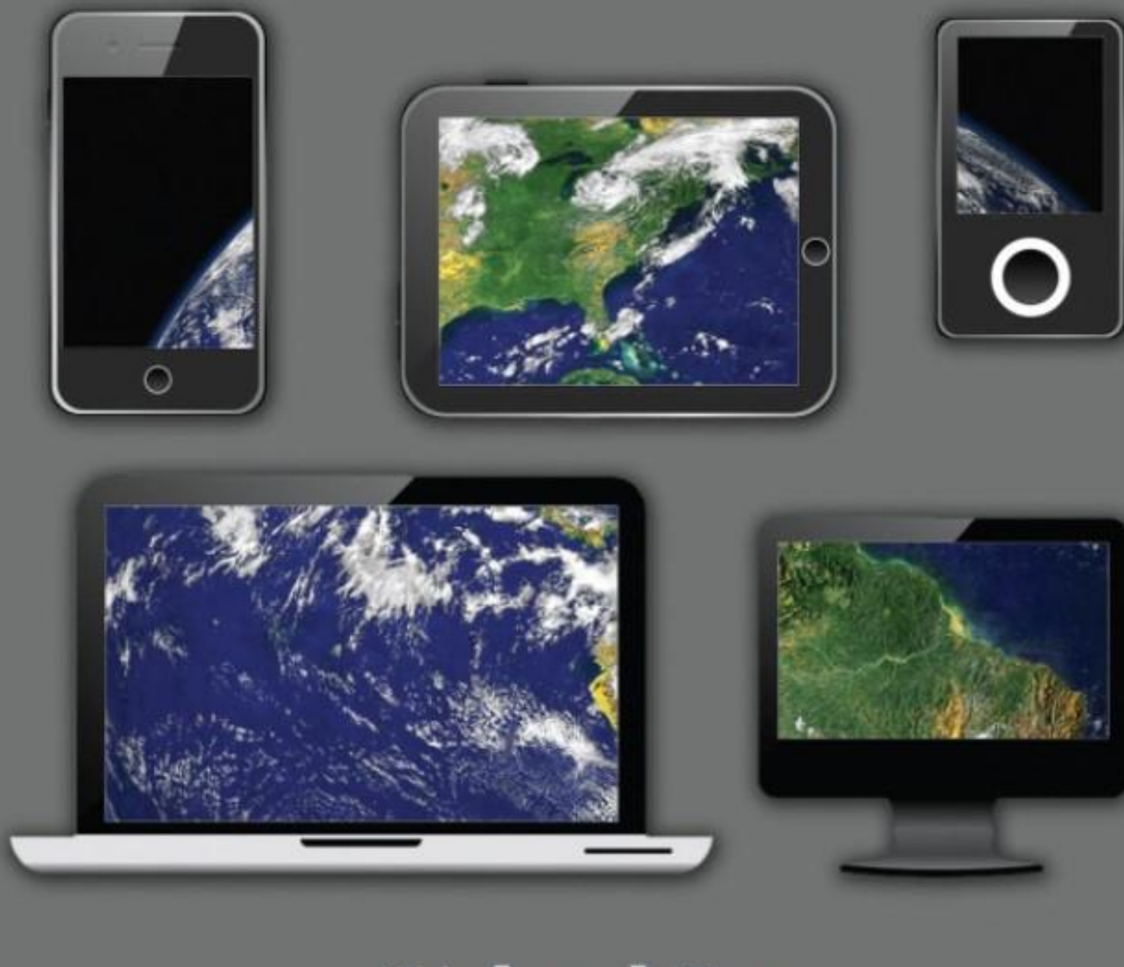
Information Technology

An Introduction for Today's Digital World



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CHAPTER 1

Introduction to Information Technology

This textbook is an introduction to information technology (IT) intended for students in IT-related fields. This chapter introduces the different career roles of an IT person, with emphasis on system administration, and the types of skills required of an IT professional. In this chapter, the elements that make up the IT infrastructure—the computer, software, users—are introduced.

The learning objectives of this chapter are to

- Describe and differentiate between types of IT careers.
- Describe the set of skills required to succeed in IT.
- Introduce the types of hardware found in a computer system.
- Describe and differentiate between the components of a computer system: hardware, software, and users.

WHAT IS INFORMATION TECHNOLOGY?

So, what is information technology (IT) anyway? IT is a term used to describe several things, the task of gathering data and processing it into information, the ability to disseminate information using technology, the technology itself that permits these tasks, and the collection of people who are in charge of maintaining the IT infrastructure (the computers, the networks, the operating system). Generically, we will consider IT to be the technology used in creating, maintaining, and making information accessible. In other words, IT combines people with computing resources, software, data, and computer networks.

IT personnel, sometimes referred to collectively as "IT," are those people whose job it is to supply and support IT. These include computer engineers who design and build computer chips, computer scientists who write software for computers, and administrators who provide the IT infrastructure for organizations.

What will your role be in IT? There are many varied duties of IT personnel. In some cases, a single individual might be the entire IT staff for an organization, but in many cases, there will be several, perhaps dozens or hundreds of personnel involved, each with separate roles to play. Most IT personnel, however, have two general roles: administration and support. An administrator is someone who is in charge of some portion of the IT infrastructure. There are a variety of administrator roles, as shown in Table 1.1.

Let us examine some of the administrator roles in Table 1.1 in more detail. The most common role in IT is the system administrator. System administration is the process of maintaining the operating system of a computer system. On a stand-alone computer, system administration is minimal and usually left up to the individual(s) using the computer. However, for a network of computers or computers that share files or other resources, system administration becomes more significant and more challenging. The system administrator is the person (or people) who perform system administration.

Maintenance of a computer system (computers, resources, network) will include an understanding of software, hardware, and programming. From a software point of view, administration requires installing software, making it available, troubleshooting problems that arise during usage, and making sure that the software is running efficiently. Additionally, the administrator(s) must understand the operating system well enough to configure the software appropriately for the given organization, create accounts, and safeguard the system from outside attack.

From a hardware point of view, administration requires installing new hardware and troubleshooting existing hardware. This may or may not include low-level tasks such as repairing components and laying network cable. It may also require installing device driver software whenever new hardware is added.

From a programming point of view, operating systems require "fine-tuning," and thus administrators will often have to write their own shell scripts to accomplish both simple

TABLE 1.1 Administrator Roles in IT

Role	Job/Tasks
System Administrator	Administer the computers in an organization; install software; modify/update operating system; create accounts; train users; secure system; troubleshoot system; add hardware
Network Administrator	Purchase, configure, and connect computer network; maintain computer network; troubleshoot network; secure network from intrusion
Database Administrator	Install, configure, and maintain database and database management system; back up database; create accounts; train users
Web Administrator	Install, configure, and maintain website through web server; secure website; work with developers
Web Developer	Design and create web pages and scripts for web pages; maintain websites
Security Administrator	Install, configure, and administer firewall; create security policies; troubleshoot computer system (including network); work proactively against intrusions

and complex tasks. In Linux, for instance, many components of the operating system rely on configuration files. These are often shell scripts. An administrator may have to identify a configuration file and edit it to tailor how that component works within the organization. The goal of writing shell scripts is to automate processes so that, once written, the administrator can call upon the scripts to perform tasks that otherwise would be tedious. A simple example might be to write a script that would take a text file of user names and create a new account for each user name.

System administration may be limited to the administration of the computers, printers, and file servers. However, system administration may extend to network administration and possibly even web server, ftp server, mail server, and database server administration depending on the needs and size of the company and abilities of the system administrator(s). Finally, a system administrator may also be required to train users on the system. Therefore, the skills needed for system administration can vary greatly. Specific common tasks of a system administrator include:

- Account management: creating new user accounts and deleting obsolete user accounts.
- Password management: making sure that all users have passwords that agree with the security policy (e.g., passwords must be changed every month, passwords must include at least one non-alphabetic character)—you might be surprised, but in systems without adequate password management, many users use "" as their password (i.e., their password is just hitting the enter key). Most organizations today require the use of *strong passwords*: passwords that contain at least eight characters of which at least one is non-alphabetic and/or a combination of upper- and lower-case letters, and are changed at least once a month without reusing passwords for several months at a time.
- File protection management: making sure that files are appropriately protected (for instance, making sure that important documents are not writable by the outside world) and performing timely backups of the file system.
- Installing and configuring new hardware and troubleshooting hardware including the network.
- Installing and configuring new software including updating new operating system (OS) patches, and troubleshooting software.
- Providing documentation, support, and training for computer users.
- Performing system-level programming as necessary (usually through scripting languages rather than writing large-scale applications or systems software).
- Security: installing and maintaining a firewall, examining log files to see if there are any odd patterns of attempted logins, and examining suspicious processes that perhaps should not be running.

WHO STUDIES IT?

IT personnel in the past were often drafted into the position. Consider the following scenario. Joe received his bachelor's degree in Computer Science from the University of Illinois. He was immediately hired by a software firm in Chicago where he went to work as a COBOL programmer. However, within 3 months, he was asked by the boss, being the new guy, "surely you know something about this Linux operating system stuff, don't you?" Joe, of course, learned Unix as part of his undergraduate degree and answered "Sure." So the boss told Joe "From now on, I want you to spend 10 hours of your week putting together this new network of computers using Linux. Make sure it can connect to our file servers and make it secure." Joe spent 10 hours a week reading manuals, installing the Linux operating system, playing around with the operating system, and eventually getting the system up and running.

After some initial growing pains in using the system, more and more employees switched to the Linux platform. Now, 9 months later, half of the company has moved to Linux, but the system does not necessarily run smoothly. Whenever a problem arises, Joe is usually the person who has to respond and fix it. The boss returns to Joe and says "Fine work you did on the network. I want to move you full time to support the system." Joe did not go to school for this, but because he had some of the skills, and because he is an intelligent, hardworking individual (he would have to be to graduate from University of Illinois's Computer Science program!), he has been successful at this endeavor. Rather than hiring someone to maintain the system, the easier solution is to move Joe to the position permanently. Poor Joe, he wanted to write code (although perhaps not COBOL). But now, the only code he writes are Linux shell scripts!

Sound unlikely? Actually, it was a very common tale in the 1980s and 1990s and even into the 2000s. It was only in the mid 2000s that an IT curriculum was developed to match the roles of IT personnel. Otherwise, such jobs were often filled by computer scientists or by people who just happened to be computer hobbyists. The few "qualified" personnel were those who had associates degrees from 2-year technical colleges, but those colleges are geared more toward covering concepts such as PC repair and troubleshooting rather than system and network administration. Today, we expect to see IT people who have not only been trained on the current technology, but understand all aspects of IT infrastructure including theoretical issues, the mathematics of computers (binary), the roles of the various components that make up a computer system, programming techniques, the operations of databases, networks, the Internet, and perhaps specialized knowledge such as computer forensics.

Common IT curricula include introductions to operating system platforms, programming languages, and computing concepts. We would expect a student to have experience in both Windows and Linux (or Unix). Programming languages might include both scripting languages such as Linux/Unix shell scripting, Ruby or Python, and JavaScript, and compiled languages such as C, C++, Java, or Visual Basic. Concepts will include operating systems and networks but may go beyond these to include web infrastructure, computer architectures, software applications (e.g., business software), digital media and storage, and e-commerce.

TYPES OF IT PROGRAMS

Although the 4-year IT degree is relatively new, it is also not standardized. Different universities that offer such an IT program come at the degree from different perspectives. Here, we look at the more common approaches.

First are the programs that are offshoots of computer science degrees. It seems natural to couple the degrees together because there is a good deal of overlap in what the two disciplines must cover: hardware technology, programming, database design, computer ethics, networking. However, the computer science degree has always heavily revolved around programming, and the IT degree may require less of it. Additionally, math plays a significant role in computer science, but it is unclear whether that amount of math is required for IT.

Next, there are the management information systems variations. The idea is that IT should be taught from a usage perspective—more on the applications, the data storage, the database, and less on the technology underlying the business applications. E-commerce, database design, data mining, computer ethics, and law are promoted here. Furthermore, the course work may include concepts related to managing IT.

Then there is the engineering technology approach that concentrates on hardware—circuit boards, disk drives, PC construction and troubleshooting, physical aspects of networking. There is less emphasis on programming, although there is still a programming component.

Another school of thought is to provide the foundations of computer systems themselves. This textbook follows this idea by presenting first the hardware of the computer system and then the operating systems. We also look at computer networks, programming, and computer storage to have a well-rounded understanding of the technology side to IT. The IT graduate should be able to not only work on IT, say as an administrator, but also design IT systems architecturally from the hardware to the network to the software.

SIGITE, the ACM Special Interest Group on IT Education, provides useful guidelines to build a model IT curriculum.

Who should study IT? To be an IT person, you do not necessarily have to have the rigorous mathematical or engineering background of computer scientists and computer engineers; there are many overlapping talents. Perhaps the most important talent is to have *troubleshooting* skills. Much of being an IT person is figuring out what is going wrong in your system. These diagnostic skills cannot be purely taught. You must have experience, background knowledge, and instinct. Above all, you have to know how the system works whether the system is a Linux operating system, a computer network, a web server, or other. Another talent is the ability to write program code—in all likelihood, you would write small programs, or scripts, as opposed to the software engineer who will be involved in large-scale projects.

You should also be able to communicate with others so that you can understand the problems reported by your colleagues or clients, and in turn describe solutions to them. This interaction might take place over the phone rather than in person. You should also be able to write technically. You may often be asked to produce documentation and reports. Finally, you will need the ability to learn on your own as technology is ever-changing. What you have learned in school or through training may be obsolete within a year or two. Yet, what you learn should form a foundation from which you can continue to learn. See Table 1.3, which highlights the skills expected or desired from IT personnel.

almost something that they already do as a hobby. And yet the student, when hired, might be responsible for maintaining the IT infrastructure in an organization of dozens or hundreds of employees. The equipment may cost hundreds of thousands of dollars, but the business itself might make millions of dollars. Therefore, the IT specialist must take their job seriously—downtime, system errors, intrusions, and so forth could cost the organization greatly. The IT specialist has duties that go beyond just being a system administrator. Some of these expectations are elaborated upon below.

To start, the system administrator must be aware of developments in the field. At a minimum, the system administrator has to know the security problems that arise and how to protect against them. These might include securing the system from virus, network intrusions, denial of service attacks, and SQL injection attacks. In addition, the system administrator should keep up on new releases of the operating system and/or server software that he/she maintains. However, a system administrator may have to go well beyond by reading up on new hardware, new software, and other such developments in the field.

In order for the system administrator to keep up with the new technology, new trends, and new security fixes, continuing education is essential. The system administrator should be a life-long learner and a self-starter. The system administrator might look toward Internet forums but should also regularly read technology news and be willing to follow up on articles through their own research. The system administrator should also be willing to dive into new software and experiment with it to determine its potential use within the organization.

A system administrator will often be "on call" during off hours. When disaster strikes, the system administrator must be accessible. An emergency call at 3 A.M. or while you are on vacation is quite possible. Although every employee deserves their own down time, a system administrator's contract may include clauses about being reachable 24/7. Without such assurance, an organization may find themselves with inaccessible data files or the inability to perform transactions for several hours, which could result in millions of dollars of damage. Some companies' reputations have been harmed by denial of service attacks and the inability to recover quickly.

The system administrator must also behave ethically. However, it is often a surprise to students that ethics is even an issue. Yet, what would you do if you are faced with some moral dilemma? For instance, your employer is worried that too many employees are using company e-mail for personal things, and so the boss asks you to search through everyone's e-mail. How would you feel? Now, imagine there is a policy in the company that states that employees can use company e-mail for personal purposes as long as e-mail does not divulge any company secrets. In this case, if you are asked to search through employee e-mail, would this change how you feel about it?

Unethical behavior might include:

- Spying on others (e-mail, web browsing habits, examining files)
- Setting up backdoor accounts to illegally access computer systems
- Illegally downloading software or files, or encouraging/permitting others to do so
- Performing theft or sabotage because of your system administration access

IT INFRASTRUCTURE

IT revolves around the computer. Have you used a computer today? Even if you have not touched your desktop (or laptop) computer to check your e-mail, chances are that you have used a computer. Your cell phone is a computer as is your Kindle. These are far less powerful than desktop units, but they are computers nonetheless. There are computer components in your car and on the city streets that you drive. The building you work or study in might use computers to control the lighting and air conditioning. Yes, computers are all around us even if we do not recognize them.

We will define a computer to be a piece of electronic equipment that is capable of running programs, interacting with a user (via input–output devices), and storing data. These tasks are often referred to as the IPOS (input, processing, output, storage) cycle. A general-purpose computer is one that can run any program. Many devices today are computers but may not be as general purpose as others. For instance, your iPod is capable of playing music; it has a user interface, and may have a small number of applications loaded into it to handle a calendar, show you the time of day, and offer a few games. Your cell phone has an even greater number of applications, but it is not capable of running most software. The degree to which a computer is general purpose is largely based on its storage capacity and whether programs have been specifically compiled for the processor.

Computers range in size and capability—from supercomputers that can fill a room, to desktop units that are not very heavy but are not intended to be portable, to laptop units that are as light as perhaps a heavy textbook, to handheld devices such as cell phones and mp3 players. The general difference between a handheld unit and a desktop or laptop unit is the types of peripheral devices available (full-sized keyboard and mouse versus touch screen, 20-in. monitor versus 2-in. screen), the amount of memory and hard disk storage space, and whether external storage is available such as flash drives via USB ports or optical disks via an optical disk drive.

Computers

We will study what makes up a computer in more detail in the next chapter. For now, we will look at the computer in more general terms. A computer is an electronic, programmable device. To run a program, the device needs a processor [Central Processing Unit (CPU)], memory to store the program and data, input and output capabilities, and possibly long-term storage and network capabilities (these last two are optional). Based on this definition, computers not only encompass desktop and laptop units, servers, mainframe computers, and supercomputers, but also netbooks, cell phones, computer game consoles, mp3 players, and book readers (e.g., Kindles). In the latter two cases, the devices are special-purpose—they run only a few select programs. The notion of the historical computer is gone. Today, we live with computers everywhere.

Figure 1.1 illustrates some of the range in computers. Desktop units with large monitors and system units are common as are laptop computers today with large monitors. Even more popular are handheld devices including personal digital assistants (PDAs), cell phones, and e-book readers. Monitors are flat screens. We no longer expect to find

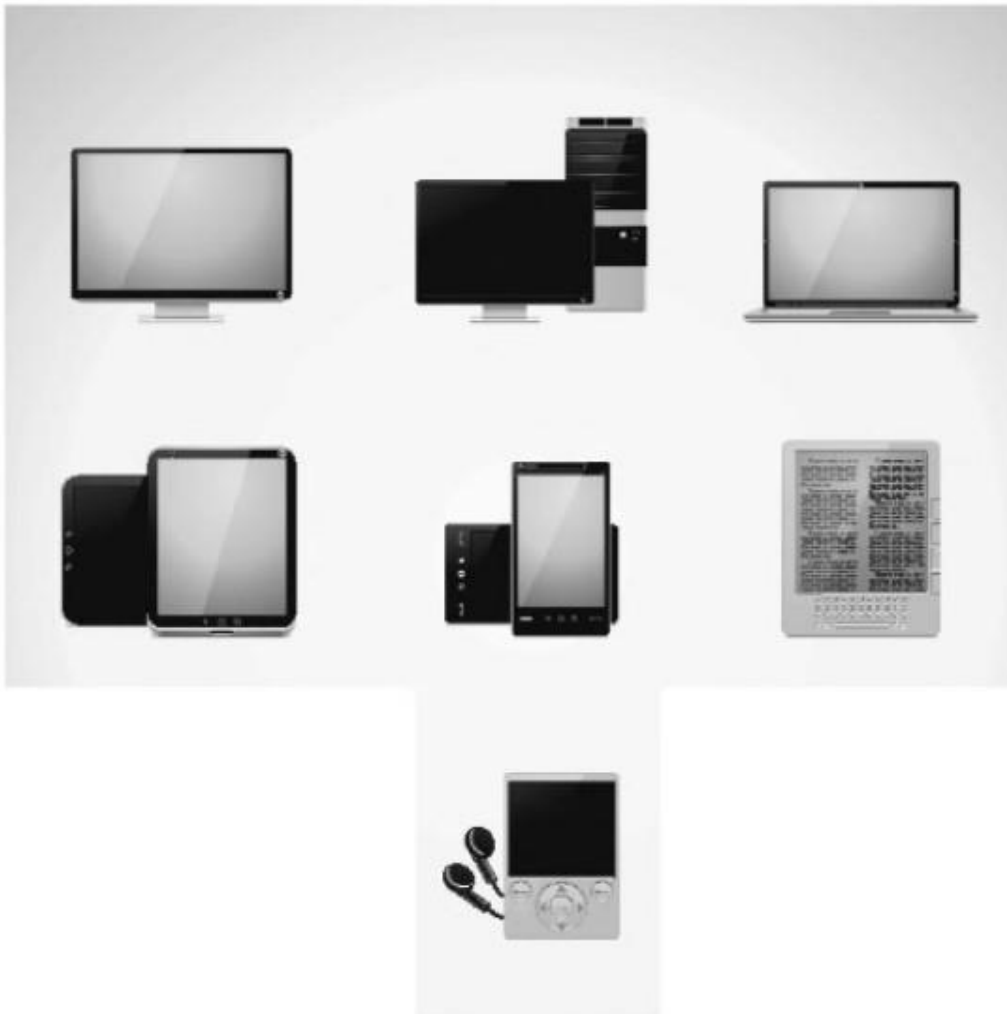

FIGURE 1.1 Types of computers. (Adapted from Shutterstock/tele52.)

bulky monitors on our desktop computers. Even so, the system unit, which allows us to have numerous disk drive devices and other components, is bulky. We sacrifice some of the peripheral devices when we use laptop computers. We sacrifice a greater amount of accessibility when we move on to handheld devices. In the case of the PDA, laptop, and notebook, the chips and motherboard, and whatever other forms of storage, must be placed inside a very small area. For the PDA, there is probably just a wireless card to permit access to the cell phone network (and possibly wi-fi). For the laptop and notebook computers, there is probably a hard disk drive. The laptop will also probably have an optical disk drive.

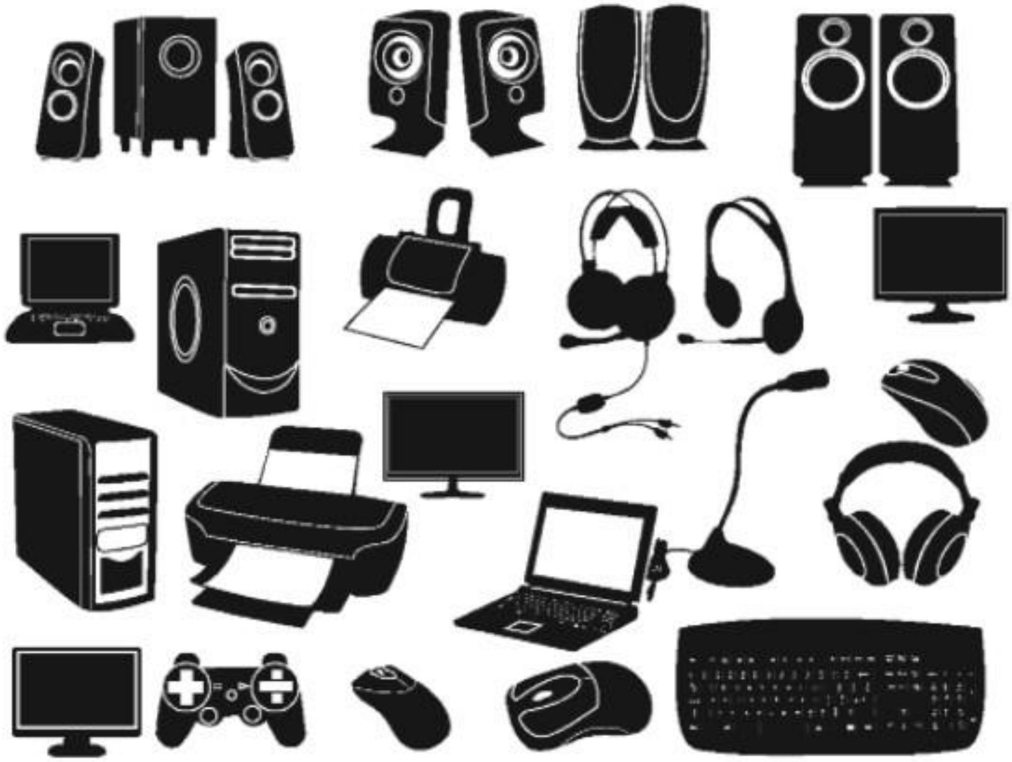

FIGURE 1.2 Computer peripherals. (Courtesy of Shutterstock/Nevena.)

the network card offers a much higher bandwidth (transmission rate) than a MODEM. We will study wired and wireless MODEMs and network cards later in the textbook when we look at computer networks.

Let us now summarize our computer. A computer is in essence a collection of different devices, each of which performs a different type of task. The typical computer will comprise the following:

1. System unit, which houses
   a. The motherboard, which contains
      i. The CPU
      ii. A cooling unit for the CPU
      iii. Possibly extra processors (for instance, for graphics)
      iv. Memory chips for RAM, ROM
      v. Connectors for peripherals (sometimes known as ports)