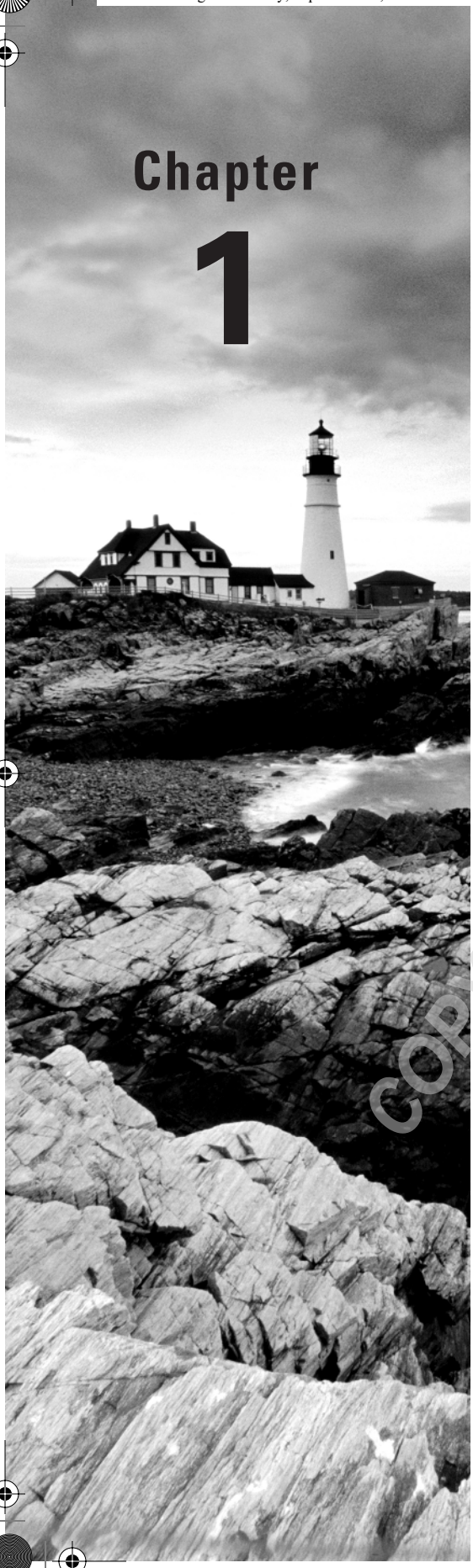
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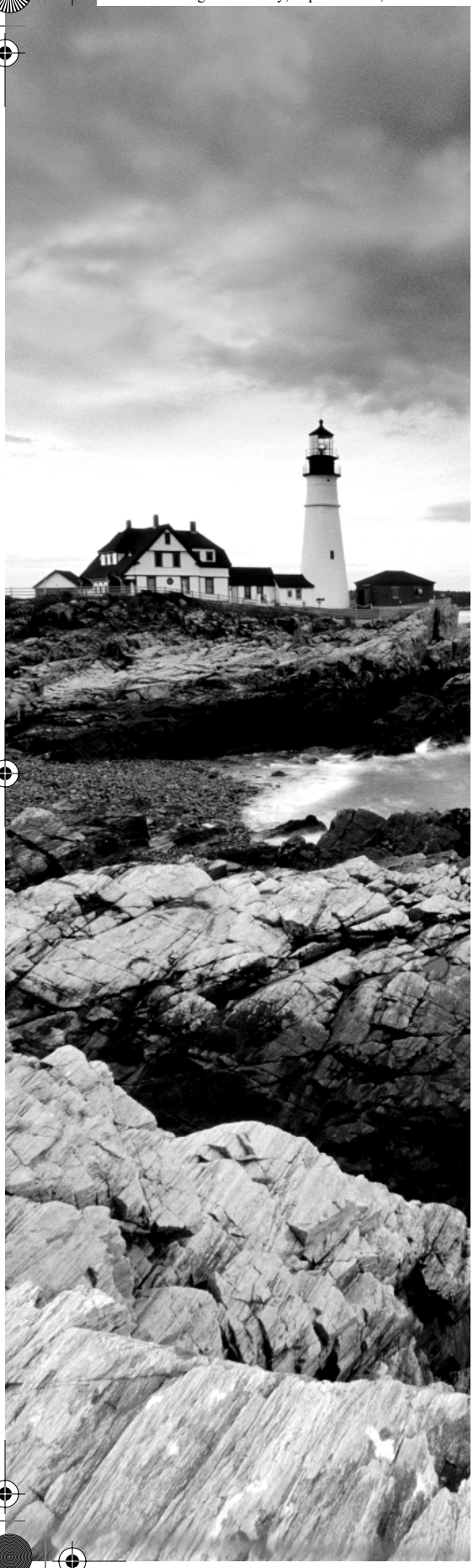
Chapter 1

Identifying Personal Computer Components

THE FOLLOWING COMPTIA A+ ESSENTIALS EXAM OBJECTIVES ARE COVERED IN THIS CHAPTER:

- ✓ **1.1 Identify the fundamental principles of using personal computers**
  - Identify the names, purposes and characteristics of storage devices
    - FDD
    - HDD
    - CD/DVD/RW (e.g. drive speeds, media types)
    - Removable storage (e.g. tape drive, solid state such as thumb drives, flash and SD cards, USB, external CD-RW and hard drive)
  - Identify the names, purposes and characteristics of motherboards
    - Form Factor (e.g. ATX/BTX, micro ATX/NLX)
    - Components
      - Integrated I/Os (e.g. sound, video, USB, serial, IEEE 1394 / firewire, parallel, NIC, modem)
      - Memory slots (e.g. RIMM, DIMM)
      - Processor sockets
      - External cache memory
      - Bus architecture
      - Bus slots (e.g. PCI, AGP, PCIe, AMR, CNR)
      - EIDE/PATA
      - SATA
      - SCSI Technology

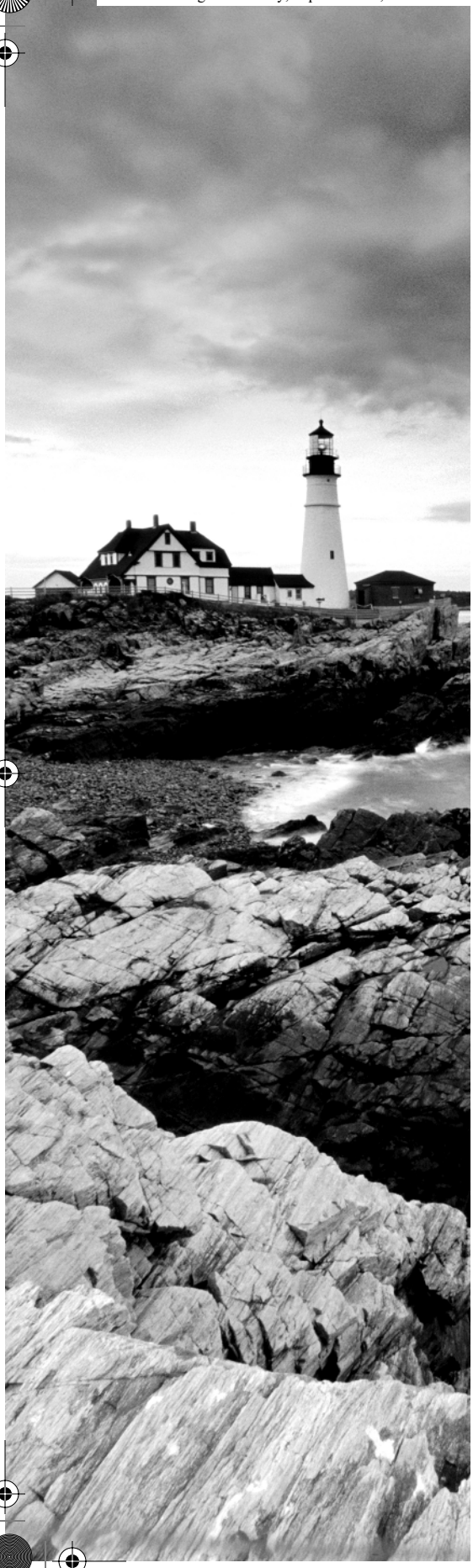
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- Chipsets
- BIOS / CMOS / Firmware
- Riser card / Daughter board

- Identify the names, purposes and characteristics of power supplies, for example: AC adapter, ATX, proprietary, voltage
- Identify the names, purposes and characteristics of processor / CPUs
  - CPU chips (e.g. AMD, Intel)
  - CPU technologies
    - Hyperthreading
    - Dual core
    - Throttling
    - Micro code (MMX)
    - Overclocking
    - Cache
    - VRM
    - Speed (real vs. actual)
    - 32 vs. 64 bit
- Identify the names, purposes, and characteristics of memory
  - Types of memory (e.g. DRAM, SRAM, SDRAM, DDR / DDR2, RAMBUS)
  - Operational characteristics
    - Memory chips (8, 16, 32)
    - Parity versus non-parity
    - ECC vs. non-ECC
    - Single-sided vs. double-sided
- Identify the names, purposes and characteristics of display devices, for example: projectors, CRT and LCD
  - Connector types (e.g. VGA, DVI / HDMi, S-Video, Component / RGB)
  - Settings (e.g. V-hold, refresh rate, resolution)

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- Identify the names, purposes and characteristics of input devices for example: mouse, keyboard, bar code reader, multimedia (e.g. web and digital cameras, MIDI, microphones), biometric devices, touch screen.
- Identify the names, purposes, and characteristics of adapter cards
  - Video including PCI / PCI-E and AGP
  - Multimedia
  - I/O (SCSI, serial, USB, parallel)
  - Communications including network and modem
- Identify the names, purposes and characteristics of ports and cables for example: USB 1.1 and 2.0, parallel, serial, IEEE1394 / firewire, RJ45 and 11, PS2 / MINI-DIN, centronics (e.g. mini, 36) multimedia (e.g. 1 / 8 connector, MIDI COAX, SPDIF)
- Identify the names, purposes and characteristics of cooling systems for example heat sinks, CPU and case fans, liquid cooling systems, thermal compound



A *personal computer (PC)* is a computing device made up of many distinct electronic components that all function together in order to accomplish some useful task (such as adding up the numbers in a spreadsheet or helping you write a letter). By this definition, note that we're describing a computer as having many distinct parts that work together. Most computers today are modular. That is, they have components that can be removed and replaced with a component of similar function in order to improve performance. Each component has a very specific function. In this chapter, you will learn about the components that make up a typical PC, what their function is, and how they work together inside the PC.



Unless specifically mentioned otherwise, throughout this book the terms *PC* and *computer* can be used interchangeably.

In this chapter, you will learn how to identify personal computer components, including the following:

- Motherboards
- Processors
- Memory
- Storage devices
- Power supplies
- Display devices
- Input devices
- Adapter cards
- Ports and cables
- Cooling systems

Identifying Components of Motherboards

The spine of the computer is the *motherboard*, otherwise known as the *system board* (and less commonly referred to as the *planar board*). This is the olive green or brown circuit board that lines the bottom of the computer. It is the most important component in the computer because it connects all the other components of a PC together. Figure 1.1 shows a typical PC system board, as seen from above. All other components are attached on this sheet. On the system board, you will

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find the central processing unit (CPU), underlying circuitry, expansion slots, video components, random access memory (RAM) slots, and a variety of other chips.

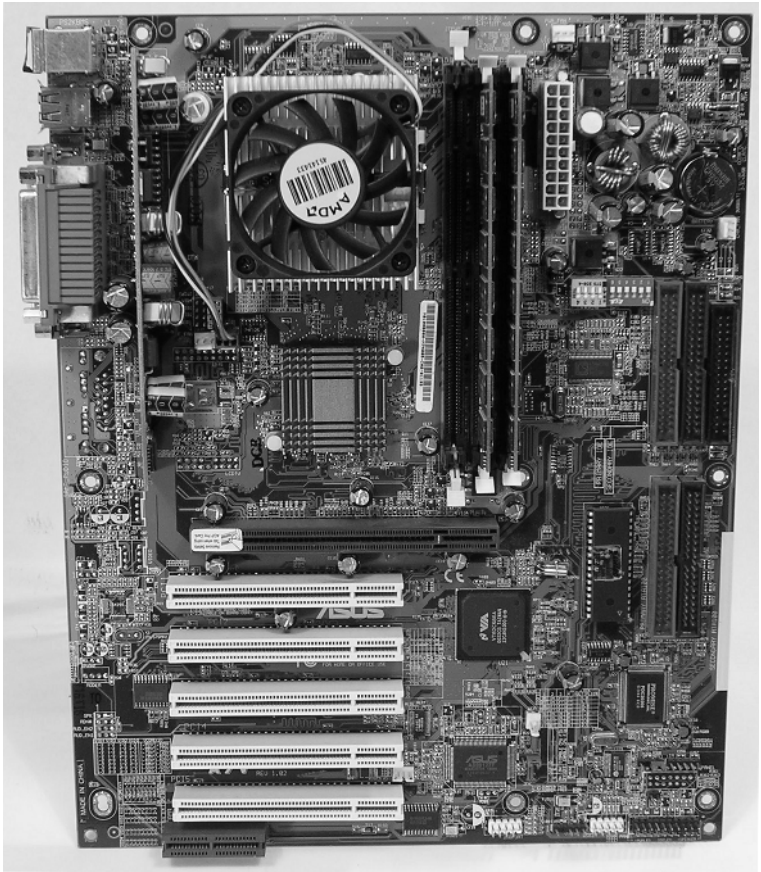
Types of System Boards

There are two major types of system boards: integrated and nonintegrated:

Nonintegrated System Board Each major assembly is installed in the computer as an expansion card. The major assemblies we're talking about are items like the video circuitry, disk controllers, and accessories. *Nonintegrated system boards* can be easily identified because each expansion slot is usually occupied by one of these components.

It is difficult to find nonintegrated motherboards these days. Many of what would normally be called nonintegrated system boards now incorporate the most commonly used circuitry (such as IDE and floppy controllers, serial controllers, and sound cards) onto the motherboard itself. In the early 1990s, these components had to be installed externally to the motherboard.

FIGURE 1.1 A typical system board



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Integrated System Board Most of the components that would otherwise be installed as expansion cards are integrated into the motherboard circuitry. *Integrated system boards* were designed for simplicity. Of course, there's a drawback to this simplicity: When one component breaks, you can't just replace the component that's broken; the whole motherboard must be replaced. Although these boards are cheaper to produce, they are more expensive to repair.

With integrated system boards, there is a way around having to replace the whole motherboard when a single component breaks. On some motherboards, you can disable the malfunctioning onboard component (for example, the sound circuitry) and simply add an expansion card to replace its functions.

System Board Form Factors

System boards are also classified by their form factor (design): ATX, micro ATX, BTX, or NLX (and variants of these). Exercise care and vigilance when acquiring a motherboard and case separately. Some cases are less flexible than others and might not accommodate the motherboard you choose.

Advanced Technology Extended (ATX)

The *ATX motherboard* has the processor and memory slots at right angles to the expansion cards. This arrangement puts the processor and memory in line with the fan output of the power supply, allowing the processor to run cooler. And because those components are not in line with the expansion cards, you can install full-length expansion cards in an ATX motherboard machine. ATX (and its derivatives) are the primary motherboards sold today.

Micro ATX

One form factor that is designed to work in standard ATX cases, as well as its own smaller cases, is known as micro ATX (also referred to as µATX). Micro ATX follows the same principle of component placement for enhanced cooling over pre-ATX designs but with a smaller footprint. With this smaller form come trade-offs. For the compact use of space, you must give up quantity: quantity of memory modules, quantity of motherboard headers, quantity of expansion slots, quantity of integrated components, even quantity of micro ATX chassis bays, although the same small-scale motherboard can fit into much larger cases, if your original peripherals are still a requirement.

Be aware, however, that micro ATX systems tend to be designed with power supplies of lower wattage, in order to help keep down power consumption and heat production, which is generally acceptable with the standard micro ATX suite of components. As more off-board USB ports are added and larger cases are used with additional in-case peripherals, larger power supplies might be required.

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New Low-profile Extended (NLX)

An alternative motherboard form factor, known as *New Low-profile Extended (NLX)*, is used in some low-profile case types. NLX continues the trend of the technology it succeeded, Low Profile Extended (LPX), placing the expansion slots (ISA, PCI, and so on) sideways on a special *riser card* to use the reduced vertical space optimally. Adapter cards, or *daughter boards*, that normally plug into expansion slots vertically in ATX motherboards, for example, plug in parallel to the motherboard, so their most demanding dimension does not affect case height.

LPX, a technology that lacked formal standardization and whose riser card interfaces varied from vendor to vendor, enjoyed great success in the 1990s until the advent of the Pentium II processor and the Accelerated Graphics Port (AGP). These two technologies placed a spotlight on how inadequate LPX was at cooling and accommodating high pin counts. NLX, an official standard from Intel, IBM, and DEC, was designed to fix the variability and other shortcomings of LPX, but NLX never quite caught on the way LPX did. Newer technologies, such as micro ATX, and proprietary solutions have been more successful and have taken even more market share from NLX.

Balanced Technology Extended (BTX)

In 2003, Intel announced its design for a new motherboard, slated to hit the market mid- to late-2004. When that time came, the new BTX motherboard was met with mixed emotions. (Postpone accusations of acronym reverse-engineering until "CTX" is announced as the name of the next generation.) Intel and its consumers realized that the price for faster components that produced more heat would be a retooling of the now-classic (since mid-1990s) ATX design. The motherboard manufacturers saw research and development expense and potential profit loss simply to accommodate the next generation of hotter-running processors, processors manufactured by the same designers of the BTX technology. It was this resistance that caused the BTX form factor to gain very little ground over the next couple of years. Nevertheless, with the early support of Gateway, Inc., and later buy-in of Dell, Inc., the BTX design dug in and charted a path for future success.

Marketing aside, the BTX technology is well thought out and serves the purpose for which it was intended. By lining up all heat-producing components between air intake vents and the power supply's exhaust fan, Intel found that the CPU and other components could be cooled properly by passive heat sinks. Fewer fans and a more efficient airflow path create a quieter configuration overall. While the BTX design benefits any modern onboard implementation, Intel's recommitment to lower-power CPUs has at once lessened the need to rush to more expensive BTX systems and given the market a bit more time to assimilate this newer technology.



There are other motherboard designs, but these are the most popular and also the ones that are covered on the exam. Some manufacturers (such as Compaq and IBM) design and manufacture their own motherboards, which don't conform to the standards. This style of motherboard is known as a *proprietary design* motherboard.

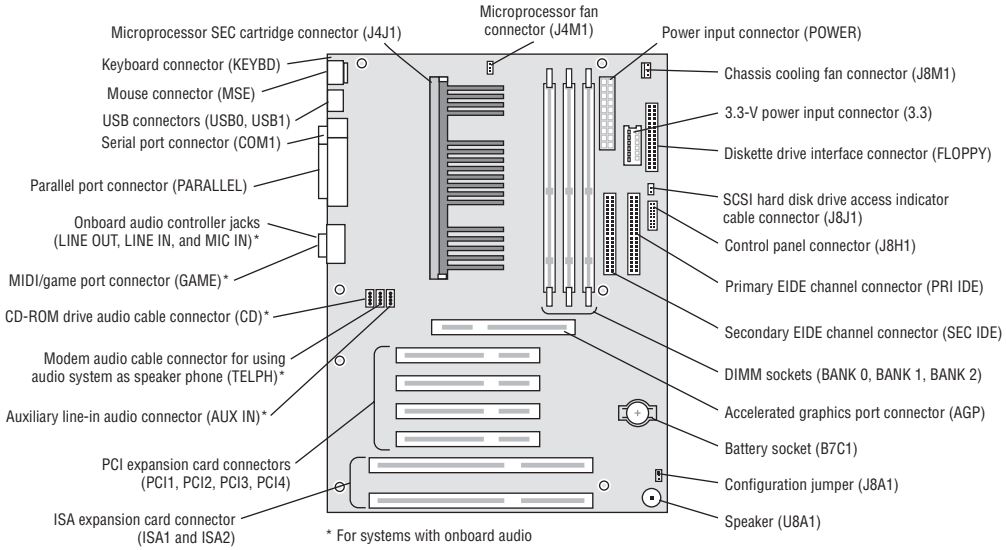
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System Board Components

Now that you understand the basic types of motherboards and their form factors, it's time to look at the components found on the motherboard and their locations relative to each other. Figure 1.2 illustrates many of the following components found on a typical motherboard:

- Chipsets
- Expansion slots
- Memory slots and external cache
- CPU and processor slots or sockets
- Power connectors
- Onboard disk drive connectors
- Keyboard connectors
- Peripheral port and connectors
- BIOS chip
- CMOS battery
- Jumpers and DIP switches
- Firmware

FIGURE 1.2 Components on a motherboard



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In this subsection, you will learn about the most-used components of a motherboard, what they do, and where they are located on the motherboard. We'll show what each component looks like so you can identify it on any motherboard you run across. Note, however, that this is just a brief introduction to the insides of a computer. The details of the various devices in the computer and their impact on computer service practices will be covered in later chapters.

Chipsets

A *chipset* is a collection of chips or circuits that perform interface and peripheral functions for the processor. This collection of chips is usually the circuitry that provides interfaces for memory, expansion cards, and onboard peripherals and generally dictates how a motherboard will talk to the installed peripherals.

Chipsets are usually given a name and model number by the original manufacturer. For example, if you see that motherboard has a VIA KT7 chipset, you would know that the circuitry for controlling peripherals was designed by VIA and was given the designation KT7. Typically, that would also mean that you would know that a particular chipset has a certain set of features (for example, onboard video of a certain type/brand, onboard audio of a particular type, and so on).

Chipsets can be made up of one or several integrated circuit chips. Intel-based motherboards typically use two chips, whereas the SiS chipsets typically use one. To know for sure, you must check the manufacturer's documentation.

The functions of chipsets can be divided into two major functional groups, called Northbridge and Southbridge. Let's take a brief look at these groups and the functions they perform.

Northbridge

The *Northbridge* subset of a motherboard's chipset is the set of circuitry or chips that performs one very important function: management of high-speed peripheral communications. The Northbridge subset is responsible primarily for communications with integrated video using AGP and PCIe, for instance, and processor-to-memory communications. Therefore, it can be said that much of the true performance of a PC relies on the performance of the Northbridge chipset and the communications between it and the peripherals it controls.



When we use the term Northbridge chipset, there isn't actually a Northbridge brand of chipset, but we are referring to the set of chips and circuits that make up a particular subset of a motherboard's chipset.

The communications between the CPU and memory occur over what is known as the *front-side bus (FSB)*, which is just a set of signal pathways between the CPU and main memory. The *backside bus*, on the other hand, is a set of signal pathways between the CPU and Level 2 cache memory (if present).

The Northbridge chipsets also manage the communications between the Southbridge chipset (discussed next) and the rest of the computer. Finally, if a motherboard has onboard video circuitry (especially if it needs direct access to main memory), that circuitry will be found within the Northbridge chipset.

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It might help you to remember that the Northbridge plays "traffic cop" with the data within a computer, to ensure that data gets to where it needs to go in a timely fashion.

Southbridge

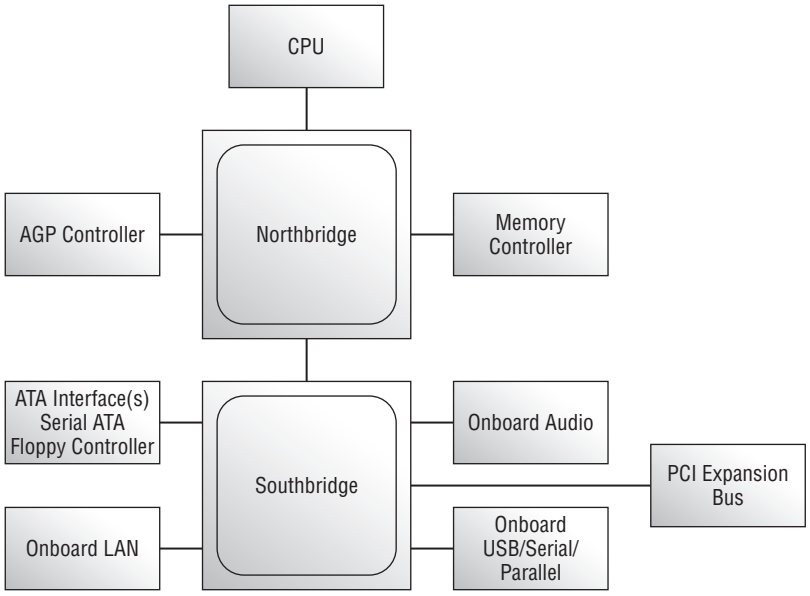
The *Southbridge* chipset, as mentioned earlier, is responsible for providing support to the myriad onboard peripherals (PS/2, Parallel, IDE, and so on), managing their communications with the rest of the computer and the resources given to them.

Most motherboards today have integrated PS/2, USB, Parallel, and Serial. Some of the optional features handled by the Southbridge include LAN, audio, infrared, and FireWire (IEEE 1394). When first integrated, the quality of onboard audio was marginal at best, but the latest offerings (such as the AC97 audio chipset) rival Creative Labs in sound quality and number of features (even including Dolby Digital Theater Surround technology).

The Southbridge chipset is also responsible for managing communications with the other expansion buses, such as PCI, USB, and legacy buses.

Figure 1.3 shows an example of a typical motherboard chipset (both Northbridge and Southbridge) and the components they interface with. Notice which components interface with which parts of the chipset.

FIGURE 1.3 A typical motherboard chipset



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Expansion Slots

The most visible parts of any motherboard are the *expansion slots*. These look like small plastic slots, usually from 3 to 11 inches long and approximately ½ inch wide. As their name suggests, these slots are used to install various devices in the computer to expand its capabilities. Some expansion devices that might be installed in these slots include video, network, sound, and disk interface cards.

If you look at the motherboard in your computer, you will more than likely see one of the main types of expansion slots used in computers today:

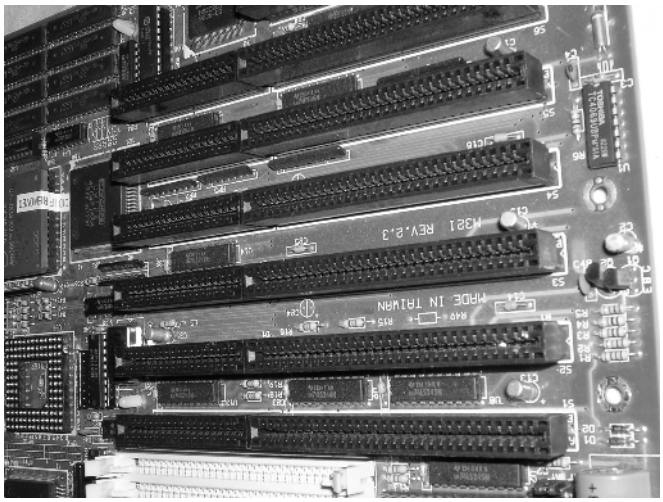
- ISA
- PCI
- AGP
- PCIe
- AMR
- CNR

Each type differs in appearance and function. In this section, we will cover how to visually identify the different expansion slots on the motherboard.

ISA Expansion Slots

If you have a computer made before 1997, chances are the motherboard has a few *Industry Standard Architecture (ISA) expansion slots*. They're easily recognizable because they are usually black and have two parts: one shorter and one longer. Computers made after 1997 generally include a few ISA slots for backward compatibility with old expansion cards (although most computers are phasing them out in favor of PCI). Figure 1.4 shows an example of ISA expansion slots.

FIGURE 1.4 ISA expansion slots



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PCI Expansion Slots

Most computers made today contain primarily *Peripheral Component Interconnect (PCI)* slots. They are easily recognizable because they are short (around 3 inches long) and usually white. PCI slots can usually be found in any computer that has a Pentium-class processor or higher. Figure 1.5 shows an example of several PCI expansion slots.

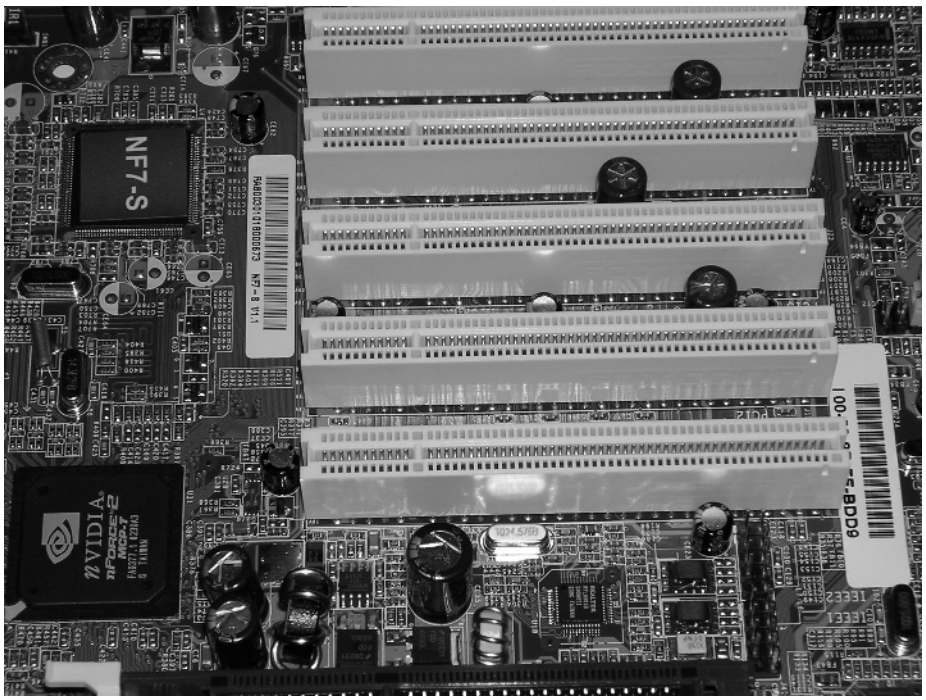
AGP Expansion Slots

Accelerated Graphics Port (AGP) slots are very popular for video card use. In the past, if you wanted to use a high-speed, accelerated 3D graphics video card, you had to install the card into an existing PCI or ISA slot. AGP slots were designed to be a direct connection between the video circuitry and the PC's memory. They are also easily recognizable because they are usually brown, are located right next to the PCI slots on the motherboard, and are shorter than the PCI slots. Figure 1.6 shows an example of an AGP slot, along with a PCI slot for comparison. Notice the difference in length between the two.

PCIe Expansion Slots

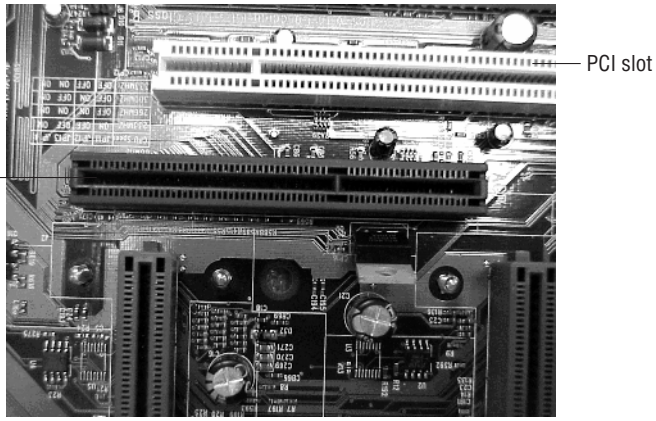
The newest expansion slot architecture that is being used by motherboards is *PCI Express (PCIe)*. It was designed to be a replacement for AGP and PCI. It has the capability of being faster than AGP while maintaining the flexibility of PCI. And motherboards with PCIe will have regular PCI slots for backward compatibility with PCI.

FIGURE 1.5 PCI expansion slots



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FIGURE 1.6 An AGP slot compared to a PCI slot



There are seven different speed levels for PCIe, and they are designated 1X, 2X, 4X, 8X, 12X, 16X, and 32X. These designations roughly correspond to similarly designated AGP speeds. The slots for PCIe are a bit harder to identify than other expansion slot types because the slot size corresponds to its speed. For example, the 1X slot is extremely short (less than an inch). The slots get longer in proportion to the speed; the longer the slot, the higher the speed. The reason for this stems from the PCIe concept of *lanes*, which are the multiplied units of communication between any two PCIe components and are directly related to physical wiring on the bus. Because all PCIe communications are made up of unidirectional coupling between devices, each PCIe card negotiates for the best mutually supported number of lanes with each communications partner.



You can, however, use a shorter (lower-speed) card in a longer (higher-speed) slot. For example, you can put an 8X card in a 16X slot. The 8X card won't completely fill the slot, but it will work. The converse, however, is not true.

AMR Expansion Slots

As is always the case, Intel and other manufacturers are constantly looking for ways to improve the production process. One lengthy process that would often slow down the production of motherboards with integrated analog I/O functions was FCC certification. The manufacturers developed a way of separating the analog circuitry, for example, modem and analog audio, onto its own card. This allowed the analog circuitry to be separately certified (it was its own expansion card), thus reducing time for FCC certification.

This slot and riser card technology was known as the *Audio Modem Riser*, or *AMR*. AMR's 46-pin slots were once fairly common on many Intel motherboards, but technologies including CNR and Advanced Communications Riser (ACR) are edging out AMR. In addition and despite FCC concerns, integrated components still appear to be enjoying the most success comparatively. Figure 1.7 shows an example of an AMR slot.

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CNR Expansion Slots

The *Communications and Networking Riser (CNR)* slots that can be found on some Intel motherboards are a replacement for Intel's AMR slots. Essentially, these 60-pin slots allow a motherboard manufacturer to implement a motherboard chipset with certain integrated features. Then, if the built-in features of that chipset need to be enhanced (by adding Dolby Digital Surround to a standard sound chipset, for example), a CNR riser card could be added to enhance the onboard capabilities. Additional advantages of CNR over AMR include networking support, Plug and Play compatibility, support for hardware acceleration (as opposed to CPU control only), and no need to lose a competing PCI slot unless the CNR slot is in use. Figure 1.8 shows an example of a CNR slot.

FIGURE 1.7 An AMR slot

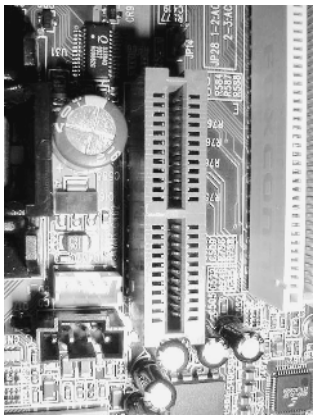
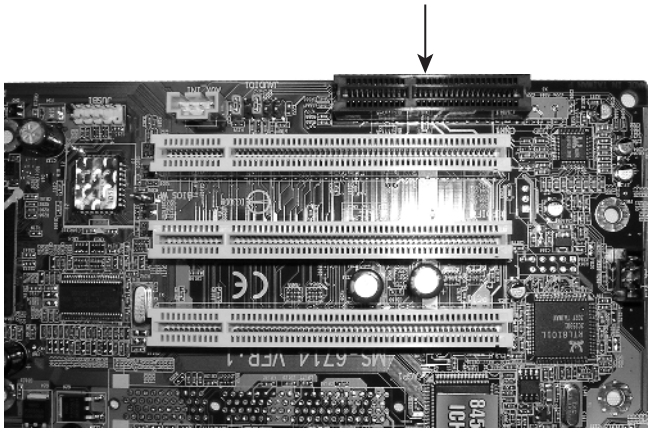


FIGURE 1.8 A CNR slot



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Memory Slots and External Cache

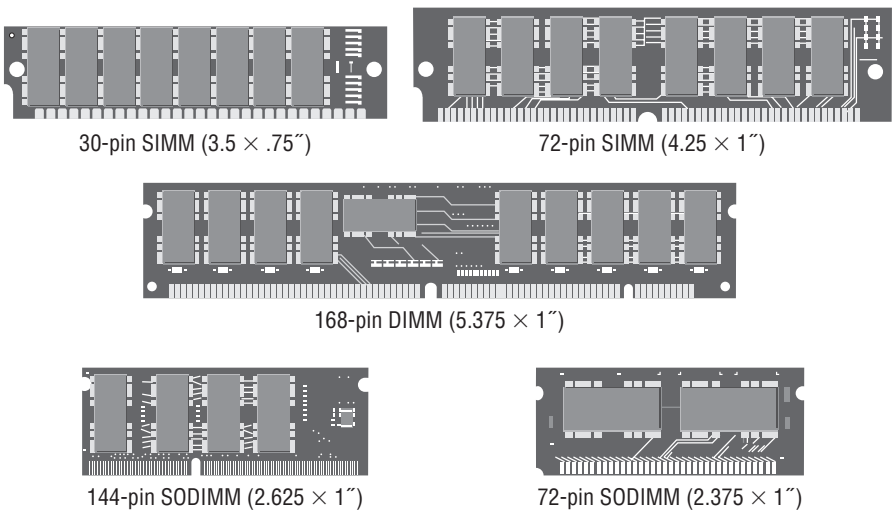
Memory or random access memory (RAM) slots are the next most prolific slots on a motherboard, and they contain the modules that hold memory chips that make up primary memory, the memory used to store currently used data and instructions for the CPU. Many and varied types of memory are available for PCs today. In this chapter, you will learn the appearance of the slots on the motherboard, so you can identify them.

For the most part, PCs today use memory chips arranged on a small circuit board. Certain of these circuit boards are called *Dual Inline Memory Modules (DIMMs)*. Today's DIMMs differ in the number of conductors, or *pins*, that the particular physical specification uses. Some common examples include 168-, 184-, and 240-pin configurations. In addition, laptop memory comes in smaller form factors known as Small Outline DIMMs (SoDIMMs) and MicroDIMMs. Figure 1.9 shows the form factors for the most popular memory chips. Notice how they basically look the same, but the memory module sizes are different.

Memory slots are easy to identify on a motherboard. DIMM slots are usually black and placed very close together. The number of memory slots varies from motherboard to motherboard, but the appearance of the different slots is similar. Metal pins in the bottom make contact with the soldered tabs on each memory module. Small metal or plastic tabs on each side of the slot keep the memory module securely in its slot.

Sometimes primary memory gets a bit overwhelmed with the requests coming from the processor. To get its bearings, the RAM must obtain the information the CPU wants immediately, but RAM is not as fast as the CPU, and the CPU must wait. The result is that the entire system slows down noticeably, on average. One solution for this is to use the hard drive as RAM. This space on the hard drive is known as *virtual RAM (VRAM)*. VRAM is a contiguous, optimized space that can deliver information to RAM faster than if it came from the general storage pool of the drive.

FIGURE 1.9 Different memory module form factors



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There is something that can be done on the CPU side of RAM to speed things up a bit as well. That something is adding *cache memory*. Cache memory is a very fast form of memory forged from static RAM, which is discussed in detail in the "Identifying Purposes and Characteristics of Memory" section of this chapter. Cache improves system performance by predicting what the CPU will ask for next and prefetching this information before being asked. This paradigm allows the cache to be smaller in size than the RAM itself. Only the most recently used data and code or that which is expected to be used next is stored in cache. Cache on the motherboard is known as *external cache* because it is external to the processor. Also called *Level 2 (L2) cache*, this is as opposed to the *Level 1 (L1) cache* built into the processor. See the section titled "Identifying Purposes and Characteristics of Processors" later in this chapter for more on L1 cache.

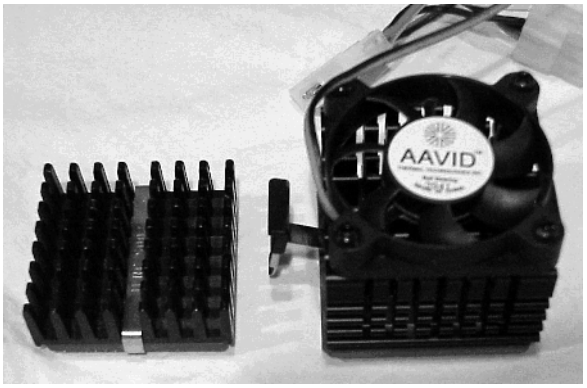
Central Processing Unit (CPU) and Processor Socket or Slot

The "brain" of any computer is the *central processing unit (CPU)*. This component does all the calculations and performs 90 percent of all the functions of a computer. There are many different types of processors for computers—so many, in fact, that you will learn about them later in this chapter in the section "Identifying Purposes and Characteristic of Processors."

Typically, in today's computers, the processor is the easiest component to identify on the motherboard. It is usually the component that has either a fan or a heat sink (usually both) attached to it (as shown in Figure 1.10). These devices are used to draw away the heat a processor generates. This is done because heat is the enemy of microelectronics. Theoretically, a Pentium (or higher) processor generates enough heat that without the heat sink it would self-destruct in a matter of hours.

Sockets and slots on the motherboard are as plentiful and varied as processors. Sockets are basically flat and have several rows of holes arranged in a square, as shown in Figure 1.11. The processor slot is another method of connecting a processor to a motherboard, but one into which an Intel Pentium II or Pentium III–class processor on a special expansion card can be inserted (as shown in Figure 1.12). Newer, more complex processors, such as the Intel Itanium, use a package known as a pin array cartridge (PAC). The socket that receives a PAC works on the very low insertion force (VLIF) principle. To see which socket type is used for which processors, examine Table 1.1.

FIGURE 1.10 Processors with a fan and heat sinks



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FIGURE 1.11 An example of a CPU socket

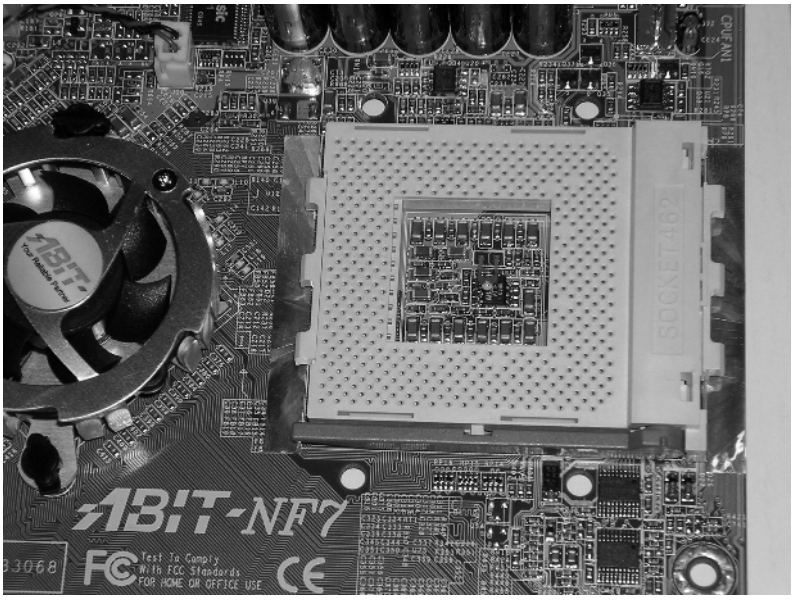
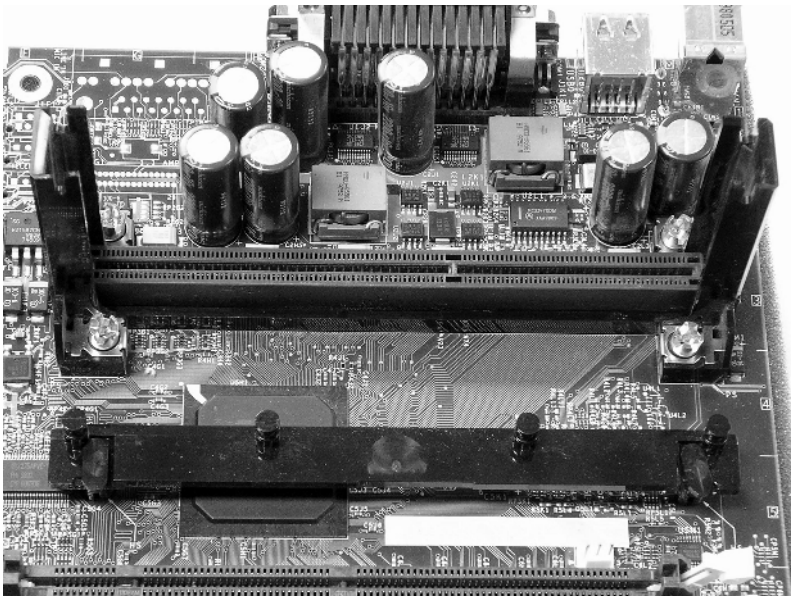


FIGURE 1.12 A Slot 1 connector slot



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TABLE 1.1 Socket/Slot Types and the Processors They Support

Socket/Slot	Processors
Socket 4	Pentium 60/66, Pentium 60/66 OverDrive
Socket 5	Pentium 75-133, Pentium 75+ OverDrive, AMD K5
Socket 6*	486DX4, 486 Pentium OverDrive
Socket 7	Pentium 75-200, Pentium 75+ OverDrive, Pentium MMX, AMD K6
Super Socket 7	AMD K6-2, K6-III
Socket 8	Pentium Pro
Slot 1	Pentium II, Pentium III, Celeron, and all SECC and SECC2
Slot 2	Pentium II Xeon, Pentium III Xeon
Slot A	Early AMD Athlon
Socket 370	PPGA processors, including Pentium III and Celeron
Socket 423	Early Pentium 4
Socket A (Socket 462)	AMD Athlon, Athlon XP, Athlon XP-M, Athlon MP, Thunderbird, Duron, Sempron
Socket 478	Pentium 4, Pentium 4 Extreme Edition, Celeron
Socket 479	Pentium M, Celeron M
Socket 486	80486
Socket 563	AMD low-power mobile Athlon XP-M
Socket 603	Intel Xeon
Socket 604	Intel Xeon with Micro FCPGA package
Socket 754	Athlon 64, Sempron, Turion 64
Socket 771	Xeon 50x0 dual-core
Socket T (LGA 775)	Pentium 4, Pentium D dual-core, Celeron D, Pentium Extreme Edition
Socket 939	Athlon 64, Athlon 64 FX, Athlon 64 X2, Opteron 100-series

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TABLE 1.1 Socket/Slot Types and the Processors They Support *(continued)*

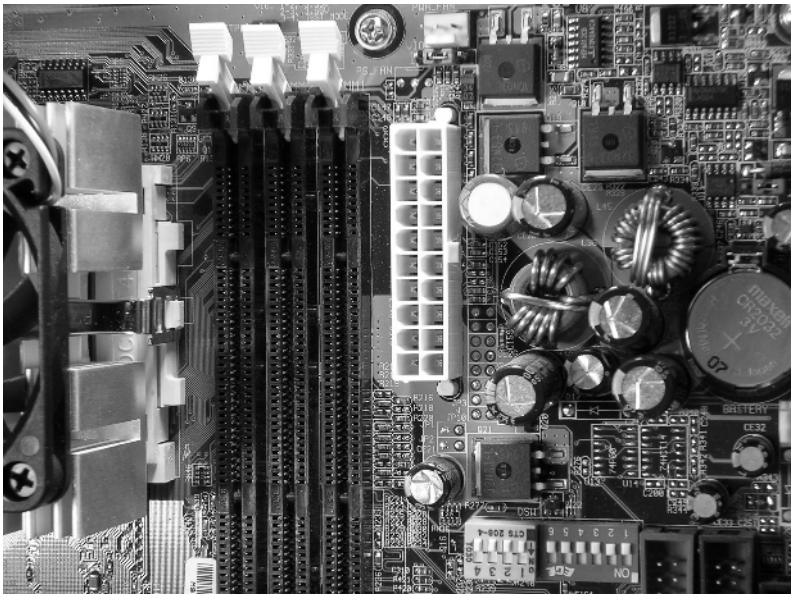
Socket/Slot	Processors
Socket 940	Athlon 64 FX (FX-51), Opteron
Socket F (Socket 1207)	Replaces Socket 940 when used with Opteron multiprocessor systems
Socket AM2	AMD single-processor systems, replaces Socket 754 and Socket 939
Socket S1	AMD-based mobile platforms, replaces Socket 754 in the mobile sector
PAC418	Itanium
PAC611	Itanium 2

*Socket 6 was a paper standard only and was never implemented in any systems.

Power Connectors

In addition to these sockets and slots on the motherboard, a special connector (shown in Figure 1.13) allows the motherboard to be connected to the power supply to receive power. This connector is where the ATX power connector (mentioned later in this chapter in the section "Identifying Purposes and Characteristics of Power Supplies") plugs in.

FIGURE 1.13 An ATX power connector on a motherboard



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Onboard Floppy and Hard Disk Connectors

Almost every computer made today uses some type of disk drive to store data and programs until they are needed. Most drives need a connection to the motherboard so the computer can "talk" to the disk drive. These connections are known as *drive interfaces,* and there are two main types: *floppy drive interfaces* and *hard disk interfaces*. Floppy disk interfaces allow floppy disk drives (FDDs) to be connected to the motherboard and, similarly, hard disk interfaces do the same for hard disks. When you see them on the motherboard, these interfaces are said to be *onboard*, as opposed to being on an expansion card (*off-board*). The interfaces consist of circuitry and a port. Most motherboards produced today include both the floppy disk and hard disk interfaces on the motherboard.

Today, the headers you will find on most motherboards are for Enhanced IDE (EIDE/PATA) or *Serial ATA (SATA)*. Advanced Technology Attachment (ATA) is the standard term for what is more commonly referred to as Integrated Drive Electronics (IDE). The AT component of the name was borrowed from the IBM PC/AT, which was the standard of the day. However, because ATA is not the only technology that integrates the drive controller circuitry into the drive assembly (ESDI, for example, was another), IDE is somewhat of a misnomer and not the best term when referring only to ATA drives.

Nevertheless, the original ATA standard was referred to as IDE and had an upper limit of 528MB per logical drive. An enhanced version, Enhanced IDE (EIDE), was developed to circumvent the obstacles to accessing more drive space per volume, increasing the limit to 8GB. Since then, the limit has been increased to 144PB through various enhancements. A petabyte (PB) is the number of bytes represented by 2 raised to the 50th power.

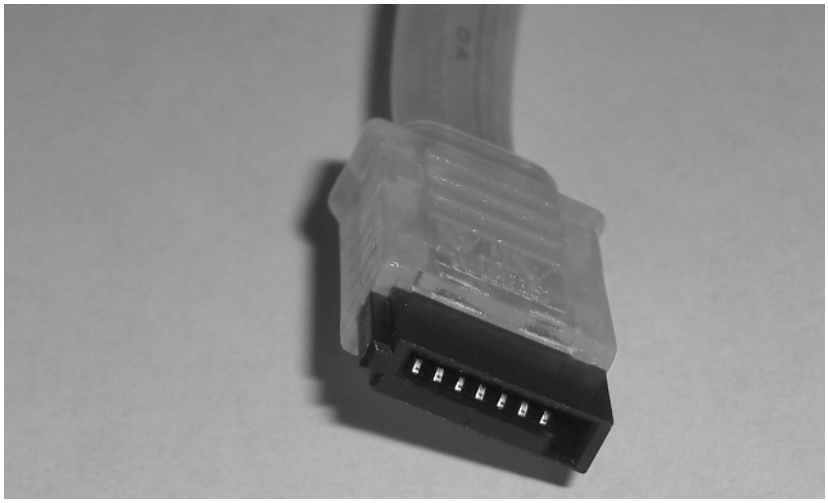
If your motherboard has PATA headers, they will normally be black or some other neutral color if they follow the classic ATA 40-wire standard. If your PATA headers are blue, these represent PATA interfaces that employ the Ultra DMA (UDMA) technology that increases transfer rates by reducing crosstalk in the parallel signal by alternating another 40 wires that act as grounds among the other wires. The connectors and headers are still 40 pins, however. The color coding alerts you to the enhanced performance, which is downward compatible with the 40-wire technology.

The original 40-pin ATA header transfers data between the drive and motherboard multiple bits in parallel, hence the name *Parallel ATA (PATA)*. SATA, in comparison, which came out later and prompted the retroactive PATA moniker, transfers data in serial, allowing a higher data throughput because there is no need for more advanced parallel synchronization of data signals. The SATA headers are vastly different from the PATA headers. Figure 1.14 shows an example of the SATA data connector.

Many motherboards, especially higher-end boards like those found in servers, also include the more complex SCSI circuitry built in so that SCSI-attached drives can connect directly to the system board without an external adapter.

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FIGURE 1.14 The Serial ATA connector



Keyboard Connectors

The most important input device for a PC is the keyboard. All PC motherboards contain a connector (as shown in Figures 1.15 and 1.16) that allows a keyboard to be connected directly to the motherboard through the case. There are two main types of keyboard connectors. Once, these were the AT and PS/2 connectors. Today, the PS/2-style connector remains popular, but it is quickly being replaced by USB-attached keyboards. The all-but-extinct original AT connector is round, about ½ inch in diameter, in a 5-pin DIN configuration. Figure 1.15 shows an example of the AT-style keyboard connector.

The PS/2 connector (as shown in Figure 1.16) is a smaller 6-pin mini-DIN connector. Most new PCs you can purchase today contain a PS/2 keyboard connector as well as a PS/2 mouse connector right above it on the motherboard. Compare your PC's keyboard connector with Figures 1.15 and 1.16.



Newer motherboards have color coded the PS/2 mouse and keyboard connectors to make connection of keyboards and mice easier. PS/2 mouse connectors are green (to match the standard green connectors on some mice), and the keyboard connectors are purple.

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FIGURE 1.15 An AT connector on a motherboard

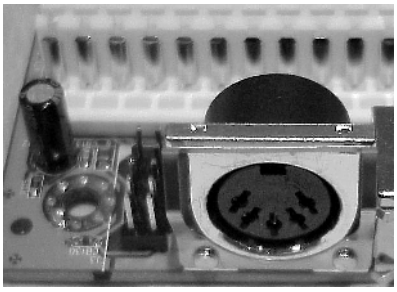
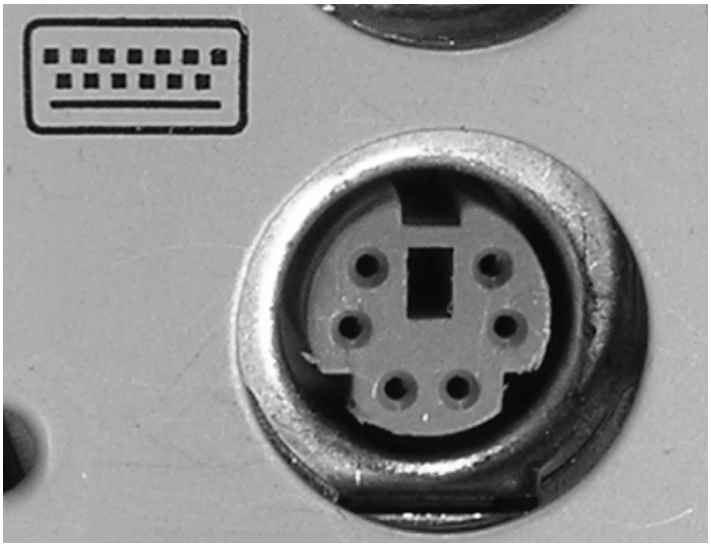


FIGURE 1.16 A PS/2-style keyboard connector on a motherboard



Peripheral Ports and Connectors

In order for a computer to be useful and have the most functionality, there must be a way to get the data into and out of it. Many different ports are available for this purpose. We will discuss the different types of ports and how they work later in this chapter.

Briefly, the seven most common types of ports you will see on a computer are serial, parallel, Universal Serial Bus (USB), video, Ethernet, sound in/out, and game ports. Figure 1.17 shows some of these and others on a *docking station* or *port replicator* for a laptop. From left to right, the interfaces shown are as follows:

- DC power in
- Analog modem RJ-11

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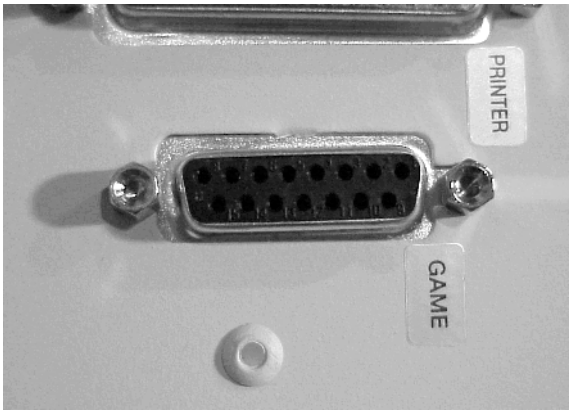
- Ethernet NIC RJ-45
- S-video out
- DVI-D out
- SVGA out
- Parallel (on top)
- Standard serial
- Mouse (on top)
- Keyboard
- S/PDIF (out)
- USB

Figure 1.18 shows an example of a *game port* (also called a *joystick port* because that's the most common device connected to it). As discussed later in this chapter, the game port can be used to connect to *Musical Instrument Digital Interface (MIDI)* devices as well. Game ports connect such peripheral devices to the computer using a DA-15F 15-pin female *D-subminiature (D-sub)* connector.

FIGURE 1.17 Peripheral ports and connectors



FIGURE 1.18 A game port



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Figure 1.19 shows another set of interfaces not shown in Figure 1.17, the sound card jacks. These jacks are known as *1/8-inch* (3.5mm) stereo minijacks, so called for their size and the fact that they make contact with both the left and right audio channels through their tip and ring. Shown in the diagram are an input, the microphone jack on the left, and an output, the speaker jack on the right. Software can use these interfaces to allow you to record and play back audio content in file or CD/DVD form.

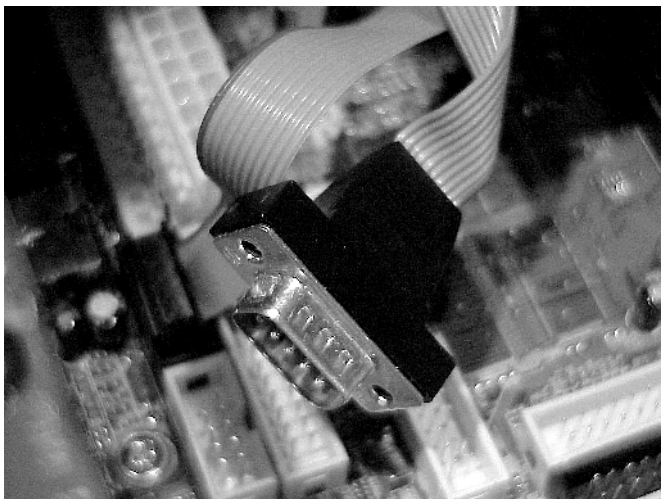
Motherboard Attachment

There are two ways of connecting these ports to the motherboard (assuming the circuitry for providing these functions is integrated into the motherboard). The first, called a *header connection*, allows you to mount the ports into the computer's case, usually on the backplane, with a special cable connected to a *header*, or male connector that terminates the motherboard's traces for that function, as shown in Figure 1.20.

FIGURE 1.19 Sound card jacks



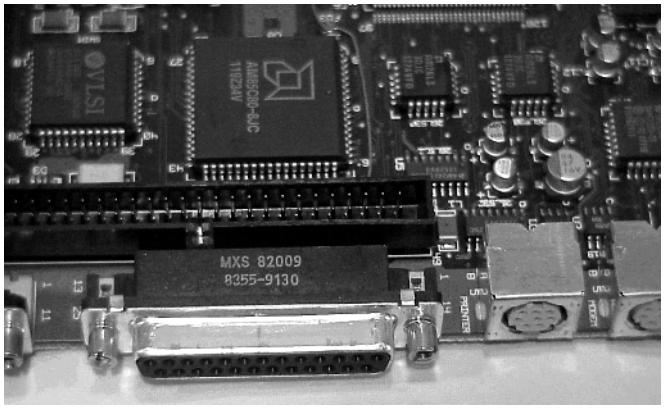
FIGURE 1.20 Connecting a port to the header on a motherboard



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The second method of connecting a peripheral port is known as the *direct-solder method*. With this method, the individual ports are soldered directly to the motherboard. This method is used mostly in integrated motherboards in non-clone machines. Figure 1.21 shows peripheral ports connected to a motherboard with the direct-solder method. Notice that there is no cable between the port and the motherboard and that the port is part of the motherboard. As discussed earlier, these onboard ports can be disabled in the BIOS setup if necessary.

FIGURE 1.21 Peripheral ports directly soldered to a motherboard



BIOS Chip

Aside from the processor, the most important chip on the motherboard is the Basic Input/Output System (BIOS) chip. This special memory chip contains the BIOS software that tells the processor how to interact with the rest of the hardware in the computer. The BIOS chip is easily identified: If you have a non-clone computer (Compaq, IBM, HP, and so on), this chip has on it the name of the manufacturer and usually the word *BIOS*. For example, the BIOS chip for a Compaq has something like *Compaq BIOS* printed on it. For clones, the chip usually has a sticker or printing on it from one of the major BIOS manufacturers (AMI, Phoenix/Award, Winbond, and so on).

CMOS Battery

Your PC has to keep certain settings when it's turned off and its power cord is unplugged. These settings include the following:

- Date
- Time
- Hard drive configuration
- Memory

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Your PC keeps these settings in a special memory chip called the Complimentary Metal Oxide Semiconductor (CMOS) chip. Actually, CMOS (usually pronounced *see-moss*) is a type of memory chip; it is the parameter memory for the BIOS. But that doesn't translate into an easy-to-say acronym. So because it's the most important CMOS chip in the computer, it has come to be called the CMOS.

To keep its settings, the memory must have power constantly. When you shut off a computer, anything that is left in main memory is lost forever. To prevent CMOS from losing its information (and it's rather important that it doesn't), motherboard manufacturers include a small battery called the *CMOS battery* to power the CMOS memory. The batteries come in different shapes and sizes, but they all perform the same function. Most CMOS batteries look like either large watch batteries or small, cylindrical batteries.

Jumpers and DIP Switches

The last components of the motherboard we will discuss in this section are jumpers and DIP switches. These two devices are used to configure various hardware options on the motherboard. For example, some processors use different voltages (1.5, 3.3, or 5 volts). You must set the motherboard to provide the correct voltage for the processor it is using. You do so by changing a setting on the motherboard with either a jumper or a DIP switch. Figure 1.22 shows both a jumper set and DIP switches. Motherboards often have either several jumpers or one bank of DIP switches. Individual jumpers are often labeled with the moniker JP*x* (where *x* is the number of the jumper).

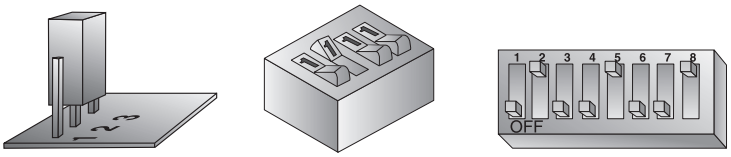


Many of the motherboard settings that were set using jumpers and DIP switches are now either automatically detected or set manually in the CMOS setup program.

Firmware

Firmware is the name given to any software that is encoded into a read-only memory (ROM) chip and can be run without extra instructions from the operating system. Most computers use firmware in some limited sense. The best example of firmware is a computer's CMOS setup program, which is used to set the options for the computer's BIOS (time/date and boot options, for example). Also, some expansion cards, such as Small Computer System Interface (SCSI) cards, use their own firmware utilities for setting up peripherals.

FIGURE 1.22 Jumpers and DIP switches



Jumper Rocker-type DIP switch Slide-type DIP switch

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Identifying Purposes and Characteristics of Processors

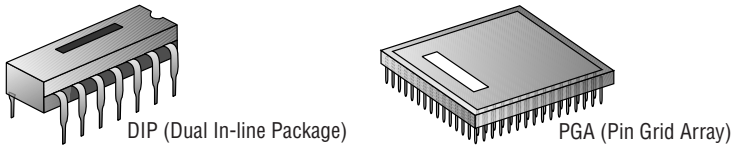
Now that you've learned the basics of the motherboard, you need to learn about the most important component on the motherboard: the CPU. The role of the CPU, or central processing unit, is to control and direct all the activities of the computer using both external and internal buses. It is a processor chip consisting of an array of *millions* of transistors.



The term *chip* has grown to describe the entire package that a technician might install in a socket. However, the word originally denoted the silicon wafer that is generally hidden within the carrier that you actually see. The external pins you see are structures that can withstand insertion into a socket and that are carefully threaded from the wafer's minuscule contacts. Just imagine how fragile the structures must be that you don't see.

Older CPUs are generally square, with contacts arranged in a Pin Grid Array (PGA). Prior to 1981, chips were found in a rectangle with two rows of 20 pins known as a Dual Inline Package (DIP); see Figure 1.23. There are still integrated circuits that use the DIP form factor. However, the DIP form factor is no longer used for PC CPUs. Most CPUs use either the PGA or the Single Edge Contact Cartridge (SECC) form factor. SECC is essentially a PGA-type socket on a special expansion card.

FIGURE 1.23 DIP and PGA



As processor technology grows and motherboard real estate stays the same, more must be done with the same amount of space. To this end, the *Staggered PGA (SPGA)* layout was developed. An SPGA package arranges the pins in what appears to be a checkerboard pattern, but if you angle the chip diagonally, you'll notice straight rows, closer together than the right-angle rows and columns of a PGA. This feature allows a higher pin count per area.



This discussion only scratches the surface of the topic surrounding chip packaging and carriers. For more information on the various packaging for chips, start with `en.wikipedia.org/wiki/Category:Chip_carriers`.

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You can easily identify which component inside the computer is the CPU because it is a large square lying flat on the motherboard with a very large heat sink and fan (as shown earlier in Figure 1.10). Or if the CPU is installed in a Slot 1 motherboard, it is a large ½-inch-thick expansion card with a large heat sink and fan integrated into the package. It is located away from the expansion cards. Figure 1.24 shows the location of the CPU in relation to the other components on a typical ATX motherboard. Notice how prominent the CPU is.

FIGURE 1.24 The location of a CPU inside a typical computer



Modern processors can feature the following:

Hyperthreading This term refers to Intel's Hyper-Threading Technology (HTT). HTT is a form of simultaneous multithreading (SMT). SMT takes advantage of a modern CPU's superscalar architecture. Superscalar processors are able to have multiple instructions operating on separate data in parallel.

HTT-capable processors appear to the operating system to be two processors. As a result, the operating system can schedule two processes at the same time, as in the case of symmetric multiprocessing (SMP), where two or more processors use the same system resources. In fact, the operating system must support SMP in order to take advantage of HTT. If the current process stalls because of missing data caused by, say, cache or branch prediction issues, the execution resources of the processor can be reallocated for a different process that is ready to go, reducing processor downtime.

Multicore A processor that exhibits a *multicore* architecture has two completely separate processors in the same package. Whether there are multiple dies in the same package or the single

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Real World Scenario

What's Your CPU?

The surest way to determine which CPU your computer is using is to open the case and view the numbers stamped on the CPU, which today requires removal of the active heat sink. However, you may be able to get an idea without opening the case and removing the heat sink and fan, because many manufacturers indicate the type of processor by placing a very obvious sticker somewhere on the case indicating the processor type. Failing this, you can always go to the manufacturer's website and look up the information on the model of computer you have. If you have a no-name clone, there is always the System Information dialog found by right-clicking My Computer and selecting Properties. The General tab, which is the default, contains such information.

Another way to determine a computer's CPU is to save your work, exit any open programs, and restart the computer. Watch closely as the computer returns to its normal state. You should see a notation that tells you what chip you are using.

die contains the equivalent circuitry of multiple processors, the operating system can treat the single processor as if it were two separate processors. As with HTT, the operating system must support SMP. In addition, SMP is not an enhancement if the applications run on the SMP system are not written for parallel processing. *Dual-core* processors are a common specific case for the multi-core technology.

Throttling CPU *throttling*, or clamping, is the process of controlling how much CPU time is spent on an application. By controlling how individual applications use the CPU, all applications are treated more fairly. The concept of application fairness becomes a particular issue in server environments, where each application could represent the efforts of a different user. Thus, fairness to applications becomes fairness to users, the real customers. Clients of today's terminal servers benefit from CPU throttling.

Microcode *Microcode* is the set of instructions (known as an *instruction set*) that make up the various microprograms that the processor executes while carrying out its various duties. The Multimedia Extensions (MMX) microcode is a specialized example of a separate microprogram that carries out a particular set of functions. Microcode is at a much lower level than the code that makes up application programs. Each instruction in an application will end up being represented by many microinstructions, on average. The MMX instruction set is incorporated into most modern CPUs from Intel and others. MMX came about as a way to take much of the multimedia processing off the CPU's hands, leaving the processor to other tasks. Think of it as sort of a coprocessor for multimedia, much like the floating-point unit (FPU) is a math coprocessor.

Overclocking *Overclocking* your CPU offers increased performance, on par with a processor designed to operate at the overclocked speed. However, unlike with the processor designed

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to run that fast, you must make special arrangements to ensure that an overclocked CPU does not destroy itself from the increased heat levels. An advanced cooling mechanism, such as liquid cooling, might be necessary to avoid losing the processor and other components.

Cache As mentioned in the "Memory Slots and External Cache" section earlier in this chapter, cache is a very fast chip memory that is used to hold data and instructions that are most likely to be requested next by the CPU. The cache located on the CPU is known as L1 cache and is generally smaller in comparison to L2 cache, which is located on the motherboard. When the CPU requires outside information, it believes it requests that information from RAM. The cache controller, however, intercepts the request and consults its tag RAM to discover if the requested information is already cached, either at L1 or L2. If not, a cache miss is recorded and the information is brought back from the much slower RAM, but this new information sticks to the L1 and L2 cache on its way to the CPU from RAM.

Voltage Regulator Module The *voltage regulator module (VRM)* is the circuitry that sends a standard voltage level to the portion of the processor that is able to send a signal back to the VRM concerning the voltage level the CPU needs. After receiving the signal, the VRM truly regulates the voltage to steadily provide the requested voltage.

Speed The speed of the processor is generally described in clock frequency (MHz or GHz). There can be a discrepancy between the advertised frequency and the frequency the CPU uses to latch data and instructions through the pipeline. This disagreement between the numbers comes from the fact that the CPU is capable of splitting the clock signal it receives from the oscillator into multiple regular signals for its own use.

32- and 64-Bit System Bus The set of data lines between the CPU and the primary memory of the system can be 32 or 64 bits wide, among other widths. The wider the bus, the more data that can be processed per unit of time, and hence the more work that can be performed. Internal registers in the CPU might be only 32 bits wide, but with a 64-bit system bus, two separate pipelines can receive information simultaneously.

Identifying Purposes and Characteristics of Memory

"More memory, more memory, I don't have enough memory!" Today, memory is one of the most popular, easy, and inexpensive ways to upgrade a computer. As the computer's CPU works, it stores information in the computer's memory. The rule of thumb is the more memory a computer has, the faster it will operate.

To identify memory within a computer, look for several thin rows of small circuit boards sitting vertically, packed tightly together near the processor. Figure 1.25 shows where memory is located in a system.

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FIGURE 1.25 Location of memory within a system



Parity checking is a rudimentary error-checking scheme that lines up the chips in a column and divides them into an equal number of bits, numbered starting at 0. All the number *n* bits, one from each chip, form a numerical set. If even parity is used, for example, the number of bits in the set is counted up, and if the total comes out even, then the parity bit is set to 0, because the count is already even. If it comes out odd, then the parity bit is set to 1 to even up the count. You can see that this is effective only for determining if there was a blatant error in the set of bits, but there is no indication as to where the error is and how to fix it. This is error checking, not error correction. Finding an error can lock up the entire system and display a memory parity error. Enough of these errors and you need to replace the memory. If that doesn't fix the problem, good luck.

In the early days of personal computing, almost all memory was parity-based. Compaq was one of the first manufacturers to employ non-parity RAM in their mainstream systems. As quality has increased over the years, parity checking in the RAM subsystem has become rarer. If parity checking is not supported, there will generally be fewer chips per module, usually one less per column of RAM.

The next step in the evolution of memory error detection is known as *Error Checking and Correcting (ECC)*. If memory supports ECC, check bits are generated and stored with the data. An algorithm is performed on the data and its check bits whenever the memory is accessed. If the result of the algorithm is all zeros, then the data is deemed valid and processing continues. ECC can detect single- and double-bit errors and actually correct single-bit errors.

In the following sections, we'll outline the four major types of computer memory—DRAM, SRAM, ROM, and CMOS—as well as memory packaging.

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DRAM

DRAM is dynamic random access memory. (This is what most people are talking about when they mention RAM.) When you expand the memory in a computer, you are adding DRAM chips. You use DRAM to expand the memory in the computer because it's cheaper than any other type of memory. Dynamic RAM chips are cheaper to manufacture than other types because they are less complex. *Dynamic* refers to the memory chips' need for a constant update signal (also called a *refresh* signal) in order to keep the information that is written there. If this signal is not received every so often, the information will cease to exist. Currently, there are four popular implementations of DRAM: SDRAM, DDR, DDR2, and RAMBUS.

SDRAM

The original form of DRAM had an asynchronous interface, meaning that it derived its clocking from the actual inbound signal, paying attention to the electrical aspects of the waveform, such as pulse width, to set its own clock to synchronize on the fly with the transmitter. *Synchronous DRAM (SDRAM)* shares a common clock signal with the transmitter of the data. The computer's system bus clock provides the common signal that all SDRAM components use for each step to be performed.

This characteristic ties SDRAM to the speed of the FSB and the processor, eliminating the need to configure the CPU to wait for the memory to catch up. Every time the system clock ticks, one bit of data can be transmitted per data pin, limiting the bit rate per pin of SDRAM to the corresponding numerical value of the clock's frequency. With today's processors interfacing with memory using a parallel data-bus width of 8 bytes (hence the term 64-bit processor), a 100MHz clock signal produces 800MBps. That's mega*bytes* per second, not mega*bits*. Such memory is referred to as *PC100*, because throughput is easily computed as eight times the rating.

DDR

Double Data Rate (DDR) SDRAM earns its name by doubling the transfer rate of ordinary SDRAM by double-pumping the data, which means transferring it on both the rising and falling edges of the clock signal. This obtains twice the transfer rate at the same FSB clock frequency. It's the rising clock frequency that generates heating issues with newer components, so keeping the clock the same is an advantage. The same 100MHz clock gives a DDR SDRAM system the impression of a 200MHz clock in comparison to a *single data rate (SDR)* SDRAM system.

You can use this new frequency in your computations or simply remember to double your results for SDR calculations, producing DDR results. For example, with a 100MHz clock, two operations per cycle, and 8 bytes transferred per operation, the data rate is 1600MBps. Now that throughput is becoming a bit tricker to compute, the industry uses this final figure to name the memory modules instead of the frequency, which was used with SDR. This makes the result seem many times better, while it's really only twice as good. In this example, the module is referred to as *PC1600*. The chips that go into making PC1600 modules are named after the perceived double-clock frequency: DDR-200.

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Referring to the original SDRAM as SDR, or single data rate SDRAM, is similar to retrospectively referring to The Great War as World War I only after the start of World War II.

DDR2

Think of the *2* in *DDR2* as yet another multiplier of 2 in the SDRAM technology, using a lower peak voltage to keep power consumption down (1.8V vs. the 2.5V of DDR and others). Still double-pumping, DDR2, like DDR, uses both sweeps of the clock signal for data transfer. Internally, DDR2 further splits each clock pulse in two, doubling the number of operations it can perform per FSB clock cycle. Through enhancements in the electrical interface and buffers, as well as through adding off-chip drivers, DDR2 nominally produces four times what SDR is capable of producing.

However, DDR2 suffers from enough additional latency over DDR that identical throughput ratings find DDR2 at a disadvantage. Once frequencies develop for DDR2 that do not exist for DDR, however, DDR2 could become the clear SDRAM leader, although DDR3 is nearing release. Continuing the preceding example and initially ignoring the latency issue, DDR2 using a 100MHz clock transfers data in four operations per cycle and still 8 bytes per operation, for a total of 3200MBps.

Just like DDR, DDR2 names its chips based on the perceived frequency. In this case, you would be using DDR2-400 chips. DDR2 carries on the final-result method for naming modules but cannot simply call them PC3200 modules because those already exist in the DDR world. DDR2 calls these modules *PC2-3200*. The latency consideration, however, means that DDR's PC3200 offering is preferable to DDR2's *PC2-3200*. After reading the "RDRAM" section, consult Table 1.2, which summarizes how each technology in the "DRAM" section would achieve a transfer rate of 3200MBps, even if only theoretically. For example, SDR PC400 doesn't exist.

TABLE 1.2 How Each Memory Type Transfers 3200MBps

Memory Type	Actual/Perceived Clock Frequency (MHz)	Bytes per Transfer
SDR SDRAM PC400*	400/400	8
DDR SDRAM PC3200	200/400	8
DDR2 SDRAM PC2-3200	100/400	8
RDRAM PC800	400/800	4**

* SDR SDRAM PC400 does not exist.
** Running in 32-bit dual-channel mode.

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RDRAM

Rambus DRAM, or *Rambus Direct RAM (RDRAM)*, named for the company that designed it, is a proprietary synchronous DRAM technology. RDRAM can be found in fewer new systems today than just a few years ago. This is because Intel once had a contractual agreement with Rambus to create chipsets for the motherboards of Intel and others that would primarily use RDRAM in exchange for special licensing considerations and royalties from Rambus. The contract ran from 1996 until 2002. In 1999, Intel launched the first motherboards with RDRAM support. Until then, Rambus could be found mainly in gaming consoles and home theater components. RDRAM did not impact the market as Intel had hoped, and so motherboard manufacturers got around Intel's obligation by using chipsets from VIA Technologies, leading to the rise of that company.

Although other specifications preceded it, the first motherboard RDRAM model was known as *PC800*. As with non-RDRAM specifications that use this naming convention, PC800 specifies that, using a faster 400MHz clock signal and double-pumping like DDR/DDR2, an effective frequency of 800MHz and a transfer rate of 800Mbps per data pin are created. PC800 uses only a 16-bit (2-byte) bus called a channel, exchanging a 2-byte packet during each read/write cycle, still bringing the overall transfer rate to 1600MBps per channel because of the much higher clock rate. Modern chipsets allow two 16-bit channels to communicate simultaneously for the same read/write request, creating a 32-bit dual-channel. Two PC800 modules in a dual-channel configuration produce transfer rates of 3200MBps.

Today, RDRAM modules are also manufactured for 533MHz and 600MHz bus clock frequencies and 32-bit dual-channel architectures. Termed PC1066 and PC1200, these models produce transfer rates of 2133 and 2400MBps per channel, respectively, making 4266 and 4800MBps per dual-channel. Rambus has road maps to 1333 and 1600MHz models. The section "RIMM" in this chapter details the physical details of the modules.

Despite RDRAM's performance advantages, it has some drawbacks that keep it from taking over the market. Increased latency, heat output, complexity in the manufacturing process, and cost are the primary shortcomings. PC800 RDRAM had a 45ns latency, compared to only 7.5ns for PC133 SDR SDRAM. The additional heat that individual RDRAM chips put out led to the requirement for heat sinks on all modules. High manufacturing costs and high licensing fees led to triple the cost to consumers over SDR, although today there is more parity between the prices.

In 2003, free from its contractual obligations to Rambus, Intel released the i875P chipset. This new chipset provides support for a dual-channel platform using standard PC3200 DDR modules. Now, with 16 bytes (128 bits) transferred per read/write request, making a total transfer rate of 6400MBps, RDRAM no longer holds the performance advantage it once did.

SRAM

The *S* in SRAM stands for *static*. Static random access memory doesn't require a refresh signal like DRAM does. The chips are more complex and are thus more expensive. However, they are faster. DRAM access times come in at 60 nanoseconds (ns) or more; SRAM has access times as fast as 10ns. SRAM is often used for cache memory.

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ROM

ROM stands for read-only memory. It is called read-only because the original form of this memory could not be written to. Once information had been written to the ROM, it couldn't be changed. ROM is normally used to store the computer's BIOS, because this information normally does not change very often.

The system ROM in the original IBM PC contained the power-on self-test (POST), Basic Input/Output System (BIOS), and cassette BASIC. Later IBM computers and compatibles include everything but the cassette BASIC. The system ROM enables the computer to "pull itself up by its bootstraps," or *boot* (start the operating system).

Through the years, different forms of ROM were developed that could be altered. The first generation was the programmable ROM (PROM), which could be written to for the first time in the field, but then no more. Following the PROM came erasable PROM (EPROM), which was able to be erased using ultraviolet light and subsequently reprogrammed. These days, our flash memory is a form of electrically erasable PROM (EEPROM), which does not require UV light, but rather a slightly higher than normal electrical pulse, to erase its contents.

CMOS

CMOS is a special kind of memory that holds the BIOS configuration settings. CMOS memory is powered by a small battery, so the settings are retained when the computer is shut off. The BIOS starts with its own default information and then reads information from the CMOS, such as which hard drive types are configured for this computer to use, which drive(s) it should search for boot sectors, and so on. Any conflicting information read from the CMOS overrides the default information from the BIOS. CMOS memory is usually *not* upgradable in terms of its capacity and is very often integrated into the modern BIOS chip.

Memory Packaging

First of all, it should be noted that each motherboard supports memory based on the speed of the frontside bus (FSB) and the memory's form factor. So, for example, if the motherboard's FSB is rated at a maximum speed of 533MHz, and you install memory that is rated at 300Mhz, the memory will operate at only 300MHz, thus making the computer operate slower than what it could. In their specifications, most motherboards list which type(s) of memory they support as well as its maximum speeds.

The memory slots on a motherboard are designed for particular module form factors or styles. In case you run across the older terms, DIP, SIMM, and SIPP are obsolete memory packages. Terms like *double-sided/single-sided memory* and *dual-bank/single-bank memory* are often confused. When speaking of sides, it is correct to refer to the two physical sides of the module and whether they contain chips. However, that says nothing of the number of banks the module satisfies. Satisfying two banks, or channels more often, as in the case of the DDR

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family, can be accomplished with single-sided memory. The most popular form factors for primary memory modules today are these:

- DIMM
- RIMM
- SoDIMM
- MicroDIMM

DIMM

One type of memory package is known as a DIMM. As mentioned earlier in this chapter, DIMM stands for Dual Inline Memory Module. DIMMs are 64-bit memory modules that are used as a package for the SDRAM family: SDRAM, DDR, and DDR2. The term *dual* refers to the fact that, unlike their SIMM predecessors, DIMMs differentiate the functionality of the pins on one side of the module from the corresponding pins on the other side. With 84 pins per side, this makes 168 independent pins on each standard SDRAM module, as shown with its two keying notches in Figure 1.26.

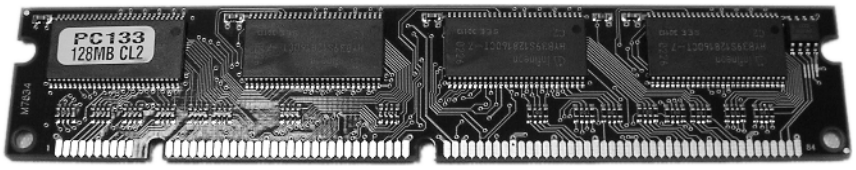
The DIMM used for DDR memory has a total of 184 pins and a single keying notch, while the DIMM used for DDR2 has a total of 240 pins, one keying notch, and an aluminum cover for both sides, called a *heat spreader*, designed like a heat sink to dissipate heat away from the memory chips and prevent overheating.

RIMM

Not an acronym, RIMM is a trademark of Rambus Inc., perhaps a clever play on the acronym DIMM, a competing form factor. A RIMM is a custom memory module that varies in physical specification based on whether it is a 16-bit or 32-bit module. The 16-bit modules have 184 pins and two keying notches, while 32-bit modules have 232 pins and only one keying notch, reminiscent of the trend in SDRAM-to-DDR evolution. Figure 1.27 shows the two sides of a 16-bit RIMM module, including the aluminum heat spreaders.

The dual-channel architecture can be implemented utilizing two separate 16-bit RIMMs or the newer 32-bit single-module design. Motherboards with the 16-bit single- or dual-channel implementation provide four RIMM slots that must be filled in pairs, while the 32-bit versions provide two RIMM slots that can be filled one at a time. A 32-bit RIMM has two 16-bit modules built in and requires only a single motherboard slot, albeit a physically different slot. So you must be sure of the module your motherboard accepts before upgrading.

FIGURE 1.26 A Dual Inline Memory Module (DIMM)



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Unique to the use of RIMM modules, a computer must have every RIMM slot occupied. Even one vacant slot will cause the computer not to boot. Any slot not populated with live memory requires an inexpensive (usually less than US$5 for the 16-bit version) blank of sorts called a *continuity RIMM*, or *C-RIMM*, for its role of keeping electrical continuity in the RDRAM channel until the signal can terminate on the motherboard. Think of it like a fusible link in a string of holiday lights. It seems to do nothing, but no light works without it. However, 32-bit modules terminate themselves and do not rely on the motherboard circuitry for termination, so vacant 32-bit slots require a module known as a *continuity and termination RIMM (CT-RIMM)*.

SoDIMM

Notebook computers and other computers that require much smaller components don't use standard RAM packages like the SIMM or the DIMM do. Instead, they can use a much smaller memory form factor called a *Small Outline DIMM (SoDIMM)*. SoDIMMs are available in many physical implementations, including the older 32-bit (72-pin) configuration and newer 64-bit (144-pin EDO, 144-pin SDRAM, and 200-pin DDR/DDR2) configurations. Figure 1.28 shows an example of a 144-pin, 64-bit module.

FIGURE 1.27 A Rambus RIMM module

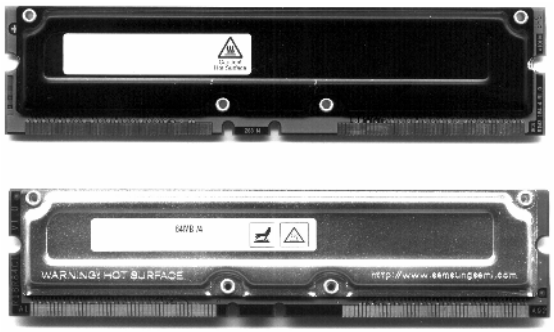
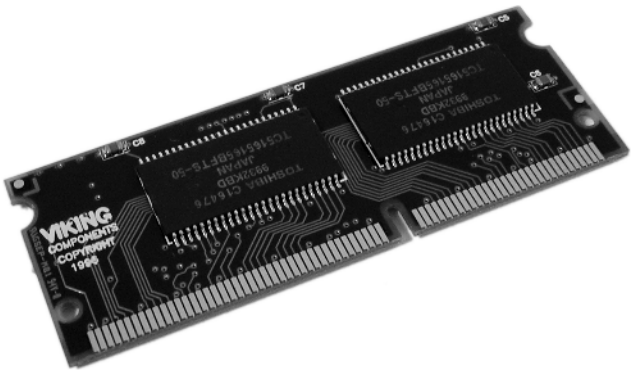


FIGURE 1.28 144-pin SoDIMM



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MicroDIMM

The newest, and smallest, RAM form factor is the MicroDIMM. The *MicroDIMM* is an extremely small RAM form factor. In fact, it is over 50 percent smaller than a SoDIMM, only 45.5 millimeters (about 1.75 inches) long and 30 millimeters (about 1.2 inches—a bit bigger than a quarter) wide. It was designed for the ultralight and portable subnotebook style of computer (like those based on the Transmeta Crusoe processor). These modules have 144 pins or 172 pins and are similar to a DIMM in that they use a 64-bit data bus. Often employed in laptop computers, SoDIMMs and MicroDIMMs are mentioned in Chapter 3 as well.

Identifying Purposes and Characteristics of Storage Devices

What good is a computer without a place to put everything? Storage media hold the data being accessed, as well as the files the system needs to operate and data that needs to be saved. The many different types of storage differ in terms of their capacity (how much they can store), access time (how fast the computer can access the information), and the physical type of media used.

Hard Disk Drive Systems

Hard disk drive (HDD) systems (hard disks or hard drives for short) are used for permanent storage and quick access (Figure 1.29). Hard disks typically reside inside the computer (although there are external and removable hard drives) and can hold more information than other forms of storage.

The hard disk drive system contains three critical components:

Controller Controls the drive. It understands how the drive operates, sends signals to the various motors in the disk, and receives signals from the sensors inside the drive. Most of today's hard disk technologies incorporate the controller and drive into one enclosure.

Hard Disk The physical storage medium. Hard disk drive systems store information on small disks (between three and five inches in diameter) stacked together and placed in an enclosure.

Host Adapter The translator, converting signals from the hard drive and controller to signals the computer can understand. Most motherboards today incorporate the host adapter into the motherboard's circuitry, offering headers for drive cable connection.

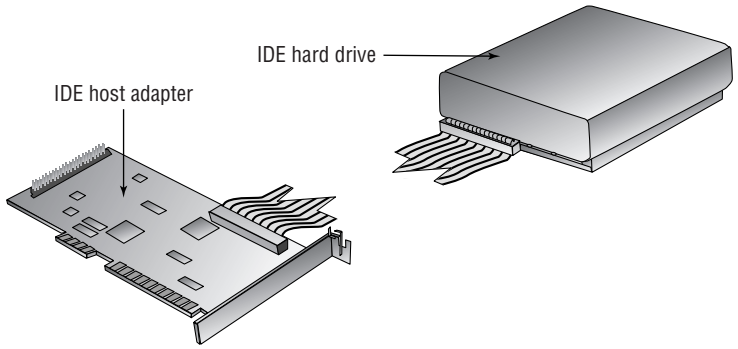
Floppy Drives

A *floppy disk* is a magnetic storage medium that uses a flexible diskette made of thin plastic enclosed in a protective casing. The floppy disk once enabled information to be transported from one computer to another very easily. Today, floppies are a little too small in capacity to be efficient anymore. They have been replaced by writable CD-ROMs and DVD-ROMs. The

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original term *floppy disk* referred to the antiquated 8-inch medium used with minicomputers and mainframes. The original PC floppy diskette, which was 5¼ inches square and known as a *minifloppy diskette*, is also obsolete; the *microfloppy diskette* is a diskette that is 3½ inches square. Most computers today use microfloppy diskettes or no floppy at all.

FIGURE 1.29 A hard disk drive system





Generally speaking, throughout this book we will use the term *floppy drive* to refer to a 3½-inch microfloppy diskette drive.

A *floppy drive* (shown in Figure 1.30) is used to read and write information to and from these drives. The advantage of these drives is that they allow portability of data (you can transfer data from one computer to another on a diskette). The downside of a floppy disk drive is its limited storage capacity. Whereas a hard drive can store hundreds of gigabytes of information, most floppy disks were designed to store only about one megabyte. Table 1.3 shows five different floppy diskette drive formats with their corresponding diskette sizes supported in PC systems over the years. The following abbreviations are used: DD means double density; HD means high density; ED means extended density.

TABLE 1.3 Floppy Disk Capacities

Floppy Drive Size	Number of Tracks	Capacity
5¼″ DD	40	360KB
5¼″ HD	80	1.2MB
3½″ DD	80	720KB
3½″ HD	80	1.44MB
3½″ ED	80	2.88MB

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CD-ROM Drives

Most computers today have a CD-ROM (Compact Disc Read-Only Memory) drive. The compact disks are virtually the same as those used in CD players. The CD-ROM is used for long-term storage of data. CD-ROMs are read-only, meaning that once information is written to a CD, it can't be erased or changed. Also, it takes much longer to access the information on a CD than it does to access data residing on a hard drive. Why, then, are CD-ROMs so popular? Mainly because they make a great software distribution medium. Programs are always getting larger and requiring more disks to install. Instead of installing a program using 100 floppy disks (a real possibility), you can use a single CD, which can hold approximately 650MB. (A second reason they are so popular is that CD-ROMs have been standardized across platforms, with the ISO 9660 standard.) Figure 1.31 shows an example of a typical CD-ROM drive.

FIGURE 1.30 A floppy disk drive



FIGURE 1.31 A typical CD-ROM drive



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CD-ROM drives are rated in terms of their data transfer speed. The first CD-ROM drives transferred data at the same speed as home audio CD players, 150KBps. Soon after, CD drives rated as "2X" drives that would transfer data at 300KBps appeared (they just increased the spin speed in order to increase the data transfer rate). This system of ratings continued up until the 8X speed was reached. At that point, the CDs were spinning so fast that there was a danger of the CDs flying apart inside the drive. So, although future CD drives used the same rating (as in 16X, 32X, and so on), their rating was expressed in terms of theoretical maximum transfer rate. The drive isn't necessarily spinning faster or transferring data at 40 or 50 times 150KBps, it is just theoretically possible using the drive's increased buffers and so on.

CD-R and CD-RW Drives

CD-recordable (CD-R) and CD-rewritable (CD-RW) drives (also known as CD *burners*) are essentially CD-ROM drives that allow users to create (or *burn*) their own CD-ROMs. They look very similar to CD-ROM drives, except the front panel of the drive includes a reference to either CD-R or CD-RW.

The difference between these two types of drives is that CD-R drives can write to a CD only once. A CD-RW can erase information from a disc and rewrite to it multiple times. Also, CD-RW drives are rated according to their read, write, and rewrite times. So instead of a single rating like 40X, they have a rating of 32X-16X-4X, which means it reads at 32X, writes at 16X, and rewrites at 4X.

DVD-ROM Drives

A newer type of drive is finding its way into computers: the DVD-ROM drive. DVD (digital video disc) technology is in use in many home theater systems. A DVD-ROM drive is basically the same as the DVD player's drive in a home theater system. As a result, a computer equipped with a DVD-ROM drive and the proper video card can play back DVD movies on the monitor.

However, in a computer, a DVD-ROM drive is much more useful. Because DVD-ROMs use slightly different technology than CD-ROMs, they can store up to 4.3GB of data. This makes them a better choice for distributing large software bundles. Many software packages today are so huge they take multiple CD-ROMs to hold all the installation and reference files. A single DVD-ROM, in a double-sided, double-layered configuration, can hold as much as 17GB (as much as 26 regular CD-ROMs).

A DVD-ROM drive looks very similar to a CD-ROM drive. The only difference is the DVD logo on the front of most drives.

DVD Burners

A DVD burner operates in a similar manner to a CD-R or CD-RW drive: It can store large amounts of data onto a DVD. Today, single-sided, double-layered (DL) discs can be burned right in your home computer, writing 8.5GB of information to a single disc. Common names for the variations of DVD burning technologies include DVD+R, DVD+RW, DVD-R, DVD-RW, DVD-RAM, DVD-R DL, and DVD+R DL. In some cases, the plus variants hold more than their dash counterparts, and drives do not support all types.

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Other Storage Media

Many additional types of storage are available for PCs today. Among the other types of storage are tape backup devices, solid-state memory, and advanced optical drives. There are also external hard drives such as the Kangaru drives and new storage media such as the USB memory sticks that can store gigabytes on a single small plastic device that can be carried on a key chain.

Removable Storage

Removable storage once meant something vastly different than what it means today. Sequential tape backup is one of the only remnants of the old forms of removable storage that can be seen in the market today. The more modern solution is random-access, solid-state removable storage. This section presents details of tape backup and the newer removable storage solutions.

Tape Backup Devices

An older form of removable storage is the tape backup. Tape backup devices can be installed internally or externally and use either a digital or analog magnetic tape medium instead of disks for storage. They hold much more data than any other medium but are also much slower. They are primarily used for archival storage.

With hard disks, it's not a matter of "if they fail"; it's "when they fail." So you must back up the information onto some other storage medium. Tape backup devices were once the most common choice in larger enterprises and networks because they were able to hold the most data and were the most reliable over the long term. Today, however, tape backup systems are steadily being phased out by writable and rewritable optical discs, which continue to advance in technology and size.

Flash Memory

Once only for primary memory usage, the same components that sit on your motherboard as RAM can be found in various physical sizes and quantities in today's solid-state storage solutions. These include older removable and nonremovable flash memory mechanisms, Secure Digital (SD) cards and other memory cards, and USB thumb drives. Each of these technologies has the potential to reliably store a staggering amount of information in a minute form factor. Manufacturers are using innovative packaging for some of these products to provide convenient transport options to users, such as key-chain attachments.

For many years, modules and PC Cards known as *flash memory* have offered low- to mid-capacity storage for devices. The name comes from the concept of easily being able to use electricity to instantly alter the contents of the memory. The original flash memory is still used in devices, such as routers and switches, that require a nonvolatile means of storing critical data and code often used in booting the device.

For example, Cisco Systems uses flash memory in various forms to store their Internetwork Operating System (IOS), which is accessed from flash during bootup and, in certain cases, throughout an administrator's configuration sessions. Lesser models store the IOS in compressed form on the flash and then decompress the IOS into RAM, where it is used during configuration. In this case, the flash is not accessed again after the bootup process is complete, unless its contents are being changed, as in an IOS upgrade. Certain devices use externally removable PC Card technology as flash for similar purposes.

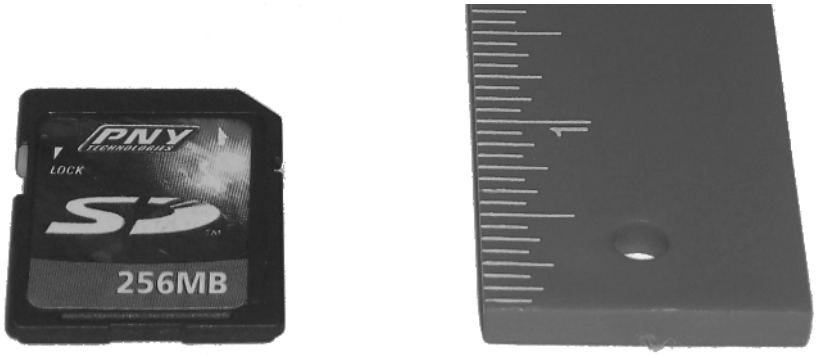
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The following sections explain a bit more about today's most popular forms of flash memory, memory cards and thumb drives.

SD AND OTHER MEMORY CARDS

Today's smaller devices require some form of removable solid-state memory that can be used for temporary and permanent storage of digital information. Gone are the days of using microfloppies in your digital camera. Even the most popular video-camera medium, mini-DVDs, have solid-state multi-GB models nipping at their heels. These more modern electronics, as well as most contemporary digital still cameras, use some form of removable memory card to store still images permanently or until they can be copied off or printed out. Of these, the *Secure Digital (SD)* format has emerged as the preeminent leader of the pack, which includes the older *MultiMediaCard (MMC)* format on which SD is based. The SD card is slightly thicker than the MMC and has a write-protect notch (and often a switch to open and close the notch), unlike MMC. Figure 1.32 is a photo of an SD card with size reference. Officially, these devices are 32mm by 24mm.

FIGURE 1.32 A typical SD card



Even smaller devices, such as mobile phones, have an SD solution for them. One of these products, known as *miniSD*, is slightly thinner than SD and measures 21.5mm by 20mm. The other, *microSD*, is thinner yet and only 15mm by 11mm. Both of these reduced formats have adapters allowing them to be used in standard SD slots.

Table 1.4 lists additional memory card formats.

TABLE 1.4 Additional Memory Card Formats

Format	Dimensions	Details	Year Introduced
CompactFlash (CF)	36mm by 43mm	Used by IBM for Microdrives; Type I and Type II variants	1994
MiniCard	45mm by 37mm	Defunct; promoted by Intel, AMD, Fujitsu, Sharp	1995

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TABLE 1.4 Additional Memory Card Formats *(continued)*

Format	Dimensions	Details	Year Introduced
SmartMedia (SM)	45mm by 37mm	From Toshiba; intended to replace floppies; still sells well	1995
Memory Stick	50mm by 21.5mm	From Sony; standard, pro, duo, and micro formats available	1998

Figure 1.33 shows the memory card slots of an HP PhotoSmart 7550 printer, which is capable of reading these devices and printing them directly or creating a drive letter for access to the contents over its USB connection to the computer. Clockwise from upper left, these slots accommodate CF/Microdrive, SmartMedia, Memory Stick (bottom right), and MMC/SD. Exclusive external card readers and those that can be mounted in a computer's drive bay are common items on the market today. The industry also provides almost any adapter or converter to allow the various formats to work together.

As a final thought on SD cards, SD slots are not for flash memory only. The more general *SDIO* (SD Input/Output) specification, which is based on and compatible with the SD specification, seeks to bring a high-speed, low-power interface to mobile devices, in the same vein as USB for computers. Not that SDIO can't be used with laptops, but it is intended more for PDAs or mobile phones for connectivity to small devices, such as GPS receivers, wireless or wired network adapters, modems, bar-code readers, wireless serial adapters, radio and television tuners, and digital cameras. Even external storage devices, such as hard drives and CD/DVD-ROM drives, could be attached to these smaller handheld devices.

FIGURE 1.33 Card slots in a printer



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THUMB DRIVES

Also known as USB flash drives, *thumb drives* are incredibly versatile and convenient devices that allow you to store large quantities of information in a very small form factor. Many such devices are merely extensions of the host's USB connector, extending out from the interface but adding very little to its width, making them very easy to transport, whether in a pocket or laptop bag. Figure 1.34 illustrates an example of one of these components and its relative size.

FIGURE 1.34 A USB thumb drive



Thumb drives capitalize on the versatility of the USB interface, taking advantage of the Plug and Play feature and the physical connector strength. Upon insertion, these devices announce themselves to Windows Explorer as removable drives and show up in the Explorer window with a drive letter. This software interface allows for drag-and-drop copying and most of the other standard Explorer functions performed on standard drives.

USB thumb drives have emerged as the de facto replacement for other removable storage devices, such as floppies, edging out Zip and Jaz offerings from Iomega, as well as other proprietary solutions.

USB-Attached External Disk Drives

Before USB, an external drive used a proprietary adapter and interface/cable combination or the standard RS-232 serial or parallel port generally built into the computer. Since USB, there seems to be no other way to do it. The fact is, there are other ways, but why muddy the water with options when USB covers all the bases and is so ubiquitous in today's systems?

USB-attached external disk drives use the same drives that you might install in a drive bay in your chassis; they simply employ a specialty chassis that houses only the drive and the supporting circuitry that converts the drive interface to USB. Most often, the drive enclosure has a DC power input and a Type-B USB interface, as shown in Figure 1.35. This external chassis has its cover removed, and you can see the internal protective casing with the hard drive mounted in it.

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FIGURE 1.35 External drive enclosure



Advanced Digital Storage

There are two technologies on the market today that seek to become the next standard in optical storage; each one offers backward compatibility to the lesser CD and DVD technologies. One of these is known as *High Density (or Definition) DVD (HD DVD)*. The other is known as *Blu-ray Disc (BD)*. Both technologies employ similar blue-violet laser and encoding techniques, as well as disc size, with slightly differing results. The blue laser has a shorter wavelength than the original red laser, which allows more data to be stored in the same space because the laser can be focused more tightly to read data placed more closely.

However, depending on the reception blue-laser technologies receive in the public sector, their times might come and go without much fanfare. Seemingly futuristic technologies, such as perpendicular and holographic recording, might be here before the market realizes it needs blue laser.

HD DVD

HD DVD can hold high-definition video or large quantities of data. HD DVD has a single-layer capacity of 15GB. Dual-layer and triple-layer formats exist that hold two and three times as much data, respectively. Publishers can include both standard DVD and HD DVD formats on a single disc. This coexistence means that consumers, manufacturers, and retailers have options during their transition to HD DVD, because the newer HD DVD discs can play in a

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standard DVD player. The incentive to upgrade remains, however, due to the higher definition video awaiting owners on the same disc.

If the HD DVD format is applied to standard DVDs that do not use the blue laser, it can result in capacities ranging from 5 to 18GB, offering a lower-cost alternative for those holding off on upgrading to HD DVD. HD DVD uses a single lens in its optical mechanism, unlike Blu-ray technology. Therefore, both red and blue LED lasers can be incorporated into HD DVD drives that are still more compact than those based on Blu-ray.

Blu-ray Disc

Although Blu-ray Disc uses a similar technology to that of HD DVD, it gets the laser closer to the data and is able to store more data per layer, 25GB compared to HD DVD's 15GB. Manufacturers led by Sony make players backward compatible with DVDs and capable of the same high-definition video content. Initially, Blu-ray components were priced a bit higher than those based on HD DVD, but Blu-ray was the first to hit the market with a consumer-recordable version, including drives and media.

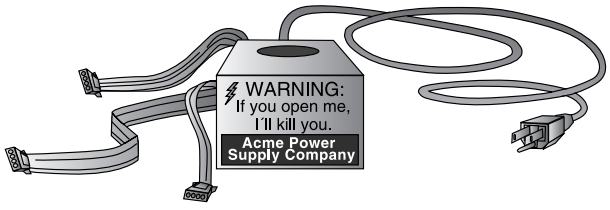
Identifying Purposes and Characteristics of Power Supplies

The computer's components would not be able to operate without power. The device in the computer that provides this power is the *power supply* (Figure 1.36). A power supply converts 110 volt or 220 volt AC current into the DC voltages that a computer needs to operate. These are +3.3 volts DC, +5 volts DC, –5 volts DC (ground), +12 volts DC, –12 volts DC (ground), and +5 volts DC standby. The 3.3 volts DC and +5 volts DC standby voltages were first used by ATX motherboards.



You might see *volts DC* abbreviated as *VDC*.

FIGURE 1.36 A power supply



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Power supplies contain transformers and capacitors that can discharge *lethal* amounts of current even when disconnected from the wall outlet. They are not meant to be serviced. *Do not* attempt to open them or do any work on them.

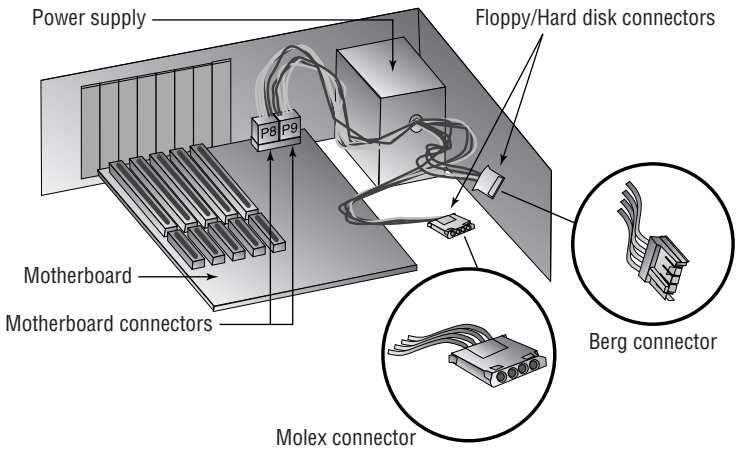
Power supplies are rated in watts. A *watt* is a unit of power. The higher the number, the more power the power supply (and thus your computer) can use. Most computers use power supplies in the 250- to 500-watt range.

Classic power supplies used only three types of connectors to power the various devices within the computer (Figure 1.37): floppy drive power connectors (Berg connectors), AT system connectors (P8 and P9), and standard peripheral power connectors (Molex connectors). Each has a different appearance and way of connecting to the device. In addition, each type is used for a specific purpose. Newer systems have a variety of similar, replacement, and additional connectors.

Floppy Drive Power Connectors

Floppy drive power connectors are most commonly used to power floppy disk drives and other small form factor devices. This type of connector is smaller and flatter (as shown in Figure 1.38) than any of the other types of power connectors. These connectors are also called *Berg connectors*. Notice that there are four wires going into this connector. These wires carry the two voltages used by the motors and logic circuits: +5VDC (carried on the red wire) and +12VDC (carried on the yellow wire); the two black wires are ground wires.

FIGURE 1.37 Standard power supply connectors



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AT System Connectors

The next type of power connector is called the *AT system connector*. There are two 6-wire connectors, labeled P8 and P9 (as shown in Figure 1.39). They connect to an AT-style motherboard and deliver the power that feeds the electronic components on it. These connectors have small tabs on them that interlock with tabs on the motherboard's receptacle. If there are two connectors, you must install them in the correct fashion. To do this (on most systems), place the connectors side by side with their black wires together, and then push the connectors onto the receptacle on the motherboard.



Although it's easy to remove this type of connector from the motherboard, the tabs on the connector make it difficult to reinstall it. Here's a hint: Place the connector at a right angle to the motherboard's connector, interlocking the tabs in their correct positions. Then tilt the connector to the vertical position. The connector will slide into place easily.

FIGURE 1.38 Floppy drive power connector

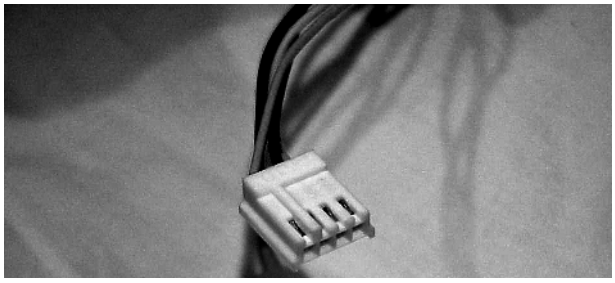
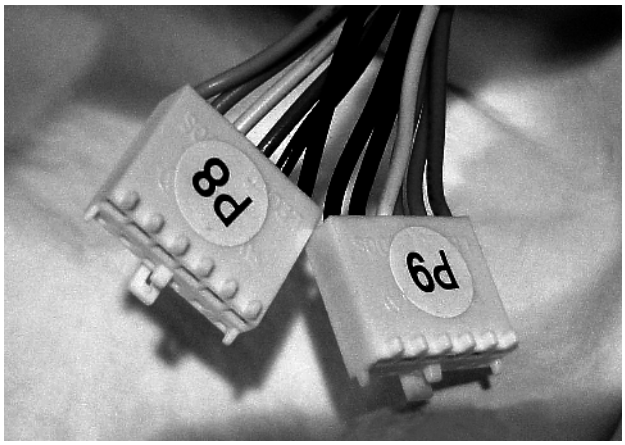


FIGURE 1.39 AT power supply system board connectors



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It is important to note that only computers with AT and baby AT motherboards use this type of power connector.



Most computers today use some form of ATX power connector to provide power to the motherboard.

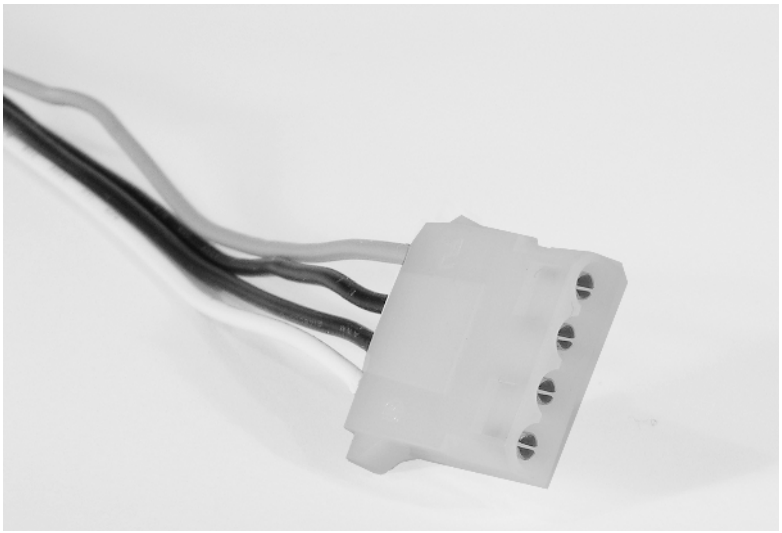
Standard Peripheral Power Connector

The *standard peripheral power connector* is generally used to power different types of internal disk drives. This type of connector is also called a *Molex connector*. Figure 1.40 shows an example of a standard peripheral power connector. This power connector, though larger than the floppy drive power connector, uses the same wiring color code scheme as the floppy drive connector.

Modern Power Connectors

Modern components have exceeded the capabilities of some of the original power supply connectors. The Molex and Berg peripheral connectors remain, but the P8/P9 motherboard connectors have been consolidated and additional connectors have sprung up.

FIGURE 1.40 A standard peripheral power connector



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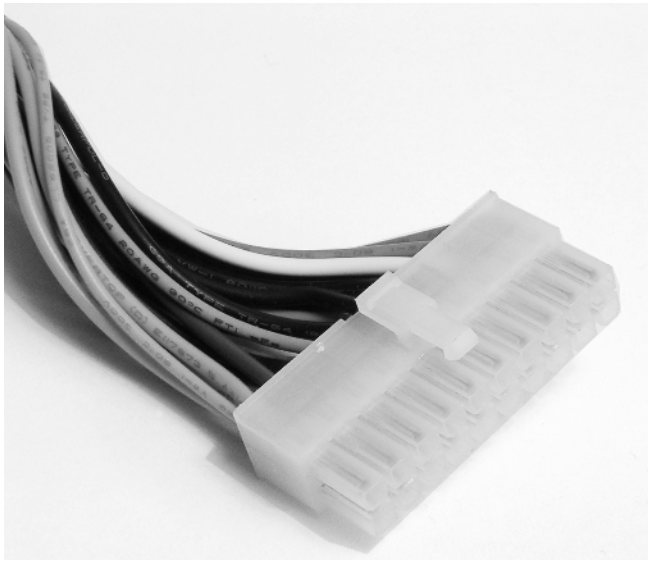
ATX, ATX12V, and EPS12V Connectors

With ATX motherboards came a new, single connector from the power supply. PCI Express has power requirements that even this connector could not satisfy. Additional 4- and 8-pin connectors supply power to components of the motherboard, such as network interfaces, specialty server components, and the CPU itself, that require a +12V supply in addition to the +12V of the standard ATX connector. These additional connectors follow the *ATX12V* and *EPS12V* standards. The ATX connector was further expanded by an additional four pins in later specifications.

The *ATX system connector* (also known as the *ATX motherboard power connector*) feeds an ATX motherboard. It provides the six voltages required, plus it delivers them all through one connector: a single 20-pin connector. This connector is much easier to work with than the dual connectors of the AT power supply. Figure 1.41 shows an example of an ATX system connector.

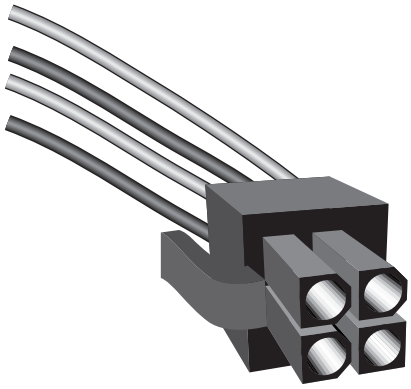
When the Pentium 4 processor was introduced, motherboard and power supply manufacturers needed to get more power to the system. The solution was the ATXV12 standard, which added two supplemental connectors. One was a 6-pin auxiliary connector similar to the P8/P9 AT connectors that supplied additional +3.3V and +5V leads and their grounds. The other was a 4-pin square mini version of the ATX connector, referred to as a P4 connector, that supplied two +12V leads and their grounds. EPS12V uses an 8-pin version, called the processor power connector, that doubles the P4's function with four +12V leads and four grounds. Figure 1.42 illustrates the P4 connector. The 8-pin processor power connector is similar but has two rows of four.

FIGURE 1.41 ATX power connector



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FIGURE 1.42 ATX12V P4 power connector

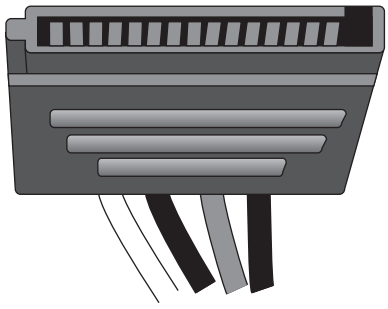


For servers and more advanced ATX motherboards that include PCIe slots, the 20-pin system connector proved inadequate. This led to the *ATX12V 2.0* standard and the even higher-end EPS12V standard for servers. These specifications call for a 24-pin connector that adds additional positive voltage leads directly to the system connector. The 24-pin connector looks like a larger version of the 20-pin connector. There are adapters available if you find yourself with the wrong combination of motherboard and power supply. The 6-pin auxiliary connector disappeared with the ATX12V 2.0 specification and was never part of the EPS12V standard.

SATA Power Connectors

SATA drives arrived on the market with their own power requirements, in addition to their new data interfaces. Refer back to Figure 1.14 and imagine a larger but similar connector for power. You get the SATA power connector, shown in Figure 1.43. This connector is made up of three each of +3.3V, +5V, and +12V leads, as well as five ground leads.

FIGURE 1.43 SATA power connector



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Identifying Purposes and Characteristics of Display Devices

The primary method of getting information out of a computer is to use a computer video display unit (VDU). Display systems convert computer signals into text and pictures and display them on a TV-like screen. As a matter of fact, the first personal computers used television screens because it was simple to use an existing display technology rather than to develop a new one. Several types of computer displays are in use today, including the TV. All of them use either the same *cathode ray tube (CRT)* technology found in television sets (many desktop monitors still use this technology) or the *liquid crystal display (LCD)* technology found on all laptop, notebook, and palmtop computers. LCD is steadily gaining in popularity on the desktop, as well.

Display Concepts

Several aspects of display systems make each type of display different. However, most display systems work the same way. First, the computer sends a signal to a device called the *video adapter*—an expansion board installed in an expansion bus slot—telling it to display a particular graphic or character. The adapter then *renders* the character for the display—that is, it converts the single instruction into several instructions that tell the display device how to draw the graphic—and sends the instructions to the display device. The primary differences after that are in the type of video adapter you are using (digital or analog) and the type of display (CRT or LCD).

Video Technologies

Let's first talk about the different types of video technologies. Between digital and analog, there are transistor-transistor logic (TTL) and the technologies that began with video graphics array (VGA). Each video standard differs in two major areas: the highest resolution it supports and the maximum number of colors in its palette.

Resolution depends on how many picture elements (*pixels*) are used to draw the screen. For the same display device, more pixels yield a sharper image. Different CRTs place the physical chemical dots at different intervals, changing the image quality, despite the resolution. The smaller this dot pitch, the better the image, given the same resolution. See the section titled "Monitors" in this chapter for more on dot pitch. The resolution is described in terms of the visible image's dimensions, which indicate how many pixels across and down are used to draw the screen. For example, a resolution of 1,024 × 768 means 1,024 pixels across and 768 pixels down were used to draw the pixel matrix. The video technology in this example would use 786,432 (1,024 × 768 = 786,432) pixels to draw the screen.

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In the preceding example, if you were using 24-bit graphics, meaning each pixel requires 24 bits of memory to store that one screen element, 786,432 elements would require 18,874,368 bits or 2,359,296 bytes. Because this boils down to 2.25MB, an early video adapter with only 2MB of RAM would not be capable of such resolution at 24 bits per pixel.

Monochrome

The first video technology for PCs was *monochrome* (from the Latin *mono*, meaning one, and *chroma*, meaning color). This black-and-white video (actually, it was green and white or amber and black) was fine for the main operating system of the day, DOS. DOS didn't have any need for color. Thus, the video adapter was very basic. The first adapter, developed by IBM, was known as the Monochrome Display Adapter (MDA). It could display text but not graphics and used a resolution of 720 × 350 pixels.

The Hercules Graphics Card (HGC), introduced by Hercules Computer Technology, had a resolution of 720 × 350 and could display graphics as well as text. It did this by using two separate modes: a *text mode* that allowed the adapter to optimize its resources for displaying predrawn characters from its onboard library, and a *graphics mode* that optimized the adapter for drawing individual pixels for on-screen graphics. It could switch between these modes on the fly. These modes of operation have been included in all graphics adapters since the introduction of the HGC.

EGA and CGA

The next logical step for displays was to add a splash of color. IBM was the first with color, with the introduction of the Color Graphics Adapter (CGA). CGA could display text, but it displayed graphics with a resolution of only 320 × 200 pixels with four colors. It displayed a better resolution (640 × 200) with two colors—black and one other color. After a time, people wanted more colors and higher resolution, so IBM responded with the Enhanced Graphics Adapter (EGA). EGA could display 16 colors out of a palette of 64 with a resolution of 320 × 200 or 640 × 350 pixels.

These two technologies were the standard for color until the IBM AT was introduced. This PC was to be the standard for performance, so IBM wanted better video technology for it.

VGA

With the PS/2 line of computers, IBM wanted to answer the cry for "more resolution, more colors" by introducing its best video adapter to date: the Video Graphics Array (VGA). This video technology had a whopping 256KB of video memory on board and could display 16 colors at 640 × 480 pixels or 256 colors at 320 × 200 pixels. It became widely used and has since become the standard for color PC video; it's the starting point for today's computers, as far as video is concerned. Your computer should use this video technology at minimum.

One unique feature of VGA is that it's an analog technology, unlike the preceding standards. Thus the 256 colors it uses can be chosen from various shades and hues of a palette of 262,114

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colors. VGA sold well mainly because users could choose from almost any color they wanted (or at least one that was close). The reason for moving away from the original digital signal is because for every power of 2 that the number of simultaneously displayed colors increases, you need another pin on the connector to transmit them. Four pins for 16 colors is not a big deal, but 32 pins for over 4 billion colors become a bit unwieldy. The cable has to grow with the connector, as well, affecting transmission quality and cable length.

SuperVGA

Up to this point, IBM set most video standards. IBM made the adapters, everyone bought them, and they became a standard. Some manufacturers didn't like this monopoly and set up the Video Electronics Standards Association (VESA) to try to enhance IBM's video technology and make the enhanced technology a public standard. The result of this work was SuperVGA (SVGA). This new standard was indeed an enhancement, because it could support 16 colors at a resolution of 800 × 600 (the VESA standard), but it soon expanded to support 1,024 × 768 pixels with 256 colors.

Since that time, SVGA has been a term for any resolution and color palette to exceed that of standard VGA. This even includes the resolution presented next, XGA. New names still continue to be introduced, mainly as a marketing tool to tout the new resolution du jour. While display devices must be manufactured to support a certain display resolution, one of the benefits of analog video technology is that modern VGA monitors can advance along with the graphics adapter, in terms of the color palette. The analog signal is what dictates the color palette, and the standard for the signal has not changed since its VGA origin. This makes a discussion of a VGA monitor's color limitations a non-issue. Such a topic makes sense only in reference to graphics adapters.

XGA

IBM introduced a new technology in 1990 known as the Extended Graphics Array (XGA). This technology was available only as a Micro Channel Architecture (MCA) expansion board and not as an ISA or EISA board. (It was rather like IBM saying, "So there. You won't let me be the leader, so I'll lead my own team.") XGA could support 256 colors at 1,024 × 768 pixels or 65,536 colors at 800 × 600 pixels. It was a different design, optimized for GUIs like Windows or OS/2. It was also an *interlaced* technology, meaning that rather than scan every line one at a time to create the image, it scanned every other line on each pass, using the phenomenon known as *persistence of vision* to produce what appears to our eyes as a continuous image.

Later Video Standards

Any standard other than the ones already mentioned are probably extensions of SVGA or XGA. It is becoming easier and easier to predict the approximate resolution of a video specification based on its name. Whenever a known technology is preceded by the letter *W*, you can assume roughly the same vertical resolution but a wider horizontal resolution to accommodate 16:9 or 16:10 wide-screen formats. Preceding the technology with the letter *Q* indicates that the horizontal and vertical resolutions were each doubled, making a final resolution four times (quadruple) the original. To imply four times each, for a final resolution enhancement of 16 times, the letter *H* for hexadecatuple is used.

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Therefore, if XGA has a resolution of 1024 × 768, then QXGA will have a resolution of 2048 × 1536. If SuperXGA (SXGA) has a resolution of 1280 × 1024 and an aspect ratio of 5:4, then WSXGA might have a resolution of 1440 × 900 and a 16:10 aspect ratio. Each of these advanced resolutions has a standard 32-bit color palette, for over four billion different colors per pixel. Table 1.5 details the various video technologies, their resolutions, and the color palettes they support.

TABLE 1.5 Video Display Adapter Comparison

Name	Resolutions	Colors
Monochrome Display Adapter (MDA)	720 × 350	Mono (text only)
Hercules Graphics Card (HGC)	720 × 350	Mono (text and graphics)
Color Graphics Adapter (CGA)	320 × 200	4
	640 × 200	2
Enhanced Graphics Adapter (EGA)	320 × 200	16
	640 × 350	16
Video Graphics Array (VGA)	640 × 480	16
	320 × 200	256
SuperVGA (SVGA)	800 × 600	16
Extended Graphics Array (XGA)	1,024 × 768	256
Super XGA (SXGA)	1280 × 1024	4,294,967,296
Ultra XGA (UXGA)	1600 × 1200	4,294,967,296
Widescreen XGA (WXGA), 16:9	1280 × 720	4,294,967,296
WUXGA, 16:10	1920 × 1200	4,294,967,296
Quad XGA (QXGA)	2048 × 1536	4,294,967,296
WQXGA, 16:10	2560 × 1600	4,294,967,296
WQUXGA, 16:10	3840 × 2400	4,294,967,296
WHUXGA, 16:10	7680 × 4800	4,294,967,296

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Additional Video Technologies

While the VGA-spawned standards might keep the computing industry satisfied for quite some time to come, there is a sector in the market driving development of non-VGA specifications. These high-resolution, high-performance junkies approach video from the broadcast angle. They are interested in the increased quality of digital transmission. For them, the industry responded with technologies like DVI and HDMI. The computing market benefits from these technologies, as well.

Other consumers desire specialized methods to connect analog display devices by splitting out colors from the component to improve quality. For this group, a few older standards remain viable: component video, S-video, and composite video. The following sections present the details of these five specifications.

DVI

In an effort to return to digital video, which can be transmitted farther and at higher quality than analog, a series of connectors known collectively as the *Digital Visual (or Video) Interface (DVI)* was developed for the technology of the same name. At first glance, the DVI connector might look like a standard D-sub connector, but on closer inspection, it begins to look somewhat different. For one thing, it has quite a few pins, and for another, the pins it has are asymmetrical in their placement on the connector. Figure 1.44 illustrates the five types of connector that the DVI standard specifies.

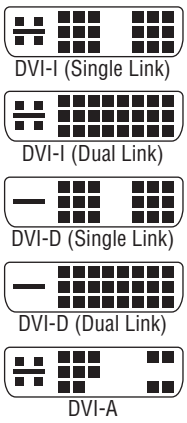
The three main categories of DVI connector are these:

DVI-A An analog-only connector

DVI-D A digital-only connector

DVI-I A combination analog/digital connector

FIGURE 1.44 Types of DVI connector



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The DVI-D and DVI-I connectors come in two varieties: single link and dual link. The dual-link options have more connectors than their single-link counterparts, which accommodate higher speed and signal quality. The additional link can be used to increase resolution from 1920 × 1080 to 2048 × 1536 or even from WUXGA to WQUXGA. Of course, all components, as well as the cable, must support the dual-link feature.

DVI-A and DVI-I analog quality is superior to that of VGA, but it's still analog, meaning it is more susceptible to noise. However, the analog signal will travel farther before degrading beyond usability. The analog portion of the connector, if it exists, comprises the four separate pins and the horizontal blade that they surround, which happens to be the analog ground lead.

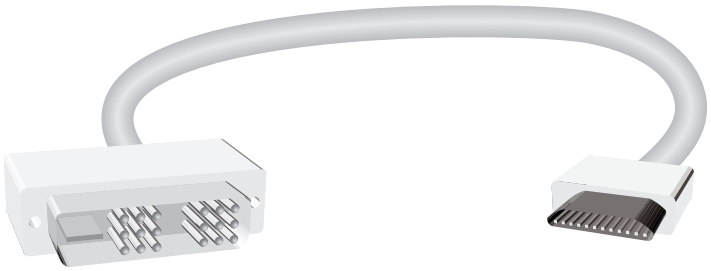
HDMI

High-Definition Multimedia Interface (HDMI) is an all-digital technology that advances the work of DVI to include higher resolution, higher motion-picture frame rates, and digital audio right on the same connector, as well as a function to share the signals of a remote control throughout the HDMI interconnection. The connector is not the same as the one used for DVI. In June 2006, revision 1.3 of the HDMI specification was released to support the bit rates necessary for HD DVD and Blu-ray Disc. HDMI is compatible with DVI-D through proper adapters, but only single-link is supported and HDMI's audio and remote-control pass-through features are lost. Figure 1.45 shows a DVI-to-HDMI adapter for single-link DVI-D and the Type-A 19-pin HDMI cable. There is also a Type-B connector that has 29 pins and promises higher resolution for the components that use it.

Component Video

When analog technologies outside the VGA realm are used for broadcast video, you are generally able to get better-quality video by splitting the red, green, and blue components in the signal into different streams right at the source. The technology known as *component video* performs a signal-splitting function similar to RGB separation, but it creates a signal called *luminance* (Y) that corresponds to the colorless (call it black and white) portion of the feed. It also creates two color difference signals known as Pb and Pr (or Cb and Cr, in some cases). These *chrominance* signals work together to mathematically approximate the original RGB signal. Figure 1.46 shows the three RCA connectors of a component cable.

FIGURE 1.45 Types of DVI connector



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S-video

S-video is a component video technology that combines the two chrominance signals into one, resulting in video quality not quite as high as that of true component video. One example of an S-video connector, shown in Figure 1.47, is a 7-pin mini-DIN, mini-DIN of various pin counts being the most common connector type. The most basic connector is a 4-pin mini-DIN that has, quite simply, one luminance and one chrominance (C) output lead and a ground for each. A 4-pin male connector is compatible with a 7-pin female connector, both in fit and pin functionality. The converse is not also true, however. These are the only two standard S-video connectors.

FIGURE 1.46 A component video cable

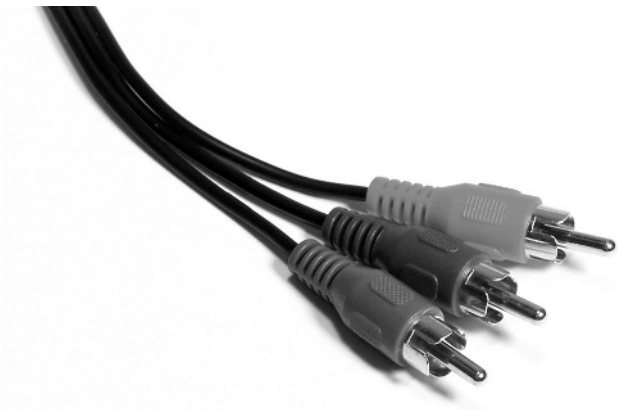


FIGURE 1.47 A 7-pin S-video port



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The 6-pin and 7-pin versions are also output only, but they add composite video leads, which are discussed next, as well. ATI uses 8-, 9-, and 10-pin versions of the connector that include such added features as S-video input in addition to output, or even bidirectional pin functionality, and audio input/output.

Composite Video

When the preceding component video technologies are not feasible, the last related standard, *composite video*, combines the luminance and all chrominance leads into one. Composite video is truly the bottom of the analog-video barrel. Very often a single yellow RCA jack, the composite video jack is rather common on computers and home and industrial video components. While still fairly decent in video quality, composite video is more susceptible to undesirable video phenomena and artifacts, such as aliasing, cross coloration, and dot crawl.

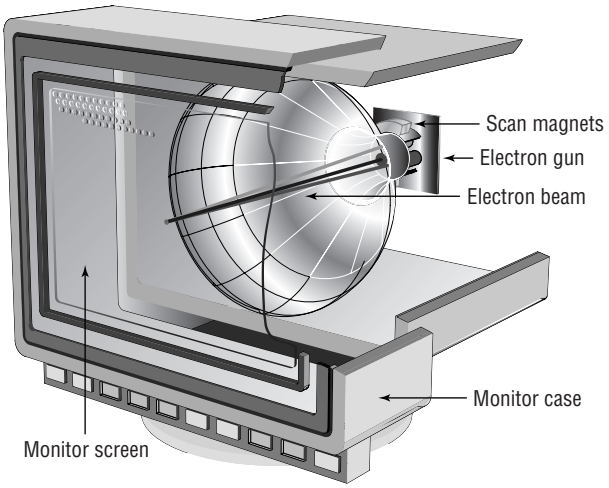
Monitors

As already mentioned, an older-style (yet still popular) non-LCD monitor contains a CRT. But how does it work? Basically, a device called an *electron gun* shoots electrons toward the back side of the monitor screen (see Figure 1.48). The back of the screen is coated with special chemicals (called *phosphors*) that glow when electrons strike them. This beam of electrons scans across the monitor from left to right and top to bottom to create the image.

There are two ways to measure a monitor's image quality:

Dot Pitch The shortest distance between two dots of the same color on the monitor. Usually given in fractions of a millimeter (mm), the dot pitch tells how "sharp" the picture is. The lower the number, the closer together the pixels are, and, thus, the sharper the image. An average dot pitch is 0.28mm. Anything smaller than 0.28mm is considered great.

FIGURE 1.48 How a monitor works



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Refresh Rate (Technically called the *vertical scan frequency*.) Specifies how many times in one second the scanning beam of electrons redraws the screen. The phosphors stay bright for only a fraction of a second, so they must constantly be hit with electrons to stay lit. Given in draws per second, or Hertz, the refresh rate specifies how much energy is being put into keeping the screen lit. The refresh rate on smaller monitors, say 14 to 16 inches, does fine in the range 60 to 72Hz. However, the larger a monitor gets, the higher the refresh rate needs to be to reduce eyestrain from perceivable flicker. It is not uncommon to see refresh rates of 85Hz and higher.

One note about monitors that may seem rather obvious: You must use a video card that supports the type of monitor you are using. For example, you can't use a CGA monitor on a VGA adapter.



CRT monitors manufactured today are not susceptible to damage caused by setting the video adapter's refresh rate too high, unlike older monitors. They simply refuse to operate at a rate higher than they are capable of. Refresh rates are set on the video card through the operating system or special utility software. In order to see a proper image, however, the monitor must support the rate you select.

Liquid Crystal Displays (LCDs)

Portable computers were originally designed to be compact versions of their bigger brothers. They crammed all the components of the big desktop computers into a small, suitcase-like box called (laughably) a *portable computer*. No matter what the designers did to reduce the size of the computer, the display remained as large as the desktop version's. That is, until an inventor found that when he passed an electric current through a semicrystalline liquid, the crystals aligned themselves with the current. It was found that by combining transistors with these liquid crystals, patterns could be formed. These patterns could represent numbers or letters. The first application of these *liquid crystal displays* (LCDs) was the LCD watch. It was rather bulky, but it was cool.

As LCD elements got smaller, the detail of the patterns became greater, until one day someone thought to make a computer screen out of several of these elements. This screen was very light compared to computer monitors of the day, and it consumed little power. It could easily be added to a portable computer to reduce the weight by as much as 30 pounds. As the components got smaller, so did the computer, and the laptop computer was born.

LCDs are not just limited to laptops; desktop versions of LCD displays are available as well. They use the same technologies as their laptop counterparts but on a much larger scale. Plus, these LCDs are available in either analog or digital interfaces for the desktop computer. The analog interface is exactly the same as the interface used for most monitors. All digital signals from the computer are converted into analog signals by the video card, which are then sent along the same 15-pin connector as a monitor. Digital LCDs, on the other hand, are directly driven by the video card's internal circuitry. They require the video card to be able to support

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digital output (through the use of a Digital Visual Interface, or DVI, connector). The advantage is that since the video signal never goes from digital to analog, there is no conversion-related quality loss. Digital displays are generally sharper than their analog counterparts.

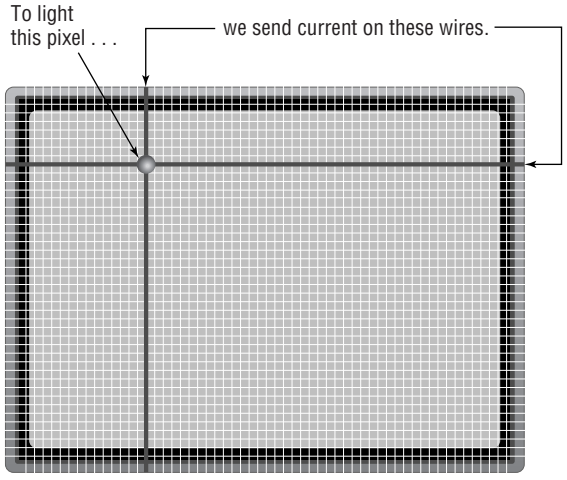
Two major types of LCD displays are used today: active-matrix screen and passive-matrix screen. The main differences lie in the quality of the image. However, both types use lighting behind the LCD panel to make the screen easier to view:

Active Matrix An active-matrix screen works in a similar manner to the LCD watch. The screen is made up of several individual LCD pixels. A transistor behind each pixel, when switched on, activates two electrodes that align the crystals and turn the pixel dark. This type of display is very crisp and easy to look at. The major disadvantage of an active-matrix screen is that it requires large amounts of power to operate all the transistors. Even with the backlight turned off, the screen can still consume battery power at an alarming rate. Most laptops with active-matrix screens can't operate on a battery for more than two hours.

Passive Matrix Within the passive-matrix screen are two rows of transistors: one at the top, another at the side. When the computer's video circuit wants to turn on a particular pixel (turn it black), it sends a signal to the x- and y-coordinate transistors for that pixel, thus turning them on. This then causes voltage lines from each axis to intersect at the desired coordinates, turning the desired pixel black. Figure 1.49 illustrates this concept.

The main difference between active matrix and passive matrix is image quality. Because the computer takes a millisecond or two to light the coordinates for a pixel in passive-matrix displays, the response of the screen to rapid changes is poor, causing, for example, an effect known as *submarining*: On a computer with a passive-matrix display, if you move the mouse pointer rapidly from one location to another, it will disappear from the first location and reappear in the new location without appearing anywhere in between.

FIGURE 1.49 A passive-matrix display



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To keep the quality of the image on an LCD the best, the screen must be cleaned often. Liquid crystal displays are typically coated with a clear plastic covering. This covering commonly gets dirtied by fingerprints as well as a generous coating of dust. The best way to clean the LCD lens coating is to wipe it off occasionally with a damp cloth. Doing so will ensure that the images stay crisp and clear.

Identifying Input Devices

An *input device* is one that transfers information outside the computer system to an internal storage location, such as system RAM, video RAM, flash memory, or disk storage. Without input devices, computers would be unable to change state from their originally manufactured personality. This section details six different input devices. It will demonstrate the similarities shared by devices that provide input to computer systems as well as their differences.

Mouse

Although the computer mouse was born in the 1970s at Xerox's Palo Alto Research Center (PARC), it was Apple in 1984 that made the mouse an integral part of the personal computer image with the introduction of the Macintosh. In its most basic form, the mouse is a hand-fitting device that uses some form of motion-detection mechanism to translate its own physical two-dimensional movement into on-screen cursor motion. Many variations of the mouse exist, including trackballs, tablets, touchpads, and pointing sticks. Figure 1.50 illustrates the recognizable form of the mouse.

FIGURE 1.50 A computer mouse



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The motion-detection mechanism of the original Apple mouse was a simple ball that protruded from the bottom of the device so that when the bottom was placed against a flat surface that offered a slight amount of friction, the mouse would glide over the surface, but the ball would roll, actuating two rollers that mapped the linear movement to the software interface. This method of motion detection remains popular today.

Later technologies used optical receptors to catch LED light reflected from specially made surfaces purchased with the devices and used like a *mouse pad*. A mouse pad is a special surface to improve mechanical mouse traction while offering very little resistance to the mouse itself. As optical science advanced for the mouse, lasers were used to allow a sharper image to be captured by the mouse and more sensitivity in motion detection. The mouse today can be wired to the computer system or wireless. Wireless versions use batteries to power them, and the optical varieties deplete these batteries more quickly than their mechanical counterparts.

The final topic is one that is relevant for any mouse: buttons. The number of buttons you need for your mouse to have is dependent on the software interfaces you use. For the Macintosh, one button has always been sufficient, but for a Windows-based computer, at least two are recommended, hence the pop-culture term *right-click*. Today, the mouse is commonly found to have a wheel on top to aid in scrolling. The wheel has even developed a click in many models, sort of an additional button underneath the wheel. Buttons on the side of the mouse that can be programmed for whatever the user desires are more common today as well.

Keyboard

More ubiquitous than the mouse, the keyboard is easily the most popular input device, so much so that its popularity is more of a necessity. Very few users would even think of beginning a computing session without a working keyboard. Few would even know how. The U.S. English keyboard places keys in the same orientation as the QWERTY typewriter keyboards, which were first seen in the 1870s.

In addition to the standard QWERTY layout, modern computer keyboards often have separate cursor-movement and numerical keypads. The numerical keys in a row above the alphabet keys send different scan codes to the computer from those sent by the numerical keypad.

Keyboards have also added function keys (not to be confused with the common laptop key labeled Fn), which are often placed in a row across the top of the keyboard above the numerical row. Key functionality can be modified by using one or more combinations of the Ctrl, Alt, Shift, and Fn keys along with the normal QWERTY keys.

Technically speaking, the keys on a keyboard complete individual circuits when each one is pressed. The completion of each circuit leads to a unique scan code that is sent to the keyboard connector on the computer system. The computer uses a keyboard controller chip to interpret the code as the corresponding key sequence. The computer then decides what action to take based on the key sequence and what it means to the computer and the active application.

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Bar-code Reader

A *bar-code reader* (or *bar-code scanner*) is a specialized input device commonly used in retail and other industrial sectors that manage inventory. The systems that the reader connects to can be so specialized that they have no other input device. Bar-code readers can use LEDs or lasers as light sources and can scan one- or two-dimensional bar-codes.

Bar-code readers can connect to the host system in a number of ways, but serial connections, such as RS-232 and USB are fairly common. If the system uses proprietary software to receive the reader's input, the connection between the two might be proprietary as well. The simplest software interfaces call for the reader to be plugged into the keyboard's PS/2 connector using a splitter that allows the keyboard to remain connected. The scanner converts all output to keyboard scans so that the system treats the input as if it came from a keyboard. For certain readers, wireless communication with the host is also possible, using IR, RF, Bluetooth, Wi-Fi, and more.

Multimedia Devices

Multimedia input devices vary in functionality based on the type of input being gathered. Two broad categories of input are audio and video. Digital motion and still cameras are incredibly popular as a replacement for similar products that do not transfer information to a computer, simply to make sharing and collaboration so much easier. Microphones and audio recording and playback devices are common components connected to the sound card of many systems so that audio input from these devices can be collected and processed. This includes MIDI devices that provide musical input for further processing.

Biometric Devices

Any device that measures one or more physical or behavioral features of an organism is considered a *biometric device*. When the same device forwards this biometric information to the computer, it becomes an input device. The list includes fingerprint scanners, retinal scanners, voice recognition, and facial recognition, to name a few. A computer can use this input to authenticate the user based on preestablished information regarding this biometric information.

Touch Screens

Touch-screen technology converts stimuli of some sort, which are generated by actually touching the screen, to electrical impulses that travel over serial connections to the computer system. These input signals allow for the replacement of both the keyboard *and* the mouse. However, standard computer systems are not the only application for touch-screen enhancement. This technology can also be seen in PDAs, point-of-sale venues for such things as PIN entry and signature capture, handheld and bar-mounted games, ATMs, remote controls, appliances, and vehicles.

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For touch screens there are a handful of solutions for how to convert a touch to a signal. Some less-successful ones rely on warm hands, sound waves, or dust-free screens. The more successful screens have optical or electrical sensors that are quite a bit less fastidious. In any event, the sensory system is added onto a standard monitor at some point in the creation of the monitor.

Identifying Purposes and Characteristics of Adapter Cards

An *adapter card* (also known as an *expansion card*) is simply a circuit board you install into a computer to increase the capabilities of that computer. Adapter cards come in many different kinds, but the important thing to note is that no matter what function a card has, the card being installed must match the bus type of the motherboard you are installing it into (for example, you can install a PCI network card only into a PCI expansion slot).

Five of the most common expansion cards that are installed today are as follows:

- Video card
- Network interface card (NIC)
- Modem
- Sound card
- I/O card

Let's take a quick look at each of these cards, their functions, and what some of them look like.

Video Card

A *video adapter* (more commonly called a *video card*) is the expansion card you put into a computer in order to allow the computer to display information on some kind of monitor or LCD display. A video card also is responsible for converting the data sent to it by the CPU into the pixels, addresses, and other items required for display. Sometimes, video cards can include dedicated chips to perform certain of these functions, thus accelerating the speed of display.

With today's motherboards, most video cards are AGP and, with increasing popularity, PCIe expansion cards that fit in the associated slot on a motherboard. Figure 1.51 shows an example of an AGP-based video card.

Network Interface Card (NIC)

A *network interface card (NIC)* is an expansion card that connects a computer to a network so that it can communicate with other computers on that network. It translates the data from the parallel data stream used inside the computer into the serial data stream of packets used on the network. It has a connector for the type of expansion bus on the motherboard (PCIe, PCI, ISA, and so on) as well as a connector for the type of network (such as RJ-45 for UTP or BNC for coax). In addition to the NIC, you need to install software or drivers on the computer in order for the computer to use the network. Figure 1.52 shows an example of a NIC.

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FIGURE 1.51 A video expansion card

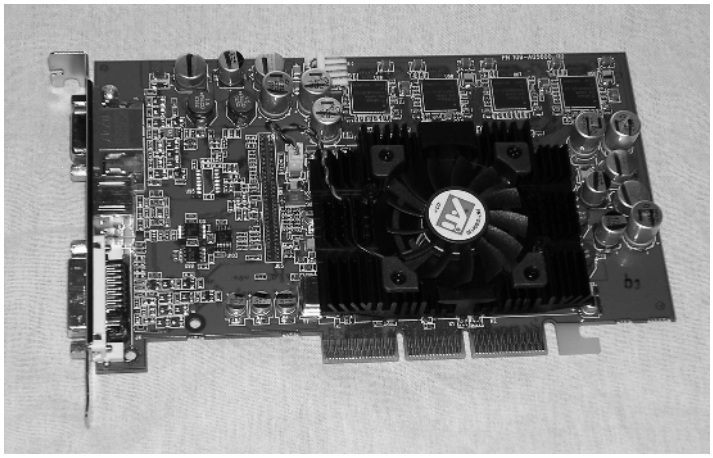
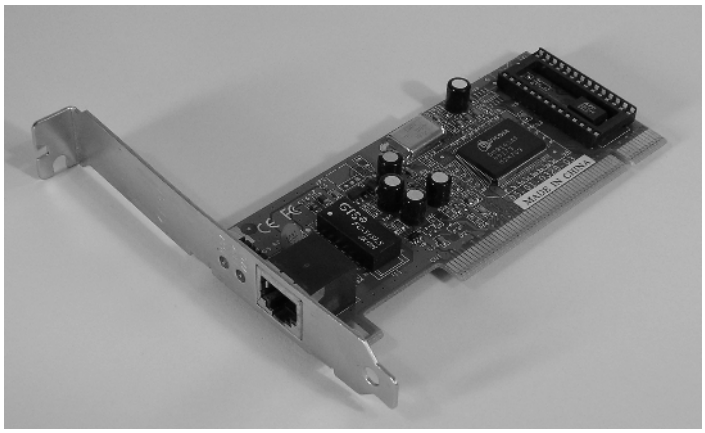


FIGURE 1.52 A network interface card (NIC)





Some computers have NIC circuitry integrated into their motherboards. Therefore, a computer with an integrated NIC wouldn't need to have a NIC expansion card installed, unless you were using the second NIC for load balancing, security, or fault-tolerance applications.

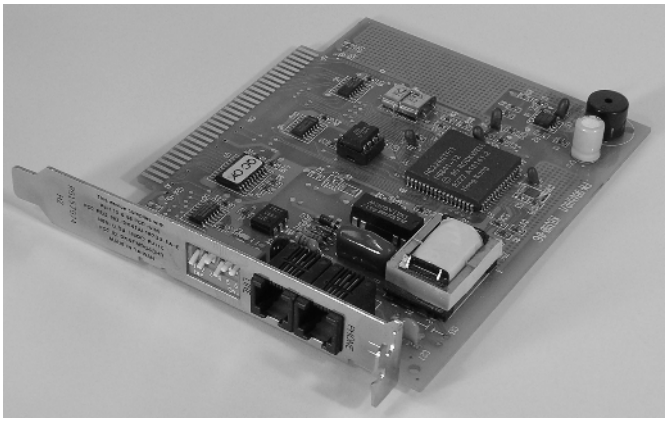
Modem

Any computer that connects to the Internet using a dial-up connection needs a modem. A *modem* is a device that converts digital signals from a computer into analog signals that can

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be transmitted over phone lines and back again. These expansion card devices have one connector for the expansion bus being used (PCIe, PCI, ISA, and so on) and another for connection to the telephone line. Actually, as you can see in Figure 1.53, there are two RJ-11 ports: one for connection to the telephone line and the other for connection to a telephone. This is the case primarily so that putting a computer online still lets someone hook a phone to that wall jack (although he won't be able to use the phone while the computer is connected to the Internet).

FIGURE 1.53 A modem



Sound Card

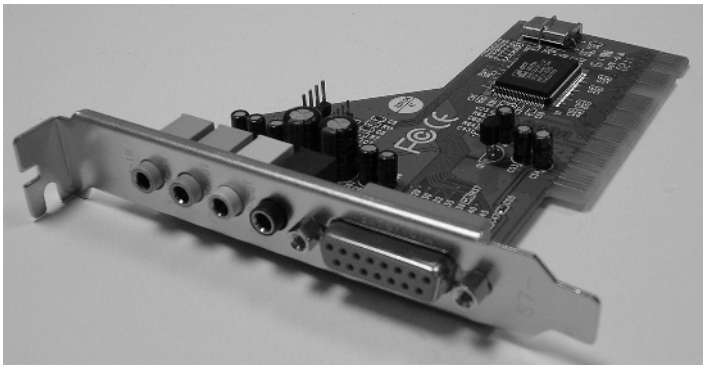
Just as there are devices to convert computer signals into printouts and video information, there are devices to convert those signals into sound. These devices are known as *sound cards*. Many different manufacturers make sound cards, but the standard has been set by Creative Labs with its SoundBlaster series of cards.

A sound card typically has small, round, 1/8-inch jacks on the back of it for connecting to microphones, headphones, and speakers as well as other sound equipment. Many sound cards also have a DA15 game port (discussed below), which can be used for either joysticks or MIDI connections (it allows a computer to talk to a digital musical instrument, such as a digital keyboard). For MIDI, the DA15 port is bidirectional. MIDI devices use a 5-pin DIN connector like the larger original-style PC keyboard connector. An adapter is required for two of these unidirectional DIN connectors, a MIDI-in and a MIDI-out, to interface with the DA15. Figure 1.54 shows an example of a sound card.

Sound cards today might come with an RCA jack (see the section "Audio/Video Jacks" later in this chapter). This is decidedly not for composite video. Instead, there is a digital audio specification known as the *Sony/Philips Digital Interface (S/PDIF)*. Not only does this format allow you to transmit audio in digital clarity, but in addition to the RCA jack and coaxial copper cabling it specifies optical fiber connectors and cabling for electrically noisy environments, further increasing transmission quality of the digital signal.

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FIGURE 1.54 A typical sound card



I/O Card

I/O card is often a catchall phrase for any adapter card that expands the system to interface with devices that offer input to the system, output from the system, or both. Common examples of I/O are the serial and parallel ports of the system, drive interface connections, and so on. A very popular expansion card of the 1980s and early 1990s was known as the Super I/O card. This one adapter had the circuitry for two standard serial ports, one parallel port, two PATA controllers, and one floppy controller. Some versions included more still. For many years, if you wanted to use a SCSI hard drive in your system, you had to install an adapter card that expanded the motherboard's capabilities to allow the use of SCSI hard drives. The drives would them cable to the adapter, and the adapter would perform the requisite conversion of the drive signals to those that the motherboard and the circuits installed on it could use. Today, common I/O adapter cards tend to be USB 2.0 adapters and FireWire adapters.

Identifying Characteristics of Ports and Cables

Now that you've learned the various types of items found in a computer, let's discuss the various types of ports and cables used with computers. A *port* is a generic name for any connector on a computer into which a cable can be plugged. A *cable* is simply a way of connecting a peripheral or other device to a computer using multiple copper or fiber-optic conductors inside a common wrapping or sheath. Typically, cables connect two ports, one on the computer and one on some other device.

Let's take a quick look at some of the different styles of port connector types as well as peripheral port and cable types. We'll begin by looking at peripheral port connector types.

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Peripheral Port Connector Types

Computer ports are interfaces that allow other devices to be connected to a computer. Their appearance varies widely, depending on their function. In this section we'll examine the following types of peripheral ports:

- D-subminiature
- RJ-series
- Other types

D-subminiature Connectors

D-sub connectors, for a number of years the most common style of connector found on computers, are typically designated with D*Xn*, where the letter *X* is replaced by the letters *A* through *E*, which refer to the size of the connector, and the letter *n* is replaced by the number of pins or sockets in the connector. See the discussion on D-sub nomenclature in Chapter 12. D-sub connectors are usually shaped like a trapezoid, as you can see in Figure 1.55. The nice part about these connectors is that only one orientation is possible. If you try to connect them upside down or try to connect a male connector to another male connector, they just won't go together, and the connection can't be made. Table 1.6 lists common D-sub ports and connectors as well as their most common uses.

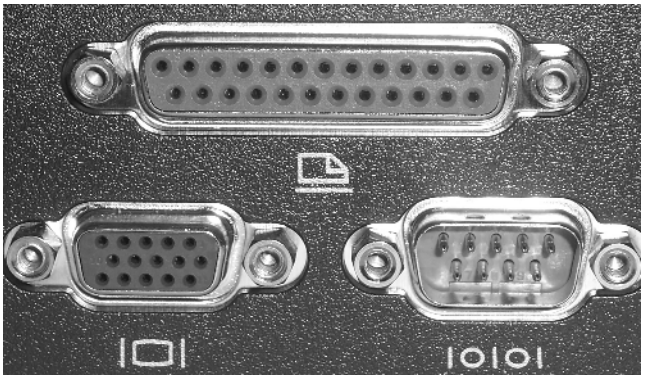
On the left in Figure 1.55 is a DE15F 15-pin video port, in the center is a DB25F 25-pin female printer port, and on the right is a DE9M 9-pin male serial port.

TABLE 1.6 Common D-sub Connectors

Connector	Gender	Use
DE9	Male	Serial port
DE9	Female	Connector on a serial cable
DB25	Male	Serial port or connector on a parallel cable
DB25	Female	Parallel port, or connector on a serial cable
DA15	Female	Game port or MIDI port
DA15	Male	Connector on a game peripheral cable or MIDI cable
DE15	Female	Video port (has three rows of 5 pins as opposed to two rows)
DE15	Male	Connector on a monitor cable

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FIGURE 1.55 D-sub ports and connectors



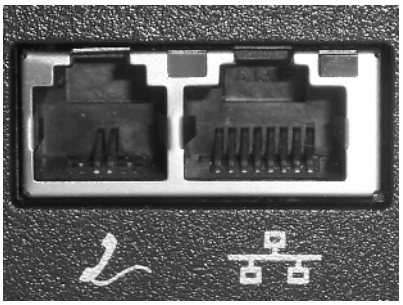
RJ-Series

Registered jack (RJ) connectors are most often used in telecommunications. Figure 1.56 shows the two most common examples of RJ ports: RJ-11 and RJ-45. RJ-11 connectors are used most often in telephone hookups; your home phone jack is probably an RJ-11 jack. RJ-45 connectors, on the other hand, are most commonly found on Ethernet networks that use twisted-pair cabling. Although RJ-45 is a widely accepted description for the larger connectors, it is not correct. Generically speaking, they are 8-pin modular connectors.

On the left in this picture is an RJ-11 connector and on the right is an RJ-45 connector. Notice the size difference.

As you can see, RJ connectors are typically square with multiple gold contacts on the top (flat) side. A small locking tab on the bottom prevents the connector and cable from falling or being pulled out of the jack accidentally.

FIGURE 1.56 RJ ports



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Other Types of Ports

A few other ports are used with computers today. These ports include the following:

- Universal Serial Bus (USB)
- IEEE 1394 (FireWire)
- Infrared
- Audio jacks
- PS/2 (mini-DIN)
- Centronics

Let's look at each one and how it is used.

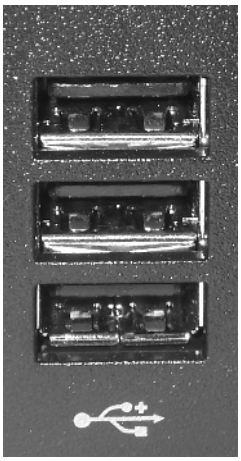
Universal Serial Bus (USB)

Most computers built after 1997 have one or more flat ports in place of one DE9M serial port. These ports are Universal Serial Bus (USB) ports, and they are used for connecting multiple (up to 127) peripherals to one computer through a single port (and the use of multiport peripheral *hubs*). USB version 1.1 supported data rates as high as 12Mbps (1.5MBps). The newest version, USB 2.0, supports data rates as high as 480Mbps (60MBps). Figure 1.57 shows an example of a set of Type A USB ports. Port types are explained in the "Common Peripheral Interfaces and Cables" section later in this chapter.



The newest version of USB, USB 2.0, uses the same physical connection as the original USB, but it is much higher in transfer rates and requires a cable with more shielding that is less susceptible to noise. You can tell if a computer supports USB 2.0 by looking for the red and blue "High Speed USB" graphic somewhere on the computer (or on the box).

FIGURE 1.57 USB ports



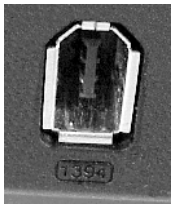
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Because of USB's higher transfer rate, flexibility, and ease of use, most devices that in the past used serial interfaces now come with USB interfaces. It's rare to see a newly introduced PC accessory with a standard serial interface cable. For example, PC cameras (such as the Logitech QuickCam) used to come as standard serial-only interfaces. Now you can buy them only with USB interfaces.

IEEE 1394 (FireWire)

Recently, one port has been slowly creeping into the mainstream and is seen more and more often on desktop PCs. That port is the IEEE 1394 port (shown in Figure 1.58), more commonly known as a *FireWire* port. Its popularity is due to its ease of use and very high (400MBps) transmission rates. Originally developed by Apple, it was standardized by IEEE in 1995 as IEEE 1394. It is most often used as a way to get digital video into a PC so it can be edited with digital video editing tools.

FIGURE 1.58 A FireWire port on a PC



Infrared

Increasing numbers of people are getting fed up with being tethered to their computers by cords. As a result, many computers (especially portable computing devices like laptops and PDAs) are now using infrared ports to send and receive data. An *infrared (IR) port* is a small port on the computer that allows data to be sent and received using electromagnetic radiation in the infrared band. The infrared port itself is a small, dark square of plastic (usually a very dark maroon) and can typically be found on the front of a PC or on the side of a laptop or portable. Figure 1.59 shows an example of an infrared port.

FIGURE 1.59 An infrared port



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Infrared ports send and receive data at a very slow rate (maximum speed on PC infrared ports is less than 4Mbps). Most infrared ports on PCs that have them support the *Infrared Data Association (IrDA) standard*, which outlines a standard way of transmitting and receiving information by infrared so that devices can communicate with each other.



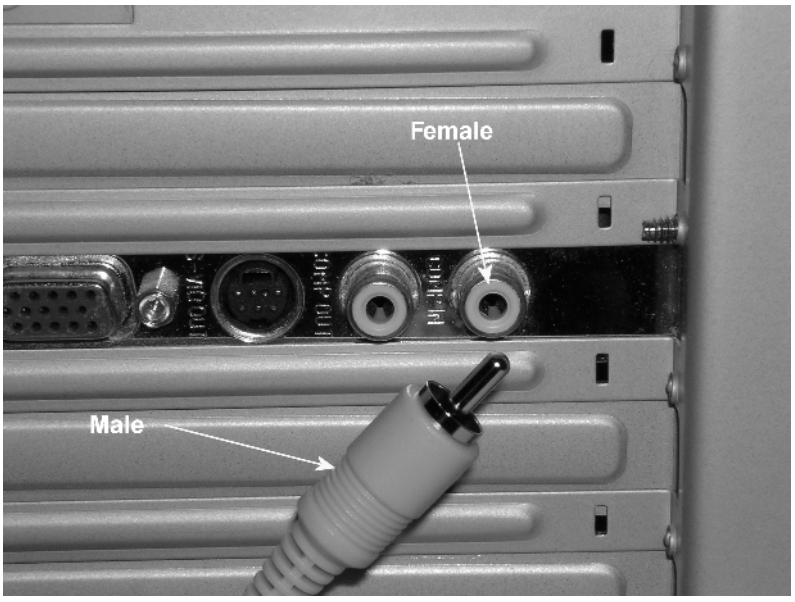
More information on the IrDA standard can be found at the organization's website: `http://www.irda.org`.

Note that although infrared is a wireless technology, most infrared communications (especially those that conform to the IrDA standards) are line-of-sight only and take place within a short distance (typically less than four meters). Infrared is typically used for point-to-point communications such as controlling the volume on a device with a handheld remote control.

Audio/Video Jacks

The RCA jack (shown in Figure 1.60) was developed by the RCA Victor Company in the late 1940s for use with its phonographs. You bought a phonograph, connected the RCA plug on the back of your phonograph to the RCA jack on the back of your radio or television, and used the speaker and amplifier in the radio or television to listen to records. It made phonographs cheaper to produce and had the added bonus of making sure everyone had an RCA Victor radio or television (or at the very least, one with the RCA jack on the back). Either way, RCA made money.

FIGURE 1.60 An RCA jack (female) and RCA plug (male)



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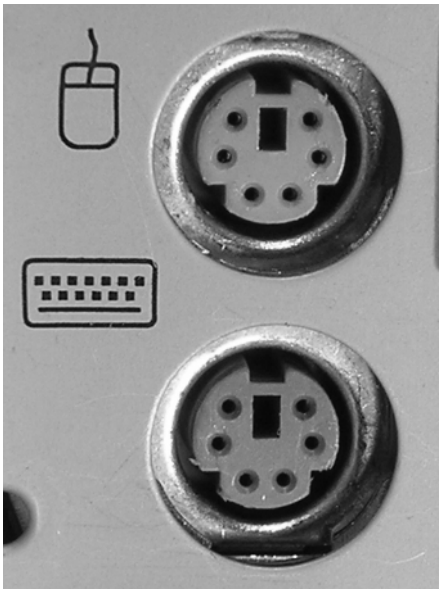
Today, RCA jacks and connectors (or plugs) are used to transmit both audio and video information. Typically, when you see an RCA connector on a PC video card (next to a DE15F connector), it's for composite video output (output to a television or VCR). However, digital audio uses *S/PDIF*, which is an RCA jack. Figure 1.17 showed an S/PDIF jack. Although they aren't used for video, it bears mentioning that the 1/8-inch stereo minijack and mating miniplug are more commonly used on computers these days for analog audio. Your sound card, microphone, and speakers have them.

In the spirit of covering interfaces that support both audio and video, don't forget the HDMI jack, which carries both over the same interface. Only CATV coaxial connections to TV cards can boast that on the PC. An RCA jack and cable carry either audio or video, not both simultaneously.

PS/2 (Keyboard and Mouse)

Another common port, as mentioned earlier, is the PS/2 port. A *PS/2 port* (also known as a *mini-DIN 6* connector) is a mouse and keyboard interface port first found on the IBM PS/2 (hence the name). It is smaller than previous interfaces (the DIN-5 keyboard port and serial mouse connector), and thus its popularity increased quickly. Figure 1.61 shows examples of both PS/2 keyboard and mouse ports. You can tell the difference because usually the keyboard port is purple and the mouse port is green. Also, typically there are small graphics of a keyboard and mouse, respectively, imprinted next to the ports.

FIGURE 1.61 PS/2 keyboard and mouse ports

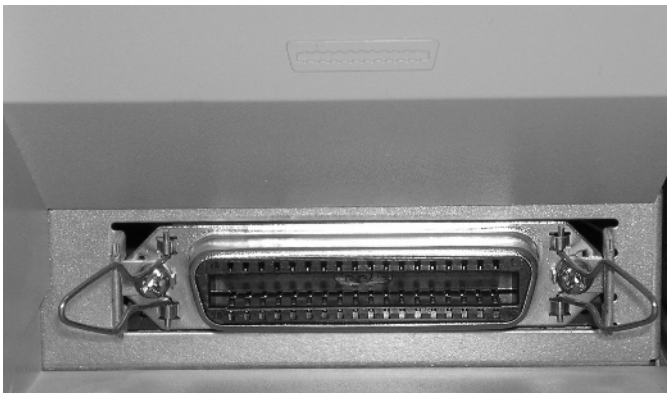


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Centronics

The last type of port connector is the Centronics connector, a micro ribbon connector named for the Wang subsidiary that created it. It has a unique shape, as shown in Figure 1.62. It consists of a central connection bar surrounding by an outer shielding ring. The Centronics connector was primarily used in parallel printer connections and SCSI interfaces. It is most often found on peripherals, not on computers themselves (except in the case of some older SCSI interface cards).

FIGURE 1.62 A Centronics connector



Common Peripheral Interfaces and Cables

An *interface* is a method of connecting two dissimilar items together. A *peripheral interface* is a method of connecting a peripheral or accessory to a computer, including the specification of cabling, connector type, speed, and method of communication used.

The most common interfaces used in PCs today include these:

- Parallel
- Serial
- USB
- IEEE 1394 (FireWire)
- Infrared
- RCA
- PS/2

For each type, let's look at the cabling and connector used as well as the type(s) of peripherals that are connected.

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Parallel

For many years, the most popular type of interface available on computers was the parallel interface. Parallel communications take the interstate approach to data communications. Normally, interstate travel is faster than driving on city roads. This is the case mainly because you can fit multiple cars going the same direction on the same highway by using multiple lanes. On the return trip, you take a similar path, but on a completely separate road. The *parallel interface* (an example is shown in Figure 1.55) transfers data eight bits at a time over eight separate transmit wires inside a parallel cable (one bit per wire). Normal parallel interfaces use a DB-25 female connector on the computer to transfer data to peripherals. Parallel was faster than the original serial technology, which was also once used for printers in electrically noisy environments or at greater distances from the computer, but the advent of USB has brought serial, fast serial, back to the limelight.

The most common use of the parallel interface is printer communication. There are three major types: standard, bidirectional, and enhanced parallel ports. Let's look at the differences between the three.

Standard Parallel Ports

The standard parallel port only transmits data *out* of the computer. It cannot receive data (except for a single wire carrying a Ready signal). This parallel port came with the original IBM PC, XT, and AT. It can transmit data at 150KBps and is commonly used to transmit data to printers. This technology also has a maximum transmission distance of 10 feet.

Bidirectional Parallel Ports

As its name suggests, the bidirectional parallel port has one important advantage over a standard parallel port: It can both transmit and receive data. These parallel ports are capable of interfacing with such devices as external CD-ROM drives and external parallel port backup drives (Zip, Jaz, and tape drives). Most computers made since 1994 have a bidirectional parallel port.



In order for bidirectional communication to occur properly, the cable must support bidirectional communication as well.

Enhanced Parallel Ports

As more people began using parallel ports to interface with devices other than printers, they started to notice that the available speed wasn't good enough. Double-speed CD-ROM drives had a transfer rate of 300KBps, but the parallel port could transfer data at only 150KBps, thus limiting the speed at which a computer could retrieve data from an external device. To solve that problem, the Institute of Electrical and Electronics Engineers (IEEE) came up with a standard for enhanced parallel ports called IEEE 1284. The IEEE 1284 standard provides for greater data transfer speeds and the ability to send memory addresses as well as data through a parallel port. This standard allows the parallel port to theoretically act as an extension to the main bus. In addition, these ports are backward compatible with the standard and bidirectional ports.

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There are two implementations of IEEE 1284: ECP parallel ports and EPP parallel ports. An *enhanced capabilities port* (ECP port) is designed to transfer data at high speeds to printers. It uses a DMA channel and a buffer to increase printing performance. An *enhanced parallel port* (EPP port) increases bidirectional throughput from 150KBps to anywhere from 600KBps to 1.5MBps.



The cable must also have full support for IEEE 1284 in order for proper communications to occur in both directions and at rated speeds.

Parallel Interfaces and Cables

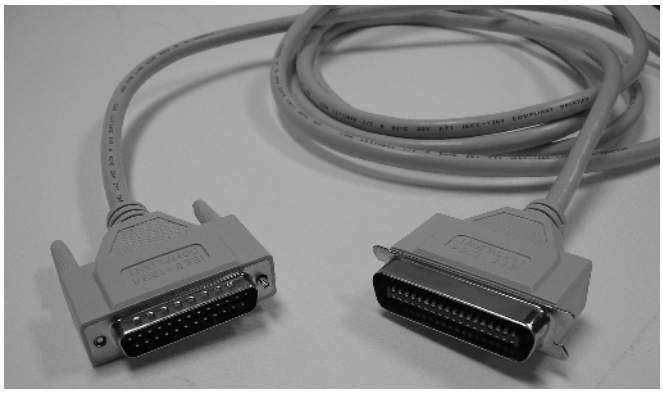
Most parallel interfaces use a DB-25 female connector, as shown earlier in this chapter. Most parallel cables use a DB-25 male connector on one end and either a DB-25 male connector or Centronics-36 connector on the other. The original printer cables typically used the DB-25M–to–Centronics-36 configuration. Inside a parallel cable, eight wires are used for transmitting data, so one byte can be transmitted at a time. Figure 1.63 shows an example of a typical parallel cable (in this case, a printer cable).

If a printer today uses a parallel port through which to connect to the computer, the likely interface on the printer is known as a mini-Centronics. Figure 1.64 shows the component end of a mini-Centronics cable. Again, however, nothing is more popular today for printer connectivity than USB.

Serial

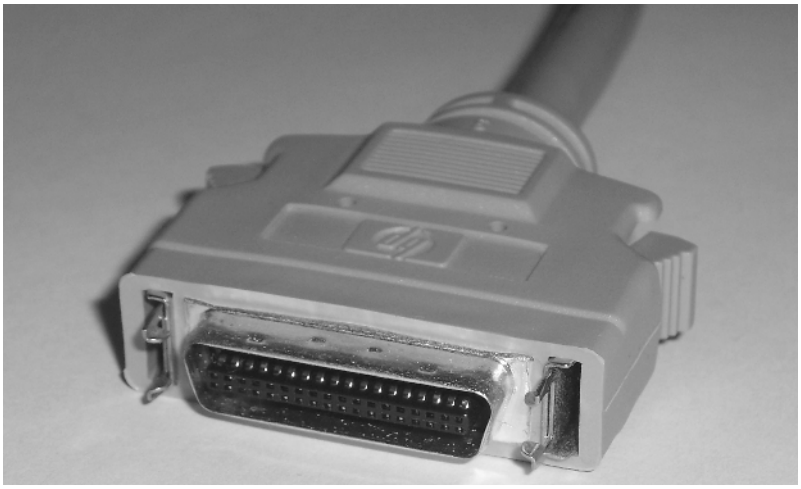
If parallel communications are similar to taking the interstate, then serial communications are similar to taking a country road. In serial communications, bits of data are sent one after another (single file, if you will) down one wire, and they return on a different wire in the same cable. Three main types of serial interfaces are available today: standard serial, Universal Serial Bus (USB), and FireWire.

FIGURE 1.63 A typical parallel cable



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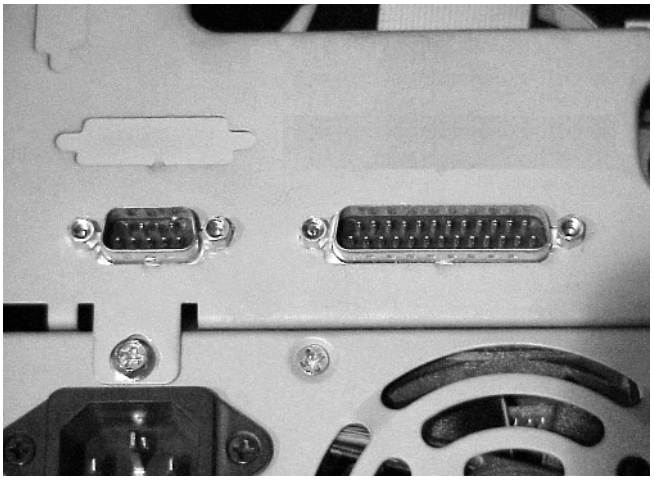
FIGURE 1.64 The mini-Centronics connector



Standard Serial

Almost every computer made since the original IBM PC has at least one serial port. These computers are easily identified because they have either a DE-9 male or a DB-25 male port (shown in Figure 1.65). Standard serial ports have a maximum data transmission speed of 57Kbps and a maximum cable length of 50 feet.

FIGURE 1.65 Standard DE-9 and DB-25 male serial ports



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Serial cables come in two common wiring configurations: *standard serial cable* and *null modem serial cable*. A standard serial cable is used to hook various peripherals such as modems and printers to a computer. A null modem serial cable is used to hook two computers together without a modem. The transmit wires on one end are wired to the receive pins on the other side, so it's as if a modem connection exists between the two computers but without the need for a modem. Figures 1.66 and 1.67 show the wiring differences (the *pinouts*) between a standard serial cable and a null modem cable. In the null modem diagram, notice how the transmit (tx) pins on one end are wired to the receive (rx) pins on the other.

FIGURE 1.66 A standard serial cable wiring diagram

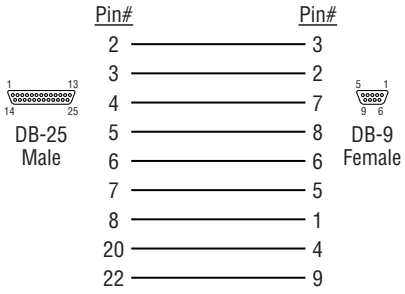
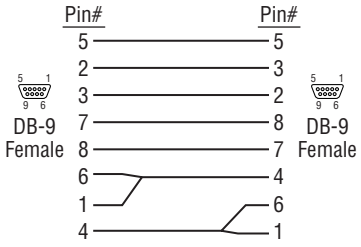


FIGURE 1.67 A null modem serial cable wiring diagram



Finally, because of the two different device connectors (DE-9M and DB-25M), serial cables have a few different configurations. Table 1.7 shows the most common serial cable configurations.

TABLE 1.7 Common Serial Cable Configurations

1st Connector	2nd Connector	Description
DE-9 female	DB-25 male	Standard modem cable
DE-9 female	DE-9 male	Standard serial extension cable

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TABLE 1.7 Common Serial Cable Configurations *(continued)*

1st Connector	2nd Connector	Description
DE-9 female	DE-9 female	Null modem cable
DB-25 female	DB-25 female	Null modem cable
DB-25 female	DB-25 male	Standard serial cable or standard serial extension cable

Universal Serial Bus (USB)

USB cables are used to connect a wide variety of peripherals to computers, including keyboards, mice, digital cameras, printers, and scanners. The latest version of USB, version 2.0, requires a cable with better shielding than did earlier versions. Not all USB cables work with USB 2.0 ports. The connectors are identical, so look for cables that are transparent with a view to the silver metallic shielding within.

USB's simplicity of use and ease of expansion make it an excellent interface for just about any kind of peripheral. This fact alone makes the USB interface one of the most popular on the modern computer, perhaps behind only the video, input, and network connectors.

The USB interface is fairly straightforward. Essentially, it was designed to be Plug and Play—just plug in the peripheral, and it should work (providing the software is installed to support it). The USB cable varies based on the USB male connector on each end. Because there can be quite a number of daisy-chained USB devices on a single system, it helps to have a scheme to clarify their connectivity. The USB standard specifies two broad types of connector. They are designated Type A and Type B connectors. A standard USB cable has some form of Type A connector on one end and some form of Type B connector on the other end. Figure 1.68 shows four USB cable connectors. From left to right, they are

- Type A
- Standard mini-B
- Type B
- Alternate mini-B

One part of the USB interface specification that makes it so appealing is the fact that if your computer runs out of USB ports, you can simply plug a device known as a *USB hub* into one of your computer's USB ports, which will give you several more USB ports from one USB port. Figure 1.69 shows an example of a USB hub.

From the perspective of the cable's plug, Type A is always oriented toward the system from the component. As a result, you might notice that the USB receptacle on the computer system that a component cables back to is the same as the receptacle on the USB hub that components cable back to. The USB hub is simply an extension of the system and becomes a component that cables back to the system.

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FIGURE 1.68 USB cables and connectors

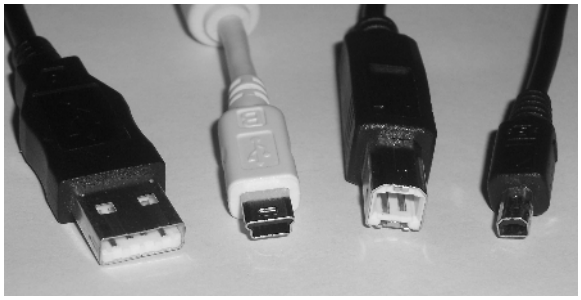


FIGURE 1.69 A USB hub



Type B plugs connect in the direction of the component. Therefore, you see a Type B interface on the hub as well as on the end devices to allow them to cable back to the system or another hub. Although they exist, USB cables with both ends of the same type, a sort of extension cable, are in violation of the USB specification. Collectively, these rules make cabling your USB subsystem quite straightforward.

While the system receptacle, the Type A, remains constant, the component receptacle differs, often based on the size of the USB device. For example, a USB-attached printer is large enough for a Type B connector, but a compact digital camera might only be large enough to accommodate a mini-B receptacle of some sort. While the standard calls for one mini-B connector, others have been developed, some common, others a bit rarer. The four connectors shown in Figure 1.68 are the most common. You might also run across mini-A connectors, which are not discussed further in this book.



USB connectors are keyed and will go into a USB port only one way. If the connector will not go into the port properly, try rotating it.



For more information on USB, check out `http://www.usb.org`.

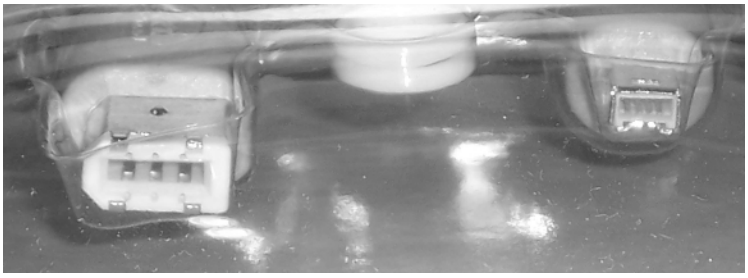
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IEEE 1394 (FireWire)

The IEEE 1394 interface is about one thing: speed. Its first iteration, now known as FireWire 400, has a maximum data throughput of 400Mbps. The latest iteration, FireWire 800, has a maximum data throughput of 800Mbps. It carries data at that speed over a maximum cable length of 4.5 meters (FireWire 400) and 100 meters (FireWire 800 over fiber-optic cables).

FireWire (also known as i.Link in Sony's parlance) uses a very special type of cable, as shown in Figure 1.70. Notice the difference in the system end on the left and the component end on the right. It is difficult to mistake this cable for anything but a FireWire cable.

FIGURE 1.70 A FireWire (IEEE 1394) cable

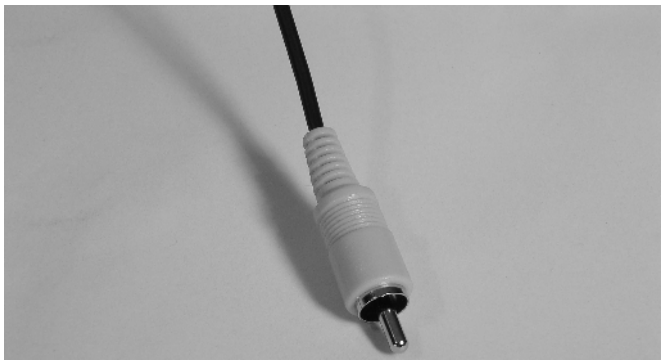


Although most people think of FireWire as a tool for connecting their digital camcorders to their computers, it's much more than that. Because of its high data transfer rate, it is being used more and more as a universal, high-speed data interface for things like hard drives, CD-ROM drives, and digital video editing equipment.

RCA

The RCA cable is simple. There are two connectors, usually male, one on each end of the cable. The male connector connects to the female connector on the equipment. Figure 1.71 shows an example of an RCA cable. An RCA male-to-RCA female connector is also available; it's used to extend the reach of audio or video signals.

FIGURE 1.71 An RCA cable



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The RCA male connectors on a connection cable are sometimes plated in gold to increase their corrosion resistance and to improve longevity.

PS/2 (Keyboard and Mouse)

The final interface we'll discuss is the PS/2 interface for mice and keyboards. Essentially, it is the same connector for the cables from both items: a male mini-DIN 6 connector. Most keyboards today still use the PS/2 interface, whereas most mice are gravitating toward the USB interface (especially optical mice). However, mice that have USB cables still may include a special USB-to-PS/2 adapter so they can be used with the PS/2 interface. Figure 1.72 shows an example of a PS/2 keyboard cable.

FIGURE 1.72 A PS/2 keyboard cable





Most often, PS/2 cables have only one connector, because the other end is connected directly to the device being plugged in. The only exception is PS/2 extension cables used to extend the length of a PS/2 device's cable.

Identifying Purposes and Characteristics of Cooling Systems

It's a basic concept of physics: electronic components turn electricity into work and heat. The heat must be dissipated or the excess heat will shorten the life of the components. In some cases (like the CPU), the component will produce so much heat that it can destroy itself in a matter of seconds if there is not some way to remove this extra heat.

Most PCs use air-cooling methods to cool their internal components. With air cooling, the movement of air removes the heat from the component. Sometimes, large blocks of metal called heat sinks are attached to a heat-producing component in order to dissipate the heat more rapidly.

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Fans

When you turn on a computer, you will often hear lots of whirring. Contrary to popular opinion, the majority of the noise isn't coming from the hard disk (unless it's about to go bad). Most of this noise is coming from the various fans inside the computer. Fans provide airflow within the computer.

Most PCs have a combination of these six fans:

Front Intake Fan This fan is used to bring fresh, cool air into the computer for cooling purposes.

Rear Exhaust Fan This fan is used to take hot air out of the case.

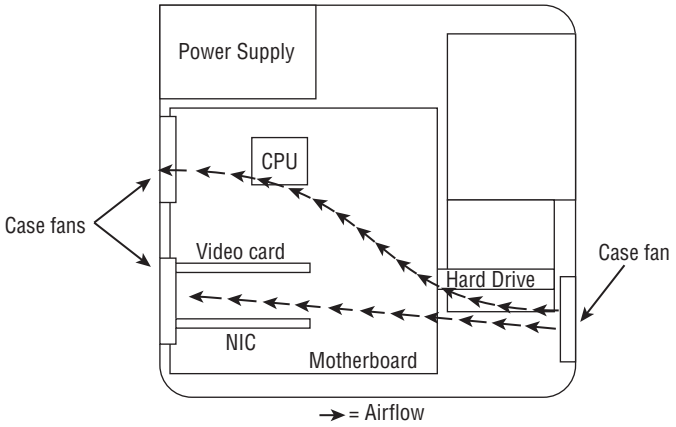
Power Supply Fan This fan is usually found at the back of the power supply and is used to cool the power supply. In addition, there are fans used to pull hot air from above the CPU into the power supply so that it can be exhausted.

CPU Fan This fan is used to cool the processor. Typically, this fan is attached to a large heat sink, which is in turn attached directly to the processor.

Chipset Fan Some motherboard manufacturers replaced the heat sink on their onboard chipset with a heat sink and fan combination. This fan aids in the cooling of the onboard chipset (especially useful when overclocking).

Video Card Chipset Fan As video cards get more complex and have higher performance, more video cards have cooling fans right on their video cards.

Ideally, the airflow inside a computer should resemble the following:



Memory Cooling

If you are going to start overclocking your computer, you will want to do everything in your power to cool all the components in your computer, and that includes the memory.

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There are two methods of cooling memory: passive and active. The passive memory cooling method just uses the ambient case airflow to cool the memory through the use of enhanced heat dissipation. For this, you can buy either heat sinks or special "for memory chips only" devices known as heat spreaders. These are special aluminum or copper housings that wrap around memory chips and conduct the heat away from the memory chips.

Active cooling, on the other hand, usually involves forcing some kind of cooling medium (air or water) around the RAM chips themselves or around their heat sinks. Most often, active cooling methods are just high-speed fans directing air right over a set of heat spreaders.



Some memory models allow you to put activity lights on top of your memory coolers.

Hard Drive Cooling

You might be thinking, "Hey, my hard drive is working all the time. Is there anything I can do to cool it off as well?" There are both active and passive cooling devices for hard drives. Most common, however, is the active cooling bay. You install a hard drive in a special device that fits into a 5.25-inch expansion bay. This device contains fans that draw in cool air over the hard drive, thus cooling it. Figure 1.73 shows an example of one of these active hard drive coolers. As you might suspect, you can also get heat sinks for hard drives.

FIGURE 1.73 An active hard disk cooler



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Chipset Cooling

Every motherboard has a chip or chipset that controls how the computer operates. As with other chips in the computer, the chipset is normally cooled by the ambient air movement in the case. However, when you overclock a computer, the chipset may need to be cooled more as it is working harder than it normally would be. Therefore, it is often desirable to replace the onboard chipset cooler with a more efficient one.

CPU Cooling

Probably the greatest challenge in cooling is the cooling of the computer's CPU. It is the component that generates the most heat in a computer. As a matter of fact, if it isn't actively cooled all the time, it will generate enough heat to burn itself up in an instant. That's why most motherboards have an internal CPU heat sensor and a CPU_FAN sensor. If no cooling fan is active, these devices will shut down the computer before damage occurs.

There are many different types of CPU cooling methods, but the two most important are air cooling and advanced cooling methods.

Air Cooling

The parts inside most computers are cooled by air moving through the case. The CPU is no exception. However, because of the large amount of heat produced, the CPU must have (proportionately) the largest surface area exposed to the moving air in the case. Therefore, the heat sinks on the CPU are the largest of any inside the computer.

It should be noted that the highest performing CPU coolers use copper plates in direct contact with the CPU. They also use high-speed and high-CFM cooling fans to dissipate the heat produced by the processor. CFM is short for cubic feet per minute, an airflow measurement of the volume of air that passes by a stationary object per minute.

Some CPU heat sinks use heat pipes to transfer heat away from the CPU. With any cooling system, the more surface area exposed to the cooling method, the better the cooling. Plus, the heat pipes can be used to transfer heat to a location away from the heat source before cooling. This is especially useful in small form factor cases where heat is limited.

With advanced heat sinks and CPU cooling methods like this, it is important to improve the thermal transfer efficiency as much as possible. To that end, cooling manufacturers have come up with a compound that helps to bridge the extremely small gaps between the CPU and the heat sink. This compound is known as thermal compound and can be bought in small tubes.



In addition to using thermal compound, you can enhance the cooling efficiency of a CPU heat sink by lapping (polishing) the heat sink.

If you've ever installed a brand new heat sink onto a CPU, you've most likely used thermal compound or a thermal compound patch. However, some people have designed special thermally conductive compounds such as Arctic Silver, which contain micronized silver in an organic suspension fluid, that are supposed to conduct heat better while filling in the microscopic peaks and valleys in a heat sink's surface.

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Advanced CPU Cooling Methods

In addition to standard air-cooling methods, there are other methods of cooling a CPU (and other chips as well). These methods are somewhat unorthodox but usually deliver extreme results. These methods can also result in permanent damage to your computer, so try them at your own risk.

Liquid Cooling

A new trend in PC cooling is *liquid cooling*. Liquid cooling is a technology whereby a special water block is used to conduct heat away from the processor (as well as from chipsets). Water is circulated through this block to a radiator, where it is cooled.

The theory is that you could achieve better cooling performance through the use of liquid cooling. For the most part, this is true. However, with traditional cooling methods (which use air and water), the lowest temperature you can achieve is room temperature. Plus, with liquid cooling, the pump is submerged in the coolant (generally speaking), so as it works, it produces heat, which adds to the overall system temperature.

The main benefit to liquid cooling is silence. There is only one fan needed: the fan on the radiator to cool the water. So a liquid cooled system can run extremely quietly.

Liquid cooling, while more efficient that air cooling and much quieter, has its drawbacks. Most liquid cooling systems start around $100 (although the price is always coming down) and that includes reservoir, pump, water block(s), hose, and radiator. Air-cooling systems are usually cheaper (although if you are really into cooling performance, the prices of all your fans and heat sinks could easily add up to more than $100).

Peltier Cooling Devices

Water- and air-cooling devices are extremely effective by themselves, but they are more effective when used with a device known as a Peltier cooling element. These devices, also known as thermo-electric coolers (TECs), essentially will facilitate the transfer of heat from one side of the element to the other. Thus, they have a hot side and a cold side. The cold side should always be against the CPU die and the hot side against a heat sink or water block so that the heat can be dissipated.

Phase Change Cooling

There is one new type of PC cooling that is just starting to be seen: *phase change cooling*. With this type of cooling, the cooling effect from the change of a liquid to a gas is used to cool the inside of a PC. It is a very expensive method of cooling, but it does work. Most often, external air-conditioner-like pumps, coils, and evaporators cool the coolant, which is sent, ice cold, to the heat sink blocks on the processor and chipset. Think of it as a water-cooling system that chills the water below room temperature. It is possible to get CPU temps in the range of -4°F (-20°C). Normal CPU temperatures hover between 104°F and 122°F (40°C and 50C).

The major drawback to this method is that in higher-humidity conditions, condensation can be a problem. The moisture from the air condenses on the heat sink and can run off onto the processor and motherboard, thus shorting them out. Designers of phase change cooling systems (like the Prometeia Mach II from Chip-Con) ensure this isn't a problem by sealing the processor in insulating foam.

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Summary

In this chapter, we took a tour of the components of a PC. You learned about the different components that make up a PC, including the case, motherboard, drives and storage, expansion cards, and display devices. In addition, we discussed common peripheral ports and cables and their appearance. Finally, you learned about the various methods used for cooling a PC. You also learned what each of these items looks like and how they function.

Exam Essentials

Know the types of system boards. Know the characteristics of and differences between ATX, micro ATX, NTX, and BTX motherboards.

Know the components of a motherboard. Be able to describe motherboard components, such as chipsets, expansion slots, memory slots and external cache, CPU and processor slots or sockets, power connectors, onboard disk drive connectors, keyboard connectors, peripheral ports and connectors, BIOS chips. CMOS batteries, jumpers and DIP switches, and firmware.

Understand the purposes and characteristics of processors. Be able to discuss the different processor packaging, old and new, and know the meaning of the terms hyperthreading, multicore, throttling, microcode, overclocking, cache, voltage regulator module, speed, and system bus width (32 or 64 bits).

Understand the purposes and characteristics of memory. Know about the characteristics that set the various types of memory apart from one another. This includes the actual types of memory, such as DRAM, which includes several varieties, SRAM, ROM, and CMOS, as well as memory packaging, such as DIMMs, RIMMs, SoDIMMS, and MicroDIMMs.

Understand the purposes and characteristics of storage devices. Be able to compare and contrast the various storage devices, which include hard and floppy drives, CD and DVD drives, and removable storage, such as flash memory and USB-attached drives.

Understand the purposes and characteristics of power supplies. Know the job the power supply performs, as well as the connectors it uses to connect to the rest of the system to supply power to various components.

Understand the purposes and characteristics of display devices. Be comfortable with the historical video standards and know the various modern VGA-based standards and their naming convention. Be able to discuss the modern analog and digital video technologies. Know the similarities and differences between CRT and LCD monitors.

Understand the purposes and characteristics of input devices. Know the various forms of input devices and their categories, such as standard and multimedia. Be able to describe individual devices and their uses.

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Understand the purposes and characteristics of adapter cards and their ports and cables. Familiarize yourself with the variety of expansion cards and integrated components in today's computer systems, as well as the ports they use and any cables that connect to external devices.

Understand the purposes and characteristics of cooling systems. Know the different ways that internal components can be cooled and how overheating can be prevented.

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Review Questions

1. Which computer component contains all the circuitry necessary for *all* components or devices to communicate with each other?
   - **A.** Motherboard
   - **B.** Adapter card
   - **C.** Hard drive
   - **D.** Expansion bus
2. Which packaging is used for DDR SDRAM memory?
   - **A.** DIP
   - **B.** SIMM
   - **C.** DIMM
   - **D.** RIMM
3. What technology is used in the original-style monitor?
   - **A.** Video Display Unit
   - **B.** CRT
   - **C.** LCD
   - **D.** Optical Display Unit
4. Which motherboard design style is the most popular?
   - **A.** ATX
   - **B.** AT
   - **C.** Baby AT
   - **D.** NLX
5. Which motherboard socket type is used on the Pentium 4 chip?
   - **A.** Slot 1
   - **B.** Socket A
   - **C.** Socket 370
   - **D.** Socket 478
6. What is the official name for the IDE/EIDE family of drive interfaces?
   - **A.** SCSI
   - **B.** ATA
   - **C.** SATA
   - **D.** TAT

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7. Which is another term for the motherboard?

A. A fiberglass board

B. A planar board

C. A bus system

D. An IBM system board XR125

8. Which of the following is used to store data and programs for repeated use? Information can be added and deleted at will, and it does *not* lose its data when power is removed.

A. Hard drive

B. RAM

C. Internal cache memory

D. ROM

9. Which motherboard socket type is used with the AMD Athlon XP?

A. Slot 1

B. Socket A

C. Socket 370

D. Socket 478

10. You want to plug a keyboard into the back of a computer. You know that you need to plug the keyboard cable into a PS/2 port. Which style of port is the PS/2?

A. RJ-11

B. DE9

C. DIN 5

D. Mini-DIN 6

11. What are the five voltages produced by a common PCs power supply? (Choose all that apply.)

A. +3.3VDC

B. –3.3VDC

C. +5VDC

D. –5VDC

E. +12VDC

F. –12VDC

G. +110VAC

H. –110VAC

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12. What is the maximum speed of USB 2.0 in Mbps?

A. 1.5

B. 12

C. 60

D. 480

13. If you wanted to connect a LapLink cable (a parallel data transfer cable) so that you could upload and download files from a computer, which type of parallel port(s) could handle this application? (Choose all that apply.)

A. Standard

B. Bidirectional

C. EPP

D. ECP

14. What peripheral port type was originally developed by Apple and is currently primarily used for digital video transfers?

A. DVD

B. USB

C. IEEE 1394

D. IEEE 1284

15. What peripheral port type is expandable using a hub, operates at 1.5MBps, and is used to connect various devices (from printers to cameras) to PCs?

A. DVD 1.0

B. USB 1.0

C. IEEE 1394

D. IEEE 1284

16. Which peripheral port type was designed to transfer data at high speeds to printers only?

A. DVD

B. USB

C. IEEE 1394

D. IEEE 1284

17. Which motherboard form factor places expansion slots on a special riser card and is used in low-profile PCs?

A. AT

B. Baby AT

C. ATX

D. NLX

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18. Which Intel processor type(s) use the SEC when installed into a motherboard? (Choose all that apply.)

A. AMD Athlon

B. 486

C. Pentium

D. Pentium II

19. Which of the following can a DVD-ROM store in addition to movies? (Choose all that apply.)

A. Audio files

B. Word documents

C. Digital photos

D. All of the above

20. What type of expansion slot is almost always used for high-speed, 3D graphics video cards?

A. USB

B. AGP

C. PCI

D. ISA

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Answers to Review Questions

1. A. The spine of the computer is the system board, otherwise known as the motherboard. On the motherboard you will find the CPU, underlying circuitry, expansion slots, video components, RAM slots, and various other chips.

2. C . DDR SDRAM is manufactured on a DIMM. DIPs are the original chips that memory was delivered in. The SIMM is the predecessor to the DIMM, on which DDR was never deployed. RIMM is the Rambus proprietary competitor for the DIMM that carries RDRAM instead of SDRAM.

3. B . A cathode-ray tube, or CRT, is the technology used in the original televisions and computer monitors.

4. A. Although all the motherboard design styles listed are in use today, the ATX motherboard style (and its derivatives) is the most popular design.

5. D. Most Pentium 4 chips use the Socket 478 motherboard CPU socket.

6. B. Although these drives and their interfaces have become known as IDE and EIDE, the official name for the technology is ATA. Serial ATA is the next generation of this technology and is not the official name for the interface in general. In fact, its interface is different from the PATA interface of IDE and EIDE. SCSI is a competing drive interface, and TAT is not a valid drive-interface technology.

7. B. The spine of the computer is the system board, otherwise known as the motherboard and less commonly referred to as the planar board.

8. A. A hard drive stores data on a magnetic medium, which does not lose its information after the power is removed, and which can be repeatedly written to and erased.

9. B. The Socket A motherboard socket is used primarily with AMD processors, including the Athlon XP.

10. D. A PS/2 port is also known as a mini-DIN 6 connector.

11. A, C, D, E, F. A PC's power supply produces +3.3VDC, +5VDC, –5VDC, +12VDC, and –12VDC from 110VAC.

12. D. The USB 2.0 spec provides for a maximum speed of 480 megabits per second (Mbps—not megabytes per second, or MBps).

13. B, C, D. Bidirectional parallel ports can both transmit and receive data. An ECP was designed to transfer data at high speeds. EPP parallel ports provide for greater transfer speeds and the ability to send memory addresses as well as data through a parallel port. The standard parallel port only transmits data out of the computer. It cannot receive data.

14. C. The 1394 standard provides for greater data transfer speeds and the ability to send memory addresses as well as data through a serial port.

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15. B. USBs are used to connect multiple peripherals to one computer through a single port. They support data transfer rates as high as 1.5MBps (for USB 1.0, which is the option listed here).

16. D. IEEE 1284 standard defines the ECP parallel port to use a DMA channel and the buffer to be able to transfer data at high speeds to printers.

17. D. The NLX form factor places expansion slots on a special riser card and is used in low-profile PCs.

18. D. The unique thing about the Pentium II is that it uses a Single Edge Connector (SEC) to attach to the motherboard instead of the standard PGA package.

19. D. The DVD-ROM can store many types of data as well as movies. In the computer world, data can be audio files, Word documents, digital photos, and many other things.

20. B. Although technically PCI and ISA could be used for video adapters, AGP was specifically designed for the use of high-speed, 3D graphic video cards.