

Information Technology Foundations

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What You Will Learn in This Chapter

- What types of computers are needed for business applications?
- What are the basic objects that computers process?
- How do computers handle music and video?
- What are the main components of a computer?
- Why is the operating system so important?
- How does the Internet change the role of computers?
- What are the main software applications used in business?
- Is it possible to handle all computing tasks with online services?

Dell

Should you buy new computers? How is information technology changing and how do you evaluate and choose technologies for business? These are difficult questions to answer for any business. Buying one new computer is not the problem—replacing hundreds or thousands of computers is expensive. One of the keys to changing technology is that buying a computer is not a one-time event. Organizations need to plan on buying new machines on a regular basis. Of course, you also have to think about how to dispose of the old computers.

The computer industry is driven by change and growth. An interesting feature of computers is that they have a short shelf life. A computer that sits unsold for a few weeks quickly becomes obsolete as more powerful or cheaper machines are introduced. From a manufacturer's perspective, this pattern of change is difficult to handle. It is even harder when you realize that people often want to try out a computer first. At one time, Dell tried to sell computers through retail stores, but had to give up. Dell's solution has become a driving force in the industry. Dell tightly manages the supply chain and builds each machine to order. Components such as disk drives, processors, and cases are purchased in bulk—often with long-term contracts. The majority of the components are delivered in small just-in-time batches to manufacturing facilities. The individualized machines are built and formatted for each specific customer. Dell holds costs down by minimizing inventory and producing the exact products ordered by customers. Dell risks losing sales to retail stores, but the company knows it will make a profit on every machine.

Which options should you choose on a computer? Do you need the fastest processor, a huge amount of RAM, and a monster disk drive? Where can you cut performance slightly and save money? These questions are hard enough for buyers to answer, but cause headaches for vendors. Again, Dell's made-to-order process reduces the risks. But vendors like Hewlett-Packard, Lenovo, and Acer have shown that with accurate predictions, it is possible to capture a substantial slice of the retail market. The key is to have the combination of features that are demanded by customers, at the right price.

Getting rid of old computer equipment could involve almost as big a decision as purchasing a new computer. California and Massachusetts have banned computer equipment from landfills. Europe and Japan have relatively strict recycling laws. Vendors are struggling to create recycling programs. Dell has committed to increasing the recycling rates by offering new programs that embed the cost of recycling into the new equipment. Other vendors will take back old equipment for a fee of \$30 to \$50.

Introduction

What types of computers are needed for business applications?

Figure 2.1 shows the challenge of the choices. A wide range is available from portable devices like cell phones and tablets to large-screen desktops to enterprise servers and super computers. The interesting aspect is that at each level, the performance and capabilities have continued to improve. So today's desktops have the power of super computers from a few years ago. You are probably familiar

Trends

The first computers were simple pieces of hardware. Like all computers, they had to be programmed to produce results. Programming these machines was a time-consuming task, because all of the pieces were connected by individual wires. Programming the computer consisted of rearranging the wires to change the way the pieces were connected. As computer hardware improved, it became possible to program the processor without having to change the internal wiring. These new programs were just a list of numbers and short words that were input to the machine. These lists of commands were called *software*, because they were easier to change.

Programmers soon learned that some tasks needed to be performed for most programs. For example, almost every program needs to send data to a printer or retrieve information stored on a disk drive. It would be a waste of time if every programmer or user had to write a special program to talk to the printer. By writing these common routines only once, the other programmers could concentrate on their specific applications. As a result, every computer has a basic collection of software programs called an *operating system*. The operating system handles jobs that are common to all users and programmers. It is responsible for controlling the hardware devices, such as displays, disk drives, and printers.

The Internet changed everything by focusing on networks and sharing data. The Web changed everything by making the browser the most important display device. Increasingly, software and data are stored on Web servers. Users rely on browsers installed on a variety of clients—from desktops to handheld computers, tablets, and cell phones.

Hardware trends have been astonishing compared to older industries. Performance, size, and price have continued to improve each year. These changes have created new, portable products and pushed advanced computing into everyday products.

with common user devices such as laptops, cellphones, and tablets. These devices are also important in business, but today they are essentially commodity items that are purchased in bulk and replaced every couple of years. Servers require more attention because they are more expensive and handle important tasks for the entire company.

Some basic aspects of computing hardware have remained the same for many years. However, the continued improvements have led to powerful changes in capabilities and physical size. Small, portable devices now have huge processing and communication capabilities. These changes are leading to new applications, new ways to build information systems, and new ways to interact with computers. Some of these effects are explored throughout this book. In terms of hardware choices, the main impact in this chapter is the question of whether hardware selection matters anymore. For example, most people in the U.S. essentially lease their cell phones paying a small up-front price and paying for the device with higher monthly contract prices. Consequently, it is relatively painless to replace the equipment every two years. As more applications move to cell phones and browsers, the choice of hardware becomes less important every year. Still, it will be a few years before all hardware reaches this state. So, it is still useful to understand some of the foundations of information technology hardware and software.

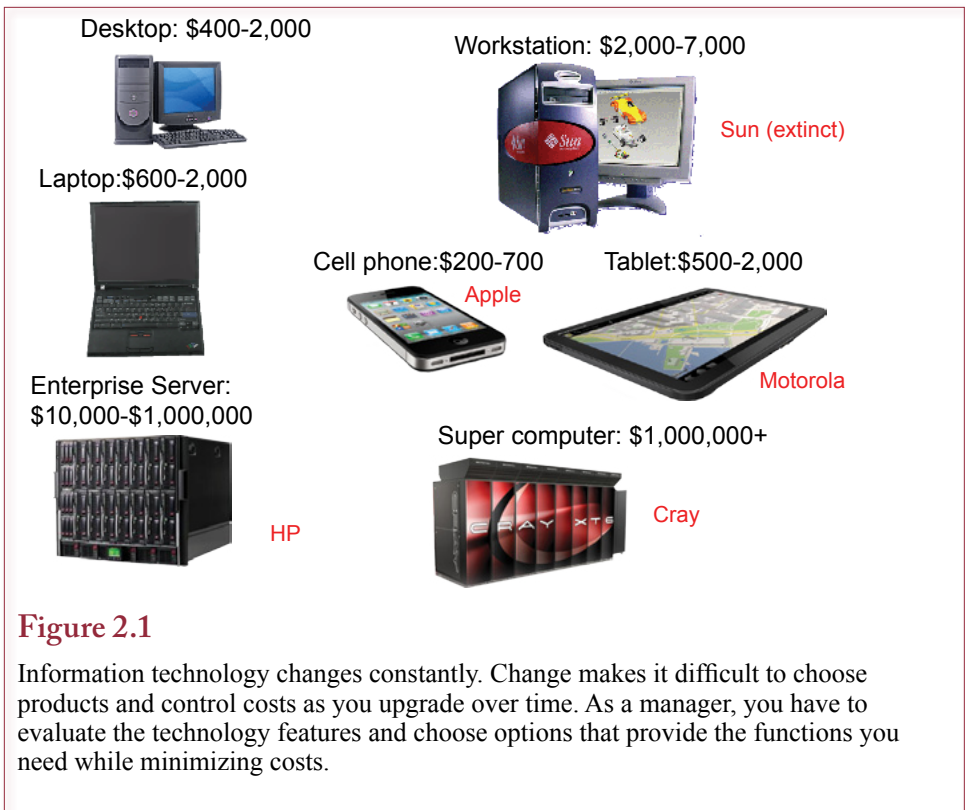


Figure 2.1

Information technology changes constantly. Change makes it difficult to choose products and control costs as you upgrade over time. As a manager, you have to evaluate the technology features and choose options that provide the functions you need while minimizing costs.

Keep in mind that the demands for data storage and computational tasks continue to increase. So someone has to buy more computing power and data storage on a continuing basis. Most businesses purchase information technology at multiple levels: devices for users, servers for business tasks and data storage, long-run backup, and sometimes intensive analytical tasks. Each of these categories requires different types of computers, and it means someone has to monitor the investments and changes to technology.

Why do you care how computers work? After all, it is easy to use a photocopy machine without understanding how it works. Automobiles cost more than most computers, yet you can buy an automobile without knowing the difference between a manifold and a muffler. You can also make telephone calls without understanding fiber optic cables and digital transmissions.

On the other hand, when you buy an automobile you need to decide if you want options such as power windows, a turbo charger, or a sunroof. Almost every product you purchase has a set of technical elements, and you can find an expert (techie) who is more concerned about details than others. But, does it truly matter to you? Perhaps not, but if you do not understand the options, you might not end up with the car, telephone service, photocopier, or computer that you need. Or you could end up paying extra money for services that you will not use. To choose among the various options, you need to know a little about how computers work.

Computers are typically discussed in terms of two important classifications: hardware and software. **Hardware** consists of physical items; **software** is the logical component such as a set of instructions. Of course, many functions can

Single bit: one or zero (on or off)
 8 bits = 1 Byte: 10101010
 1 Byte holds values from 0 - 255

$2^0 = 1$	$2^6 = 64$
$2^1 = 2$	$2^7 = 128$
$2^2 = 4$	$2^8 = 256$
$2^3 = 8$	$2^9 = 512$
$2^4 = 16$	$2^{10} = 1024$
$2^5 = 32$	$2^{20} = 1,048,576$

Bytes	bits	Power of 2
1	8	256
2	16	65,536
3	24	16,777,216
4	32	4,294,967,296
8	64	18,446,744,073,709,551,616

Figure 2.2

Byte and bits. Binary counting imposes some limitations based on the size of the counter. Note that 32-bit hardware and software can only address 4 GB of memory. Windows 7/32-bit is limited to 3 GB. To use more RAM, you need 64-bit hardware and software.

be provided in either software or hardware, and a computer user often cannot tell which has been used, and most often does not care. The one main difference is that it is easier to make changes to software than to hardware—especially since software patches can be transmitted across the Internet. Before looking at the various hardware components and software options, it helps to examine the primary data types. You care most about the tasks a computer can perform, and the data types are the fundamental blocks within any information system.

Types of Data

What are the basic objects that computers process? To a computer user, the most important aspect of the computer is the data that it handles. Today, computers are used to process five basic types of data: numbers, text, images, sound, and video. Because of limited speed and storage capacity, early computers could handle only simple text and numbers. Only in the past few years have computers become fast enough and inexpensive enough to handle more complex sound and video data on a regular basis. As computers continue to improve, these new capabilities will alter many aspects of our jobs and society.

Term	Name	Power of 10	Power of 2	IEC term	Binary value
Kilo	Thousand	3	10	Kibi	1,024
Mega	Million	6	20	Mibi	1,048,576
Giga	Billion	9	30	Gibi	1,073,741,824
Tera	Trillion	12	40	Tebi	1,099,511,627,776
Peta	Quadrillion	15	50	Pebi	1,125,899,906,842,624
Exa	Quintillion	18	60	Exbi	1,152,921,504,606,846,976
Zetta	Sextillion	21	70	Zebi	1,180,591,620,717,411,303,424
Yotta	Septillion	24	80	Yobi	1,208,925,819,614,629,174,706,176

Figure 2.3

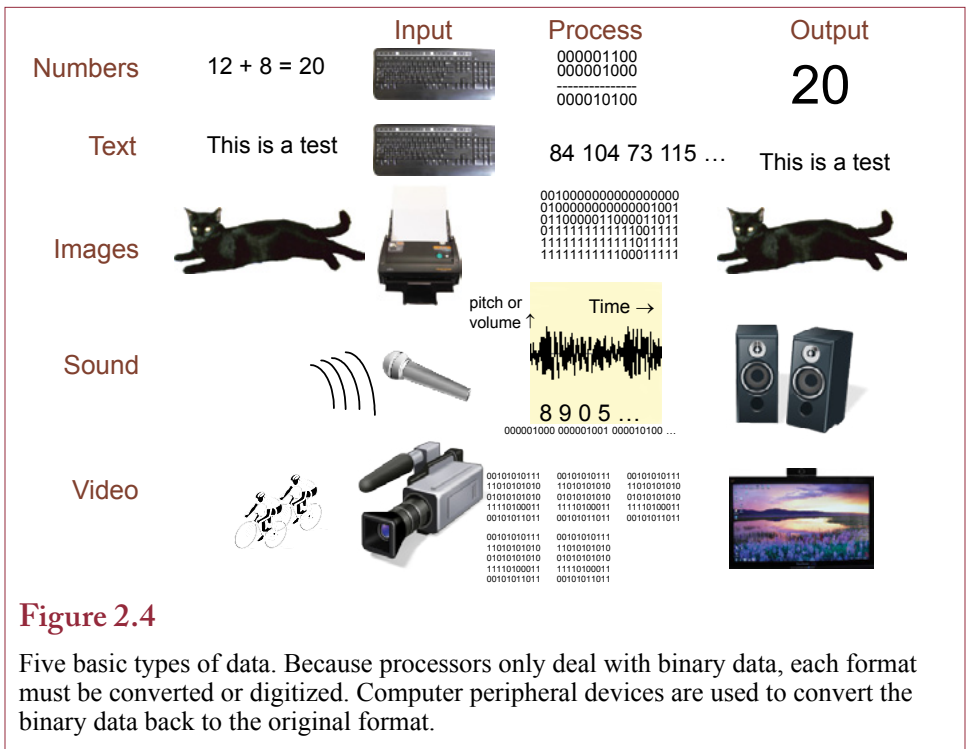
Terms and prefixes. The IEC (electrical) has proposed using different names for powers of two instead of decimal. The new versions are sometimes used in Europe and have been adopted as standards. The goal is to reduce confusion.

Object Orientation

One of the most important concepts to understand with computers is that all data are represented as **binary data**. The computer processor can handle only binary data in the form of bits. Each bit can be on or off or mathematically, zero or one. Processors operate on groups of bits at a time. The smallest group of 8 bits is called a **byte**. The industry often refers to the maximum number of bits that a processor can handle. Common machines use 32-bit processors, but the industry is shifting to 64-bit processors. A 64-bit processor can process 8 bytes of data in one operation.

The number of bits (or bytes) determines the size of individual data that can be handled or addressed. Figure 2.2 summarizes some of the values of binary numbers that commonly arise in computing. In particular, note that a 32-bit system has a limitation of about 4 gigabytes (GB). Consequently, a 32-bit Windows operating system can only address 3 gigabytes of RAM. If you want to use more memory, you need to install 64-bit versions of the operating system and other software.

It can be difficult to deal with huge numbers. So instead of trying to write out strings of zeros and commas, people create names for different levels of numbers. Figure 2.3 lists the main prefixes in use today and some that might be reached in a few years. Notice that there are some differences between decimal and binary values because binary is based on 1024 instead of 1000. These differences were minor at small numbers but become larger with higher powers. Consequently, there is some confusion when you see a number expressed as gigabytes or terabytes. For instance, disk drive vendors commonly count storage space in decimal values (because it sounds bigger); but the Windows operating system reports drive space in binary values so a 512 GB drive (in decimal) only contains about 488 gigabytes of space counted in binary. Drive vendors would probably be happier if operating system programmers reported data in decimal counts instead.



In common business usage, the prefixes tera and peta are becoming relatively common. Even desktops and laptops can have terabyte-sized drives. Some large companies collect petabytes of raw data, which are a thousand times larger than terabyte systems. A couple of companies have reached the exabyte scale for specialized data. Think about a million terabyte drives for a minute and you will begin to see what happens as companies collect increasing amounts of data.

One of the key points in terms of data storage is that companies avoid deleting data. It can be difficult to know exactly which data might be valuable in the future. Given falling prices for storage, many companies simply decide to keep everything.

Beyond counting, humans do not deal well with bits or bytes. Real-world data consists of analog objects such as numbers, text, images, sound, and video. Figure 2.4 illustrates the five basic data types. Computers need **input** devices to convert these objects into bits. **Output** devices then change this data back to a form that humans can understand. Understanding these types makes it easier to see the industry trends and to understand applications.

Each of the basic data types has its own characteristics. Numbers have a precision and usually a scaling factor. Text has a typeface and display size, as well as appearance attributes such as bold, underline, and italic. Pictures can be described by their resolution and the number of colors. Digitized sound is based on a specified sampling and playback rate, and fits into frequency and amplitude ranges. Video combines the attributes of pictures with a frames-per-second definition.

Along with the attributes, several predefined functions can operate on each data type. Basic functions dealing with numbers include totals, calculations, and comparisons. Standard methods to manipulate text include searching, formatting, and

Reality Bytes: RAM: Smaller, Faster, Less Power

In early 2011, Samsung announced the production of the first DDR4 RAM module. Based on 30 nanometer (nm) lithography the module doubles the access speed from DDR3's 1.6Gbits/sec to 3.2Gbit/sec. Samsung also noted a 40 percent reduction in power consumption when used in notebook computers. At the same time, prices for existing DDR2 and DDR3 RAM was continuing to decline. The market research firm iSuppli noted that in the last six months of 2010, the contract price for 2GB DDR3 dropped from \$44.40 to \$21. Mike Howard, a principal analyst at iSuppli predicted that DDR3 prices might drop as low as \$1 per gigabyte, which would be less than the marginal cost of production.

Adapted from Lucas Mearian, "Samsung Announces First DDR4 DRAM Module," *Computerworld*, January 4, 2011.

spell-checking. Methods dealing with pictures involve artistic alterations such as color or lighting changes, rescaling, and rotation. Existing functions for sound and video are often limited to recording, playback, and compression/decompression.

Most application packages create their own objects as combinations of the basic data types. For example, graphs consist of numbers, text, and pictures. As a result, all of the attributes, and functions that apply to the base types also apply to derived graph objects. Hence, graphing packages can perform calculations on numbers, select fonts for displaying text, and enable you to set colors and rotation for the graph. Other applications, such as slide shows, provide additional functions, like controls for how one slide is replaced by another (e.g., fades, dissolves, and wipes). The point is, once you understand the properties and functions of the basic data types, you can learn how to use any new application by concentrating on the new objects, their attributes and functions. This approach is especially true since many applications are designed and built using object-oriented methods. Increasingly, operating systems are designed around these data types. They have search functions and applications to find and use files that contain specific types of data.

Numbers and Text

Numbers and text are still the most common types of computer data used in business—for example, each cell in a spreadsheet can display a number or text (labels). Most business reports consist of tables of numbers with supporting text.

As shown in Figure 2.5, a key aspect of numbers is that you must be careful with round off—particularly within spreadsheets. Consider the first column of numbers with three decimal digits. What happens when the format command tells a spreadsheet to display those numbers in the third column with only two decimal places? The computer will perform the addition first and round off the displayed result, which means the total will appear to be incorrect. If you really want only two digits of precision, you should use the Round function to convert each number before it is added, as shown in the second column. Precision of calculations is important in business. For example, the 1999 European Union standards require that all monetary conversions be computed to six digits to the right of the decimal point.

Since processors can handle only binary data, how can they deal with text? The answer is that they assign a number to each character in the alphabet, which raises

Precision	ROUND()	Format
5.563	5.56	5.56
0.354	0.35	0.35
6.864	6.86	6.86
12.781	12.77	12.78

Figure 2.5

Numeric precision. If you tell a spreadsheet to display two decimal-digits, it performs the additions in the full precision of the data—and displays the data in the right column. If you really want two-digit precision, you should use the Round(x, 2) function to roundoff the data before adding—giving the results in the middle column.

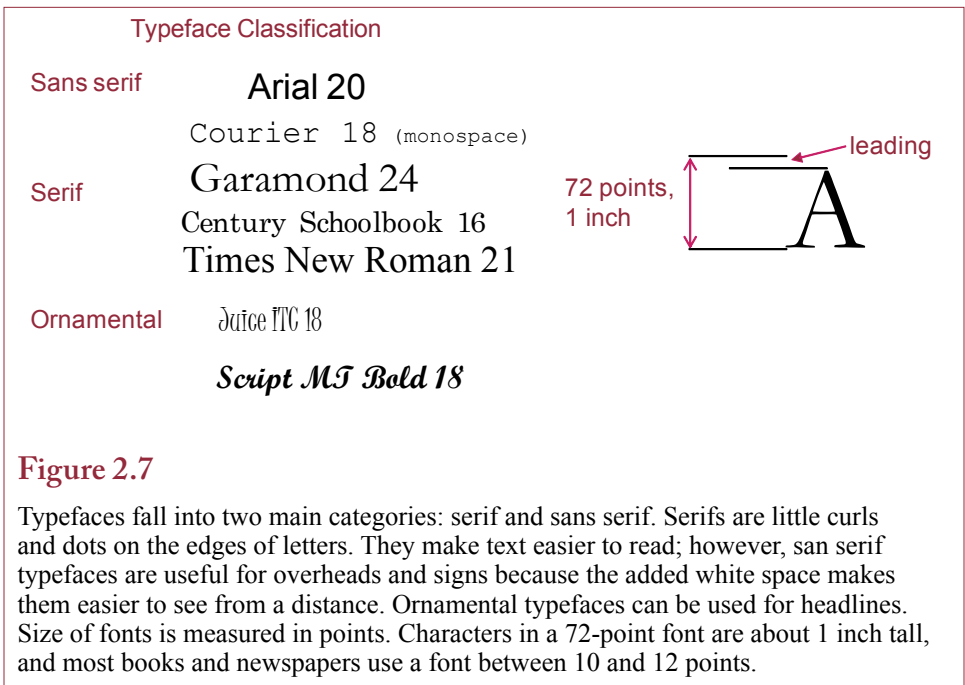
a very important, but tricky, question: How many letters are there in the alphabet? The question is tricky because you need to first ask: Which alphabet? Until the 1990s (or later), most computer systems were based on an English-language assumption that there are only 26 letters in the alphabet (plus uppercase letters, numbers, and punctuation). The key to numbering the alphabet is that all hardware and software vendors have to agree to use the same numbering system. It is a little hard for everyone to agree on a system that only displays English characters. Consequently, most computers today support the **Unicode** system. Unicode is an international standard that defines character sets for every modern language and even most dead languages.

Figure 2.6 shows that a key feature of Unicode is that it can handle oriental languages such as Chinese and Japanese that use ideograms instead of characters. The challenge with ideograms is that each language contains tens of thousands of different ideograms. Character-based languages like English used to be handled by storing one character number in one byte. But one byte can only hold 256 (2^8) numbers—which is not enough to handle ideograms. Consequently, Unicode uses two bytes to count each character or ideogram, enabling it to handle 65,536 (2^{16})

Figure 2.6

Character sets. Standards define how alphabets and ideograms are converted to numbers. Early systems were based on the English language and extended to handle Latin-based characters. Today, Unicode is the preferred way to encode text because it can handle any language. However, it takes twice as much space to store Unicode data.

Time	Languages	Character Sets
Early	U.S. and England	ASCII and EBCDIC 127 characters, 7 bits/1 byte
1980s	Latin-based characters: tilde, accent, umlaut, ... ñ, é, ö	Code pages and extended character sets 255 characters, 8 bits/1 byte
1990s	Asian ideograms, plus any language 日本語 中文 Российская	Unicode All modern languages and most dead languages 1 character, 2 (or 3) bytes



ideograms in each language. It also has the ability to switch to three bytes if even more characters or ideograms are needed.

Why do you care? Remember the increasing importance of international trade. If you build a computer system or database that needs to be used around the world, make sure that you use the Unicode character set so you can collect data in multiple languages. Unfortunately, some systems by default still use the older character systems, and you have to deliberately change the settings to ensure you can handle other languages.

Figure 2.7 illustrates one of the more important properties of text: its typeface. You can choose from several thousand typefaces to achieve a desired style. Be careful with your choices. Some choices are obvious; for example, do not use an ornamental (script) typeface to write a business report. Also, serif fonts are typically used for printed material, and sans-serif fonts are used for very small or very large presentations. Other choices are more subtle and may require the assistance of a professional designer. You will also have to choose font sizes. The basic rules of thumb are that most printed text is displayed at 10 to 12 points. It is also useful to know that letters in a 72-point font are approximately one inch tall.

Pictures

Pictures, graphics, and icons are used to display graphs and charts. Pictures are sometimes used as backgrounds or as **icons** in presentations that are used to help the audience remember certain points. In fact, almost all of the computer work that you do today is based on a graphical perspective. Video screens and printers are designed to display everything, including text, in a graphical format. The graphical foundation provides considerably more control over the presentation. For example, you can change the appearance of characters or combine figures and graphs in your reports.

Reality Bytes: Print Your Own Parts

Have you ever tried to track down a replacement part for a faucet, a toy, a lawn mower, printer, or some other device? You might be able to track down the manufacturer and order the part. Today, many of the manuals are online so it is feasible, but you still have to wait. What about designing and building new objects? If you are an inventor and have a new product idea, you need a fabrication shop with expensive tools to create prototypes. What if you could build any small-size part you need using a 3D fabricator that essentially prints the part in plastic or metal powders? Manufacturers could put design specifications for replacement parts online, you could download the design, run the “fabber” and have your part built from scratch in a few minutes or a couple of hours. The really cool part? You can build your own fabber for \$2400 in parts! The Fab@Home Web site (fabathome.com) has a complete list of parts and directions on how to build the fabber. It also has examples of the projects they have built. The device is computer-controlled and works like a printer but uses syringes to deposit silicon, epoxy, or cake icing in layers—building up the product one layer at a time.

Adapted from Tom Simonite, “Desktop Fabricator May Kick-start Home Revolution,” *New Scientist*, January 9, 2007.

Two basic ways to store images are bitmap and vector formats. The easiest to visualize is bitmap (or raster or pixel) format. A **bitmap image** is converted into small dots or **pixels** (picture elements). If the picture is in color, each dot is assigned a (binary) number to represent its color. This method is often used to display photographic pictures where subtle changes in color (such as blends) are important. Bitmap pictures are evaluated in terms of the number of colors and resolution of the picture. **Resolution** is often measured in **dots per inch (dpi)**. You will encounter certain problems with bitmap images. Consider what happens if you create a bitmap picture in a square that has 50 pixels per side. How do you make the image larger? Use larger dots? Then the lines are very rough. How can you stretch the picture into a box that is 100 by 200 pixels? Although these operations are possible, they do not usually produce good results.

Historically, it took several years, and the Web, for companies to standardize on the types of image file formats. Today, although individual software packages still have their own proprietary formats, most of them can save and edit files in the three major formats: GIF, JPEG, and PNG. All three are bitmap formats and have slightly different benefits. The PNG format is newer and combines most of the benefits of the other two formats, so it is a good default choice. However, JPEG (Joint Photographic Experts Group) is still commonly used by most digital cameras.

When you need to change the size of pictures and keep fine lines and smooth edges, it is better to store pictures in vector format. **Vector images** consist of mathematical descriptions instead of dots. In most cases, they take up less storage space than bitmaps. For example, a line is described by a statement such as: “line from (0,0) to (10,10) in yellow.” Do not worry: you do not have to be a mathematician to use vector images. Most of the current drawing packages store their work in vector format. Web browsers are beginning to support a new Internet vector

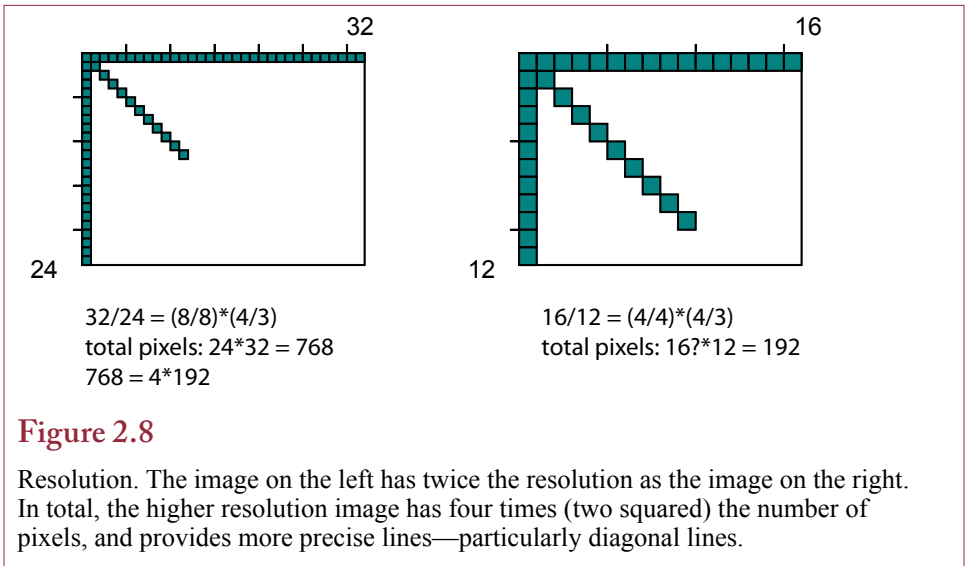
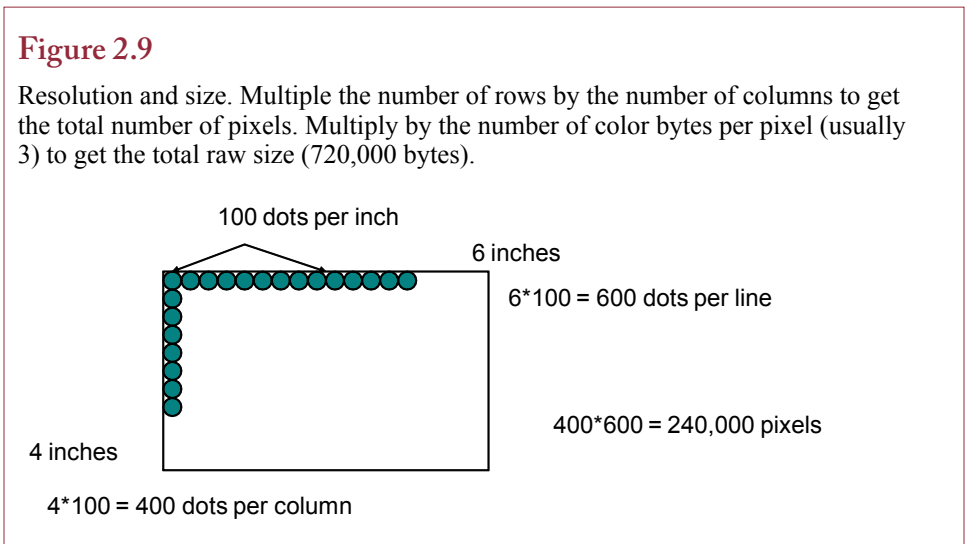


image (SVG: scalable vector graphics) format that provides for faster image transfers and scalable images.

Graphics devices—including displays, printers, digital cameras, and scanners—are evaluated largely in terms of resolution. Resolution is commonly measured by the number of pixels (or dots) per inch. Figure 2.8 shows the importance of resolution. Doubling the number of pixels per inch delivers much finer lines—particularly for diagonal lines. But doubling the resolutions results in four times the number of total pixels—which requires substantially more memory and processing time to handle.

Figure 2.9 shows how to compute the data size of an image. A photo taken with a resolution of 100 dots per inch and a size of 6 x 4 inches has 600*400 or 240,000 pixels. How many bytes are needed to store one pixel? The answer depends on the number of colors. How many colors do you need? The human eye can distin-



Video		Print		Camera	
Video	Pixels	Method	Pixels/Inch	Print Size	Pixels/Inch
VGA	640 x 480	Fax	100-200	3" x 4"	768
XGA	1024 x 768	Ink Jet	300-700	4" x 6"	512
SXGA	1280 x 1024	Laser	600-1200	8" x 10"	307
UXGA	1600 x 1200	Typeset	2400	pixels	3072 x 2304
WSXGA	1680 x 1050				
HDTV	1920 x 1080				

Figure 2.10

Resolution examples. Video screens use the 4/3 aspect ratio from the older television standard. HDTV uses a wider 16/9 ratio and about 2.5 times the resolution of the original VGA/TV screen. Final resolution values depend on the physical size of the screen or paper.

guish at most about 16 million colors. Three bytes of storage is 24 bits and 2^{24} is 16,777,216, so many systems use a three-byte color coding. Consequently, the raw data for the image requires $3 \times 240,000$ or 720,000 bytes of storage. But, 100 dpi is a weak resolution, 200 dpi would be better for printing. Doubling the resolution results in a total size that is four times larger (2-squared), or slightly under 3 megabytes. A few systems use 32-bit color for a broader color gamut and faster processing.

Most digital cameras express resolution in terms of total pixels instead of dots per inch—largely because the dpi changes depending on the size of the print. Most of the time, you care about the total number of pixels available. More pixels means you get a higher-quality print. Figure 2.10 shows resolutions for some common devices. Notice how the resolution of a photograph declines when it is printed in a larger size. Print resolutions less than 300 pixels per inch (ppi) are grainy and jagged. A similar effect occurs with video screens. On the other hand, almost all operating systems draw text characters with a set font size. Increasing a monitor's resolution results in smaller text. For example, if you have a monitor with a physical diagonal measure of 16 inches, an SVGA resolution produces 80 pixels per inch, so the dot on an 'i' is 1/80 of an inch. Increasing the resolution to UXGA creates 125 ppi, so every character and dot shrinks to a little over half the original size (64 percent). Microsoft documents have suggested Windows might someday be rewritten to solve this problem by separating the size of the fonts from the resolution. Screen displays will behave the way printers do now, so that increasing the resolution will leave the text the same height but provide sharper characters with finer details. The main Microsoft tools including Office and Internet Explorer support this approach by providing a zoom feature that enables you to increase the display of the font without changing the font size.

The **aspect ratio** is another topic in graphics that has become important—largely because it has been changing. The aspect ratio is the ratio of the horizontal width to the vertical height of an image. It is usually expressed in terms of two numbers, such as 4:3. Early film projectors were limited by the physical size of

Reality Bytes: SSD Performance Surpasses Hard Drives

In the first quarter of 2011, Micron Technology, the leading U.S. manufacturer of RAM, began shipping the RealSSD C400 flash drive. The 1.8 and 2.5-inch drives connect to laptops using SATA 3 which supports a data transfer rate of 6 G bit/second. The drives are created from NAND flash chips using a 25 nanometer lithography technology. The largest drive capacity is 512 GB and offers sequential read speeds up to 255 MB/sec and write speeds up to 215 MB/sec. These speeds are faster than hard drives and the half-terabyte capacity puts it in the range of many existing hard drives. On the other hand, the \$900 consumer price (for 512 GB) is substantially higher than a hard drive cost; but a significant drop for SSDs.

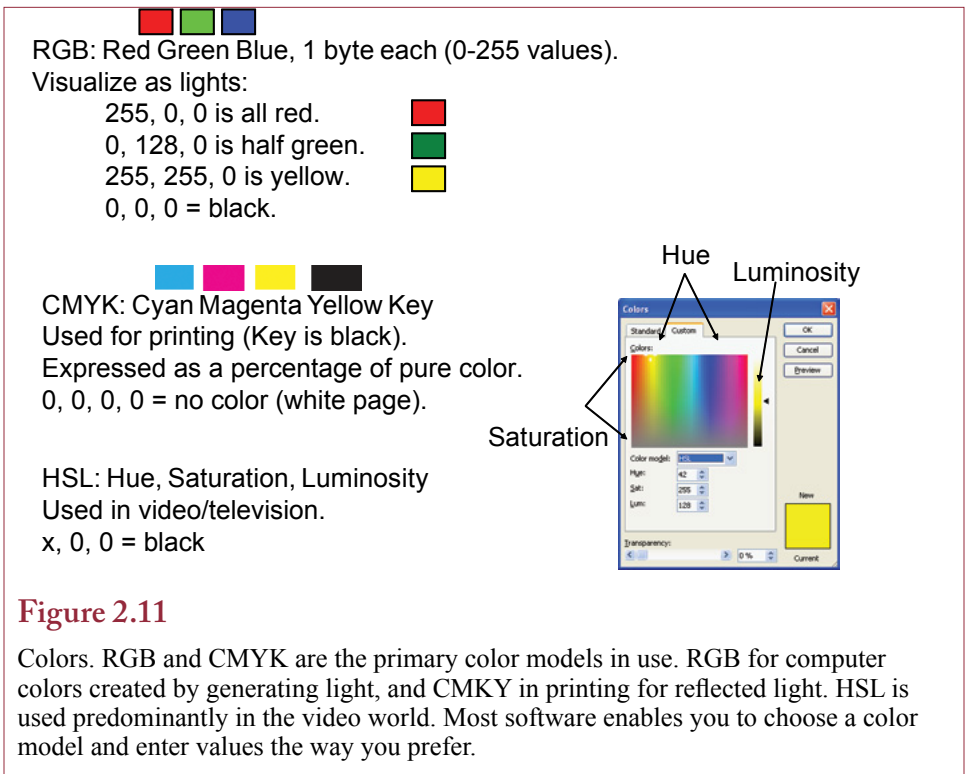
Adapted from Lucas Mearian, "Micron Releases Half-terabyte Laptop SSDs," *Computerworld*, January 4, 2011.

the film so the 4:3 ratio was selected to fit the film's properties. Photographs often had a similar ratio. Television adopted the same ratio. Movie studios then adopted a widescreen format with a 1.85:1 or 2.40:1 ratio. When computer displays arrived, they followed the standard television 4:3 ratio; eventually leading to resolutions of 640 x 480 and 1600 x 1200. Then HDTV was introduced, partially with the goal of displaying higher-quality images for movies. The standard aspect ratio adopted for HDTV was 16:9 (or 1.78:1). Eventually, computer monitors and laptop screens adopted the same aspect ratio. But, a tremendous variation still exists in aspect ratios among monitors, laptops, tablets, and cell phones. As a designer you cannot count on a specific resolution or aspect ratio. Which often means it is necessary to create images and layouts in multiple formats; or to choose a size that will fit reasonably well on the most common displays.

Color

Color is an important component of images and video. It is also important in Web sites and graphics design of print pages. To date, most organizations rely on black-and-white for basic internal reports and memos. However, as color printing costs decline and as organizations move towards electronic documents, color is becoming popular in many reports. To begin to understand color, you need to study art and graphics design. In particular, color and design convey emotion, so you need to be careful about overall color schemes. Fortunately, most software packages support **templates**, so you can choose a template that fits your needs without needing to be a design expert. However, for complex designs and documents that are published, you should get expert advice.

Figure 2.11 provides a brief introduction to three of the basic color models. These models are used to identify colors, but do not do much to help you choose colors appropriate to your job. In the computer world, **RGB** (red, green, blue) is the most common model. You should use a color picker to explore how the colors work so you can find or adjust colors when you need them. Think of each color byte as a spotlight. Increasing a single value increases the brightness of that color. **CMYK** (cyan, magenta, yellow, key) is commonly used by print shops, so if you create large print jobs that need to be sent to a print shop, you should work with the CMYK model. Each color number represents the percentage strength of the specified color. The challenge to printing is that your display screen rarely shows



colors the same way they will appear in print. Different lighting strongly affects the color and brightness of printed images. It also affects your display, but usually to a lesser degree. If you need to see colors as they will appear in print, you have to run a gamma correction program on your monitor. It can adjust the display to match the desired output characteristics. High-end graphics packages, such as those produced by Adobe, automatically install the gamma correction software and provide instructions for adjusting it. A related problem you will face with printing is that some colors you see on your monitor cannot be reproduced by printers. For example, a pure high-intensity blue is usually printed in a darker shade. The better graphics packages will show you the constrained color palette. You probably do not need to become a color expert, but these concepts explain why your system will sometimes display colors differently than you expected.

Style Sheets

When working on large documents, Web sites, or portfolios, consistency becomes a critical design factor. Actually, even a small document quickly becomes ugly and impossible to read if someone uses multiple typefaces, font sizes, and discordant colors. But the challenge with large documents is that it can be difficult to remember exactly which fonts were used for each element. It is even more difficult if the document or Web site is created by multiple people. **Style sheets** were designed to solve these problems and ensure consistency across a collection of documents. Style sheets have been used for many years in the publishing industry, but computer tools have made them more powerful and easier to use.

Reality Bytes: Choosing the Right Tools at Thule

In computer programming terms, the term “spaghetti code” represents logic that wanders all over the place—much like a plate of intertwined spaghetti. This code is hard to read and difficult to debug or change. Programmers are taught to write clearer structures that are easier to follow. But, most people who use spreadsheets learn just the basic concepts of the tools and then go and build complex monsters. Bicyclists and Skiers know Thule as a company that makes high-end bike and ski racks for cars. The Thule Vehicle Solutions North America division has 400 people and generates 15 percent of the corporate revenue. Vice President of Finance, Mark Cohen, notes the importance of the data, particularly for budgeting and forecasting: “We’re a seasonal company, so we have to have product ready to go or the sale will go to our competitor.” (The main competitor is Yakima.) Cohen noted that this data was maintained with spreadsheets. “We had one person in accounting who kept all the data as up to date as possible, including departmental expenses that outlined the costs of running the factory. However, it wasn’t unusual for it to take a week to consolidate cross-company information, and it wasn’t unusual to discover that what managers were looking at wasn’t the final spreadsheet.” In 2008, Cohen threw out the spreadsheet approach and went with an online system from Host Analytics Budget that provides real-time collaboration and mobile access to the data and projections. Individuals are now responsible for entering their own data and everyone gets immediate access to current values. The problem with the spreadsheet is that it was the wrong tool for the job. Yes, it could generate forecasts, but the bulk of the requirements were to collect and share current data—something spreadsheets do poorly.

Adapted from Sandra Gittlen, “Why Some Companies are Ditching Their Spreadsheets,” *Computerworld*, January 19, 2011.

The basic goal is to predefine all of the styles that will be needed in a document and store these definitions in one location. When creating a document or Web page, you simply write the content and assign the appropriate style from the list. For example, first-level titles might have a *Heading 1* style. The typeface, font, color, and other attributes are defined within the style. By assigning the style to a section of text, that text is displayed correctly. The power of a style sheet is that a graphics designer can tweak the entire layout and design simply by modifying the style definitions in one location. Then every page automatically picks up the new style. Without a style sheet, making a design change requires searching every single page and editing multiple locations.

If your job consists of creating content—writing articles, presenting data, and so on—you simply have to use the predefined styles. But you must always be careful. Any special font or emphasis that you want to add should never be made directly to the text. Every design element has to be defined within the style sheet and then attached to specific objects. Any change that is made directly to a document, such as setting a word or letter to boldface, will be almost impossible to find and change later. Unfortunately, existing tools such as word processors make it relatively easy to select a word and set it to bold or italic—which bypasses the style sheet. You should avoid this temptation and instead open the style sheet list and assign a style instead of assigning bold or italic.

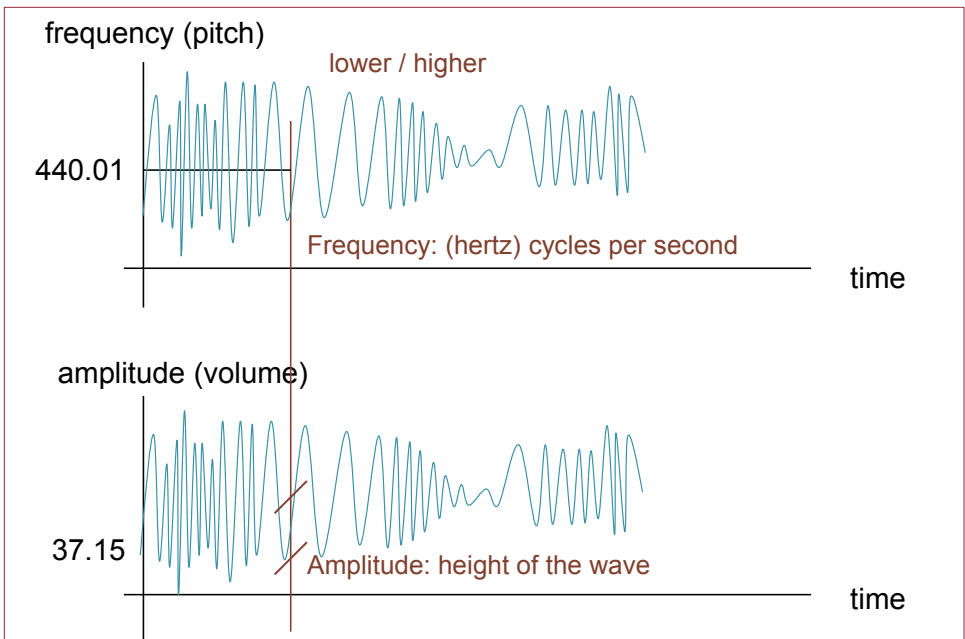


Figure 2.12

Sound sampling. At a specific point in time, the system measures frequency and amplitude using 16-bit numbers. The quality of the sample is largely determined by the number of times per second the audio is measured. The CD standard is 44,100 times per second.

Sound

Digitized sound is increasingly important for computer users. For example, you can use music to add emphasis and entertainment to a presentation. More important, you can use your computer to send voice mail messages and to store notes with your e-mail and documents. Tools exist to convert text to voice—so you can have your computer read your e-mail messages over the phone. Increasingly, voice input is being used both to control the computer and for dictation. Increased storage capacity and declining costs make it easier for sound to be stored in digital format.

As shown in Figure 2.12, sound consists of two basic components: volume (amplitude) and pitch (frequency). These two values are changed over time to produce words and music. To digitize sound, volume and pitch are measured several thousand times per second. The resulting binary numbers are stored in sequence. Synthesizers convert the sampled numbers back into music or speech and play them through amplifiers and speakers. The challenge is to sample the source often enough so no important information is lost.

Most audio applications store sound by digitizing the sound waves. These files can become very large—depending on the quality. If you tell the computer to sample the sound more often, you will get a higher quality recording, but it can take considerably more storage space. Sound-recording systems generally allow you to specify the sampling parameter to control the initial quality. From that point,

Object	Raw	Compressed	Lossy
Text and numbers	5 KB/page	2.3 KB/page	N/A
Image (300 dpi, 24-bit color, 4 x 6 in.)	6.32 MB	2.4 MB	78-245 KB
Sound (44.1 KHz stereo)	170 KB/sec	100 KB/sec	0.01 KB/sec
Video (NTSC 30 fps, stereo sound)	25 MB/sec	3.7 MB/sec	1 MB/sec
HDTV (1080p: 1920 x 1080) MP4	6.8 GB/min		1.5 MB/sec

Figure 2.13

Size complications. Lossy compression results in substantially less data but at a lower quality. Text file is compressed with a Zip folder. Image is compressed with JPEG from high to low quality. Sound is compressed with a WAV file (44.1 kbps) and WMA (64 kbps). Video is compressed with the DV standard and WMV at 6383 kbps.

compression methods can be used to reduce the file size; but some of them result in a loss of quality.

An even more efficient method of storing music is to file it in the musical instrument data interchange (MIDI) format. MIDI is a method of specifying music based on the musical notation and instrument, so it is substantially more efficient. A version of this method was designed for the MP4 standard, but this standard has not been widely adopted.

Video

Computerized video has dramatically increased in the past few years, even in business. However, most of the video is relatively low quality, in terms of low resolution and low frame rates. Some video applications are better than others, but it is still challenging to transmit high-quality video. Yet, as transportation costs increase, there is considerable incentive to use video communication for some types of meetings.

Converting motion picture and television signals to binary form generates a tremendous amount of raw data. The process is similar to that for single pictures, except standard movies display 24 frames (images) per second, while U.S. televisions display 30 frames per second. Video can also be completely computer-generated. These tools are commonly used in marketing and engineering to display prototypes and product features.

It is relatively easy to display video—even cell phones have enough processing power to display high-resolution video. **High-definition TV (HDTV)** has become popular, and most devices have the ability to play standard HDTV files. Even relatively inexpensive cameras have the ability to capture images in HDTV format. The challenge arises in trying to edit video—particularly HDTV files. Editing requires that the files be decompressed and edited in raw format, which is a large amount of data. The next sections illustrates some of the issues with data size.

Size Complications

To understand the importance of the five types of data, it helps to examine the size of each type. For many years, computers predominantly handled numbers and limited text. Over time, usage has gradually changed to include images, sound,



Figure 2.14

Data compression. Storing every single pixel requires a huge amount of space. Compression looks for patterns. For example, instead of storing 1,000 black dots in a row, it is much shorter to store a note that says 1,000 black dots come next.

and video. The more complex data types require much greater storage space, processing power, and transmission capacity.

Consider a typical single-spaced printed page. An average page might contain 5,000 characters. A 300-page book would hold about 1.5 million characters. Now, consider a picture. At 300 dots per inch, a full 8.5- by 11-inch page would require a little over a million bytes if it were scanned in black and white. A photograph in a base resolution with 16 million colors (24 bits per pixel) would require 18 **megabytes** (million bytes) of storage space.

Sound and video require considerably more storage space. Remember that thousands of numbers are being generated every second. A typical CD holds 700 megabytes of data, which can store 72 minutes of stereo music or almost 10 megabytes per minute. At lower quality, the current standard for digitizing telephone conversations generates 64 kilobits per second, almost half a megabyte per minute. Video generates approximately 3 megabytes of data every second, while the highest resolution HDTV generates about 113 megabytes per second. Figure 2.13 summarizes the basic size characteristics for the standard data types.

Data Compression

An individual photograph at high resolution takes a large amount of space in raw form (typically over 20 megabytes). Storing and handling raw video creates substantially larger files. The answer in many cases is data compression. Look at the photograph in Figure 2.14 for a second. Consider the line of data from the lower left corner. To store it as raw pixels, you would have several lines of black pixels. Instead of recording every one of these pixels, data compression builds up patterns. It takes less space to encode a note that a section contains a large set of black pixels, than to store every pixel. Some systems, such as the JPEG method, support lossy compression. In these cases, patterns are matched as long as the pixels are “close” to an existing match. When you compress the data, you get to select how close of a match to allow. For example, with a tight match, the system might allow a very dark gray pixel to count as black, but might not allow a dark blue one to match a black pattern. Lossy compression methods are commonly used to transmit photographs, audio files, and videos.

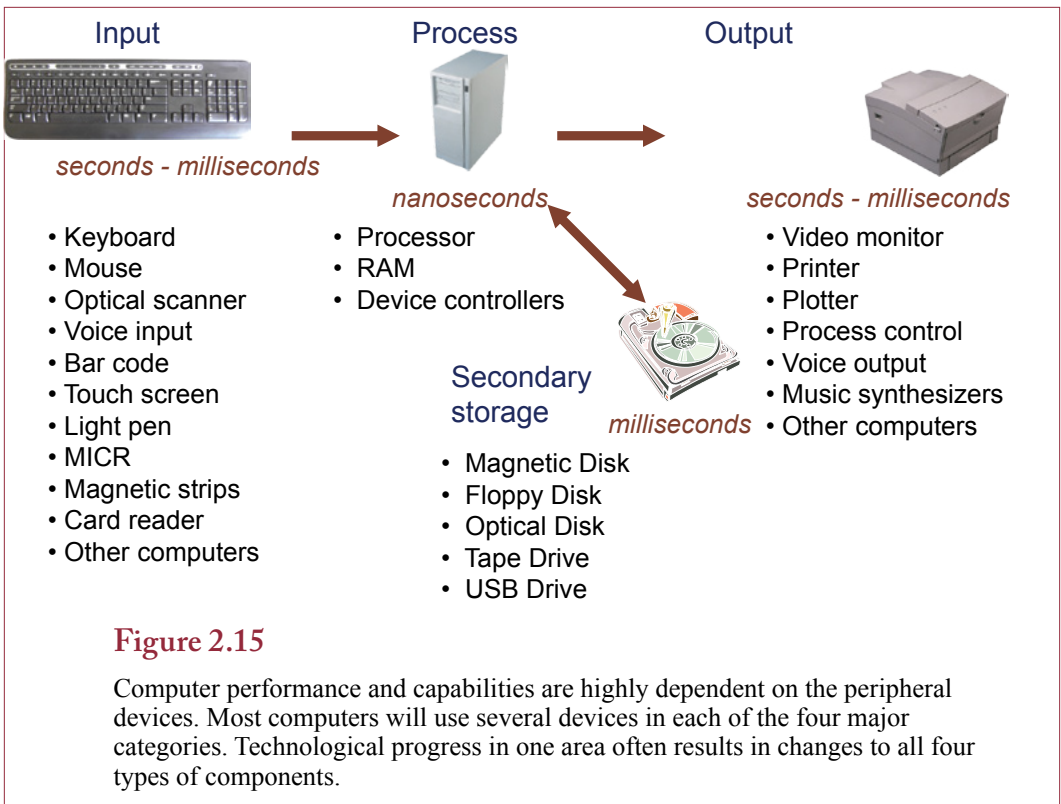


Figure 2.15

Computer performance and capabilities are highly dependent on the peripheral devices. Most computers will use several devices in each of the four major categories. Technological progress in one area often results in changes to all four types of components.

Hardware Components

What are the main components of a computer? As a manager, you need to understand the basic features of hardware. You do not have to be a computer-repair expert, but you need to understand the fundamental structure and characteristics of the computer components. The most important first step is to recognize that declining prices rule this industry. Because of technological advancements and standardization you know that you can buy a new computer next year that is faster than the one you just bought today. Instead of worrying about your “new” computer becoming obsolete, just accept that you will be able to buy a faster computer next year, which raises the questions: How often should you buy a new computer and what features should you buy? The answers to these questions change over time and depend on your specific uses, but as long as you understand how to evaluate the major components, you will be able to make a rational decision.

Along with declining prices, one of the most important trends in hardware is the shrinking size. But regardless of the size, computers contain four primary types of components to handle: input, output, processing, and secondary storage. Of course, each category has hundreds of options so that you can tailor the computer to your specific needs. One trend that you have to remember is that the hardware industry changes rapidly, especially for small systems. Most computers that you buy today will have a short economic life—perhaps only three years. At the end of that time, each component will have changed so much that typically you will want to replace the entire computer.

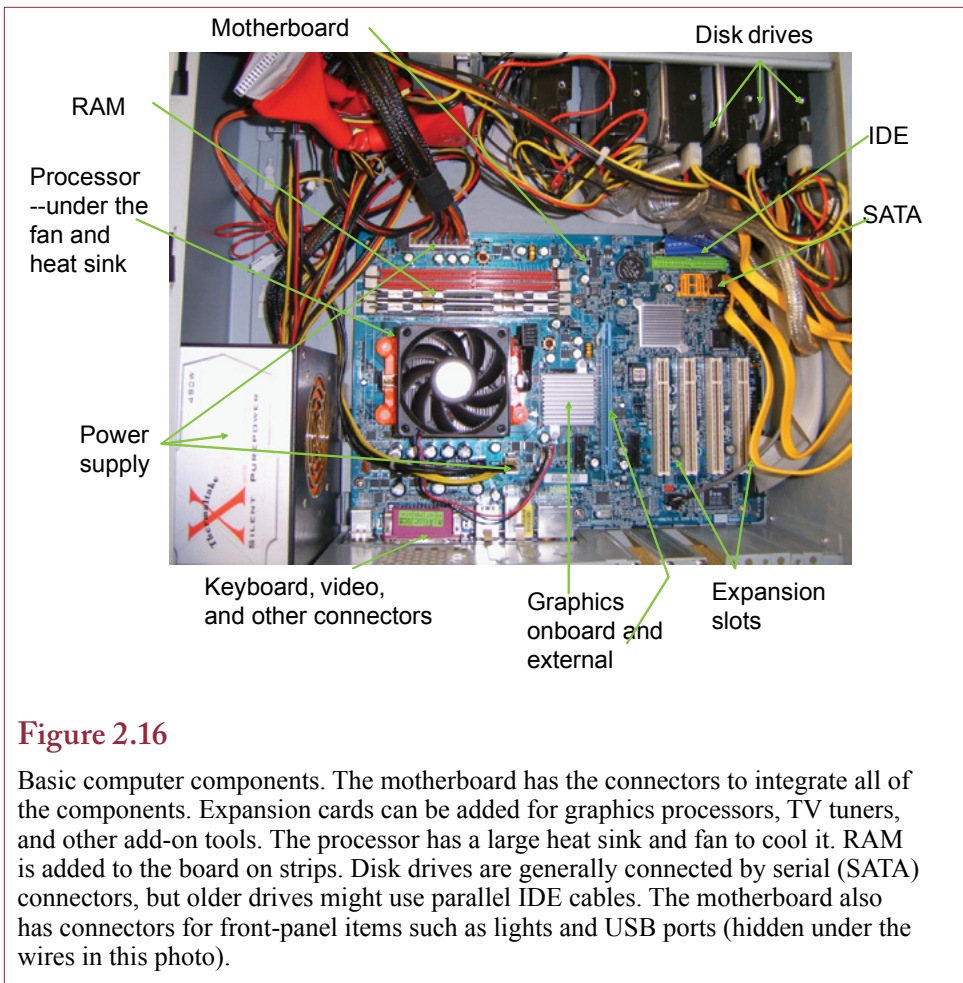


Figure 2.16

Basic computer components. The motherboard has the connectors to integrate all of the components. Expansion cards can be added for graphics processors, TV tuners, and other add-on tools. The processor has a large heat sink and fan to cool it. RAM is added to the board on strips. Disk drives are generally connected by serial (SATA) connectors, but older drives might use parallel IDE cables. The motherboard also has connectors for front-panel items such as lights and USB ports (hidden under the wires in this photo).

The relationship among the four components is summarized in Figure 2.15. Note that the process subsystem consists of **random access memory (RAM)** and at least one processor. In many ways, the **processor** is the most important component of the computer. It carries out instructions written by programmers. It uses RAM to temporarily store instructions and data. Data and instructions that need to be stored for a longer time are transferred to secondary storage.

One of the interesting aspects of computers is that the various components operate at different speeds. The processor is the fastest of the group and its performance is measured in **nanoseconds** (billionths of a second). Processors are even faster than RAM. As a result, processors contain separate memory caches embedded in the chip. When the processor asks for data items from RAM, it loads a large chunk of data at one time so that it can fetch related items from its internal cache to save time. Secondary storage devices are substantially slower. Because most disk drives are mechanical, performance time is measured in **milliseconds** (thousandths of a second). Divide those numbers, and you see that the processor is a million times faster than the disk drive! Of course, humans are even slower—most people type a couple of characters per second. Why do these speed differences matter? It means the processor can be told to do multiple tasks—apparently at

the same time. While you are typing, the processor can take a fraction of its time to store your keystroke, then retrieve some data from the disk drive, then send an item to the printer, then add some numbers together, and finally return to get another keystroke.

Figure 2.16 shows the basic components of a PC. The **motherboard** contains connectors for the processor, RAM, drives, and expansion cards. Many boards also contain built-in graphics processors; however, add-on graphics cards generally provide better performance. The processor is relatively small—about the size of a 50-cent coin, but it is covered by a large metal heat sink and the processor fan to remove heat. RAM is added by installing strips. RAM styles change over time to provide better performance, so you need to get the right type of RAM for each board. Disk drives require a power connection and a data connection. Serial (SATA) connectors are commonly used now because they can move data faster than the older parallel IDE connections. Video connections and other data connections for networks and USB devices also change over time as new devices and technologies are introduced.

Warning: You should avoid taking apart your computer; and if you do—be sure to unplug it first! You also have to “ground” your body before touching any computer component. Static electricity can instantly destroy almost any electronic item. But, if you are careful, it is relatively easy to install new disk drives or even RAM into a computer. But always remember that you can never force a part to fit. Computer parts are designed to fit together with almost no effort. And remember that static electricity is your enemy.

Processors

Processors come in a wide variety of formats, but most of the existing mainstream processors (Intel and AMD) can run the same code sets. Increasingly, manufacturers are placing multiple processors on a single chip. So a single processor chip can contain 2, 4, 6, or more independent processing cores.

Processors are relatively complex today and include many components. **Cache memory** is a factor that influences the overall performance. The processor runs faster than any other device in the computer, including RAM. Any time there is a large speed difference performance can be improved by adding a memory cache to the faster device. The processor chip contains several megabytes of high-speed internal memory. When it retrieves data from RAM, the processor grabs the data in large chunks. It then works from the internal (level 2 or level 3) cache, which it periodically refills.

The processor is the component that does the hard work of calculations and executing the software code. You can check on the status of your processor and its various tasks by opening the Task Manager. Right-click on the Windows menu bar and select the Processes tab, but be careful not to end any of the processes or your computer might crash. Most of the time the System Idle Process will be the main user—which means the processor is simply waiting. You can also watch the performance chart to see the total demands placed on your processor. Windows has a sidebar gadget to let you monitor your processor all the time. If you find that the processor is consistently in heavy use, you should consider buying a new machine. However, unless you are running huge computational tasks or video-intensive applications, it is more likely that something is wrong with your computer and you should check it for viruses and spyware software described in Chapter 5. Typical users will find that they have plenty of processing power for almost all tasks.

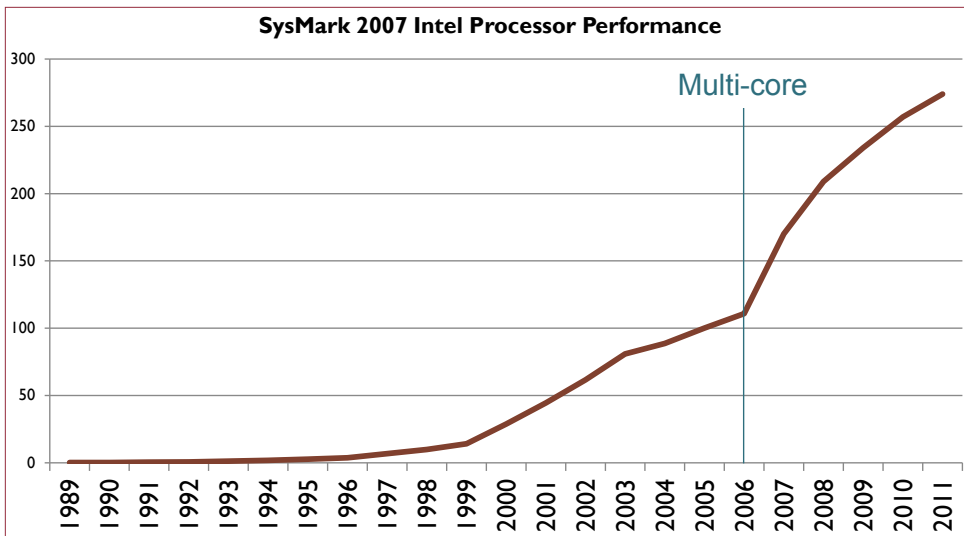


Figure 2.17

To assist buyers, Intel provides a measure of its own processors. The rating is an index that measures relative performance. A processor with a rating of 200 would generally be about twice as fast as a processor with a rating of 100. Of course, your other devices also influence the overall system speed, so just buying a faster processor does not guarantee that your machine will run faster.

The Evolution of Processors

Figure 2.17 shows an approximate measure of Intel processor performance over time, as indicated by an index value (estimated SysMark). The exponential increase in performance arises because the industry has been able to follow Moore's Law: the number of components placed on a chip doubles every 18 months. But three potential problems are facing the chip industry: (1) light waves are too wide to draw increasingly smaller lines; (2) when the components shrink to the size of a couple of atoms, the electronic properties no longer behave the same (quantum effects); and (3) the power requirements and heat generation increase dramatically.

For at least two decades, the IT industry has lived with and relied on this increasing performance (and reduction in costs). Eventually, this pattern will stop—possibly within 10 or 20 years. With luck and research, the industry will develop entirely new technology that will produce even greater performance. But in any case, managers need to monitor technical developments and be prepared for substantial changes.

The industry is switching to new chemicals to improve the electrical properties of the chips to buy some improvements. Several researchers are experimenting with optical computing (using light instead of electricity), and more esoteric concepts such as quantum computing and biological processors.

In practical terms, the biggest change to processors has been the switch to multi-core processors—where each chip contains multiple independent processors. Dual core processors gained importance in 2006, and the quad-cores made it to standard production in 2007. Experimental designs have been built with dozens, and potentially hundreds of processor cores on a chip. These features are discussed in the section on parallel processing.

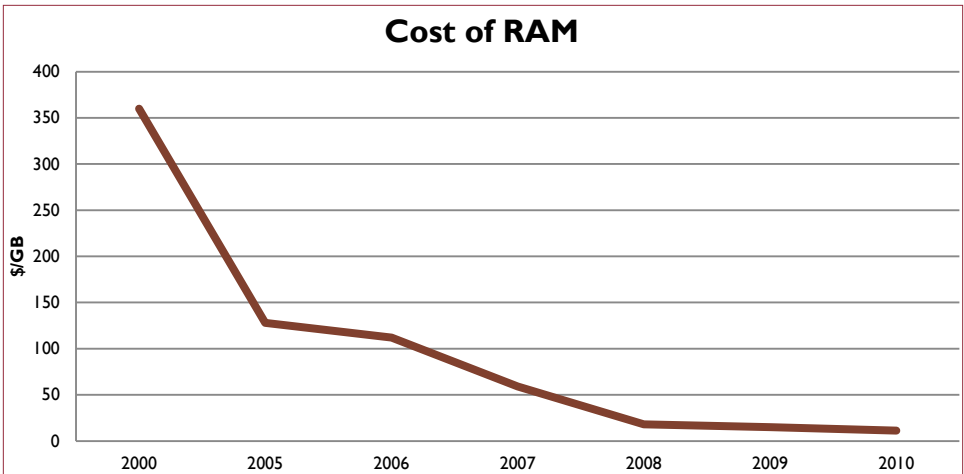


Figure 2.18

RAM prices over time. RAM prices have dropped at exponential rates as manufacturing processes have evolved, even as RAM speeds have increased.

Random Access Memory

As processor speed has improved, RAM has become a crucial factor in system performance. Because disk drives are mechanical, they are the greatest bottleneck in a computer system. Hence, modern operating systems try to hold as much data as possible in RAM. Figure 2.18 shows that RAM price has dropped substantially over the last decades. In relative terms, RAM is virtually free. For a couple hundred dollars, you can easily buy enough RAM to hold several applications and their data in RAM at one time. Operating systems, particularly Windows, take advantage of RAM to cache as much data and code as possible. Disk drives are notoriously slow, so system performance is dramatically improved by adding RAM. High-speed RAM enables the processor to pull data from RAM faster, leading to improved performance, but it is relatively more expensive.

Parallel Processors

In the past, when processors were more expensive, designers used only one processor in a machine. Today, many computers contain multiple processors. Although it can be a desirable feature, you must be careful when evaluating parallel-processing machines. If a computer has four processors (or four cores), it is tempting to say that the machine is four times faster than a computer with only one processor. Indeed, many computer companies advertise their computers this way. Can a computer with four processors really do your job four times faster? The answer is that it depends on your job. Consider an example. A computer with two processors has to add two sets of numbers together. Each processor works on one pair of numbers and finishes in half the time of a single processor. Now, the same two computers have to work the problem in Figure 2.19.

Notice that the second calculation depends on the outcome of the first one. The second one cannot be computed until the first one is finished. Even if we assign one processor to each calculation, the parallel-processing machine will take just as long as the single processor. On the other hand, if you commonly run multiple

Technology Toolbox: Voice Input

Problem: You are a slow typist or need to use your hands for other tasks.

Tools: A voice input system is built into Microsoft Office. You need a decent microphone to use it, and a headset microphone is recommended because it minimizes external noise. The system is relatively easy to set up, but it takes a half hour to train so that it recognizes your voice. Remember that no voice system is perfect, so you will still have to edit the text that it enters. You can find information on speech recognition in the Office help system by searching on the “speech” key word.

You can install the speech recognition software within either Word or the Microsoft Windows Control Panel. Within Word, select Tools/Speech. From the Control Panel, select Add/Remove Programs, find Office and Change it. Use Add or Remove Features and find the option to add Speech under the Alternative User Input. Once the software is installed, you have to train it. Follow the installation instructions to perform the basic training. To improve recognition accuracy, you should also take the time to read at least one of the additional training documents. Once the system is installed and trained, you can dictate text into an Office document. Remember that the system works better if you dictate complete sentences.



The voice toolbar enables you to turn the microphone off, so that you can speak to someone else or cough. Notice that it also enables you to switch between Dictation and Voice Command modes. The help system provides additional information about command mode and the additional things that you can say to control the computer with voice. For example, in Voice Command, you can say the word “font” followed by the name of the font to change the font in use. You can also start other programs and select items on the menu. The help documentation includes information on commands you can use during dictation. Some of the common commands are in the table.

Command	Result
period or dot	.
comma	,
new line	enter key/new line
new paragraph	Enter twice
open paren or parenthesis	(
close paren or parenthesis)
force num, pause, digits	numbers (for several numbers in a row)
spel it or spelling mode	spell out a word
microphone	turn microphone on or off
correct that	change or delete the last phrase entered
scratch that	delete the last phrase entered
go to top	move to top of the document (or use bottom)
move up	move up one line (also accepts down, left, and right)
backspace	delete one character to the left
select word	select a word (or use phrase with several options)

Quick Quiz: Use the help system to find the commands for the following:

1. !, ?, #, \$
2. Make a word boldface or italic.
3. Print the current page.

$$\begin{array}{r} 23 \\ + 54 \\ \hline xx \end{array} \qquad \begin{array}{r} xx \\ + 92 \\ \hline yyy \end{array}$$

Figure 2.19

Some computations must be performed in sequence, so there is little to be gained with multiple parallel processors. In this example, the second computation (yyy) must wait for the first one to finish.

applications at the same time, multiple processors will improve performance because each processor can handle the applications separately.

Massively parallel machines can include thousands of processors. They are used for some highly specialized applications. For example, governments use them to break codes; physicists use them to simulate large-scale events such as nuclear explosions and weather patterns; computer artists use them at special-effects studios, such as Industrial Light & Magic, to create movies. This concept has been extended with the use of **grid computing**, where thousands or millions of separate computers are assigned portions of a task. The search for extraterrestrial intelligence (SETI) project is the most famous example using a grid approach. Users are encouraged to download a small program that runs in the background on the computer. The program retrieves portions of radio-astronomy data from an Internet site and scans them looking for patterns. The millions of participating computers provide a huge (free) resource to process data that could not be handled by any other method. Using similar software, the grid concept can be applied to business and scientific applications. A company could use existing clerical computers or, since personal computers are so inexpensive today, could buy hundreds of machines and tie them together to handle large databases.

Today's computers take advantage of multiple processors in more subtle ways. Most computers today utilize a separate graphics processor to draw items on the screen. It is a sophisticated processor with its own RAM that handles complex three-dimensional calculations. This additional processor is particularly important for 3D graphics, such as those used in games. However, Windows Vista takes advantage of the processor for all display chores and offloads the drawing tasks to the graphics processor—creating faster graphics and enabling special effects within applications.

Connections

Even if two computers have the same basic components, it is still possible for one machine to be substantially faster than the other. The reason is that the components need to exchange data with each other. This communication typically uses a short-distance electrical connection. Most computers have special slots that form the connection between add-on boards and the processor bus. Various manufacturers make boards that fit into these slots. The processor can exchange data with these other devices, but it is constrained by the design of the bus. For example, even if a processor can handle 64 bits of data at a time, the bus might not have the connections to allow it to transfer that much data at a time. Standards enable users to exchange cards and devices from one computer to another. The problem is that a bus designed for today's computers will eventually become obsolete as the pro-

Method	Max Speed	Primary Purpose
PCI-e 2.0 x16	500 M Bytes/s * 16 64 G bits/sec	Connect peripherals, particularly graphics cards
SATA II	3 G bits/sec	Disk drives
SATA 3	6 G bits/sec	Disk drives
Fibre Channel	20 G bits/sec	Data center storage network
Firewire 2.0	800 M bits/sec	Video, drives
HDMI	3.4 G bits/sec	HDTV video
USB 2.0	480 M bits/sec	External drives
USB 3.0	4.8 G bits/sec	External devices
Intel Thunderbolt	10 - 100 G bits/sec	External devices
LAN/gigabit	1 G bits/sec	Computers, drives

Figure 2.20

Common methods to connect peripheral devices to computers. The max speed is never achieved but it can reveal bottlenecks. Hard drive transfer rates are often limited by drive write speeds. But the newer methods (SATA 3 and USB 3.0) will improve the performance of large data transfers—particularly with large solid state drives.

cessor improves. At some point, the standards need to be changed. In the personal computer market, standards for the bus have gradually evolved. For several years, the industry has relied on an Intel-sponsored design known as the *Personal Computer Interconnect (PCI)* bus. PCI was also designed to make it easier for users to set up their computers. Over time, manufacturers have increased the transfer speeds of PCI, but it is increasingly a limitation in computer performance.

External components also need to be connected to computers, such as thumb drives, external disk drives, cameras, and video cameras. For example, the IEEE 1394 or firewire standard is commonly used to transfer data from video equipment, but can also be used to connect disk drives to the computer. USB 2.0 is a similar standard used to connect peripherals including disk drives and RAM drives. Fiber channel and serial ATA are used to connect disk drives at high speeds. Ultra-wide-band wireless (UWB) might eventually be used to connect devices at high speeds without using cables. For example, you could tell your video camera to send the signal to your television simply by setting it next to the TV and pushing a button. Figure 2.20 shows the common connection methods available and their maximum transfer rates. Be cautious with the transfer rate numbers. No system ever reaches those numbers, but they do impose a speed limit. For example, hard disk drives are limited by their write speed (perhaps 400 mbps), so a SATA 3 connection will provide no improvement over a SATA II cable. But you would see better performance if you connect that drive through USB 3.0 or eSATA than with USB 2.0. With overhead transfer costs, USB 2.0 is probably restricting the data transfer. The basic rule is that when you purchase newer, faster peripherals, you need to connect them through faster cables. So do not expect to be happy connecting a new high-speed device to a three-year old computer running USB 2.

Reality Bytes: People Can't Memorize Computer Industry Acronyms

The computer industry lives on acronyms. Any time a new product is created, a new acronym is developed so that everyone can use shorthand letters to refer to it. TLAs (three-letter acronyms) are best, but sometimes they are longer. Actually, every industry uses acronyms to save time when communicating—but the computer and network industries change so quickly that they continually develop new products and new acronyms. But, ordinary people have considerable difficulty memorizing the acronyms. Read any computer ad and try to figure out the specifications if you do not know the acronyms. Mike Molloy, USAF, Ret. and his wife, Susan Ebert, have come to your rescue. They have created a Web site, www.AcronymFinder.com, that lists any acronym you can imagine and the various interpretations. Many acronyms have multiple definitions—depending on which industry or field is using it. If you spend hours a day writing text messages, you might think you are an expert on acronyms, but remember that new ones are introduced every day. As a central source, where all of the acronyms are validated by Mr. Molloy and his wife, the site can save you time in your research.

Adapted from Barry Newman, “BTW, if You Need Info About C4ISR, Read This ASAP,” *The Wall Street Journal*, January 13, 2007.

Input

A variety of input devices are available because of the need to handle the many data types. Hundreds of variations exist because of the challenges of adapting the devices to human needs. People have different preferences and styles, so manufacturers are constantly improving their products. The purpose of an input device is to convert data into electronic binary form. Keyboards are the most common method of entering new text and data. Note that you can purchase different types of keyboards to suit individual users. For example, some keyboards enable you to change the layout of the keys. Keyboards have their own feel; some individuals prefer sensitive keys requiring a light touch, while others like stiffer keys to support their hands.

Ergonomics is the study of how machines can be made to fit humans better. One of the main conclusions of this research in the computer area is that individuals need to be able to adjust input (and output) devices to their own preference. Forcing people to adapt to rigid devices can lead to complaints and even physical injuries. Since the mid-1980s, some workers have encountered a disabling condition known as repetitive stress injury, which some people claim results from extended use of tools that do not physically match the worker.

Although there is limited scientific study of these injuries and causes, some people have found relief after ergonomic changes to their work environment. Complaints typically involve back pain, eye strain, headaches, arm and shoulder pain, and finger or wrist pain due to carpal tunnel syndrome. Common ergonomic suggestions include adjustable chairs, footrests, armrests, adjustable keyboards, high-resolution low-flicker monitors, and improved lighting. Most of these adjustments are relatively inexpensive today, but can add up if new chairs and desks are needed for thousands of workers.

Pointing Devices

With the increased use of graphics and pictures, it is common for computers to use pointing devices for input. A mouse is the most popular device in use today, although pressure-sensitive pens, touch screens, and digitizer tablets are heavily used in some applications. Touch screens are commonly used for displays that involve customers or other atypical computer users, but they are also common on tablet PCs. Many tourist bureaus, hotels, and shopping areas use computer displays with touch screens to give directions to visitors. Besides the fingerprints, the biggest problem with touch screens is that the tip of your finger is often too large to be a useful pointer. For more detailed use, an engineer who is designing a wiring diagram for an automobile would use a digitizer tablet with a special pen to draw fine lines and select individual points that are close together.

Scanners

When you are dealing with pictures, it is often helpful to have a scanner convert a paper-based image into digital (bitmap) form. For certain types of images (line drawings and text), vector tracing software can convert the bitmap image into vector form. Most digital cameras also have the ability to take photographs of paper documents. The benefit of the camera approach is that the camera is much faster at capturing the image. Some photocopiers use a similar process to enable workers to scan documents and e-mail them to a computer.

The quality of a scanner is measured by the number of pixels per inch that it can distinguish as well as the number of colors. Most scanners can read at least 600 dots per inch. More dots mean you get finer lines and sharper pictures.

Scanners also can be used to input text and data into a computer. The scanner first converts the page into a picture of dots. Then **optical character recognition (OCR)** software examines the picture and looks for text. The software checks each line and deciphers one character at a time. Although OCR software is improving, it is not 100 percent accurate. Some systems automatically look up each word in a dictionary to spot conversion errors and improve accuracy. Even then, users report about a 95 percent accuracy rate—which is highly dependent on the quality of the original document.

Digital cameras can also function as scanners. The principle is the same—the camera has a sensor that captures individual pixels. Most cameras have a setting optimized for taking pictures of black-and-white pages of text. It can be useful for quick captures of a couple of pages, or for storing notes taken on a board.

Sound

Sound is initially captured with a microphone that converts sound pressure waves into electrical signals. A *sampler* then converts these signals into numeric data that can be stored on the computer. Musical **synthesizer** technology is used to convert the numbers back to electrical signals that can be heard with speakers. Sound boards can be purchased for personal computers that contain both the sampler and synthesizer technology. Digital sound conversion occurs on almost every long distance telephone call you make. Your voice is converted to 1s and 0s to be sent across fiber-optic telephone lines.

Speech Recognition

As long as computers have existed, individuals have dreamed of being able to talk to them and have their words translated into text. Today, computers can digitize

Reality Bytes: People Really do Want Digital Content

For several years, book publishers have resisted shifting to digital books. Part of the reason is because several early e-book readers were weak, had limited support, and were not adopted by customers for those reasons. After Amazon introduced the Kindle e-book reader, and then dropped prices with the second and third versions, people began buying them in large numbers—although Amazon does not report the actual number of Kindle sales, which are estimated to be in the millions. Several other companies, including Apple through its iPhone and iPad apps also provide reading devices for digital text. At the end of 2010, Amazon reported that it had sold 15 percent more Kindle e-books than paperbacks. By the middle of 2011, Amazon reported that sales of e-books exceeded the sales of all print books. And that is not counting downloads of the free, public domain e-books.

Adapted from Matt Hamblen, “Amazon.com Touts More e-Book Sales than Paperbacks,” *Computerworld*, January 28, 2011.

and record speech, and they can convert spoken words into computer text. Some problems still exist, and the systems need to be trained to a specific user. Common problems include the use of homonyms, variations in speech patterns or dialects, and the effects of punctuation on meaning.

Initially, speech recognition systems were adopted by occupations that require note taking along with two hands to do the job. Quality control inspectors and surgeons use them regularly. As performance continues to improve, we will see an expanded use of speech recognition systems among all users. Ultimately, speech recognition will be a key element in dealing with computers. Keyboards do not work well in a wireless environment. They are too large to be portable and hard to use.

Today, speech recognition is built into the Windows operating system. Speech recognition generally requires you to train the system to recognize the way you pronounce various words and phrases. If you enunciate clearly and learn to dictate in complete sentences, speech recognition is relatively accurate. You can also use voice commands to start applications and issue simple commands to the computer. However, the industry still has a long path ahead for speech recognition to begin replacing keyboards.

Video Capture

As technology improves, companies are increasingly adding video clips to presentations and Web sites. Digital video transmissions are also being used for communication. Today, most television monitors can be used as computer monitors. The HDMI connector that is common on HDTVs is becoming a standard way of connecting video equipment, including computers. On the flip side, capturing or displaying television signals on your computer requires additional hardware—specifically a tuner or capture card. A common television digital video recorder (DVR) is really just a computer with a capture card and a large hard drive. The challenge is that the capture card has to be matched to the type of input: over-the-air digital broadcast, cable-TV digital signal, satellite signal, or video camera input. Throw in the complication that most digital broadcasts are encrypted, and it becomes difficult to build your own capture system. Interestingly, it is actually

Printer	Initial Cost (dollars)	Cost per Page (cents)	Quality (dots/inch)	Speed (pages/min)
Laser: B&W	300 - 20,000	0.6 - 3	600 - 1200	4 - 8 - 17 - 150+
Laser: Color	500+	5 - 75	600 - 1200	1 - 30
Ink jet	50 - 800	5 - 150	300 - 1200	1 - 20

Figure 2.21

Printer evaluations. Printers are evaluated in terms of initial cost, cost per page, resolution, and speed. There are many types of printers, led by laser, ink jets, and dot matrix printers. Prices vary depending largely on speed and resolution. Technological changes are leading to new varieties of printers that can produce full color at a cost of around 5 to 10 cents per page.

easier to deal with over-the-air HDTV broadcasts in 2011. The quality is generally good (often better than cable TV), the signal is not encrypted, and it is free.

Output

Most people are interested in two types of output: video and paper copy. Video output is created by a video card and displayed on a monitor. Computer projection systems for meetings and presentations use high-intensity light to project an image onto a screen. In addition to resolution, they are evaluated by the intensity of the light, measured in lumens. Other display technologies have been developed including heads-up displays for cars, personal projection systems that project an image from special glasses, and electronic ink that displays text and images on flexible displays.

The other common output device is the printer. Printers come in many different forms. The most common formats are laser and ink jet, where the output is created by printing dots on the page. Common resolutions include 600 dpi and 1200 dpi lasers. In contrast, standard typesetters, such as those that are used to print books, operate at resolutions of at least 2,400 dots per inch. Again, higher-resolution devices are more expensive. Also, the increased amount of data being displayed takes longer to print (for the first copy).

Laser printers operate much like photocopiers. In fact, newer copiers include hardware to connect to a local network so the departmental copier can function as a high-speed printer. From your desktop, you can tell the printer to make multiple copies and collate and staple them—at speeds of over 70 pages per minute. As noted in Figure 2.21, the initial cost is usually only a minor component of a printer's price. It is more important that you look at the cost per page—particularly for color copies.

Secondary Storage

Why are there secondary storage devices? Why not just store everything in high-speed RAM? The main reason is that standard RAM is dynamic—which means that the data disappears when the power is turned off. The second reason is cost: a terabyte hard drive costs less than \$100. Even at today's relatively low prices, the equivalent amount of RAM would cost several thousand dollars. On the other hand, because disk drives are mechanical, they are slow and can fail. Some companies, notably Google, have invested in huge RAM drive storage. All of the

Drive	Capacity (gigabytes)	Speed (Write MB/s)	Initial Cost (dollars)	Cost/GB (dollars)
Magnetic hard	80 - 3,000	60 - 200	65 - 200+	0.07
SSD	16 - 512	60 - 320	200 - 900	1.76
USB drive	2 - 64	25 - 150	10 - 115	1.80
Tape	250 - 2,000	20 - 120	300 - 5,000+	0.50 - 1.00
CD-ROM	0.70	2 - 8	50	0.18
DVD	4.77 (8.5 DL)	2 - 21	50	0.04
Blu-Ray	25 (50 DL)	4.5 - 36	80	0.12
Blu-Ray BDXL	128			

Figure 2.22

Secondary storage comparison. Hard drive prices and speed make them the best choice for secondary storage. Tapes make good backup systems because of the cost per gigabyte and 50-100 gigabyte storage per tape, but the sequential storage makes it harder to retrieve data.

search indexes are stored in RAM, resulting in substantially faster searches instead of relying on disk drives.

Hard disk drives are the most common method of secondary storage. The primary drawback to disk drives is that data transfer is limited by the physical need to spin the disk and to move the read/write heads. Besides being slower, mechanical processes are sensitive to movement and deteriorate faster than pure electronic systems. Consequently, several manufacturers have developed static memory chips that hold data for portable devices—like Sony’s memory stick. The USB drives are a popular method for transporting data and have quickly replaced floppy disk drives.

A more recent variation is the **solid state drive (SSD)** which has even faster read/write speeds and is packaged similar to a standard hard drive. In particular, SSDs for laptops plug into the same slot as a standard hard drive. Today’s USB and SSD drives are as fast or faster than hard drives—even for write speeds. So, the biggest problem is price. SSDs are roughly fifty times more expensive than hard drives. But, this price difference has been declining, and as vendors focus on improving the chips and the production capacities increase—these prices should continue to drop.

Except for prices (declining) and capacity (increasing), typical hard drives have changed little during the last few years. Secondary storage is needed to hold data and programs for longer periods. Secondary storage is evaluated by three attributes: capacity, speed, and price. Figure 2.22 shows the values for different types of storage.

With the increasing importance of data, companies are searching for ways to prevent loss of data by providing continuous backups. One straightforward method is to install an extra disk drive and keep duplicate copies of all files on this *mirror drive*. If something goes wrong with one of the drives, users simply switch to the other drive. A second method of protecting data is known as a **redundant array of independent drives (RAID)**. Instead of containing one large drive, this

system consists of several smaller drives. Large files are split into pieces stored on several different physical drives. At the same time, the pieces can be duplicated and stored in more than one location. In addition to the duplication, RAID systems provide faster access to the data, because each of the drives can be searching through its part of the file at the same time. Essentially, RAID drives use parallel operations to dramatically improve the storage and retrieval of large documents.

On personal machines, even if you do not want to spend the money for a RAID solution, it can be a good idea to buy two hard drives instead of one large drive. Particularly for data-intensive applications like video editing, it is wise to put the operating system and application software on one drive and place the data files on the second drive. Two drives are better than one because the computer can retrieve the data simultaneously from both drives. In fact, video and large database applications often benefit from using three drives: one for the system, one for the main data, and one to hold temporary files. Putting everything on one drive forces the computer to trade between tasks and wait for the single drive to spin to the proper location.

Magnetic tapes are also used to store data. Their biggest drawback is that they can only store and retrieve data sequentially. That means you have to search the tape from the beginning to find any data. A single tape can hold 20 to 400 gigabytes of data. Compression can double or triple the capacity of a single tape, driving the cost per gigabyte from \$0.50 down to \$0.20 or lower. Because of these two features, tapes are most commonly used to hold backup data. Just be careful to store the tapes safely, and stay away from ultra low-cost drives that might fail.

With the increased use of images, sound, and video, there is a need for substantially greater storage capacity for data files. Optical disks have provided substantial capacity at relatively low costs. The optical (or magneto-optical) disk drive uses a laser light to read data stored on the disk. **CD-ROM** stands for compact disk-read only memory, the format used to store music CDs. The ROM portion of the name means that you can only read data from the disk. But, actual storage depends on the type of blank disk and your CD burner. Standard disks can be written once, or you can use rewritable disks. However, rewritable disks might not be compatible with other systems. The biggest drawback is that saving data to a CD is relatively slow. And, 700 megabytes does not go far these days.

The **DVD** (digital video disk or digital versatile disk) is a significantly better technology. DVD was created to distribute digitized video. Compared to CD, the strengths of DVD are (1) increased capacity, (2) significantly faster access speeds, and (3) standards for audio, video, and computer data. A basic DVD holds 4.77 GB of data. However, the commercial DVDs for movies can hold as much as 8.5 GB of data by using an advanced writing technique (dual layer).

Blu-Ray is the most recent format created for storing high-definition digital video data. Sony, the leader in the Blu-Ray consortium, reports that a dual-layer Blu-Ray disk can hold 50 GB of data—enough for about four hours of high-definition video recording. You can also purchase Blu-Ray recorders. The burners have dropped in price, but the blank disks are still expensive. Probably too expensive to use as backup devices. But, the prices should drop over time and it would be useful to be able to store 50 GB at a time on a backup disk.

Operating Systems

Why is the operating system so important? Computers follow instructions called software that are written by programmers. Every computer needs one

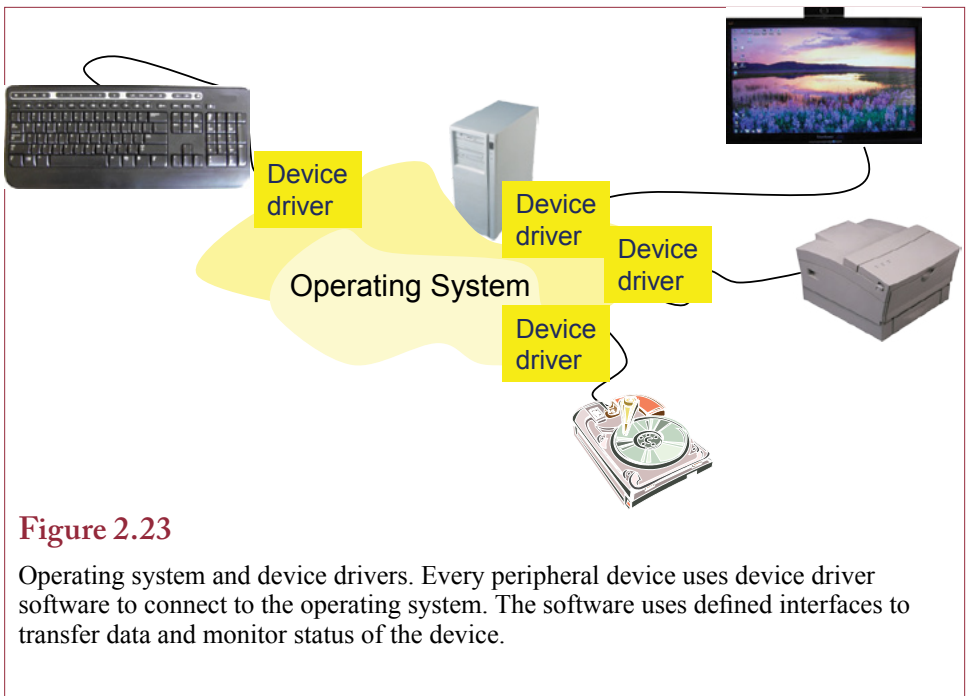


Figure 2.23

Operating system and device drivers. Every peripheral device uses device driver software to connect to the operating system. The software uses defined interfaces to transfer data and monitor status of the device.

special type of software known as the operating system. The **operating system (OS)** is software that is responsible for communication among the hardware components. The operating system is also a primary factor in determining how the user deals with the machine.

As shown in Figure 2.23, the OS handles the interaction with other devices through **device drivers**, which are small software programs that provide hooks that are called by the OS to execute commands on the device. For example, a printer driver provides a standard set of commands to the operating system, and handles the details of drawing text and objects on the specific printer. These software drivers are routinely updated by the vendors to fix bugs and add new features. The power of this approach is that any vendor can create a new device. By creating an appropriate driver, even older computers can take advantage of the new device.

Historically, each computer manufacturer created its own operating system tailored for that specific hardware. Proprietary operating systems caused many problems; in particular, changing vendors typically required purchasing new application software. AT&T researchers began to solve this problem when they created a hardware-independent operating system. It is known as UNIX and was designed to work with computers from many different manufacturers. However, UNIX is not a complete standard, and application software must generally be rewritten or at least recompiled before it can function on different computers.

Today, fewer operating system choices exist. Personal computers generally run a version of Microsoft Windows. The other main alternative is a variation of the UNIX operating system. Several years ago, much of the UNIX code was essentially released to the public (although a few lawsuits remain over exactly who owns parts of the code). Linus Torvalds used the code to create an inexpensive and rela-

Reality Bytes: Where Are You Going to Put Everything?

Most large corporations are reluctant to trust their data to anyone else. A survey of 247 Fortune 1000 firms by TheInfoPro in 2011 revealed that only 10 percent were even considering the public cloud for even the lowest tier of data. Most companies (73 percent) are relying on Fibre Channel storage area networks (SANs), even over network-attached storage (NAS). Although companies are unwilling to trust data to public cloud providers, they were willing to store data on private clouds.

Adapted from Lucas Mearian, “Fortune 1000 Firms Shun Public Cloud Storage,” *Computerworld*, May 4, 2011.

tively popular version for personal computers. His base versions are called Linux and form the core of several open source systems. The Linux system is available in several varieties for personal computers. It is also embedded in many devices such as eBook readers. Apple computer also adopted the UNIX foundation with its OS X operating system. Most midrange computers and many servers also run an operating system derived from UNIX. Notably, IBM (AIX and Linux) focuses on UNIX versions for its servers. IBM also continues to support some older, proprietary operating systems. For servers and midrange systems, you still typically use the operating system provided by the hardware manufacturer.

The battle over operating systems continues today. At least some portion of Microsoft’s market strength is tied to its ownership and control of the desktop operating system (Windows). The standardization of the operating system has made it possible for vendors to create thousands of useful software applications. The relatively open platform has encouraged the development of thousands of new hardware devices that can be easily installed in millions of computers worldwide. Yet the common operating system has also made it easier for hackers and viruses to attack millions of machines. And many smaller companies are concerned about the ability to compete against a company as firmly entrenched as Microsoft.

The operating system battle now extends into cell phones—which are essentially small handheld computers. For years, cell phone manufacturers used their own proprietary operating systems. As smart phones became more popular, the operating system became more important and vendors began to choose among a few standard versions. Apple phones use their iOS system; many other phones use the Android operating system developed and maintained as open source by Google. Microsoft also provides a Windows operating system for cell phones, and some vendors (notably Blackberry) use their own systems.

To a user or manager the choice of an operating system is probably not important. However, it does affect how you use the device, and it might limit the applications or software available for the device. In general, you pick a device based on reliability, capabilities, and the availability of the software you want to use.

Computers in e-Business

How does the Internet change the role of computers? The Internet and the Web changed computing and business in several ways. Beyond the issues of connectivity, the key feature of the Web was the introduction and acceptance of the browser. The reason the browser is so important is that it has become the standard display mechanism. Increasingly, applications are being built that rely

Reality Bytes: How Safe is Your Data?

Check out an ad for a disk drive and you will see many specifications. The mean time between failure (MTBF) is an important one because it indicates the reliability of the drive. Manufacturer data sheets often indicate MTBF between 1 and 1.5 million hours. However, a Carnegie Mellon study coauthored by Garth Gibson of 100,000 disk drives in data centers run by Google indicate that actual failure rates are substantially higher. The posted MTBF numbers would indicate annual failure rates “of at most 0.88 percent.” In reality, typically 2 to 4 percent of the drives failed, with some systems having failure rates of 13 percent. Professor Gibson pointed out that not all of the drives had actually failed. Sometimes it is difficult to identify the cause of a problem and drives are removed in the testing process. Vendors report that as many as 50 percent of returned drives actually work fine. The dirty, hot, vibration-prone environment of a data center is also harder on drives than a clean-room testing center. Regardless of the failure rates, disk drives are mechanical so they are less reliable than pure electronic equipment. Consequently, you must always assume that a drive can fail and ensure that you have proper backups to recover your data.

Adapted from Robert L. Scheier, “Disk Drive Failures 13 Times what Vendors Say, Study Says,” *Computerworld*, March 2, 2007.

on the services of the browser. When the browser becomes the most important display device, then nothing else matters. To emphasize the point, in 2011, Google introduced an operating system for simple hardware that is based completely on their Chrome browser. All operations are designed to work across the Web. Although this approach might seem extreme to those used to working on traditional PCs, it is similar in many respects to mobile computing on cell phones and tablet computers.

A Web-based approach with a stripped down operating system has several potential benefits. The hardware can be simpler and cheaper. The computer and start up and shut down much faster. All data is automatically stored on central Web servers, which provide backup and access from any location. Software is upgraded and replaced on the servers instead of each PC.

In terms of drawbacks, the most important one is that you need good access to an Internet connection. Without the Internet, you might as well be carrying a brick. You also rely on the servers—both in terms of uptime and maintenance and in terms of pricing. Services that are free or low-cost today might suddenly become expensive if the service providers decide to charge higher prices. Your data is also no longer in your control—you run slightly higher security risks in terms of data transmission and data storage.

Many of these issues reflect ongoing decisions between centralization and decentralization, which are covered in more detail in Chapter 12. In the past, the decisions applied primarily within companies. The Web now makes them pertinent to everyone.

What Is a Browser?

At heart, browsers are simply software display devices. They read incoming files, recognize the data type, and display the data as instructed. The data could be text, images, sound, or even video. However, the sound and video are usually handled

Technology Toolbox: Creating Effective Charts

Problem: You need to create a chart that users can understand.

Tools: Spreadsheets contain powerful tools for creating charts; however, you must be careful when using the tools to ensure that the features are used to make the chart more informative and easier to read.

The first step in creating a chart is to enter the data correctly and perform any needed transformations. The second step is to choose the correct type of chart to emphasize your message. The third step is to clean up the chart and make sure it contains the proper title and labels. The table shows the main purpose for each chart type and the common mistakes made by novices.

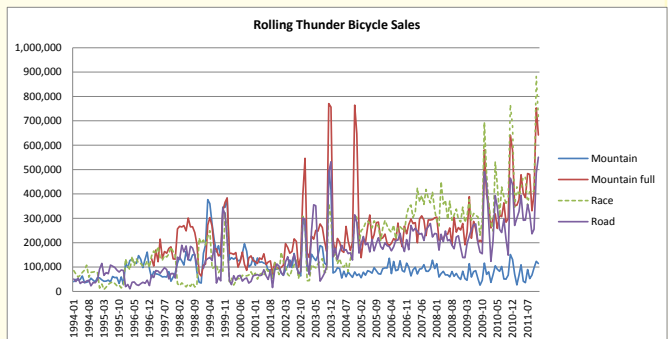
Chart Type	Purpose	Most Common Mistakes
Bar or column	Show category values.	Too many series Unreadable colors Not zero-based
Pie	Compare category percentages.	Too many observations/slices Unreadable features/3-D Poorly labeled
Line	Show trends over time.	Too many series Poor or missing legend Not zero-based
Scatter	Show relationship between two variables.	Poor choice of variables Not zero-based

One major mistake that is common to all chart types is to use excessive ornamentation. As Edward Tufte points out in his book *The Visual Display of Quantitative Information*, graphing software offers many temptations that should be avoided. Make sure every option you choose highlights the main purpose of the chart. Avoid cluttering your graph with excess lines, images, or garish color schemes. The goal of any design is to strive for elegance.

Creating a chart in Excel is straightforward. In this example, export the sales by model by month from Rolling Thunder Bicycles. Open the generated spreadsheet and select all of the data cells. Click the chart button and build the line chart. To simplify the chart, remove the Hybrid and Tour models.

Quick Quiz: Create the following charts:

1. Use the export data form in Rolling Thunder Bicycles to generate sales by state. Create a column chart and a pie chart for this data. Briefly explain why one chart is better than the other.
2. Using Bureau of Labor Statistics data, plot the unemployment rate and the hourly wage rate over three years.



Reality Bytes: GPU Processors Go High Performance

Gamers and other users of high-end graphics know that Nvidia is one of the largest providers of high-powered graphics cards. The cards are based on a graphics processing unit (GPU) architecture where each card contains many small high-speed processors. Although a high-end graphics card might appear to be expensive, on a per-GPU basis, the costs are considerably lower than for traditional processors. Consequently, Nvidia also builds specialty cards for supercomputers that use thousands of the GPUs to handle massively parallel computations. In 2011, a single Tesla M2090 card could produce up to 665 GigaFLOPs of computations. The M2090 has 512 “Cuda” cores and GDDR5 memory cards. Transferring heat off the cards is a major design consideration and the cards come complete with liquid-cooled heat sinks. The cards support code written in common languages including C++, FORTRAN, Java, and OpenCL. The M2090 can be plugged into relatively standard computers through an arrangement with HP. Nvidia also sells plug-in modules for supercomputers, including those from Cray Research.

Adapted from Jonathan Angel, “Nvidia Taps GPUs for ‘World’s Fastest’ Parallel Processing,” *WindowsForDevices.com*, May 17, 2011.

by an add-in component for the browser because standards are still evolving. To add more interactivity, browsers also have an internal programming language (JavaScript). Developers can include program code that gives detailed instructions to the browser and reacts to changes users make. For example, when users move the cursor, the code can highlight an object on the browser. Browser code is also used to check user data. This code runs entirely on the local machine, but can send data in batches to the Web server.

The beauty of the browser approach is that it standardizes the way data is displayed, so that everyone is free to choose any hardware and software platform they prefer. Since browsers are relatively easy to implement and do not require huge amounts of hardware, they can be built into smaller, portable devices. Combined with the wireless Internet possibilities, these new devices have the ability to change the business world.

As technology and the Internet become more important in our lives and businesses, portability becomes increasingly critical. Even the portability offered by laptops is useful. For example, you might need to pull up sales data in a meeting or take some work home with you. In other cases, even more portability is needed. Tablet PCs and PDAs provide the ability to access the Internet and your corporate servers as long as you can find a network connection. Wireless connections are available in many locations, but still have limited range. Newer cell phones offer greater connectivity to the Internet from any major city or transportation area in the world. As people demand greater continuous access to the Internet, portable devices become more important. At the same time, the servers that store the data and provide the major processing will also become more important.

What Is a Server?

Do you want to run a Web site? Being a participant in the Internet and running a browser is one thing. Running a Web server is completely different. Establishing an e-business requires that you either run a server or pay someone to run it for you, so you should understand some of the main issues in Web servers.

Reality Bytes: International Notations

Most applications today have the ability to use characters that are not found in the U.S. alphabet. For instance, in France or Mexico, you might need to use an acute mark (é). However, different software packages handle the characters differently, so you might have trouble converting a document from one word processor to another or to a different computer. For example, if a French subsidiary is using WordPerfect and the Canadian headquarters is using Microsoft Word, they can both print reports using the special characters. However, the document might change when the Canadian users attempt to retrieve a French document electronically.

Furthermore, if you work for an international organization, remember that people in different countries write dates differently. For example, 5/10/93 means May 10, 1993, in the United States but would be interpreted as October 5, 1993, in Europe. Most word processors enable you to choose how automatic dates should be displayed.

Numbers are also handled differently in European nations. The use of commas (,) and points (.) is reversed from the U.S. version where commas separate thousands and the decimal point delineates the fractional component. (the number 126,843.57 in the United States should be denoted as 126.843,57 in Europe.)

You also need to be careful with currencies in spreadsheets. When you transfer documents to other languages or fonts, be sure to check any currency symbols. A few systems will automatically change the symbol to the local units (e.g., change \$ to £), but unless the numbers are converted by exchange rates, these changes would be incorrect.

Technically, almost any reasonably up-to-date PC can function as a Web server. A Web server is essentially a piece of software that monitors the full-time Internet connection and delivers the requested pages. But to perform e-business tasks, the server also needs to evaluate programmed Web code and interact with a database. In most cases, the primary issue with Web servers is **scalability**, the ability to increase the computing power without changing the application. The goal is to build a server inexpensively enough to make the application profitable, yet capable of expanding to handle increased demands of the future.

In terms of hardware, the primary characteristics that you want in a Web server are (1) scalability, (2) easy backup, and (3) easy maintenance. One solution to all of these problems is splitting the major computer components into separate pieces. For example, server farms use multiple small computers instead of one large machine. A storage area network (SAN) can be built using fiber channel connections to a set of external disk drives.

High-end servers have built-in backups for all critical components. For example, they have dual power supplies, network cards, and hot-swappable disk drives in a RAID configuration. If a power-supply or disk drive fails, the other copy automatically picks up the load. In most cases, the failed component can be replaced without turning off the computer (hot-swapped). More sophisticated servers can be built into server farms that contain multiple computers that distribute the computing load and have access to the same databases. If one computer fails, the others automatically handle the incoming tasks. More importantly, the system can be scaled up by adding more computers.

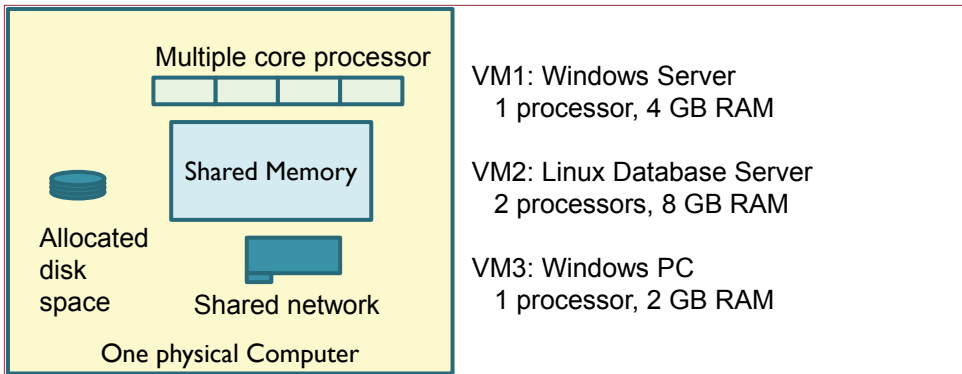


Figure 2.24

Virtual machine. One set of computer hardware is configured to run multiple, independent operating systems. Particularly useful for servers, the goal is to allocate the hardware to the tasks that are busy.

Virtual Machines

With multiple-core processors and tons of memory available, it is common practice today to set up computers as virtual machines. A **virtual machine (VM)** is the process of running a separate computer in software on top of one set of hardware. Generally, the process is used to run multiple virtual computers on a single set of hardware. Basically, one physical set of hardware is configured to run multiple operating systems at the same time so it appears to be several separate computers.

Figure 2.24 illustrates the basic concept of a virtual machine. One physical computer is used to host three separate computers. The hosted VMs are often servers, but the technique can also be used for personal computers. The goal is to allocate hardware resources to the VMs that need the additional computing power. The technique can save money, space, and electrical power, by reducing the amount of physical hardware. It is also useful for separating tasks. Some server software can interfere with other tools and it is often easier to run them separately. VMs also make it significantly easier to backup and restore the entire computer. Once the VM is created, it is stored as a software file on the disk drives. If anything goes wrong, the file can be reloaded and the entire VM is recreated immediately—without needing to reinstall the operating system and all of the applications. On personal computers, the VM technique can be used for creating development and test environments. One system could be used for day-to-day work, and another for testing experimental software. If the experimental software causes problems, the entire VM can be deleted with no effects on the production computer.

VMs can be useful, but keep in mind that you usually need separate software licenses for each VM—both the operating system and the application software. If the systems are based on open-source software, or the organization has a site license these costs are minimal.

Application Software

What are the main software applications used in business? The main reason for buying a computer is its application software. Regardless of your job, you will always perform certain tasks. As a manager and decision maker, you

first have to gather data (research). Then you analyze the data and determine alternatives (involving calculations). Next you will make decisions and implement them (requiring writing, communication, and organizing resources). Each of these tasks can be supported by computer resources. The trick is to use the appropriate tools for each task. The objective is to use the tools to make you more productive in your job.

The catch is that productivity is a slippery problem in business—especially with respect to computer tools. One measure of productivity involves efficiency: Can you perform tasks faster? A second, more complicated measure of productivity involves effectiveness: Can you make better decisions? Early uses of computers focused on improving efficiency by automating manual tasks. The tools were often justified on the basis of decreased labor costs. Today, managerial uses often focus on effectiveness, which is harder to measure.

An important concept to remember with application software is that it was created by teams of designers and programmers. In the “old” days, when software was custom-written for specific companies and users, users could tell the designers how the software should behave. Today, most companies rely on **commercial off-the-shelf (COTS)** software that is created to support the needs of millions of different users. In creating the software, designers had to make thousands of decisions about what the software should do and how it should appear. Sometimes their final choices might seem strange, and software does not always work the way you might prefer. Some issues can be resolved by customizing the software to your particular situation. Other times, just remember that you acquired the software for a tiny fraction of the price you would have paid for custom software.

Research: Databases

Almost any job involves workers searching for information. This search could involve any of the five basic types of data. Computers have made it substantially easier to find, compare, and retrieve data. Two important strengths of a *database management system (DBMS)* are the ease of sharing data and the ability to search for data by any criteria. In terms of productivity, a DBMS can both make you more efficient and improve your decisions. It improves efficiency by providing easier and faster data retrieval. By providing more complete access to data, a DBMS helps ensure that your decision incorporates all relevant data.

One complication with research is that you must first determine where the information is located. It could be located on your personal computer, the group’s networked server, the company’s central computers, a computer run by the government, or one purchased from another company. Unless all of these databases are connected, you must first determine which database to search. Chapter 5 focuses on the use of database management systems. Today, along with numbers and text, DBMSs can handle large text files, pictures, sound, and video. DBMSs form the foundation of almost all business applications.

Today, almost all data in a company is stored in a DBMS, and the things that are not stored in the DBMS really should be there. Even data outside the company such as government data and data from suppliers is often stored in a DBMS. Research typically involves finding and retrieving the relevant data from a DBMS.

Analysis: Calculations

Almost everyone performs computations in a job. Spreadsheets were initially created to overcome the limitations of simple calculators. They are useful for com-

Reality Bytes: Keyboards are Faster than Mice

Key	Task
Ctrl-A	Select all
Ctrl-C	Copy
Ctrl-V	Paste
Ctrl-P	Print
Ctrl-S	Save
Ctrl-X	Cut
Ctrl-Z	Undo
Alt	Menu, then number or letter
Alt-Tab	Switch application
Windows-#	Start applications in taskbar
Windows-D	Show desktop (and restore)
Windows-L	Lock the computer
Windows-P	Projector/switch display
Windows-R	Run box
Ctrl-F4	Close document
Alt-F4	Close application
Ctrl-F6	Switch document within application
Shift-Select	Click or arrow, select contiguous items
Ctrl-Select	Click, select multiple discrete items

Adapted from Patrick Miller, “Windows Toolkit: 50 Super Software Secrets,” *Computerworld*, July 2, 2010.

plex calculations and for creating charts. Most people find spreadsheets useful because their disciplines began with models on paper that used columns and rows of numbers. For instance, most accounting systems and financial models were designed for ledgers in this way. Whenever software mimics the way you already work, it is easier to learn.

Spreadsheets have many additional features. Graphs can be created with a couple of mouse clicks. Most packages enable users to modify the graphs by adding text, arrows, and pictures. Spreadsheets also perform various statistical and mathematical analyses. You can perform basic matrix operations such as multiplication and inversion. Statistics capabilities include multiple regression to examine the relationships among different variables. Linear programming can be used to search for optimum solutions to problems. These additional features are designed to help you make better decisions by providing more powerful decision-evaluation tools.

The problem with spreadsheets is that people use them to store data. It is also too easy to make mistakes on spreadsheets that are difficult to spot. What often happens is that someone develops a spreadsheet to analyze some data, then other people use the spreadsheet and modify the data and formulas. Fairly quickly, there

are multiple versions of the spreadsheet, out-of-date data, and errors in the calculations. And managers want to use these to make decisions. Yes, it is possible to improve the way spreadsheets are built, and Chapters 3 and 8 show ways in which spreadsheets can be shared. But, ultimately, spreadsheets are often better used as short-term tools. They are useful if you need to analyze a small set of data or make one-time calculations. Any decision that requires large, changing, data sets, multiple people, and critical analyses should be built as a specific application. Chapter 9 examines some of the more powerful analytical tools available that can be used for complex decisions.

Communication: Writing

The primary gain from word processing is increased efficiency. Word processors improve communication by making it easier to revise text, find writing errors, and produce legible reports. Word processors today also include a spell-checker, a thesaurus, and a grammar-checker. Although they are not the same as having a human editor correct your writing, these are all useful tools for writers. Grammar-checkers use standard measures to estimate the reading difficulty level of your writing. For instance, if you write an employee policy manual, you want to make sure that an average employee can understand it. Most word processors also have outline tools that help you organize your thoughts and rearrange a document, improving the communication.

The proliferation of word processors creates additional advantages. Today, all documents should be electronic. It should be possible to search electronically for existing reports, manuals, and so on.

Communication: Presentation and Graphics

In many cases, the difference between a good report and an outstanding report is the presence and quality of the artwork. Graphs and pictures are used to communicate information and feelings. Charts and graphs are easy to create, store, and modify using graphics software. Even if you are not an artist, you can buy **clip art** that was created by someone else and use it in your reports or charts. By using existing art libraries, you can create reports and presentations in a few hours. In the past, reports and presentations took days or weeks to finish by a staff of artists. By improving the appearance, a well-designed graphic can also improve communication and decision making.

To create or modify your artwork, you need a graphics package and an input device such as a mouse that enables you to draw on the computer screen. Most commercial artists use scanners so they can draw the original on paper and convert it to computer form. The digitized form enables you to make very precise changes, since you can *zoom* into a specific area. Zooming is helpful if you need to force lines to meet exactly or you want to make changes to small items, such as eyelashes on a person.

Although you do not have to be an artist to incorporate artwork into your reports and documents, you do need an element of artistic sensibility. The goal is to use art to enhance your presentation, not clutter it. Knowing what looks good and using restraint are signs of artistic talent. Remember that faster does not always mean better. Use some of the time savings to put more thought into your presentations.

Communication: Voice and Mail

All jobs require communication—with coworkers, managers, and customers or clients. Word processors help with reports and memos, but much of our communication is less formal. Everyone is familiar with answering machines for telephones. Businesses have taken this concept a step further by using voice mail systems. **Voice mail** systems record messages much like an answering machine, but they store the messages in digital form on computers. They usually give the caller control over where the message is sent. Most people in the United States have dealt with systems that direct you to press buttons on the telephone to make choices. Some voice mail systems enable you to send the same message to several people. Some systems also enable you to skip messages or fast-forward to the end. Many are now tied to e-mail systems so your messages can be integrated into a single site. This process also makes it easier for companies to back up files and store data for later use. In particular, **e-discovery** systems can be used to archive all message data for easy search and retrieval during a lawsuit.

Networked computers can be used to send messages directly to other users. These **electronic mail (e-mail)** systems are typically used to send written notices to various people. They can be used to send pictures, facsimiles (faxes), or even voice messages if the computers have sound boards and speakers. **Instant messaging (IM)** is also relatively popular—often in the form of text messages sent by cell phone. It is nice to have several options for communication. The challenge is to choose the appropriate method for each conversation and each person. Some people prefer the immediate response of voice communication, others prefer the asynchronous nature of e-mail, so they can schedule communications around their work.

The basic problem with any communication system is that sooner or later it becomes cluttered with junk mail. One of the advantages of text e-mail is that the recipient can have the computer scan the messages to search for items that are important or interesting. With the appropriate mail filters, junk mail can be discarded automatically. Messages also can be retrieved and stored for future reference or forwarded to other people.

Organizing Resources: Calendars and Schedules

An important task of managers is to organize company resources so that they are used most effectively. An important function is scheduling workers. Schedules involving line workers entail making sure that there are enough employees to get the job done, but no extra employees. Schedules involving managers typically involve meetings and require trade-offs between competing demands for a manager's time. Several software tools are available to improve both types of scheduling and make more efficient use of the human resources.

Most managers spend a considerable amount of time in meetings. In fact, it becomes difficult to keep track of appointments, set up new meetings, and re-schedule meetings. The process is even more difficult when some participants are traveling or are based in another city or country. Several software packages store appointments and schedules on electronic calendars. Electronic calendar and scheduling software enables data to be shared with other people. For instance, each person in a department would use the electronic calendar to keep track of his or her personal, departmental, and corporate appointments. To schedule a meeting with departmental members, the manager selects an approximate time, specifies the priority of the meeting, and fills in the participants, location, and subject infor-

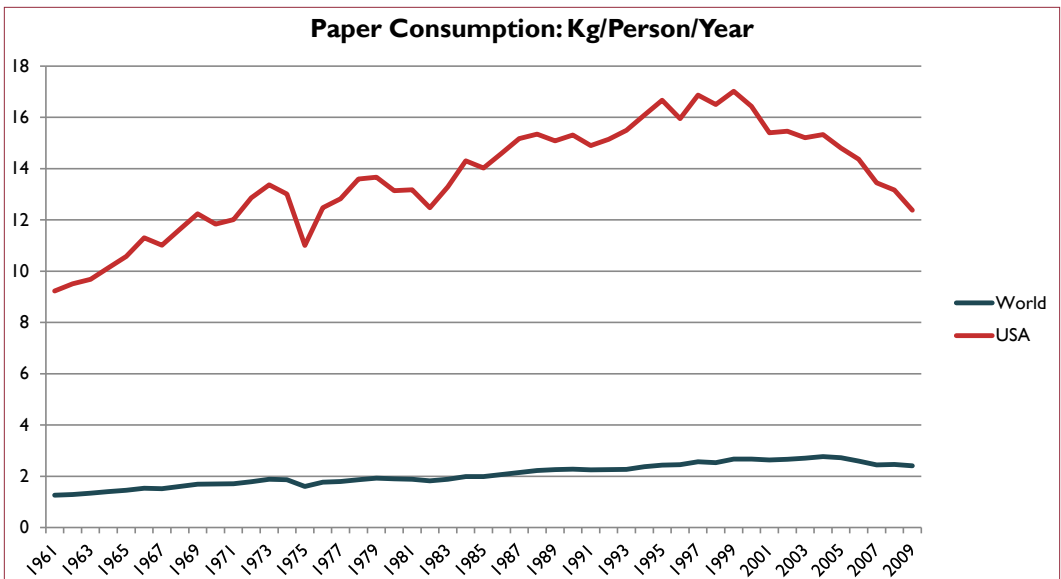


Figure 2.25

Paper (and paperboard) consumption appears to be declining in the U.S. and possibly in the world as well. As video screens improve and people become more adept at handling data online, there should be less need for paper. Raw data: UN Food and Agriculture Organization, <http://faostat.fao.org/site/626/DesktopDefault.aspx?PageID=626>.

mation. The calendar software then searches each personal calendar for the best time for the meeting. It overrides lower-priority meetings and places the complete notice on each person's calendar in a matter of seconds. Employees have to check their calendars periodically to see whether meetings have been added or changed.

Augmented Reality

Augmented reality is a specialized tool is useful in some business operations. So far, it has minimal uses in management, and the applications are still evolving. Augmented reality consists of overlaying computer-retrieved data on top of images of real-world items. One of the more useful applications was developed several years ago for mechanics working on highly-complex engines, such as jet engines for the military. Workers with special glasses would look at engine components and the computer would display an overlay of the schematics and the part numbers. The part numbers enabled the mechanic to easily order the correct replacement item for worn parts.

Today, people are more familiar with examples of cell phones, where the computer (phone) overlays information on images taken through the phone's camera. The technique combines location data with image recognition and retrieves matching data from online databases. A variation that has been proposed is to add facial recognition software and tag images with people's names. It might be useful for executives who meet hundreds of people a day, enabling them to add a "personal" touch by talking to people by name and retrieving background information. Or, the technology might lead to creepy versions of stalking.

The Paperless Office?

You might think that with increased use of electronic data, there would be less need for paper. For many years, the opposite was true. People tended to waste paper when they knew they could easily reprint a report. However, as display devices have improved, and people have become better at adjusting to electronic screens, it appears that the use of paper is decreasing—at least in some countries. Figure 2.25 uses UN data to show consumption of paper per person per year in the U.S. and the world. The world figures show a slight decline, but the drop for the U.S. is relatively strong over the last decade.

Some issues exist with long-term storage of electronic data. In terms of paper, libraries have stored books for hundreds of years. It is not clear that electronic data can survive even a few decades. First, the data might not physically last that long. Magnetic drives, Tapes, and even CDs and DVDs might lose their data over time. There are also unresolved issues about future compatibility. The hardware and software to read them may disappear in a short time.

Open Software

It is difficult and time consuming to create software. Commercial vendors spend billions of dollars researching customer needs, developing software, and updating and revising the code. For a few decades, major software development has been performed by large corporations that hire thousands of programmers and sell the software for a profit. Microsoft alone spends over \$6 billion a year on research and development. On the other hand, the marginal cost of a software product is almost zero. Almost all of the expenses are front-end fixed costs, except for marketing, distribution, and dealing with customers.

In the past few years, led by visionaries such as Richard Stallman with GNU and Linus Torvalds with Linux, a new approach to software development has arisen. Complex programs have been created by using the volunteer talents of thousands of programmers around the world. The result is software specifically developed to be distributed free of charge for anyone to use. The operating system Linux is a popular example, but several application packages exist as well.

As a manager, you will eventually have to answer the question of whether you should use open-source software or continue to rely on commercial packages. The answers are difficult, and discussions are often tinged with religious fervor. Although “free” seems like a good price, how much do you really pay for software? Today, the Windows operating system price is largely embedded in the cost of buying a new computer. On the other hand, more expensive packages such as the Office suite, graphics editor, or database management system can represent large sums of money.

Other issues in open-source software remain unresolved. Often, the open-source packages have minimal support and can be harder to use. Certainly, novices find the Linux/UNIX operating system difficult to learn. Issues about security are unresolved. With thousands of programmers working on millions of lines of code, it might be possible for someone to sneak in a tiny, but nasty, routine. On the other hand, with thousands of people looking through the code, the problem might be caught early. You also need to consider whether the open-source programs will be around for a long period of time. With no real income stream, can they survive? Will the leaders remain in charge? These are important questions to ask any software vendor. But the risks are slightly higher with open-source programs. On the other hand, you do get copies of the source code, so in theory, you could edit and

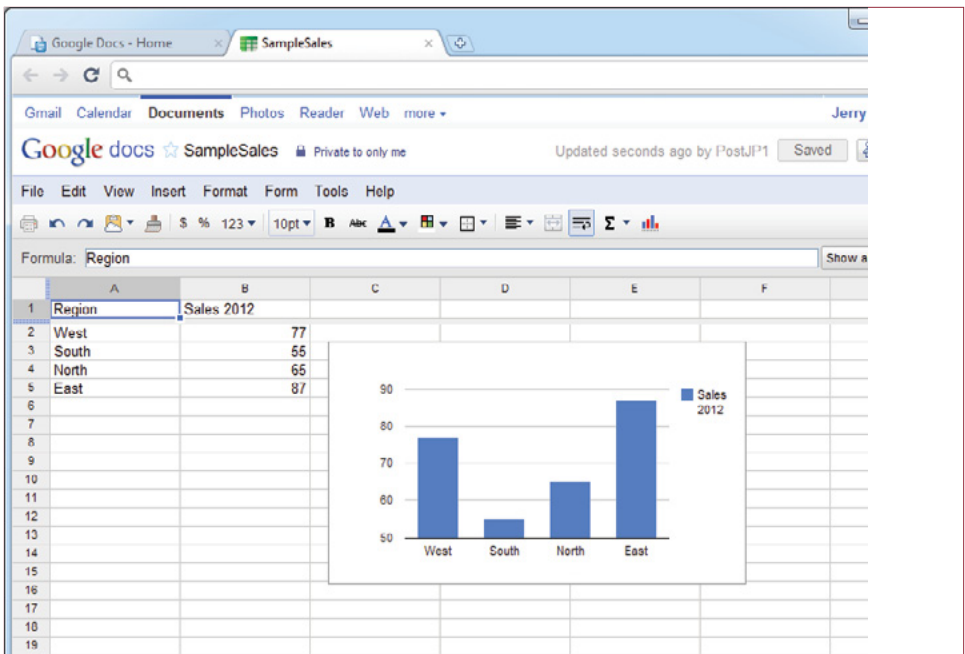


Figure 2.26

Spreadsheet in Google Docs. <http://docs.google.com>. Google Docs is a cloud service that is free for individuals or \$50/user/year for companies that need more services. You can create documents, spreadsheets, presentations, and drawings. The features are limited compared to standard Microsoft Office products but can be created using only Web browsers and are easy to share.

maintain the software indefinitely by yourself. But how many managers or companies have that ability?

In the end, the choice of software comes down to the features and the cost of support. Commercial software is generally supported and updated with the costs covered by the initial purchase price, and sometimes annual license fees. With software such as Microsoft Office, millions of people use the software and generally need minimal training. Open-source software usually has no up-front cost, but often carries annual costs for help, installation, and sometimes updates. Several companies, such as Red Hat and Oracle, make money selling support for open-source software.

Cloud Computing

Is it possible to handle all computing tasks with online services? When computers were first invented, they were large, expensive, and needed large numbers of support personnel. Consequently, all applications and data were run in a single location. Eventually, slow networks were created and display terminals were installed in various locations in a company. These terminals were basically keyboards with simple text displays but they enabled people to work on computer applications from their offices. All of the data and applications remained on the central computer. As minicomputers and personal computers were developed, computer applications and data moved outside the central computer.

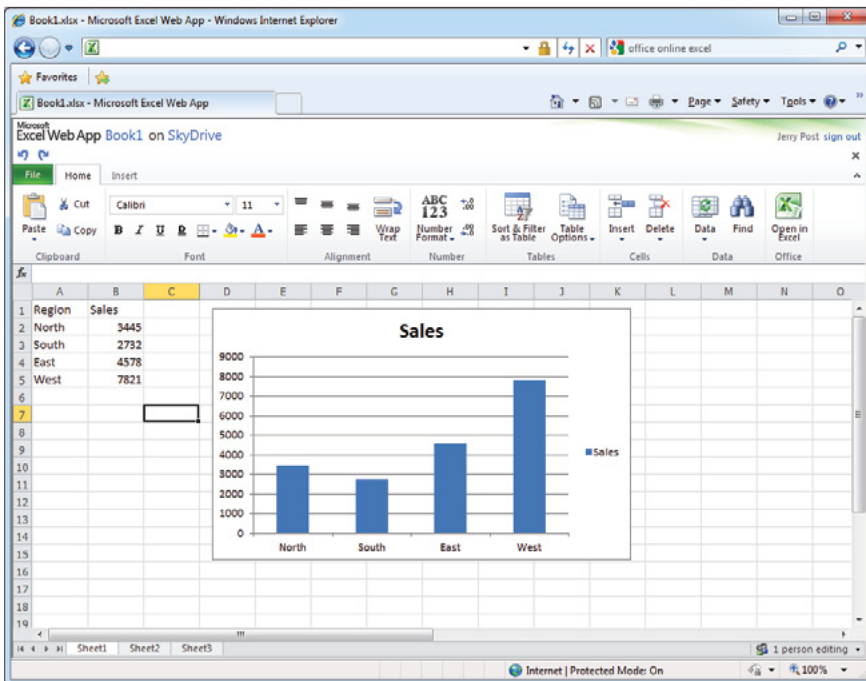


Figure 2.27

Spreadsheet in Microsoft Web Apps. <http://office.microsoft.com/en-us/web-apps>. The user interface is similar to the standalone Office tools with slightly fewer features. It is easy to upload and download documents to the standalone version and easy to share with other users. Online documents can be created and edited in a browser even on cell phones and tablets.

Gradually, computers got smaller and more powerful. At the same time, network speeds increased dramatically, making it possible to connect handheld devices at high speeds from almost anywhere in the world. These networks are explored in Chapter 3 and the consequences of data management are covered in Chapter 13. But, the key for this chapter is that these capabilities exist now, which provide a method to change the way people use computers. Today, central Web servers can hold all of the data and run applications, while users access them through powerful, but relatively inexpensive portable devices such as cell phones, tablets, and laptops.

Cloud computing is the popular term for storing applications and data on Web servers. The Internet is sometimes referred to as a *cloud* (and drawn that way) because the servers are interconnected and it does not matter where they are located. Often, cloud computing costs are based on variable prices with low or no fixed costs. Sometimes costs are low enough to be supported by advertising revenue so services are provided free to users. Most people are familiar with the social network services (Facebook, YouTube, and Twitter), as well as the search engine services (Google, Bing), and other specific applications such as photo sharing and editing sites (Picasa, Flickr, Photoshop). Thousands of cloud computing applications and sites exist and it seems that more are being created every day.

Think about cell phones and tablets for a second. For the most part, these devices use special-purpose operating systems (often Apple iOS or Google Android). These systems were not designed to run the commonly used business tools such as word processors, spreadsheets, and presentation software. But, do you really want them to run that software? And if they do, where are you going to store all of the data? Instead, it makes more sense to use the devices to display the applications, but leave the applications and data on a Web server. The two main cloud computing sites that provide these services are Google Docs and Microsoft Web Apps. Figure 2.26 and Figure 2.27 show a simple spreadsheet created on the Google and Microsoft services. The Microsoft applications are similar to the standalone Office applications, and it is easy to transfer the documents between the Web and standalone software. Both Google and Microsoft provide free access for individuals—but the advertising can be distracting. Google also sells a version for businesses that integrate a few additional features (such as a shared calendar) and eliminates the advertising for \$50 per user per year. With both the Google and Microsoft cloud services, documents can be created and edited using a basic browser, so they can be accessed by relatively simple devices include cell phones and tablets. But, most people would find it tiring to write a long document on a touch-screen keypad, so it would be useful to have a separate keyboard in many cases.

One of the strengths of cloud computing is the ability to share documents with other people. As long as the people sign up on the same service, it is straightforward to give them access to your documents—to view or even edit the document. Generally, the cloud providers handle backups and keep the servers running with high reliability. However, cases exist where documents have been lost. On the other hand, many other companies provide storage space online, so it should be possible to make your own backup copies using multiple storage or e-mail services.

So, is it possible to run most common applications online using cell phones and tablets? Possibly; but it would be tiring to create large documents with a touch-screen keyboard. Most people would find it easier to type using a separate keyboard. Still, the main documents could be created using a laptop or perhaps a tablet, then they will be available for viewing and small edits using a cell phone.

Summary

One of the original purposes of computers was to make it easier to perform basic tasks. Over time, as computers have become more powerful, they have come to support increasingly complex tasks. Today, in addition to increasing efficiency, computers can help you make better decisions. One major change is in the type of data routinely processed. The five major types of data are numbers, text, images, sound, and video. To handle more sophisticated data and more difficult tasks, computer hardware and software have grown increasingly complex.

To choose a computer that best meets your needs, you must evaluate the four basic hardware components: input, processor, output, and secondary storage devices. Each component is measured by slightly different characteristics. Input devices are selected based on the specific task (such as a keyboard for typing, mouse for pointing, or a microphone for voice input). Processors are often selected based on speed and price. Output device quality is appraised by resolution and color capabilities as well as initial and ongoing costs. Secondary storage is evaluated based on speed, capacity, and price.

Application software is the primary source of improved productivity. Packages exist to assist in research, analysis, communication, and organizing resources. Database management systems are used for research and data sharing. Spreadsheets and other analytical tools assist in calculations. Word processors, drawing packages, voice mail, and e-mail are used for communication. Electronic calendars and scheduling software are used to help organize human resources.

With the presence of global high-speed networks, it is now possible to store most applications and data using cloud computing on the Internet. Companies and individuals now have the choice of carrying smaller, simpler display devices that access everything stored on Web servers. Some limitations exist today, and cost, security, and reliability questions remain but this approach can simplify the management of fundamental computing.

A Manager's View

Technology constantly changes. New features are added every day to hardware and software. How do you know which features to buy and which to ignore? The key is to evaluate the features of the main components and to understand how you will use the computer. Given the declining prices of processors, RAM, and secondary storage, it is relatively easy to buy a reasonable computer today for most common business applications. When you get to issues of portability or Web servers, you need to evaluate the choices more carefully.

Key Words

aspect ratio	milliseconds
augmented reality	motherboard
binary data	nanoseconds
bitmap image	operating system (OS)
byte	optical character recognition (OCR)
cache memory	output
CD-ROM	pixels
clip art	processor
cloud computing	random access memory (RAM)
CMYK	redundant array of independent drives (RAID)
commercial off-the-shelf (COTS)	resolution
device drivers	RGB
dots per inch (dpi)	scalability
DVD	software
e-discovery	solid state drive (SSD)
electronic mail (e-mail)	style sheets
ergonomics	synthesizer
grid computing	templates
hardware	Unicode
high-definition TV (HDTV)	vector images
icons	virtual machine (VM)
input	voice mail
instant messaging (IM)	
megabytes	

Web Site References

Free News Sources

Associated Press	www.ap.org
CNN	www.cnn.com
ESPN	espn.go.com
Fox News	www.foxnews.com
Internet News	www.internetnews.com
MSNBC	www.msnbc.msn.com
News.com	www.news.com
News Map	newsmap.jp
USA Today	www.usatoday.com
United Press International	www.upi.com
Wired	www.wired.com
ZDNet	www.zdnet.com
Almost any Magazine or Newspaper (some charge)	
Fortune	www.fortune.com
The Economist	www.economist.com
Wall Street Journal	wsj.com
Washington Post	www.washingtonpost.com

Review Questions

1. List and describe the five basic types of data.
- ✓ 2. What are the two main color models? What are the color codes for yellow and green in each of the models?
3. What is lossy data compression and why does it create smaller files?
4. What are the primary hardware components in a computer?
5. How do you know which components to upgrade to improve your computer's performance?
6. Why are style sheets important for large documents and Web sites?
- ✓ 7. Why are SSDs better than traditional hard drives? What are the drawbacks?
8. What are the advantages and drawbacks to using removable disk drives as backup devices?
- ✓ 9. How does the operating system define the way a computer works?
10. How does the use of Web browsers change the way applications operate?
11. How does a virtual machine reduce the costs of large server farms?
12. Briefly describe five tasks you expect to perform in your job as a manager and list the application tool you will use.
13. What will it take for people to adopt a paperless office?

Exercises

- ✓ 1. What are the current best prices of disk drives (\$/GB) and RAM (\$/GB)? How much does it cost for the fastest processor you can find (not counting exotic supercomputers)?
2. Using a common Web site or retail store, find the price of a mid-level laptop. List the primary specifications. Identify the cost of doubling the amount of RAM on the laptop at the time of purchase. Use a discount Web site to compare the price of purchasing the RAM separately and installing it yourself.
- ✓ 3. Find or create a color chart that identifies and displays at least the 27 primary colors for the RGB color model. Use three levels (0, mid, max) for each of the three colors.
4. Find a high-resolution digital photograph. Using photo editing software, save several copies of the photo in JPEG format with different levels of compression. At what point do you begin to notice the photograph quality degrade? Compare the file sizes as well. Print the photo (a black and white print is fine) and compare the results to the original.
5. What is the highest capacity common SSD available? What is a typical price? How fast is the write speed?
6. How much would it cost to purchase the current release of Microsoft Office for a group of 10 people? How much would it cost to use similar software from an online provider? What are the drawbacks to going with an online provider?
7. Estimate the storage space (number of bytes) required for each of the following items:
 - a. A textbook of 700 pages. Create two single-spaced pages with a small PowerPoint drawing on one page. Convert it to PDF format and estimate the size. Compare this number to other sources.
 - b. A full-color image from a 7-megapixel camera. Both in raw form (TIFF) and an estimate of the size in high-quality JPEG format.
 - c. A 15-minute lecture recorded with the PC audio recorder. Make and save a 30-second recording and use the file size to estimate a 15-minute recording.
 - d. If you wanted to store your favorite half-hour television show in digital form, how many bytes of storage would it take? Extra credit: How much space would it take if you remove the commercials? (Hint: Time the commercials.) How much space would it take in HDTV format?
 - e. A Unicode document of about three pages of single-spaced text.
8. You have a photo from a 7-megapixel camera at 3072 x 2034 pixels. Your image editing software defaults to 72 pixels per inch, and claims the image is 42.667 x 32 inches. You want to convert to a standard 10-inch wide photo but keep the aspect ratio. You need to find a new resolution that sets the proper dpi and the height.



9. Use research to determine the percent of computers running the Linux operating system.
10. Operating systems define drive space in terms of binary numbers where $1024 = 1$ kilobyte, and 1 gigabyte is $1024 * 1024 * 1024$. But disk drive manufacturers advertise storage space in decimal values, using 1,000 instead of 1,024. If you buy a drive advertised as 200 GB, how many bytes will the operating system recognize on it?
11. Identify at least two competitors to Microsoft Office software and find reviews from people who have used them to comment on their viability for business use.



Technology Toolbox: Speech Recognition

12. Set up speech recognition on your computer and train it. Choose a paragraph of text and dictate it into Word. Do not make corrections to the text as you dictate it. When you have finished, copy the paragraph and make the corrections to the copy. Count the number of mistakes and hand in both paragraphs.
13. Do a quick survey of other students (not in the class) to find out how many have used speech input. Of the ones who have tested it, how many use it on a regular basis? Report the results and comment on the low usage rates.
14. How are the speech recognition systems used in other devices, such as cell phones, different from those used in basic personal computers?



Technology Toolbox: Charts

15. Identify the best chart to use for the following datasets, and give a brief justification for your choice:
 - a. Sales by department for the last five years.
 - b. Sales by employee for the last month.
 - c. Production data for output quality and percent of carbon.
 - d. Share of sales to five nations.
 - e. Total customer billings by employee for the last 24 months.
16. Find at least two data series from the government (try www.fedstats.gov) and plot them. Briefly explain any patterns or trends.
17. Enter the following sales data into a spreadsheet. Create two charts, one showing total sales over time and one showing the changing percentage sales over time by product type. Briefly comment on the two charts and describe the difference in the information content.

Year	Soft Goods	Hard Goods	Movies
2007	425	632	265
2008	531	789	378
2009	618	865	425
2010	692	897	581
2011	753	933	792
2012	829	989	882



Technology Toolbox: Spreadsheets

18. A company is evaluating the purchase of a machine that costs \$50,000. The company will have to pay money each year for maintenance costs. However, the machine will increase profits by several thousand dollars each year. Enter cost and profit data into a spreadsheet. Since the costs and profits occur over time, you have to discount them to a single point in time. Use the net present value (NPV) function to compute the present value of the costs and profits. Initially, assume the discount rate is 4 percent, but build the spreadsheet so managers can change the value easily. Use the Goal Seek tool to find the discount rate at which the investment breaks even. That is, search for the discount rate that sets the computed net value (net profits-net costs) to zero.

Year	Cost	Profit
2008	-50,000	10,000
2009	-2,000	12,000
2010	-2,000	13,000
2011	-2,000	14,000
2012	-5,000	15,000

19. Create a new spreadsheet for a company that has sales of two products (shoes and hats) in two regions (East and West). Put data for the East division in one worksheet and data for the West division in a separate worksheet. Create a third worksheet to display the totals of the two divisions. Chart the changes over time.

Year	Shoes	Hats	Year	Shoes	Hats	Year	East	West	Total
2008	456	110	2008	1024	234	2008			
2009	571	98	2009	1305	198	2009			
2010	632	87	2010	1525	178	2010			
2011	771	69	2011	1598	165	2011			
2012	780	120	2012	1652	208	2012			
East			West			Total			

20. You need to evaluate your employees. You have a list of their performance on four tasks—measured in terms of time. The time is the number of minutes they finished behind the fastest person. So smaller numbers represent better performance. Two of the employees were injured at different points and did not complete all of the tasks. Enter the data into a spreadsheet and analyze it by computing the mean and standard deviation for each stage. Then compute four new columns that contain the individual Z-score for each employee in each stage: $Z_i = (X_i - \text{average}) / \text{Std Dev}$. Compute the average Z-score for each person and rank them. Remember that smaller (negative) numbers are better. Chart the final averages. One extra credit point if you can identify the employees.

Employee	S0	S3	S5	Sf
Basso	0.23	3.05	1.05	7.23
Cruz	0.53	14.85	3.13	31.80
Danielson	0.17	9.92	1.33	11.50
Davis	0.32			
Hincapie	0.13	3.05	0.67	
Leipheimer	0.00	0.00	0.00	0.00
McCartney	0.32	0.07	0.42	0.90
Vandborg	0.30	14.85	3.03	25.30



Teamwork

21. Compare your cell phones. Build an Excel table and compare them based on screen resolution and camera resolution. Indicate if the phone has speech recognition and rate how well it works (on your own phone). What data entry methods are supported? How well does the Web browser work (if it has one)?
22. Each person should research a current version of a tablet computer and write a short list of its strengths and weaknesses. The group should choose one tablet that could be used by business managers, and list the main tasks for which it would be useful.
23. Find a good quality photograph or take one yourself. Have one person save the photograph to at least three copies using different levels of JPEG compression. Hint: Adobe Photoshop gives complete control, but if it is not available, use Microsoft Picture Manager or try an online site such as imageoptimizer.net. Have each team member look at the compressed photos and try to rank them from highest-to-lowest quality. Compare the rankings with the actual order. What do the results tell you about how you should store and display photographs?
24. Have each person on the team find an example of a good chart and a bad chart using newspapers and the Internet. Combine the results from each person into a document so that each person can vote on the best and worst charts.
25. Set up free accounts on one of the online application sites (such as Google). Create a short document to describe a recent movie or television show. Have each person add a couple of lines of comments about the movie. When finished, comment on the benefits and drawbacks of using the online system to write documents versus the traditional method of using separate copies and e-mailing them.



Rolling Thunder Database

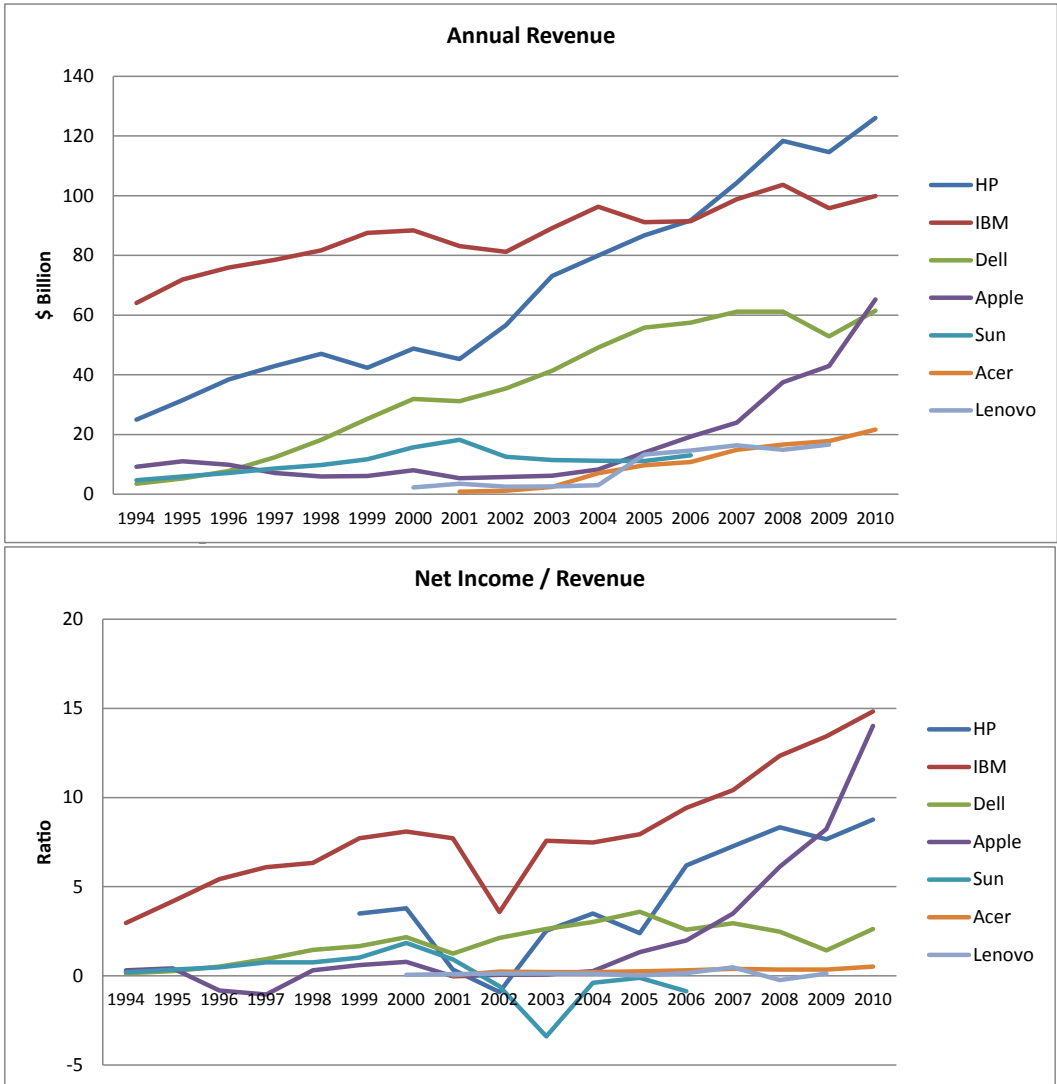
26. Using the Export Data form, copy the data to a spreadsheet and create graphs for the following situations. (Choose the type of graph you feel is best suited to present the data.)
 - a. Sales by model type.
 - b. Sales by month.
 - c. Sales by model type for each month.
 - d. Sales by state.
 - e. Sales by employee by month.
27. Using the existing forms, enter data for a new bicycle order.
28. Find at least two other bicycles (e.g., on the Internet or from a dealer). Create a spreadsheet comparing the features and costs with a similar bicycle built by Rolling Thunder Bicycles.
29. Using the Export Data form, copy the data to a spreadsheet and compute the average profit margin for each type of bicycle for one different year. Comment on any differences that you find.
30. Assume you have to give a presentation to the marketing manager. Create a slide show to compare the sales of each model type for the last two years.

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Cases: The Computer Industry

The Industry



A model can become obsolete in a few weeks, and its value can drop in a matter of days. How can a retailer stock items when they depreciate so quickly? Stores can try to forecast demand, but if the economy drops, people may stop buying and the store will be stuck with obsolete computers. Yet selling strictly by mail order means that a manufacturer might miss out on sales to a relatively large market.

These conflicts have caused considerable grief to computer firms over the last few years. Dell, the leading mail-order/Internet vendor, at one time tried retail sales and gave up. Gateway tried to ride the middle line by running its own retail stores. It, too, lost money and closed the stores. Apple has opened retail stores—and been relatively successful. But Apple's target has largely been consumer, not

businesses. As HP increased sales through stores such as Best Buy, Dell has countered by offering a few models through Wal-Mart.

After several years of dismal growth, demand for personal computers increased in 2003 and 2004. PC unit shipments in both the second and third quarters of 2003 were higher than expected. Consumer buying remained strong, and a transition from desktop computers to notebooks has helped to fuel growth in the category. As the average age of the existing machines increased, companies began replacing their computers. Aggressive price competition is a significant factor in stimulating demand. Vendors have reported disappointing PC revenues due to price competition. Competitive pricing pressures continue to drive pricing decisions. In addition, business pressures have not recovered. Consumer demand for notebook computers has also driven demand.

International sales are an increasingly important element in growth for the major computer vendors. Growth in Europe and the Middle East has seen an 18.7 percent year-to-year increase in PC shipments for the third quarter of 2003. This growth was built on the robust sales of portables, which rose 51 percent in consumer and business demand. Aggressive price competition was a significant factor in stimulating demand.

The top firms continue to fight for dominance in the industry, but the weaker firms are attempting to gain ground by consolidating. In 2004, Gateway purchased eMachines. In the process, Gateway fired most of its existing managers and replaced them with managers from eMachines. Gateway eventually filed bankruptcy. In 2006, Dell claimed that it made 1/3 of the PCs sold in the U.S. (2006 Annual Report). By 2009, HP had overtaken Dell as the leading PC manufacturer. For 2009, the worldwide rankings were: 1. Hewlett-Packard, 2. Dell, 3. Acer, 4. Lenovo, 5. Toshiba (Whitney 2010). By 2011, the argument about ranking was whether or not tablets should be counted as PCs. If so, Apple's market share would be significant.

The Consumer Electronics Market

The PC vendors are attracted to the appealing growth projections for consumer electronics markets. For a while, flat-panel TVs helped Dell and Gateway improve profits. By 2007, Gateway/e-Machines had dumped all of its stores and stopped selling televisions. Dell still listed televisions, but the market had been stolen by retailers engaged in vicious price-cutting (including Wal-Mart, Best Buy, and Circuit City).

Apple Computer had success with its retail outlets in 2003. Its stores are located in high-traffic areas, such as upscale malls, near sizable Apple customer bases. Apple's concept has been to create a setting where salespeople can demonstrate some of the new digital camera, digital music, and digital video products, and customers can work with and experience these offerings in the store. The hope is that the consumer will buy not only a new PC but also all the software and peripherals needed for the complete digital solution.

Given the trend toward maturing growth rates in the PC industry, the strategy of broadening product lines to tap higher-growth opportunities appears to be reasonable. However, the margin benefits to the vendors remain in question, given the highly competitive market dynamics of the consumer electronics industry and the uncertainty of growth projections and product life cycles.

In late 2010 and 2011, manufacturers were focused on tablets—led by Apple's success with the iPad. Yet, early tablets were largely consumer devices—capable

of displaying movies, retrieving files, playing music, and handling small e-mail messages and Facebook updates. But, with low resolution (typically 1024 x 768) and no keyboards, they were not replacements for full-blown laptops because it was difficult to enter data and create content on them. Continued evolution and features might change these relationships.

Case: Dell

Dell posted rapid sales growth since July 1994, when it discontinued retail channel sales to focus exclusively on its direct business. After entering the market for Windows-based workstations in 1997, the company quickly became the world's leading supplier. As of the first quarter 2003, Dell was the world's largest PC maker, retaking the title from Hewlett Packard Company, which with its May 2002 acquisition of Compaq Computer became Dell's largest rival. Desktop computer systems made up the largest segment (53 percent) of the business. Dell ranked first in the United States and second worldwide in desktop shipments in calendar 2002. At the end of fiscal 2006, Dell had net revenue of about \$56 billion. By 2007, Dell was rapidly losing ground to Hewlett-Packard. PC shipments increased by 13.1 percent in the first quarter of 2006 but Dell's sales grew by only 10.2 percent (ZD Net 2006). By the first quarter of 2007, Hewlett-Packard surpassed Dell as the world's largest producer and Dell's worldwide shipments fell by 6.9 percent in the first quarter of 2007 and U.S. shipments fell by 14.4 percent leaving Dell barely in the lead with 26.8 percent of the market compared to HP at 25.5 percent (Darlin 2007). In 2009, HP's share of shipments was 19.7 percent, Dell's was 12.9, and Acer was close behind at 12.7 percent.(Whitney 2010).

The company's higher margin notebooks and portables include the Latitude product lines, for corporate users, and the Inspiron line, for consumers and small businesses. Dell offers services that include professional consulting, custom hardware and software integration, and network installation and support. Manufacturing sites include Austin, Texas; Limerick, Ireland; Penang, Malaysia; and Xiamen, China.

Dell is aggressive in pricing its products. As a direct seller of PCs, Dell benefits because it can pass lower component costs through to customers faster than its rivals. As such, it can lead the competition in price cuts. The company strategy includes the ability to gain market share by leveraging its position as the low-cost producer in the PC industry. Dell's market share gains over the past year reflect the successful implementation of this strategy. This strategy is cramped, however, by the rapid growth in component prices.

In February 2007, Michael Dell, fired Kevin Rollins who had been CEO since 2004, and Mr. Dell took the job back in an effort to turnaround the company. Dell's sales model was good at holding down costs, but sales were shifting. Dell had been focused on business and educational customers who were more than willing to purchase direct from Dell. But sales to consumers surpassed sales to businesses and it turns out that individuals preferred to buy computers from retailers—notably Best Buy, Circuit City, CompUSA, and Office Depot. Markets that H-P had locked up several years earlier (Lawton and Lublin 2007). Mr. Dell continued the takeover by removing or replacing a third of its executive board.

In May 2007, Dell announced a deal with Wal-Mart to sell two desktop models directly to consumers. Bob Pearson, Dell spokesman, said “our customers are asking us for additional ways to purchase our products and we plan on delivering on

a global level... Today's announcement with Wal-Mart represents our first step. Stay tuned." (Lawton 2007). Perhaps Dell will recognize that two desktops are not going to change the world, and that many people prefer to buy laptops. But, if you put Dell laptops side-by-side with those from H-P, Sony, Apple, and IBM, will consumers reject them because of a lack of style and engineering?

Keys to Success

Much of Dell's success has been credited to the built-to-order model. Nothing is manufactured until someone buys it. This reduces inventory holding time to three to five days. Dell also applies this just-in-time approach to its marketing efforts. Advertising dollars and resources are focused on the segments that are growing the most. For example, the fourth quarter is always focused on the holiday gift season for consumers. Quarters 2 and 3 are focused on the public sector when schools and the government begin their buying cycles.

While Dell has always sold to the education market, in 1996 the sector became more interesting, thanks to the federal government's E-Rates program that provided from \$2.5 billion to \$3 billion per year to subsidize schools' technology budgets. Apple had previously addressed this market by engaging in "emotional marketing," pitching warm and fuzzy computing to teachers in the hope that they would lobby their schools. In contrast, Dell had realized that computers in the schools had moved from freestanding desktop tools to nodes in an increasingly complex web of technology that included wireless networks, handheld devices, software, and servers. While Apple advertised personal creativity, Dell marketed standardization and commoditization. Dell did not go to its education buyers and say, "We'll sell you desktops and laptops." They offered solutions including education software, packages, and IT services. They addressed storage and the leverage of the existing technology. This approach proved to be more compelling for people with limited budgets and no resources or staff.

Perhaps Dell's most important weapon was its huge customer database, the result of Dell's sales model. This provides a direct relationship with the customer. Since it sells directly, Dell can get immediate feedback from customers before, during, and after the sales process. Dell courts such feedback, maintaining a Platinum Council of buyers to offer their insight at the executive level, and also inviting customers to work with product development teams in a direct feedback loop.

Due to tight supply chain management, Dell's made-to-order model is also a financial gold mine. Dell orders and receives components as they are needed to build a machine. The computer is shipped within a few days, and the customer is charged. But Dell does not have to pay the suppliers until 30 days later. So Dell earns interest on the revenue for a couple of weeks before it pays suppliers.

Database Applications to Better Service Customers

Valerie Hausladen knew that she could get Dell's customer database to work harder. "I used to be more of a traditional marketing person," she says. "But I learned that unless I could measure and show ROI on marketing, my budget kept getting cut. I realized at Dell, you have to be able to show results" (Kuchinskas 2003). Hausladen set up a pilot program to test whether better customer relationships could be established in the interactive channel. Smaller Dell accounts were initially targeted in three areas: health care, K-12 schools, and colleges and universities.

Dell divides its accounts into the three categories of acquisition, development, or retention. Development accounts are those that the company thinks could grow,

or that are not spending all their budgets on Dell products. The tactical goal of the campaign was to get the name of one buying decision maker for each account. The strategic goal was “to become more actionable on how the company served customers with right information at the right time.” The implementation goal was to send laptop information to customers who were interested in laptops and server info to server buyers.

Dell’s database group went to work. They analyzed Dell’s customer list to establish benchmarks. To find out if Dell knew a decision maker at an organization, they analyzed job titles, asked salespeople, and even called the customer to ask. They also began outreach via e-mail and direct mail, renting mailing lists and building and refining the Dell customer database through opt-in methods.

To implement the program, Web portals were built for each of the customer verticals, offering tools and information to aid them in their technology decisions. This was aided by the fact that the three Knowledge Centers—for K-12, institutions of higher education, and government purchasers—were similar in their application. The visual identity and content for the Web pages were crafted to serve as a “virtual account executive” for each market.

The direct mail campaign focused on two goals. First was the desire to alert customers to deals and sell more products. Second was the effort to improve information in the customer database and turn names into relationships. When customers registered on the Knowledge Center sites to read content or request e-newsletters, they also selected products they were interested in from a list. The next time Dell communicated with them, it focused on the items they had checked. The Dell team set up a control group to measure the effects of their marketing and define subsequent benchmarks. Dell began to see results from this database marketing effort in 2002. The short-term gains included the maximization of tactical things like response rates. This included the establishment of 5,000 new accounts in eight months. The Web interface lets the marketers compare different campaigns, different media, and calculate the current ROI. Three years into the program, Dell’s information-rich database contains at least one key decision maker for each account. The goal is to expand this list to the names of five key decision makers for each location in the database.

Dell addresses the budget-conscious public sector market by talking to them about getting what they need, supporting them, and saving them money. In direct mail, e-mails, and on the Web, it uses a straightforward style and packs its communications with information. The postcards are not fancy. They include a couple of generic hardware close-ups and text. They follow a simple formula: one close-up of the product, another that shows the entire case, a photo of smiling customers, and lots of text, with prices prominently featured.

All this leads back to the Knowledge Center Web page, where Dell is building a deep resource that offers quick links to shopping, customer service, and technical support backed by articles that can help Dell’s customers evaluate, plan, and use technology more effectively. They are also integrated with more offers, sweepstakes, and discounts. Every time a customer clicks within a newsletter, navigates around a Knowledge Center, or responds to a postcard electronically or via a call center, the choices are recorded in Dell’s customer database. Over time, the Knowledge Center begins to appear differently from the one encountered by another education decision maker. This system results in a more interesting interaction with Dell each time the customer comes to the Web page.

Dell has Rerouted its US Support Calls to the United States

In November 2003, Dell rerouted calls from its U.S.-based users to a U.S.-based call center instead of to its facility in India. Some customers had complained about the quality of the help they had received from the offshore center. Support operations for Dell's Optiplex line of desktop PCs and its Latitude notebooks were moved back to facilities in Texas, Idaho, and Tennessee.

Ned May, an analyst at the market research firm IDC, said he had heard criticisms from corporate IT managers about the support they were getting from Dell's call center in Bangalore, India. Barry French, a Dell spokesman, said a portion of the calls from U.S. PC users would still go to India, where support has been handled since mid-2001. He indicated that Dell may shift all of the support back offshore at some point. "We are increasing the number of people we have providing support in India," he said. "Dell has a number of call centers around the world, and we will continue to optimize those to provide the best customer experience" (Brewin 2003).

In 2011, Dell and HP both began buying companies to expand offerings for business servers. Dell paid \$800 million for Compellent, which provides data tiering. A network attached storage box contains multiple levels of drives—some fast and expensive (flash drives), and some slower but large and cheap (SATA). The software automatically moves lesser-used data to the cheaper drives (Mearian 2011).

Also following HP, in 2009 Dell purchased Perot Systems—one of the large outsourcing vendors—which happens to be located in Texas (Niccolai 2011). As part of its new services unit, Dell is focusing on providing private cloud-based computing to business users. Dell partnered with SAP and several other companies to be able to host SAP applications on its servers (Kananacus 2011). With its traditional emphasis on business sales, Dell has been building server farms to provide private cloud-computing to businesses that need high-speed facilities. Dell also expanded its server offerings including blade servers with up to 96 processor cores. Dell's moves into enterprise servers and cloud-based hosting helped provide large increases to net income in 2011.

Questions

1. Is the pace of technological change slowing? Can a business wait longer now to refresh computers?
2. How is information technology critical to Dell's success?
3. What is the current status of Dell's recycling program and is it successful?
4. Why is Dell expanding into consumer electronics and corporate networking products?
5. Is there a limit to the number of computers Dell can sell through its current methods? Should it reconsider retail sales?

Case: Gateway and Acer

Gateway was the third largest manufacturer of PCs in the United States, but it struggled for several years. It tried selling computers, and plasma TVs, through standalone stores, but struggled to make profits. Gateway gained market share in

the PC industry until the second half of 2000. Since that time, its rapid growth has reversed. In 2002, Gateway estimated its market share to be 6 percent, but the company still believed it had a strong presence in the U.S. consumer market. In early 2001, management reviewed its operations and discontinued unprofitable revenue streams beginning in the second quarter of 2001 with roughly \$200 million per quarter. In the third quarter 2001, it exited its international operations. In March 2003, management planned to save \$400 million annually from workforce cuts, cost programs, and a reduction in the number of its stores. In March 2007, the former CFO and controller of Gateway were found guilty of manipulating earnings and revenue statements. Gateway also acquired a new CEO in late 2005. Sales in 2006 were just shy of \$4 billion with a net income of about \$9 million. But the company has to grow profits considerably to overcome its half-billion dollar loss in 2004. Slightly over half the sales value was for desktop computers. Most of sales (\$2.7 billion) were through retail outlets (2006 Annual Report).

In the beginning, Gateway focused on providing high-end personal computers at relatively low prices. The company led the industry consolidation through the 1990s and dominated PC sales for a time. Based in South Dakota, the company featured a cow motif as a means to create a brand identity. Eventually, headquarters was moved to San Diego. In 1997, Gateway introduced an innovative extension of its traditional business model. Instead of relying on developing customers solely through the Internet, Gateway opened 37 Gateway Country stores in which customers could test-drive PCs. One of the goals was to expand sales of consumer electronics goods such as printers, cameras, and eventually plasma televisions. After several years of expansion, the company began closing certain stores. As of December 31, 2002, Gateway had 272 retail stores in the United States, down from 327 at the end of 2000. In the first quarter of 2003, the company closed another 80 stores. In 2004, Gateway acquired eMachines largely in exchange for stock. Ted Waitt, founder and chairman, quickly replaced Gateway management with eMachines managers. In April 2004, the new management shut down all of the remaining Gateway retail stores (Zimmerman 2004).

In 1997, Gateway also launched its Internet service. In October 1999, the company announced a strategic alliance with America Online, calling for Gateway to package AOL service into all its computers. AOL was to invest \$800 million in Gateway over two years, including \$150 million in AOL stock. In December 2001, Gateway extinguished its convertible note to AOL through the issuance of 50,000 shares of Series C redeemable convertible preferred stock. This resulted in an extraordinary gain of \$4.3 million, net of tax.

Realizing the price competitiveness in technology, Gateway was among the first PC vendors to shift its focus to “beyond the box revenues.” These revenues incorporate the sales of software and peripherals, Internet access, financing, and warranty and training revenue. In 2002, these sales were \$692 million, down from \$1.2 billion in 2001 and \$1.9 billion in 2000. These sales have wide margins. Several categories offer recurring revenue streams. Gateway reported a net loss of \$0.95 in 2002. By 2006, revenue from non-PC sales had dropped to about \$650 million.

The merger with eMachines appeared to represent a refocusing on the “value” end of the computer spectrum. Originally, eMachines succeeded by building standard computers in China and beating the cost of equivalent Hewlett-Packard machines by \$150. As PCs become a commodity industry, people are less interested in the raw technology. Instead, certain features become important, such as more

memory or larger disk drives. John Hui, the owner of eMachines, explained that “they created what we called a ‘value formula’ that Wayne [Inouye] developed at Best Buy. They attach value to every single component of a PC. They can at any time tell you if you use, let’s say, a DVD RW versus a CD ROM how much more the consumer is willing to pay. Now that has nothing to do with the cost. Because (it’s) the value that the consumer will attach to every single component. For example, how much is the consumer willing to pay for a 512MB system versus a 256? They can attach value to it, because the consumer knows they can easily buy the memory and stick it in themselves. But the memory prices go up and down every day. So they have a certain perceived value. And when that perceived value is high and the cost is low, that’s when eMachines would put those components in there.” Inouye became CEO of Gateway after the merger (Zimmerman 2004). By August 2007, Gateway had failed and the name was purchased by Acer (Lemon and Nystedt 2007). Acer, a Taiwan-based manufacturer quickly became one of the leading PC manufacturers. A large part of the growth came through selling low-priced netbooks—small laptops designed for basic Web browsing and e-mail tasks.

By 2011, Acer was being squeezed on the low end by tablets, particularly the Apple iPad. People chose to purchase the small, lightweight tablets instead of buying the small netbooks that had increased Acer’s growth. Later in 2011, Acer decided to re-enter the server market. Servers often have higher profit margins, but reliability is critical and manufacturers build in duplication in case components die (Thibodeau 2011). Acer plans to use third-party makers to put the servers together. Todd Mottershead, senior manager for servers and storage noted that “I want to make sure that we can build very, very quickly and deliver much faster than everyone else.” One interesting, but unanswered, question is whether Acer will go with a proprietary server format. In late 2010, Facebook began pressuring vendors to develop a generic server. The company created design specifications down to the cabinet and motherboard layouts. Up to this point, server manufacturers built incompatible systems. Although they used off-the-shelf components for drives, RAM, and processors, it generally was not possible to even transfer a motherboard from one case to another. Standardization will make it easier to substitute parts; which ultimately increases competition and drives down prices. But it is not clear yet if vendors will be willing to build to the standards.

Questions

1. Why did the Gateway stores fail?
2. Can smaller vendors like Acer and Toshiba survive?
3. Are tablets PCs and will they replace laptops?

Case: Sun

Sun was the No. 3 manufacturer in server technology, with 13.5 percent of the market, and its market share and revenue were dropping in the early 2000s. Sun focused on the UNIX market where it was the No. 1 vendor. Founded in 1982, Sun Microsystems invented the workstation. It relied on the concept that the network is the computer. Sun was a leading supplier of networked computing products, including workstations, servers and storage products that primarily used Sun’s own

Scaleable Processor Architecture (SPARC) microprocessors and its Solaris software. Computer systems accounted for 55 percent of net revenues in 2003, network storage products 14 percent, support services 25 percent, and professional services 7 percent.

Sun's workstations were primarily used for engineering applications (CAD/CAM), desktop publishing, software development, and other applications that need a moderate amount of computing power and high-quality graphics capabilities. In terms of computing power, workstations fall between PCs and mid-range computers. UNIX has been the most common operating system for workstations, but Microsoft's Windows has posed a formidable challenge. Sun's workstations ranged from low-cost UltraSPARC-based workstations to high-end, multiprocessor color graphics systems. Sun servers can be used for file sharing, letting users access data distributed across multiple storage devices and networks, or as computer resources, to distribute computer-intensive applications across multiple processors.

In June 2000, Sun shifted its focus to include storage, launching its StorEdge T3 line, as well as software and services to enhance its storage solution offerings. In 2002, Sun introduced Solaris 9, the latest upgrade of its popular UNIX operating system. Its features include identity management and enhanced security and manageability.

Sun has concentrated on software development as well. It invented the Java object-oriented programming language. Java has attracted significant interest in the software development industry because of its portability; software created in Java can run on any type of system. As a result, it is a popular tool for designing software for distribution over the Internet.

Sales at Sun were weak through the early 2000s as customers realized that Intel-based personal computers could perform as effectively as workstations and midrange servers, at a substantially lower upfront cost. In 2004, Sun received \$1.6 billion in a settlement with Microsoft over the use of Java. Yet Sun lost \$0.75 billion in just one quarter of that year and was forced to lay off 9 percent of its workforce. In 2004, Sun began selling Intel- and AMD-based workstations that could run the Windows and Linux operating systems. But Sun could not compete in the low-end and midrange markets. Sun's 2006 Annual Report shows increasing sales revenue (to \$13 billion in 2006), but it sustained net losses from at least 2002-2006. A huge portion (15 percent) of Sun's sales were to GE. Demand for high-end data center servers declined in 2006 in favor of smaller systems—where Sun faces greater competition.

For years, Sun had relied on proprietary processors. By 2006, most production had shifted to high-end processors available from Intel and AMD. The company also expanded into the data storage market, buying StorageTek in 2005, in an attempt to provide a market for storage applications. In 2006, revenue from data management products and support services exceeded revenue from computer systems products. On the high-end, Sun lost out to IBM and Cray Research in a bid to provide supercomputers for the U.S. government. According to Sun's 2006 Annual Report, most HRM and IT functions for the company have been outsourced and are provided by other companies.

In 2009, Oracle, the database vendor, paid \$7.4 billion to acquire Sun (Clark and Worthen 2009). The general presumption was that Oracle wanted to gain control over Java, which is an important element in developing systems in the Oracle database. Sun still produces some servers, but the workstation market had largely

disappeared by 2011. Sun still markets the Sun Ray system which is one of the original thin-client approaches. All of the computing work is handled on a server and users interact with basic graphics terminals and a keyboard. The primary objective is to keep the software and data in a central location to make it easier to install and maintain. The problem is that the client terminals cost almost as much money as a complete PC and the servers are expensive. The original goal was to reduce management costs by centralizing the software and data, but with network-based controls available today, there is little reason to spend the extra amount of money on the server. In any case, Sun was struggling for years to sell servers. The business continued to decline due to uncertainty after the purchase by Oracle. But, in the first quarter of 2011, Sun saw an increase in the sales of servers hitting \$773 million in the first quarter (Nicolai 2011).

Questions

1. Can Sun survive? How will it compete against Linux and generic PCs?
2. Since much of the world has accepted Java as a Web-based programming language, can Sun make any money from it?

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Summary Industry Questions

1. What information technologies have helped this industry?
2. Did the technologies provide a competitive advantage or were they quickly adopted by rivals?
3. Which technologies could this industry use that were developed in other sectors?
4. Is the level of competition increasing or decreasing in this industry? Is it dominated by a few firms, or are they fairly balanced?
5. What problems have been created from the use of information technology and how did the firms solve the problems?