Peripherals and Expansion

THE FOLLOWING COMPTIA A+ 220-801 OBJECTIVES ARE COVERED IN THIS CHAPTER:

✓ **1.4 Install and configure expansion cards.**

- Sound cards
- Video cards
- Network cards
- Serial and parallel cards
- USB cards
- FireWire cards
- Storage cards
- Modem cards
- Wireless/cellular cards
- TV tuner cards
- Video capture cards
- Riser cards

✓ **1.7 Compare and contrast various connection interfaces and explain their purpose.**

- Physical connections
  - USB 1.1 vs. 2.0 vs. 3.0 speed and distance characteristics (connector types: A, B, mini, micro)
  - FireWire 400 vs. FireWire 800 speed and distance characteristics
  - SATA1 vs. SATA2 vs. SATA3, eSATA, IDE speeds

    - Other connector types (Serial, Parallel, VGA, HDMI, DVI, Audio, RJ-45, RJ-11)
    - Analog vs. digital transmission (VGA vs. HDMI)
  - Speeds, distances and frequencies of wireless device connections
    - Bluetooth
    - IR
    - RF

✓ **1.11 Identify connector types and associated cables.**

  - Display connector types:
    - DVI-D
    - DVI-I
    - DVI-A
    - DisplayPort
    - RCA
    - HD15 (i.e., DE15 or DB15)
    - BNC
    - miniHDMI
    - RJ-45
    - miniDIN-6
  - Display cable types:
    - HDMI
    - DVI
    - VGA
    - Component
    - Composite
    - S-video
    - RGB
    - Coaxial
    - Ethernet

- Device connectors and various connector pin-outs
  - SATA
  - eSATA
  - PATA (IDE, EIDE)
  - Floppy
  - USB
  - IEEE1394
  - SCSI
  - PS/2
  - Parallel
  - Serial
  - Audio
  - RJ-45
- Device cable types
  - SATA
  - eSATA
  - IDE
  - EIDE
  - Floppy
  - USB
  - IEEE1394
  - SCSI (68-pin vs. 50-pin vs. 25-pin)
  - Parallel
  - Serial
  - Ethernet
  - Phone

✓ **1.12 Install and configure various peripheral devices.**

  - Input devices
  - Mouse
  - Keyboard

- Touch screen
- Scanner
- Barcode reader
- KVM
- Microphone
- Biometric devices
- Game pads
- Joysticks
- Digitizer
- Multimedia devices
- Digital cameras
- Microphone
- Webcam
- Camcorder
- MIDI enabled devices
- Output devices
- Printers
- Speakers
- Display devices

With the core system components of the typical personal computer system under your belt, it is time to turn our attention to some of the peripherals that are available for connection to the computer. In doing so, we will also discuss the interfaces and cable assemblies associated with those peripherals.

Installing and Configuring Expansion Cards

An *expansion card* (also known as an *adapter card*) is simply a circuit board you install into a computer to increase the capabilities of that computer. Expansion cards come in varying formats for different uses, 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 into a PCI expansion slot only.

For today's integrated components (those built into the motherboard), you might not need an adapter to achieve the related services, but you will still need to install drivers to make the integrated devices function with the operating system. As the trend toward more integrated components was maturing, many installers found most of the integrated components to be nonfunctional. A quick check in Device Manager showed a small collection of devices to be without their device drivers. Most motherboard manufacturers supply CD-ROM discs with their motherboards that contain all the device drivers needed to get the built-in electronics recognized by the operating system. Execution of the disc's setup program generally results in all components working and Device Manager clearing its warnings.

The following are the four most common categories of expansion cards installed today:

- Video
- Multimedia
- I/O
- Communications

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

Video

A video adapter (more commonly called a graphics adapter or even more commonly a *video card*) is the expansion card you put into a computer to allow the computer to display information on some kind of monitor. A video card is also 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 some of these functions, thus accelerating the speed of display.

At a basic level, video adapters that have a PCI interface operate sufficiently. However, because AGP and PCIe slots offer more resources to the adapter, most manufacturers and computer owners prefer not to use PCI slots for video adapters. Although you might be able to find the rare motherboard that still offers an AGP slot, PCIe is the preferred expansion slot for video card attachment. The technology on which PCIe was designed performs better for video than those on which AGP and PCI are based. Figure 3.1 shows an example of a PCIe-based video card.

FIGURE 3.1 A video expansion card

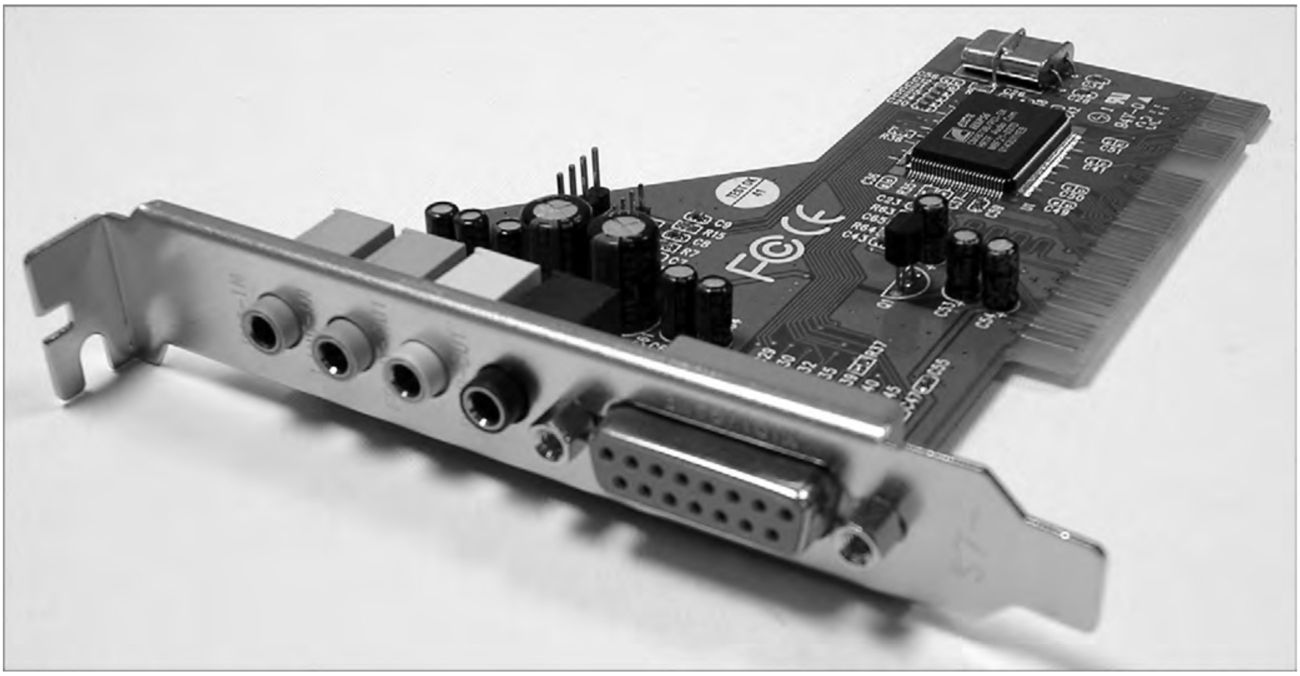
Multimedia

The most basic and prolific multimedia adapter is the sound card. TV tuner cards and video capture cards are newer multimedia adapters that continue to gain in popularity due to decreasing cost and the rise of the Internet as a forum for creative sharing.

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*. Although sound cards started out as pluggable adapters, this functionality is one of the most common integrated technologies found on motherboards today. A sound card typically has small, round, ⅛″ jacks on the back of it for connecting microphones, headphones, and speakers as well as other sound equipment. Many sound cards used to have a DA15 game port, which can be used for either joysticks or MIDI controllers. Figure 3.2 shows an example of a legacy sound card with a DA15 game port.

FIGURE 3.2 A typical 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 specifying an RCA jack and coaxial copper cabling, it specifies optical fiber connectors (TOSLINK) and cabling for electrically noisy environments, further increasing transmission quality of the digital signal.

TV Tuner Cards and Video Capture Cards

The *TV tuner card* is a class of internal and external devices that allows you to connect a broadcast signal, such as home cable television, to your computer and display the output on the computer monitor. TV tuner cards come in analog, digital, and hybrid varieties. Most TV tuner cards act as video capture cards as well. A *video capture card* can also be a standalone device and is often used to save a video stream to the computer for later manipulation or sharing. Video-sharing sites on the Internet make video capture cards quite popular with enterprises and Internet socialites alike. TV tuner cards and video capture cards need and often come with software to aid in the processing of multimedia input.

I/O

I/O card is often used as a catchall phrase for any expansion 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 classic serial (RS-232) and parallel (printer) ports and drive interface connections. A 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 IDE (PATA) controllers, and one floppy controller. Some versions included other components, such as a game port.

Often, if you want to use a SCSI hard drive in your system or a SCSI-attached printer or scanner, you have to install an expansion card that expands the motherboard's capabilities to allow the use of SCSI devices. The drives and other devices then cable to the adapter, and the adapter performs the requisite conversion of the drive signals to those that the motherboard and the circuits installed on it could use. Today, many server motherboards have SCSI controllers built in for such internal hard drives, and everything else tends to use integrated USB and FireWire interfaces, although expansion cards for these common interfaces exist as well.

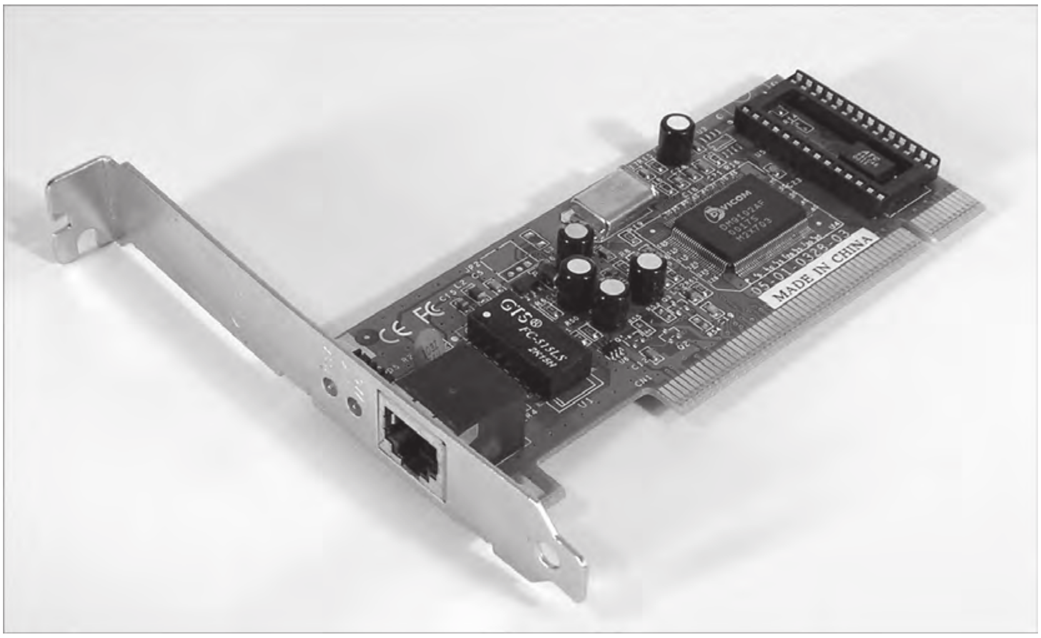
Communications

Communications adapters give a computer the ability to transmit information to other devices that might be too distant to cable up to directly. Network adapters and modems are the two most popular types of communications adapter. Network adapters are generally used within the administrative domain of a home or enterprise and rely on other devices to relay their transmissions around the world. In contrast, modems allow direct domestic or international communication between two devices across the Public Switched Telephone Network (PSTN). Although there are other devices in the PSTN, the service provider's network appears as a cloud to the end stations, unlike the intermediate devices of a home or enterprise data network.

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. *NIC* can also stand for *network interface controller*. It translates the data from the parallel data stream used inside the computer into the serial data stream that makes up the frames used on the network. It has a connector for the type of expansion bus on the motherboard (PCIe, PCI, and so on) as well as a connector for the type of network (such as fiber connectors, RJ-45 for UTP, antenna for wireless, or BNC for legacy coax). In addition to physically installing the NIC, you need to install drivers for the NIC in order for the computer to use the adapter to access the network. Figure 3.3 shows an example of a NIC.

FIGURE 3.3 A network interface card



> **NOTE** 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 it was faster or you were using the second NIC for load balancing, security, or fault-tolerance applications.

Wireless NICs

Wireless NICs have the unique characteristic of requiring that you configure their connecting device before configuring the NIC. Wired NICs can generally create a link and begin operation just by being physically connected out of the box to a hub or switch. The wireless access point or ad hoc partner computer must also be configured before secure communication, at a minimum, can occur by using a wireless NIC. These terms will be explained in greater detail in Chapter 8, "Installing Wireless and SOHO Networks."

Cellular Cards

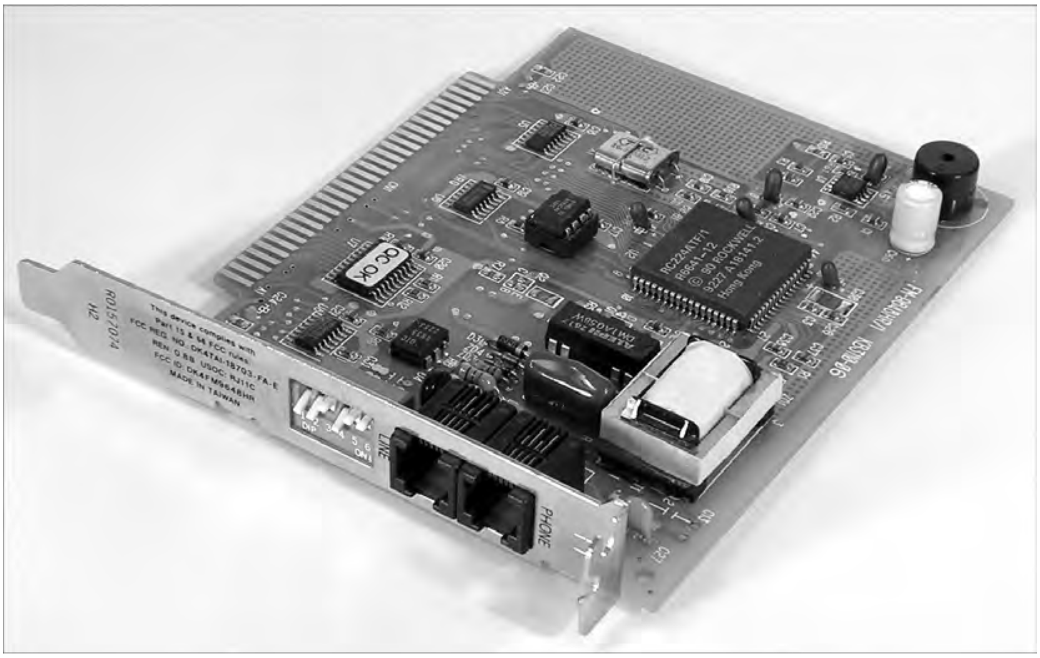
Almost every cellular service provider offers a line of adapters that can be installed into or inserted on the outside of desktop and laptop computers. In addition, depending on your service plan, most smartphones can be tethered to your computer and used as a cellular gateway.

Very often, the cellular adapter comes with a setup program that configures the card for the service provider's network. From that point, anytime you are in a cellular service area, you can use the adapter to gain access to the Internet through the provider or by roaming on the network of a partner or competitor with which an agreement has been reached in that area.

Modem

Any computer that connects to the Internet using an analog dial-up connection needs a modem, or *mo*dulator/*dem*odulator. A *modem* is a device that converts digital signals from a computer into analog signals that can be transmitted over phone lines and back again. These expansion card devices have one connector for the expansion bus being used (PCIe, PCI, and so on) and another for connection to the telephone line. Actually, as you can see in Figure 3.4, which shows an old ISA modem, there might be two RJ-11 ports: one for connection to the telephone line and the other for connection to a telephone. This is primarily so that a phone can gain access to the same wall jack that the computer connects to without swapping their cords. Keep in mind, though, that you won't be able to use the phone while the computer is connected to the Internet.

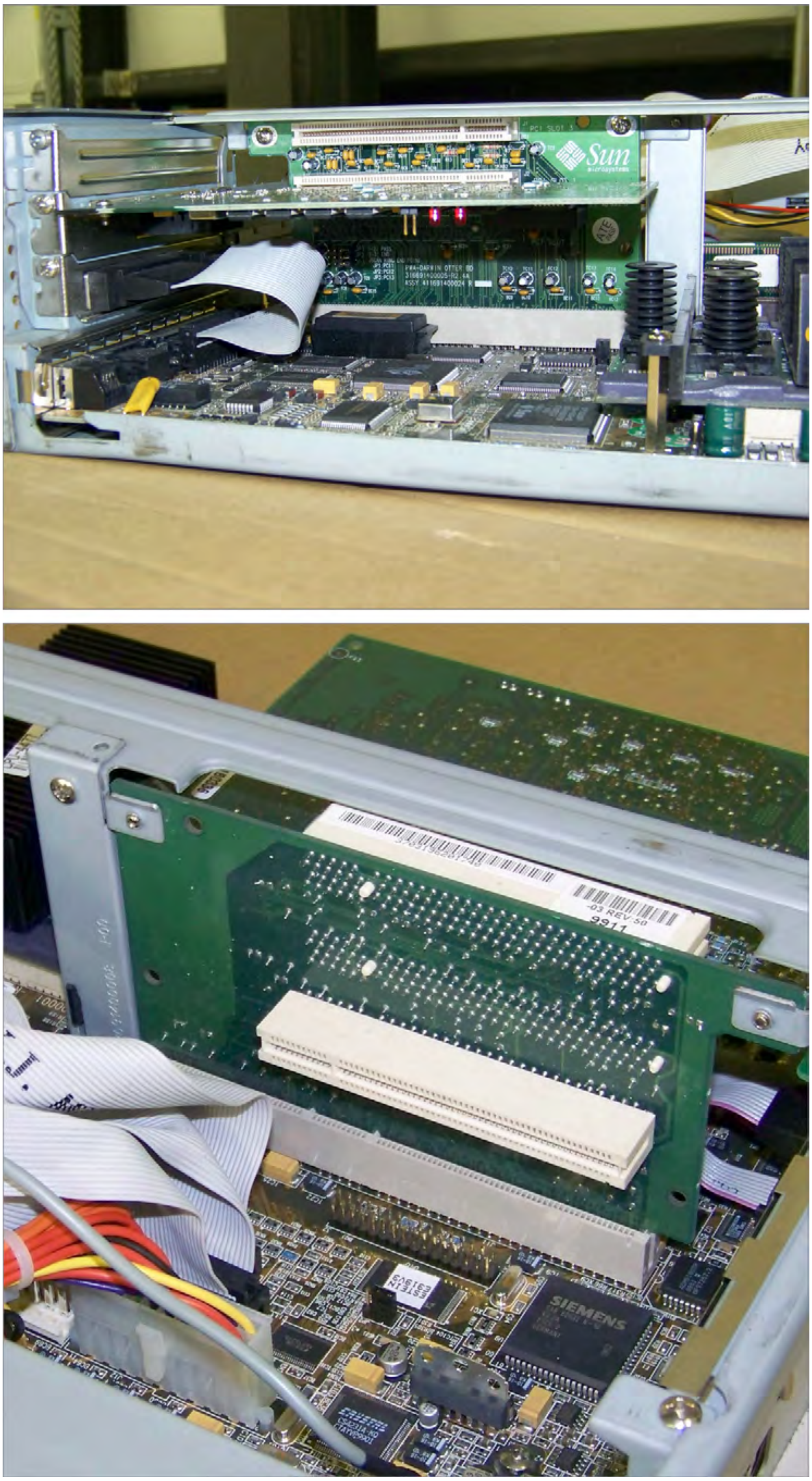
FIGURE 3.4 A modem



Riser Cards

An alternative motherboard form factor, known as New Low-Profile Extended (NLX), or one of its offshoots have been used in some types of low-profile cases. NLX places the expansion slots sideways on a special *riser card* to use the reduced vertical space optimally. Adapter cards that normally plug into expansion slots vertically in other motherboards plug in parallel to the motherboard, so their second most demanding dimension does not affect case height. Figure 3.5 shows a motherboard with its riser card attached.

FIGURE 3.5 Both sides of a riser card with adapter



Riser technology also serves to free up valuable motherboard space for circuitry that cannot or should not be placed on adapters. Without the use of the riser, the motherboard would need to be made larger to accommodate the same circuitry. The term *riser* can also be used for any board that combines many functions into a single card, such as AMR and CNR, which were introduced in Chapter 1, "Motherboards, Processors, and Memory," and don't actually allow the attachment of additional cards to themselves the way true risers do.

Adapter Configuration

Expansion cards might require configuration. However, most can be recognized automatically by a Plug and Play operating system. In other words, resources are handed out automatically without jumper settings or the installation of device drivers is handled or requested automatically. Your supplying the drivers might be the only form of configuration required. For example, unlike older ISA adapters, PCI adapters take care of requesting their own resources through Plug and Play. This is especially true of simple I/O adapters, such as those that provide USB, FireWire, parallel, and serial ports.

Some modern adapters, however, require more specific configuration steps during installation. For example, two or more PCIe graphics adapters that support SLI (see Chapter 1) must be bridged together with special hardware that comes with the adapters. Although most sound cards tend to work with no specific configuration, advanced features will need to be implemented through the operating system or through utilities that came with the adapter. Wired network adapters tend to be easier to configure than wireless ones. Wireless adapters often require the installation of a screw-on antenna, which should be postponed until after the card is fully inserted and physically secured in the system. Software configuration that allows these cards to communicate with a wireless access point can be challenging for the novice. Nevertheless, even wired NICs might require static configuration of certain protocol settings, such as IP addressing, duplex, and speed, in order for them to be productive. The functions of TV and video capture cards are sometimes not native to the operating system and therefore come with advanced utilities that must be learned and configured before the adapters will work as expected.

In any event, consult the documentation provided with your adapter for additional configuration requirements or options. The more specialized the adapter, the more likely it will come with specialty-configuration utilities.

Identifying Characteristics of Connectors 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 or peripheral 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.

Device 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. D-sub connectors are usually shaped like a trapezoid and have at least two rows of pins with no other keying structure or landmark, as you can see in Figure 3.6.

The "D" shape ensures 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 3.1 lists common D-sub ports and connectors as well as their most common uses. By the way, male interfaces have pins, while female interfaces have sockets. Be on the lookout for the casual use of *DB* to represent any D-sub connector. This is very common and is accepted as an unwritten de facto standard.

TABLE 3.1 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

Connector	Gender	Use
DA15	Male	Connector on a game peripheral cable or MIDI cable
DE15	Female	Video port (has three rows of five pins as opposed to two rows)
DE15	Male	Connector on a monitor cable

At the bottom left in Figure 3.6 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.

FIGURE 3.6 D-sub ports and connectors

RJ-Series

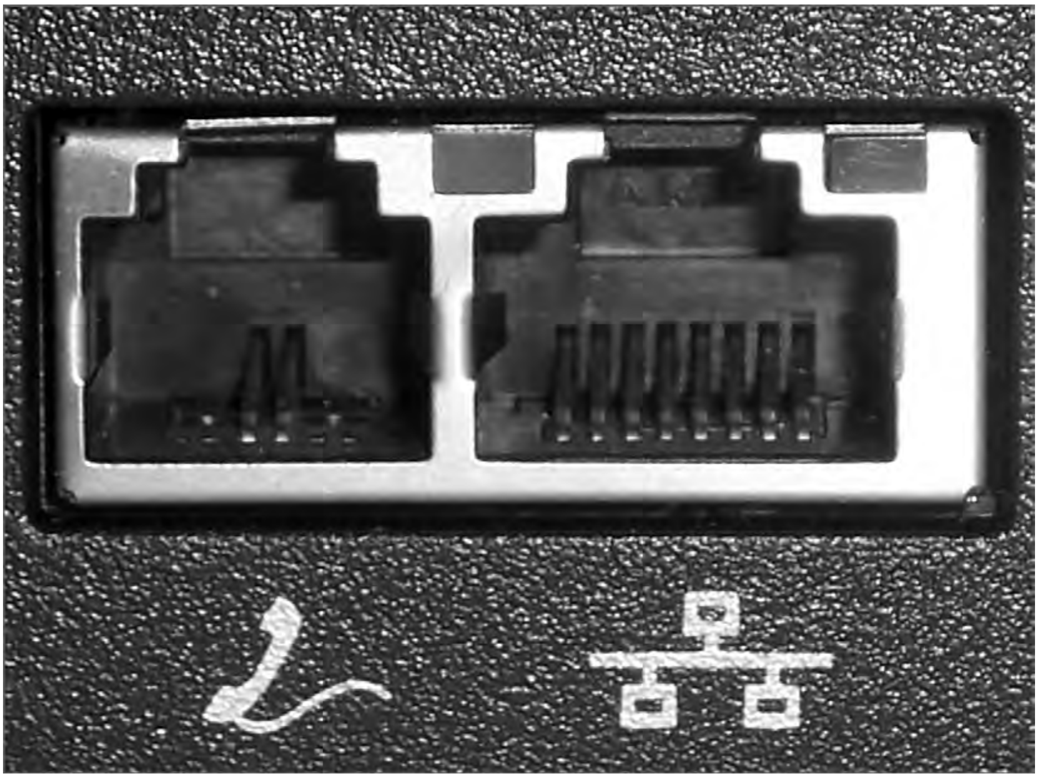
Registered jack (RJ) connectors are most often used in telecommunications. The two most common examples of RJ ports are RJ-11 and RJ-45. RJ-11 connectors are used most often on flat satin cables in telephone hookups; your home phone jack is probably an RJ-11 jack. The ports in older external and internal analog modems are RJ-11.

RJ-45 connectors, on the other hand, are larger and most commonly found on Ethernet networks that use twisted-pair cabling. Your Ethernet NIC likely has an RJ-45 jack on it. See Chapter 6, "Networking Fundamentals," for details on networking interfaces. Although

RJ-45 is a widely accepted description for the larger connectors, it is not correct. Generically speaking, Ethernet interfaces are 8-pin modular connectors, or 8P8C connectors, meaning there are eight pin positions, and all eight of them are connected, or used. RJ-45 specifies the physical appearance of the connector and also how the contacts are wired from one end to the other. Surprisingly the RJ-45 specification does not match the TIA T568A and T568B wiring standards used in data communications.

Figure 3.7 shows an RJ-11 jack on the left and an RJ-45 jack on the right. Notice the size difference. As you can see, RJ connectors are typically square with multiple gold contacts on the flat side. A small locking tab on the other side prevents the connector and cable from falling or being pulled out of the jack casually.

FIGURE 3.7 RJ ports



Other Types of Ports

There are many other types of ports that are used with computers today, including these:

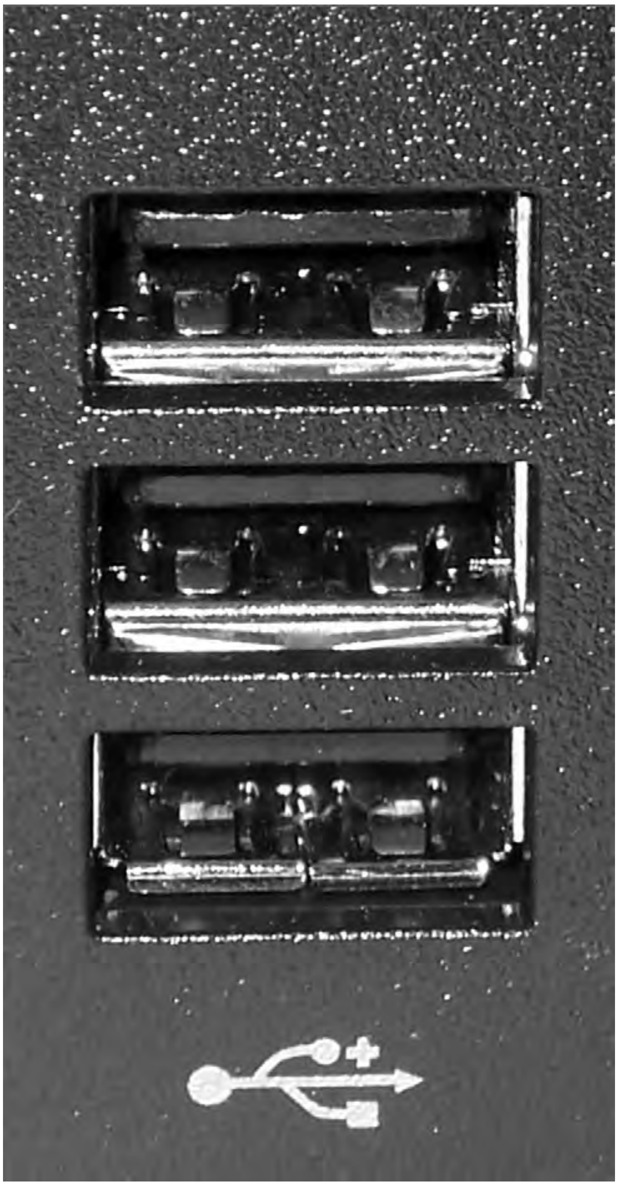
- Universal Serial Bus (USB)
- IEEE 1394 (FireWire)
- Infrared
- Audio jacks
- PS/2 (mini-DIN)
- Centronics

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.x supports data rates as high as 12Mbps (1.5MBps). USB 2.0 supports data rates as high as 480Mbps (60MBps), 40 times that of its predecessor. USB 3.0 boasts data rates of 5Gbps, more than 10 times the rate of USB 2.0. Figure 3.8 shows an example of a set of Type A USB ports. Port types are explained in the section "Common Peripheral Cables and Their Interfaces" later in this chapter.

FIGURE 3.8 USB ports



NOTE

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, hub, or cable supports USB 2.0 by looking for the red and blue "High Speed USB" graphic somewhere on the computer, device, or cable (or on its packaging). Super Speed USB 3.0 ports are also backward compatible but have additional contacts that only USB 3.0 cable connectors can access for increased performance.

Because of USB's higher transfer rate, flexibility, and ease of use, most devices that in the past used serial or parallel interfaces now come with USB interfaces. It's rare to see a newly introduced PC accessory with a standard serial interface. For example, PC cameras used to come as standard serial-only interfaces. Now, USB and FireWire are the preferred interfaces.

IEEE 1394 (FireWire)

While not as prevalent as USB ports, one other port has crept into the mainstream and is included as a standard attachment in small numbers, often only one, on motherboards and laptops. That port is the *IEEE 1394* port (shown on a desktop PC in Figure 3.9 and on a laptop in Figure 3.10), more commonly known as a *FireWire* port. Its popularity is due to its ease of use, isochronous (synchronized clock) mode, and very high (400Mbps to 3.2Gbps and higher) transmission rates.

FIGURE 3.9 A 6-pin FireWire port on a PC

FIGURE 3.10 A 4-pin FireWire port on a laptop

Originally developed by Apple, it was standardized by IEEE in 1995 as IEEE 1394. It is often used as a way to get digital video into a PC so it can be edited with digital video editing tools. Security applications benefit from FireWire's higher power output, reducing the need for external power to devices such as security cameras. Audio/video enthusiasts like this feature also and rely on the capability of headend devices to control and synchronize the various media sources.

Look for a more thorough discussion of FireWire as a technology in the section "Common Peripheral Cables and Their Interfaces" later in this chapter.

Infrared

Many years ago, increasing numbers of people became fed up with being tethered to their computers by cords. As a result, many computers (especially portable computing devices like laptops and PDAs) hit the market with infrared ports to send and receive data. Modern computers use radio frequency (RF) technologies, such as Bluetooth and WiFi, to accomplish the same and more. RF technologies such as Bluetooth and WiFi are presented in more detail, including their speed and distance limitations, in Chapter 8.

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 3.11 shows an example of an infrared port.

FIGURE 3.11 An infrared port

Part of the reason for their fall from grace is that infrared ports send and receive data at a very slow rate (the maximum speed on PC infrared ports is less than 4Mbps). Most infrared ports 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 one another.

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

Note that although infrared is a wireless technology, it shares characteristics more with light than with radio waves. In fact, infrared pulses can be carried through the air or through optical fiber, just like visible light and laser light. As a result, 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 generally used for point-to-point communications such as controlling the volume on a device with a handheld remote control.

Audio/Video Jacks

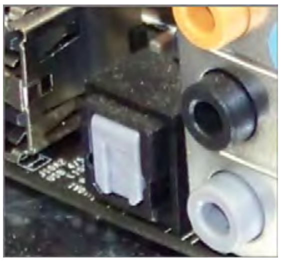
The *RCA* jack (shown in Figure 3.12) was developed by the RCA Victor Company in the late 1940s for use with its phonographs. You bought a phonograph, connected the RCA plug on the back of your phonograph to the RCA jack on the back of your radio or television, and used the speaker and amplifier in the 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 3.12 An RCA jack (female) and RCA plug (male)

Today, RCA jacks and connectors (or plugs) are used to transmit both audio and video information. Typically, when you see a yellow-coded RCA connector on a PC video card (next to a DE15F VGA connector, perhaps), it's for composite video output (output to a television or VCR). However, digital audio can be implemented with S/PDIF, which can be deployed with an RCA jack. Figure 3.19 later in this chapter shows an S/PDIF RCA jack. RCA jacks are considered coaxial because the outer circular conductor and the center pin that collectively make up the unbalanced single transmit/receive pair have the same axis of rotation, *co-axial*. S/PDIF can also be implemented by TOSLINK fiber connectors. Toshiba's TOSLINK interface is a digital fiber-optic audio technology that is implemented with its own connector.

Although they aren't used for video, it bears mentioning that the 1⁄8″ stereo minijack and mating miniplug are still commonly used on computers these days for analog audio. Your sound card, microphone, and speakers have them. Figure 3.13 is a photo of a TOSLINK optical interface with a push-in/flip-up cover, pictured to the left of a set of standard analog minijacks.

FIGURE 3.13 The TOSLINK interface



In the spirit of covering interfaces that support both audio and video, don't forget the HDMI interface, 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.

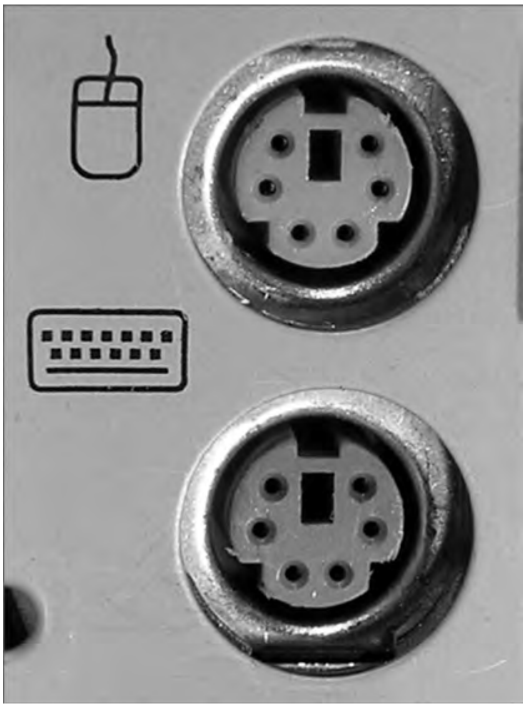
PS/2 (Keyboard and Mouse)

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 3.14 shows examples of both PS/2 keyboard and mouse ports. You can tell the difference because the keyboard port is usually purple and the mouse port is usually green. Also, typically there are small graphics of a keyboard and mouse, respectively, imprinted next to the ports.

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 3.15. 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 50-pin SCSI interface cards).

FIGURE 3.14 PS/2 keyboard and mouse ports



Common Peripheral Cables and Their Interfaces

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 and port type, speed, and method of communication used.

The most common interfaces used in PCs today include (in no particular order):

- Drive interfaces
- SCSI
- Parallel
- Serial
- USB
- IEEE 1394 (FireWire)
- RJ-45
- Audio (RCA and TOSLINK)
- PS/2

Let's look at the cabling and connectors used as well as the type(s) of peripherals that are connected to such interfaces.

FIGURE 3.15 A Centronics connector

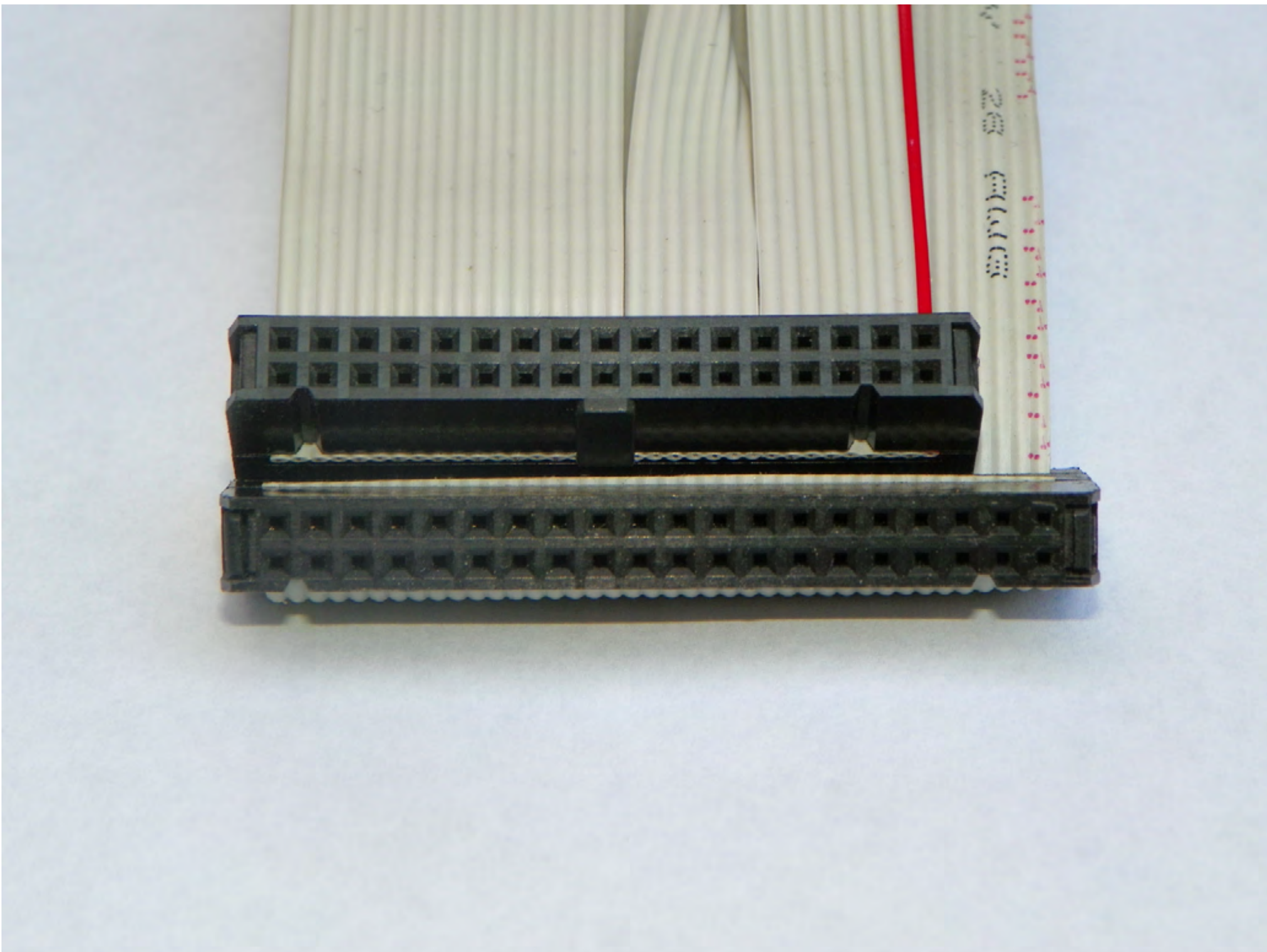
Floppy and Hard Disk Connectors

Almost every computer made today uses some type of disk drive to store data and programs until they are needed. All drives need some form of connection to the motherboard so the computer can "talk" to the disk drive. Regardless of whether the connection is built into the motherboard (*onboard*)—it could reside on an adapter card (*off-board*)—the standard for the attachment is based on the drive's requirements. These connections are known as *drive interfaces*, and there are two main types: floppy disk drive interfaces and hard disk drive interfaces.

Floppy disk drive interfaces allow floppy disk drives (FDDs) and certain other devices, such as some internal tape drives, to be connected to the motherboard, and similarly, hard disk drive interfaces do the same for hard disks and optical drives, among others. The interfaces consist of circuitry and a port, or *header*. Many motherboards produced today lack a header for FDD attachment. Almost all, however, still provide non-SCSI hard disk interfaces on the motherboard, with the latest version of SATA being the most popular. Server motherboards often include SCSI headers and circuitry as well or instead. See Chapter 2, "Storage Devices and Power Supplies," for information on SCSI cables, connectors, and pin-outs.

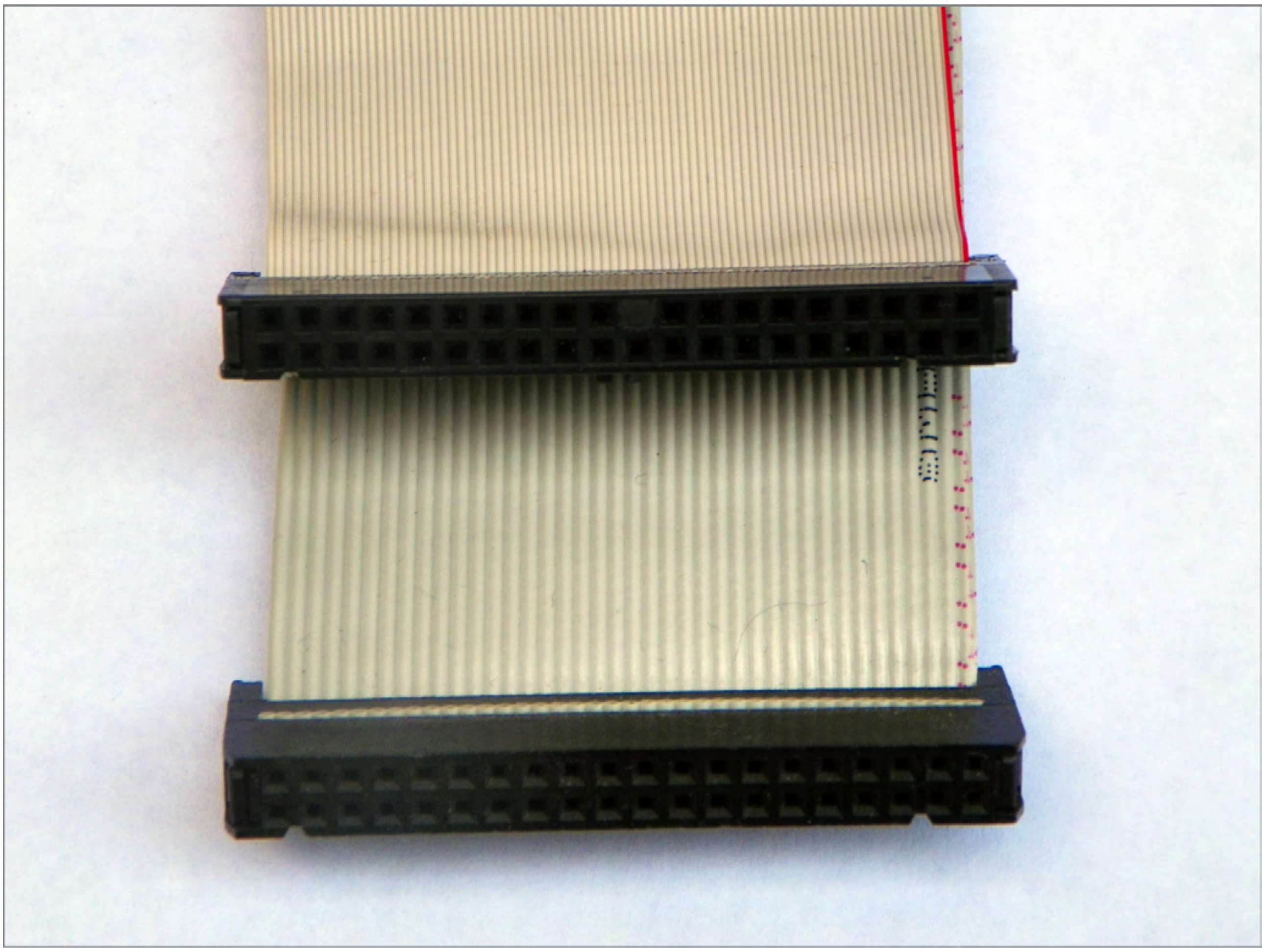
Today, the headers you will find on most motherboards are for Serial ATA (SATA), the speeds of which were discussed in Chapter 2. Enhanced IDE (EIDE)—also known retroactively as Parallel ATA (PATA)—interfaces have become exceedingly rare, with respect to the number of PATA devices still in force. As a result, you should consider your installed base of PATA drives before upgrading your motherboards. Use Figure 3.16 to compare the size of the 34-wire FDD cable and 34-pin connector to the 40-pin PATA connector underneath it.

FIGURE 3.16 The FDD and PATA cables



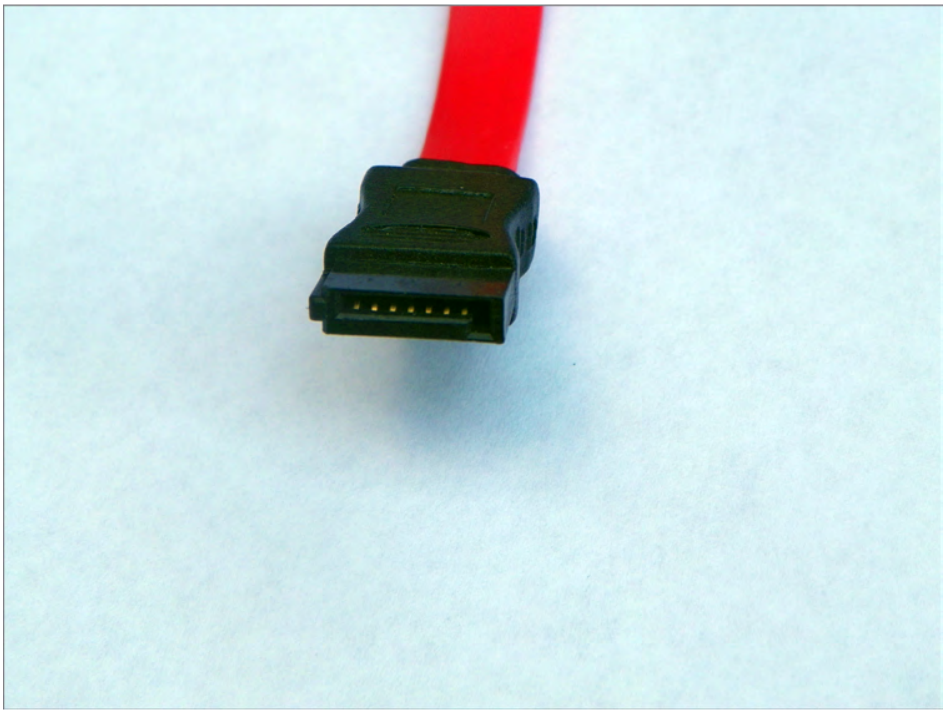
The PATA headers on older motherboards will normally be black or some other neutral color if they follow the classic ATA 40-wire standard. If your PATA headers are blue, they represent PATA interfaces that employ the ATA-5 or higher version of the Ultra DMA (UDMA) technology. These headers require 80-wire ribbon cables that allow increased transfer rates by reducing crosstalk in the parallel signal. Many headers and cable connectors are of a corresponding blue color to indicate their capability. The cables reduce crosstalk by alternating among the other wires another 40 ground wires. The connectors and headers still have 40 pins, however, because ground wires can be ganged and do not need separate pins. The color coding of the header alerts you to the enhanced performance. The headers can be downward compatible with the 40-wire technology but at reduced performance. Figure 3.17 shows the 80-wire cable lying on top of the 40-wire cable.

FIGURE 3.17 The 80- and 40-wire PATA cables



The 40-pin ATA header transfers multiple bits of data between the drive and motherboard in parallel, hence the name Parallel ATA. SATA, in comparison, which came out later and prompted the retroactive PATA moniker, transfers data in series, allowing a higher data throughput because there is no need for the more advanced parallel synchronization of data signals. The SATA headers are vastly different from the PATA headers. Figure 3.18 shows an example of the SATA data connector. Consult Chapter 2 for additional information on SATA and eSATA connectors and their flat data cables.

FIGURE 3.18 The Serial ATA connector



Common Ports and Connectors

For a computer to be useful and have as much functionality as possible, there must be a way to get the data into and out of it. Many different ports are available for this purpose. This section continues the discussion of port and connector types started earlier in the chapter but introduces additional information on those already mentioned and other interfaces.

Briefly, the seven most common types of ports you will see on a computer are Universal Serial Bus (USB), FireWire/IEEE 1394, eSATA, video, Ethernet, digital/analog sound in/out, and PS/2 keyboard and mouse. Figure 3.19 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
- Ethernet NIC RJ-45
- S-video out
- DVI-D (dual-link) out
- SVGA out
- Parallel (on top)
- Standard serial
- Mouse (on top)
- Keyboard

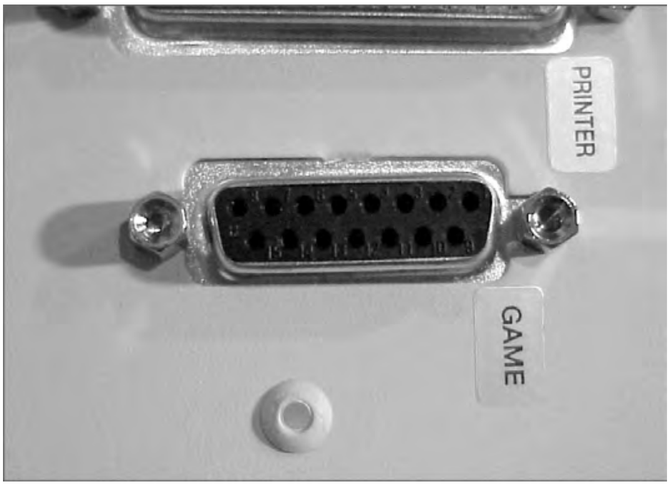
- S/PDIF (out)
- USB

FIGURE 3.19 Peripheral ports and connectors

The Classic Game Port

Figure 3.20 shows an example of a game port (also called a joystick port because that was the most common device that 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 connector. Legacy sound cards often included a game port. Devices that once connected to the game port have evolved, for the most part, into USB-attached devices.

FIGURE 3.20 A game port



Analog Sound Jacks

Figure 3.21 shows another set of interfaces not shown in Figure 3.19, the sound card jacks. These jacks are known as 1/8″ (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, rings (if they have any), and sleeve.

FIGURE 3.21 Sound card jacks

Shown in the photo is a six-jack setup capable of 8-channel audio, also known as 7.1 surround sound. The 7 represents the seven full-bandwidth channels and the 1 represents the one low frequency effects (LFE) channel, most often attached to the subwoofer. Each of the full-bandwidth channels is often represented by its own speaker in the system, but not necessarily. If there is a 1:1 channel-to-speaker representation, the eight speakers in 8-channel 7.1 are generally placed equidistant from the audience as follows, with all angles measured from front center (usually where the video source resides):

- One center speaker at 0 degrees (at the video source)
- Left and right front speakers at 22 to 30 degrees
- Left and right side speakers at 90 to 110 degrees
- Left and right rear speakers at 135 to 150 degrees
- One subwoofer possibly hidden anywhere in the room

The right column of jacks in Figure 3.21 represents the classic three minijacks found on sound cards. The middle one is a green output jack used for 2-channel audio, usually manifested as two full-bandwidth speakers, one each on the left and right channels. Both channels are provided by the single green *stereo* minijack. The other two are input interfaces; the top jack is the blue line-in interface, designed for audio sources that lack a specialized interface, less expensive keyboards, and phonographs, for example. The bottom one is the pink microphone input jack.

If you understand the concept of 8-channel 7.1, then 4-channel 3.1 and 6-channel 5.1 will be simpler to understand. The left column of jacks in Figure 3.21 was added for dedicated surround sound use and comprises the orange jack at the top for the *center* and *subwoofer* channels (used for 3.1, 5.1, and 7.1), the black middle jack for the *rear* left and right surround channels (used for 5.1 and 7.1), and the gray jack at the bottom for the *side* left and right surround channels (used only for 7.1 surround sound). With 3.1, 5.1, and 7.1, the green jack is adopted for the *front* stereo channel. Technically, 3.1 is not surround sound because there are only front and center channels and no surround channels.

Most installers place the rear speakers in 5.1 at the rearmost position recommended for the 7.1 side speakers, about 110 degrees from front center. When you're migrating to 7.1, these rear speakers are repurposed as side speakers and new ones are installed as 7.1 rear speakers, at an angle starting from about 135 degrees.

Software can use these interfaces to allow you to record and play back audio content in file—MP3, for instance—or CD/DVD form. Note, however, that the jacks themselves are not distinctive in their physical characteristics. They are uniquely addressable, but it is up to the software's programming to assign their purpose. Most programmers, of course, respect the color code. As a case study, for motherboards that support surround sound but do not supply the black and orange jacks, you have to use the blue jack for both line in and rear surround and the pink jack for both microphone and center/subwoofer. Depending on the software in use, you would need to manually swap one plug for another because the jack functions would change.

Parallel Interfaces

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 printer interface* (an example is shown at the top of Figure 3.6) transfers data 8 bits at a time over eight separate transmit wires inside a parallel cable (1 bit per wire). Normal parallel interfaces use a DB25 female connector on the computer to transfer data to peripherals.

Parallel ports are faster than the original serial ports, which were also once used for printers in electrically noisy environments or at greater distances from the computer. However, the advent of USB has brought serial—fast serial—back to the limelight. As it turns out, firing 1 bit at a time leads to faster bit rates than babysitting a parallel procession of bits.

The most common use of the parallel interface was printer communication. There are three major specifications of parallel port: standard, bidirectional, and enhanced parallel ports. Let's look at the differences among 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). The standard parallel port was found on the original IBM PC, XT, and AT. It can transmit data at only 150KBps and was most commonly used to transmit data to printers. This technology also had 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 that included a parallel printer port had this bidirectional parallel port.

TIP 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 and support cable lengths of 4.5 meters, which is almost 15 feet.

There are five data transfer implementations of IEEE 1284, two of which are EPP parallel ports and ECP parallel ports. An enhanced parallel port (EPP) increases bidirectional throughput from 150KBps to anywhere from 600KBps to 1.5MBps. An enhanced capabilities port (ECP) is designed to transfer data at even higher speeds, around 2MBps. ECP uses direct memory access (DMA) and buffering to increase printing performance over EPP. IEEE 1284 also allows for backward support of the standard parallel port (SPP) in compatibility mode.

TIP 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 DB25 female connector, as shown earlier in this chapter. Most parallel cables use a DB25 male connector on one end and either a DB25 male connector or, more commonly, a Centronics-36 connector on the other. The original printer cables typically used the DB25M–to–Centronics-36 configuration. Inside a parallel cable, eight wires are used for transmitting data so that 1 byte can be transmitted at a time. Figure 3.22 shows an example of a typical parallel cable (in this case, a printer cable). Note the IEEE 1284 compliance marking on the cable's sheath.

FIGURE 3.22 A typical parallel cable

Figure 3.23 shows the component end of a mini-Centronics cable. The mini-Centronics did not enjoy the success expected due to design issues regarding attachment reliability. Again, however, nothing is more popular today for printer connectivity than USB, so efforts to perpetuate the use of and improve the mini-Centronics were abandoned.

FIGURE 3.23 The mini-Centronics connector

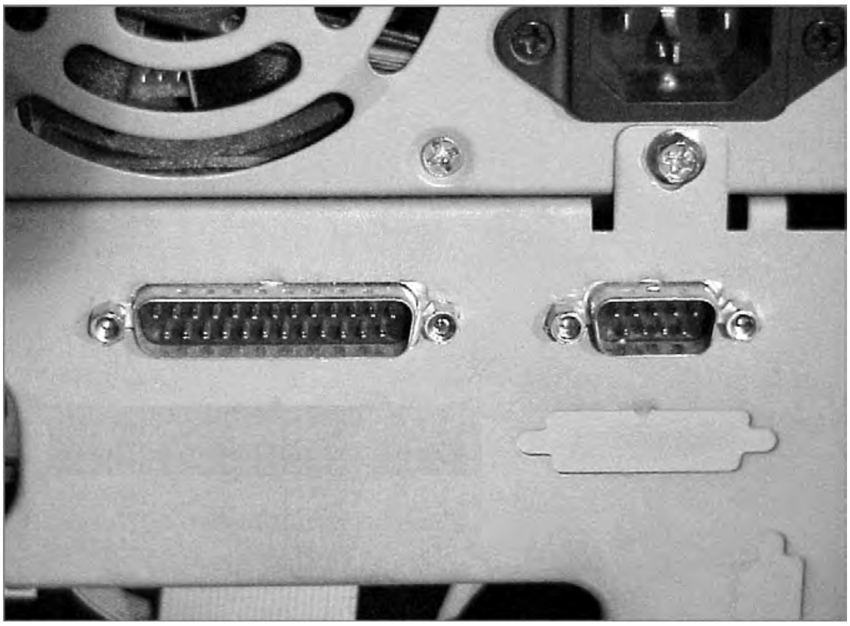
Serial

If standard parallel communications were similar to taking the interstate, then RS-232 serial communications were 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 (RS-232), Universal Serial Bus (USB), and FireWire (IEEE 1394). USB and FireWire use increased signaling frequencies to overcome serial's stigma and join other serial technologies, such as PCIe and SATA, as frontrunners in data communications.

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 DE9 or DB25 male port (shown in Figure 3.24). Standard serial ports have a maximum data transmission speed of 57Kbps and a maximum cable length of 50 feet.

FIGURE 3.24 Standard DE9 and DB25 male serial ports



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-centric pins on one end are wired to the receive-centric 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. Figure 3.25 and Figure 3.26 show the *pin-outs* and wiring differences between a standard 9- to 25-pin serial cable and a 9- to 9-pin 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 and how certain pins are looped back on each end to fool the computer into believing a modem is ready for its transmission.

FIGURE 3.25 A standard serial cable wiring diagram

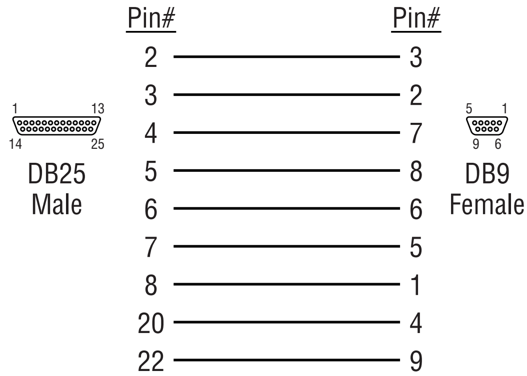
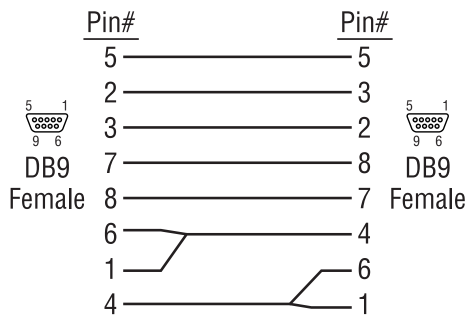


FIGURE 3.26 A null modem serial cable wiring diagram



Finally, because of the two different device connectors (DE9M and DB25M), serial cables have a few different configurations. Table 3.2 shows the most common serial cable configurations.

TABLE 3.2 Common serial cable configurations

First Connector	Second Connector	Description
DE9 female	DB25 male	Standard modem cable
DE9 female	DE9 male	Standard serial extension cable
DE9 female	DE9 female	Null modem cable
DB25 female	DB25 female	Null modem cable
DB25 female	DB25 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. Not all USB cables maximize the potential of all USB ports. USB 1.x cables cannot provide USB 2.0 and 3.0 performance; USB 2.0 cables cannot provide USB 3.0 performance. Good or bad, depending on how you look at it, the interfaces accept all cable connectors. So, ensuring that your cable is built to the specification you intend to use, whether version 2.0 or 3.0, is of utmost importance. Otherwise, the connected device will have to fall back to the maximum version supported by the cable. This is usually not an issue, except for the lost performance, but some high-performance devices will refuse to operate at reduced levels.

Table 3.3 details the differences in the maximum speeds defined by the three groups of USB specifications. Note that these speeds are not generally attainable due to a variety of factors, but USB 3.0 has the greatest likelihood of attaining its maximum rate because of its full-duplex nature. Note that all specifications are capable of *Low Speed* 1.5Mbps performance.

TABLE 3.3 USB speed limitations

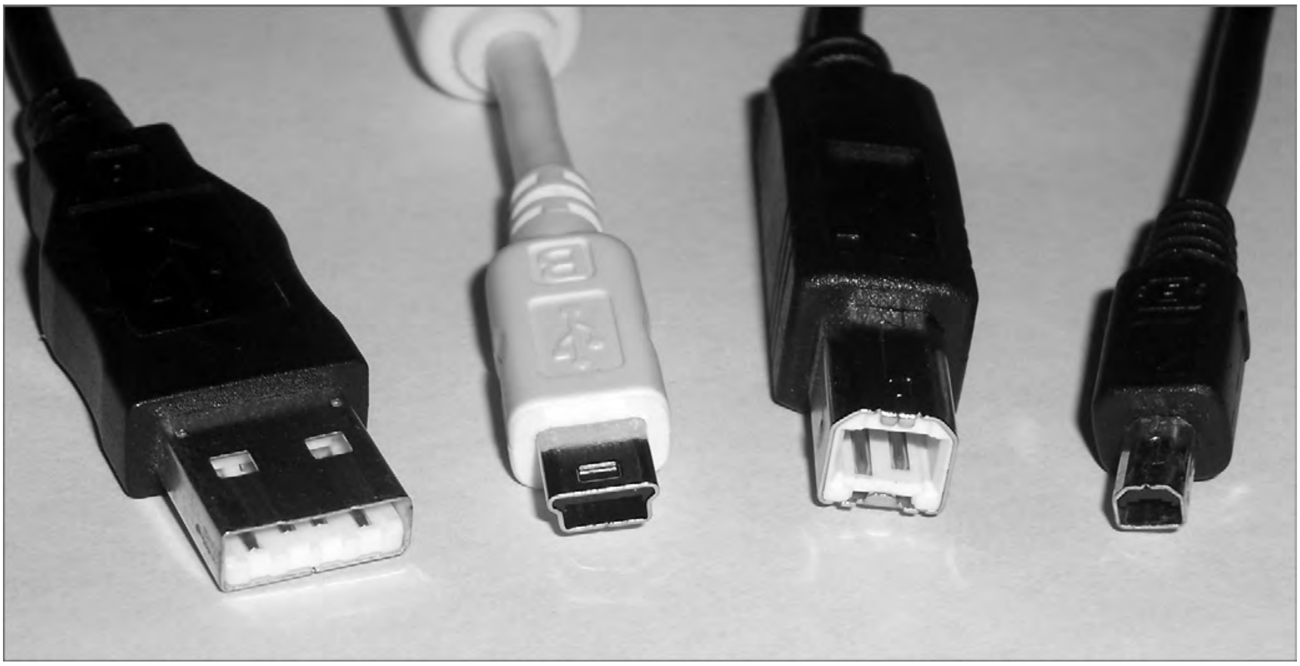
Specification	Maximum Speed	Speed Trade Name
USB 1.0/1.1	12Mbps	Full Speed
USB 2.0	480Mbps	High Speed
USB 3.0	5Gbps (5000Mbps)	SuperSpeed

The USB technology 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. Many standard devices have drivers built into the common operating systems. More complex devices come with drivers to be installed before the component is connected.

The USB cable varies most based on the USB peripheral connector on the external-device end. Because there can be quite a number of USB devices on a single system, it helps to have a scheme to clarify their connectivity. The USB standard specifies two broad types of connectors. 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 3.27 shows four USB 1.x/2.0 cable connectors. From left to right, they are as follows:

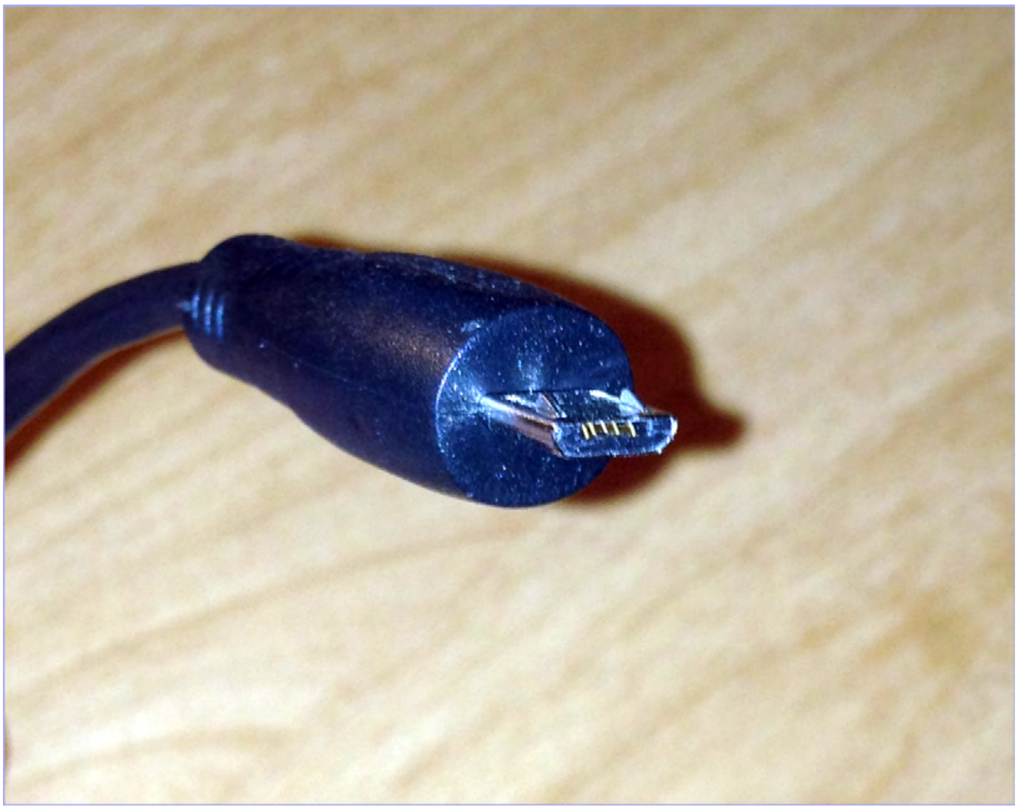
- Type A
- Standard Mini-B
- Type B
- Alternate Mini-B

FIGURE 3.27 USB cables and connectors



Modern small form-factor devices, including many phones and smaller digital cameras, use a Micro-B connector, shown in Figure 3.28, that is smaller than the Mini-B shown in Figure 3.27.

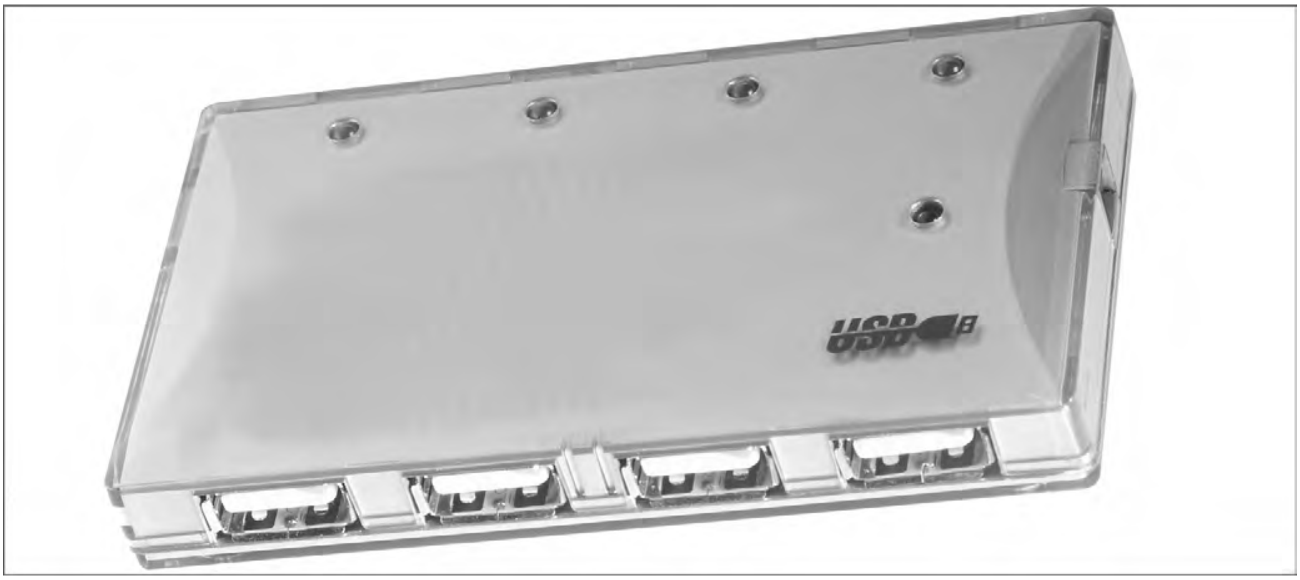
FIGURE 3.28 USB Micro-B connector



The specification for USB 3.0, also known as SuperSpeed, recommends a standard blue color coding for all interfaces and cables as a way of differentiating them from legacy cables and interfaces. The connectors also feature five additional pins that are not accessible to 1.x/2.0 connectors and receptacles shown in Figure 3.27 and Figure 3.28.

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 original port. Figure 3.29 shows an example of a USB hub.

FIGURE 3.29 A USB hub



Be aware of the limitations in the USB specification. Table 3.4 details the cable-length limitations for each of the three families of USB. The third column simply shows the combined length of all six cables used with five hubs and a sixth cable connected to the component. If you use hubs, you should never use more than five hubs between the system and any component.

TABLE 3.4 USB cable-length limitations

Specification	Maximum Cable Length	Total Cable with Five Hubs
USB 1.0/1.1	3m	18m
USB 2.0	5m	30m
USB 3.0	3m	18m

In addition to the cable length difference between USB 2.0 and 3.0, there are a host of other differences between these specifications. The following items outline some of the primary differences.

Shielding USB 3.0 requires that each pair in the cable assembly be shielded to withstand the electromagnetic interference (EMI) inherent with transmissions at higher frequencies.

Connectors Although all connectors are compatible with all receptacles, to attain SuperSpeed performance, SuperSpeed connectors with five additional pins must be used on cables and receptacles. These pins do not obstruct the four legacy pins required for backward compatibility. Instead, they sit farther back and are accessible only to compatible interfaces.

Bursting and streaming USB 2.0 does not support bursting, the low-duration, excessively fast transmission of data, nor does it support streaming, the continuous flow of data between two endpoints once the flow has begun. USB 3.0 supports continuous bursting as well as streaming.

Duplex USB 2.0 is a half-duplex technology, meaning that all devices must share a common bandwidth, making overall performance appear subpar. USB 3.0, on the other hand, supports dual simplex communications pathways that collectively imitate full-duplex transmission, where devices at both ends of the cable can transmit simultaneously.

Media access method USB 2.0 peripheral devices must wait until polled by the host before transmitting data. USB 3.0 endpoints use an asynchronous transmission mechanism, similar to that of Ethernet, where data is transmitted at will.

Host control The host (computer system) is the only device in the USB 2.0 specification that can control power management. The endpoints are the only devices that can participate in error detection and recovery as well as flow control. USB 3.0 endpoints can all control when they enter low-power mode to conserve power. Error handling and flow control are performed on each link in USB 3.0, not just at the endpoints.

Power USB 2.0 provides a maximum of 100 milliamperes (mA) of current at low power and 500mA at high power. USB 3.0 provides 150mA and 900mA, respectively, allowing for the direct powering of some of the same component types that FireWire is capable of powering but that USB 2.0 is not.

Through the use of a 7-bit identifier, providing $2^7 = 128$ possible addresses, no more than 127 devices, including hubs, should be connected back to a single USB host controller in the computer, not that you would ever want to approach this number. The 128th identifier, the highest address, is used for broadcasting to all endpoints. No interconnection of host controllers is allowed with USB; each one and its connected devices are isolated from other host controllers and their devices. As a result, USB ports are not considered networkable ports. Consult your system's documentation to find out if your USB ports operate on the same host controller.

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 receptacles 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. Each hub takes one of the 127 available addresses.

Type B plugs connect in the direction of the peripheral component. Therefore, you see a single Type B interface on the hub as well as on the peripheral endpoints 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.

WARNING

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.

NOTE

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

IEEE 1394 (FireWire)

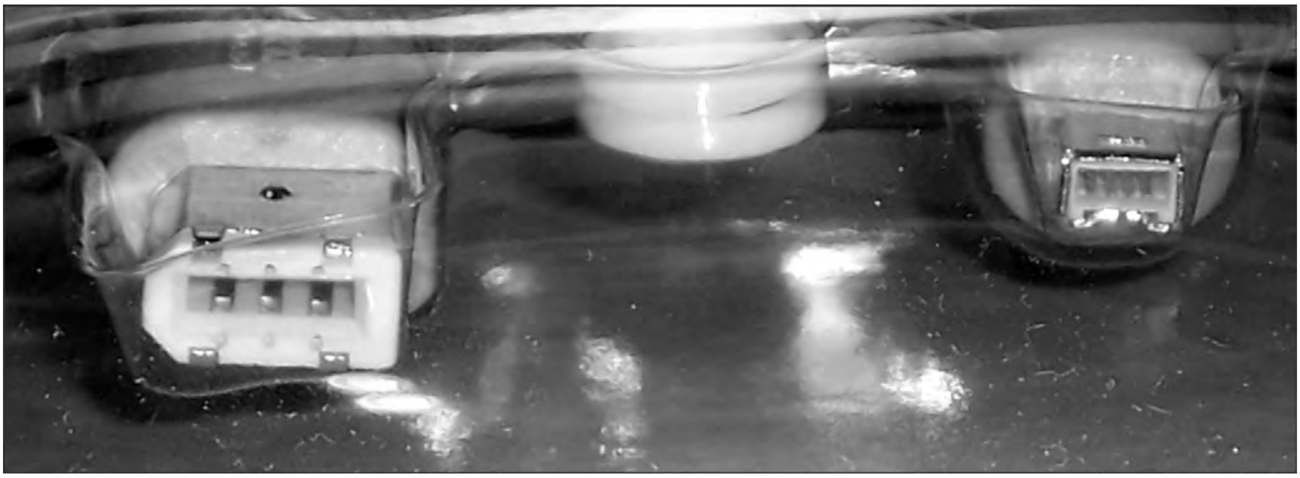
The IEEE 1394 interface is about two things, if nothing else: speed and efficiency. Its first iteration, now known as FireWire 400, has a maximum data throughput of 400Mbps in half duplex. Although the numbers imply that USB 2.0 at 480Mbps might outperform FireWire 400, the truth is that FireWire allows a closer saturation of the bandwidth by its devices due to its different encoding mechanism. USB devices are lucky to achieve half of their bus's rated bandwidth during sustained operation. The other major difference between the two technologies is the amount of power accessible to FireWire devices. Whereas USB provides less than an ampere of current at 5VDC, FireWire specifications allow for the provision of 1.5A at up to 30VDC (and slightly more in some implementations). This production of 45W of power allows for larger devices to be powered by the FireWire interface, obviating the need for separate external power.

The next iteration, FireWire 800 (specified under IEEE 1394b), has a maximum data throughput of 800Mbps and works in full duplex. FireWire 400 carries data over a maximum cable length of 4.5 meters with a maximum of 63 devices connected to each interface on the computer. Using new beta connectors and associated cabling, including a fiber-optic solution, FireWire 800 extends to 100 meters. When implemented over copper, FireWire 800, like FireWire 400, is limited to 4.5m cable runs. IEEE 1394c standardized the running of FireWire over the same Category 5e infrastructure that supports Ethernet, including the use of RJ-45 connectors. IEEE 1394b also allows for 1.6Gbps (S1600) and 3.2Gbps (S3200) implementations.

FireWire (also known as i.LINK in Sony's parlance) uses a very special type of six-wire cable, as shown in Figure 3.30 for FireWire 400. Only four wires are used when power is not supplied by the interface. These interfaces are collectively known as *alpha connectors*.

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. FireWire 800 uses a nine-wire implementation with *beta connectors*. A beta connector and one of the FireWire logos (another is a stylized “1394”) are shown on the left of Figure 3.42 later in this chapter. *Alpha* and *beta* originally referred to the different encoding methods used with FireWire 400 and FireWire 800.

FIGURE 3.30 A FireWire (IEEE 1394) 6- to 4-pin alpha 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, optical drives, and digital video editing equipment.

Because the FireWire specification was conceived to allow peripherals to be networked together in much the same fashion as intelligent hosts are networked together in LANs and WANs, a quick introduction to the concept of networking is in order; see Chapter 6 for more detail on networking concepts. A topology can be thought of as the layout of the nodes that make up the endpoints and connecting devices of the network. One of the most popular topologies today is the star topology, which uses a central concentrating device that is cabled directly to the endpoints. A tree structure is formed when these concentrating devices are interconnected to one another, each attached to its own set of endpoints. One or few concentrators appear at the first tier of the tree, sort of like the “root system” of the tree. These root devices are expected to carry more traffic than other concentrators because of their position in the hierarchy. In subsequent tiers, other concentrators branch off from the root and each other to complete the tree analogy.

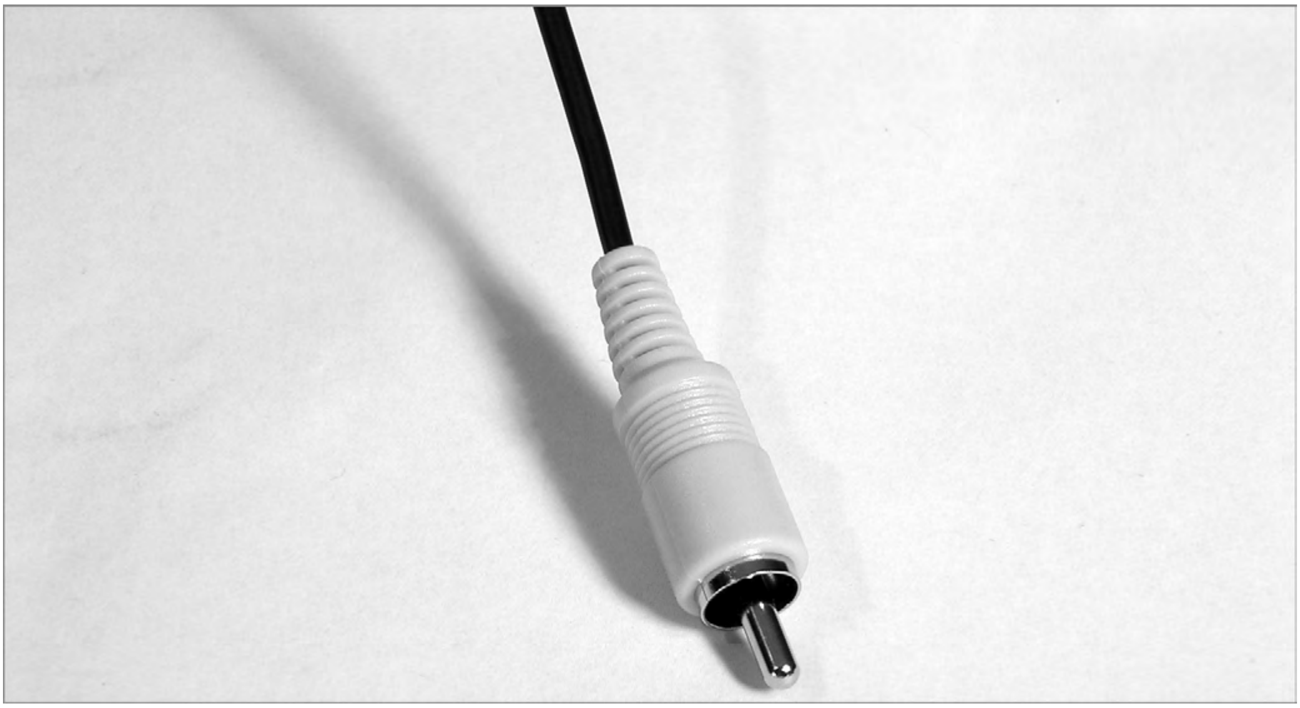
The 1995 IEEE 1394 specification that is equivalent to FireWire 400 allows 1023 buses, each supporting 63 devices, to be bridged together. This networkable architecture supports more than 64,000 interconnected devices that can communicate directly with one another instead of communicating through a host computer the way USB is required to do. Star and tree topologies can be formed as long as no two devices are separated by more than 16 hops. A *hop* can be thought of as a link between any two end devices, repeaters, or bridges, resulting in a total maximum distance between devices of 72 meters.

Through an internal hub, a single end device can use two IEEE 1394 ports to connect to two different devices, creating a daisy-chained pathway that allows the other two devices to communicate with one another as well. The device in the middle, which can be the computer system or any peripheral device, affords a physical pathway between the other two devices but is not otherwise involved in their communication with one another. Contrast this function to that of the USB host, which, prior to version 3.0, had to be involved in all transactions. USB 3.0 does not provide bridged networking the way FireWire does but allows the devices to initiate communication and other transactions.

RCA

The RCA cable is a simple coaxial cable. There are two connectors, usually male, one on each end of the cable. There are two contacts on each connector, the ground ring and the positive data pin in the middle. The male connector connects to the female connector on the equipment. Figure 3.31 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 3.31 An RCA cable



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 most important input device for a PC is the keyboard. All PC motherboards contain some sort of connector that allows a keyboard to be connected directly to the motherboard through the case. There are two main types of wired keyboard connectors. Once, these were the AT and PS/2 connectors. Today, the PS/2-style connector remains somewhat popular, but it is quickly being replaced by USB-attached keyboards. The all-but-extinct original AT connector is round, about ½″ in diameter, in a 5-pin DIN configuration. Figure 3.32 shows an example of the AT-style keyboard connector.

The PS/2 connector (as shown in Figure 3.33) is a smaller 6-pin mini-DIN connector. Many 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 the connectors in Figure 3.32 and Figure 3.33.

FIGURE 3.32 An AT connector on a motherboard

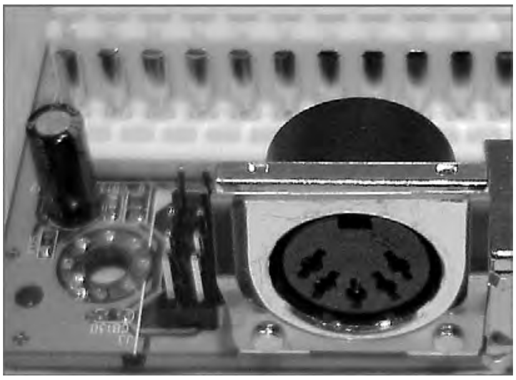
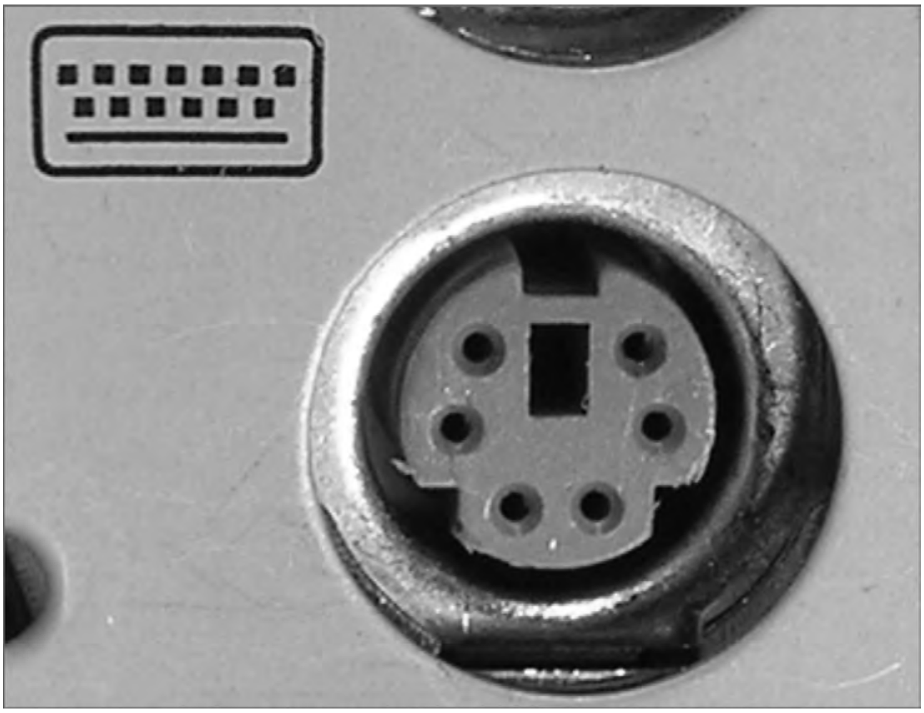


FIGURE 3.33 A PS/2-style keyboard connector on a motherboard



Wireless keyboard and mouse attachment is fairly popular today and is most often achieved with Bluetooth technology or a proprietary RF implementation.

NOTE In the past few generations of motherboards, the PS/2 mouse and keyboard connectors have been color-coded to make connection of keyboards and mice easier because they are physically identical but functionally different. PS/2 mouse connectors are green (to match the standard green connectors on some mice), and the keyboard connectors are purple. If you have trouble remembering the difference, think of the fact that mice, not keyboards, exist in nature, and mice might get seasick and turn "green."

Many keyboards and mice today still come with an adapter to change their USB connector into the PS/2 interface. Using the PS/2 connector that most motherboards still come with saves one or two USB interfaces. Manufacturers sometimes opt for a single PS/2 connector with half purple and half green color codes, indicating either device can be attached to the same interface. However, in these situations, only one of the two types of device can be connected at a time. Figure 3.34 shows an example of a PS/2 keyboard cable.

FIGURE 3.34 A PS/2 keyboard cable

NOTE 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.

Video Display Cables and Connectors

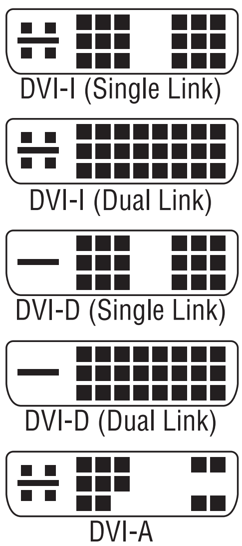
While the analog VGA-spawned standards might keep the computing industry satisfied for years to come yet, the sector in the market driving development of non-VGA specifications has become increasingly more prevalent. These high-resolution, high-performance junkies approach video from the broadcast angle. 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. DVI interfaces on graphics adapters and laptops became commonplace. In increasingly more cases, HDMI interfaces take adapters to the next generation.

Other consumers desire specialized methods to connect analog display devices by splitting out colors from the component to improve quality or simply to provide video output to displays not meant for computers. 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 leave analog VGA standards and return to digital video, which can typically be transmitted farther and at higher quality than analog, a series of connectors known collectively as Digital Visual (or Video) Interface (*DVI*) connectors was developed for the technology of the same name. These digital interfaces offer much higher performance than the original digital standards, such as CGA and EGA. 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 3.35 illustrates the five types of connectors that the DVI standard specifies.

FIGURE 3.35 Types of DVI connector



One thing to note about analog vs. digital display technologies is that all graphics adapters and all monitors deal with digital information. It is only the connectors and cabling that can be made to support analog transmission. Before DVI and HDMI encoding technologies were developed, consumer digital video display connectors could not afford the space to accommodate the number of pins that would have been required to transmit 16 or more bits of color information per pixel. For this reason the relatively few conductors of the inferior analog signaling in VGA were appealing.

There are three main categories of DVI connectors:

DVI-A An analog-only connector. The source must produce analog output, and the monitor must understand analog input.

DVI-D A digital-only connector. The source must produce digital output, and the monitor must understand digital input.

DVI-I A combination analog/digital connector. The source and monitor must both support the same technology, but this cable works with either a digital or an analog signal.

The DVI-D and DVI-I connectors come in two varieties: single link and dual link. The dual-link options have more conductors—taking into account the six center conductors—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 for devices with a 16:9 aspect ratio or from WUXGA to WQXGA for devices with a 16:10 aspect ratio. Of course, both components, as well as the cable, must support the dual-link feature. Consult Chapter 4, "Display Devices," for more information on display standards.

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 DVI analog signal will travel farther than the VGA signal before degrading beyond usability. Nevertheless, the DVI-A and VGA interfaces are pin-compatible, meaning that a simple passive adapter, as shown in Figure 3.36, is all that is necessary to convert between the two. As you can see, the analog portion of the connector, if it exists, comprises the four separate color and sync pins and the horizontal blade that they surround, which happens to be the analog ground lead that acts as a ground and physical support mechanism even for DVI-D connectors.

It's important to note that DVI-I cables and interfaces are designed to interconnect two analog or two digital devices; they cannot convert between analog and digital. DVI cables must support a signal of at least 4.5 meters, but better cable assemblies, stronger transmitters, and active boosters result in signals extending over longer distances.

HDMI

High-Definition Multimedia Interface (HDMI) is an all-digital technology that advances the work of DVI to include the same dual-link resolutions using a standard HDMI cable but with higher motion-picture frame rates and digital audio right on the same connector. HDMI cabling also supports an optional Consumer Electronics Control (CEC) feature that allows transmission of signals from a remote control unit to control multiple devices without separate cabling to carry infrared signals.

FIGURE 3.36 DVI-A–to–VGA adapter

The HDMI connector is not the same as the one used for DVI. Nevertheless, the two technologies are electrically compatible. 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. The latest version of the HDMI specification, version 1.4, was released May 28, 2009. The following two years saw the development of revisions 1.4a and 1.4b as well as the creation of the HDMI Forum on October 25, 2011. There will be no more development on version 1.4b, but the next revision will be backward compatible with 1.4b-compliant components.

HDMI is compatible with DVI-D and DVI-I interfaces through proper adapters, but HDMI's audio and remote-control pass-through features are lost. Additionally, 3D video sources work only with HDMI. Figure 3.37 shows a DVI-to-HDMI adapter between DVI-D and the Type A 19-pin HDMI interface. The first image is the DVI-D interface, and the second is the HDMI interface on the other side of the adapter. Compare the DVI-D interface to the DVI-I interface of Figure 3.36 and notice that the ground blade on the DVI-D connector is narrower than that of the DVI-A and DVI-I connectors. The DVI-D receptacle does not accept the other two plugs, for this reason as well as because the four analog pins around the blade have no sockets in the DVI-D receptacle.

FIGURE 3.37 HDMI-to-DVI adapter

There is also a Type B connector that has 29 pins and is intended to support higher resolution for the components that use it. HDMI version 1.3 specified a smaller 19-pin Type C connector for portable devices. The Type C connector, also referred to as a *mini-HDMI* connector, is compatible with the Type A connector but still requires an adapter due to its smaller size. HDMI version 1.4 specified two more interfaces, Type D and Type E. If Type C is a miniHDMI interface, then you might refer to the Type D connector as microHDMI. Figure 3.38 shows a Type D HDMI connector to the right of a Micro-B USB connector on a smartphone. Also compatible with Type A interfaces because they have the same 19 pins, Type D interfaces require but a simple adapter for conversion.

HDMI cables should meet the signal requirements of the latest specification. As a result, and as with DVI, the maximum cable length is somewhat variable. For HDMI, cable length depends heavily on the materials used to construct the cable. Passive cables tend to extend no farther than 15 meters, while adding electronics within the cable to create an active version results in lengths as long as 30 meters. Twisted-pair and fiber cabling options can extend cabling to 50 meters and 100 meters, respectively.

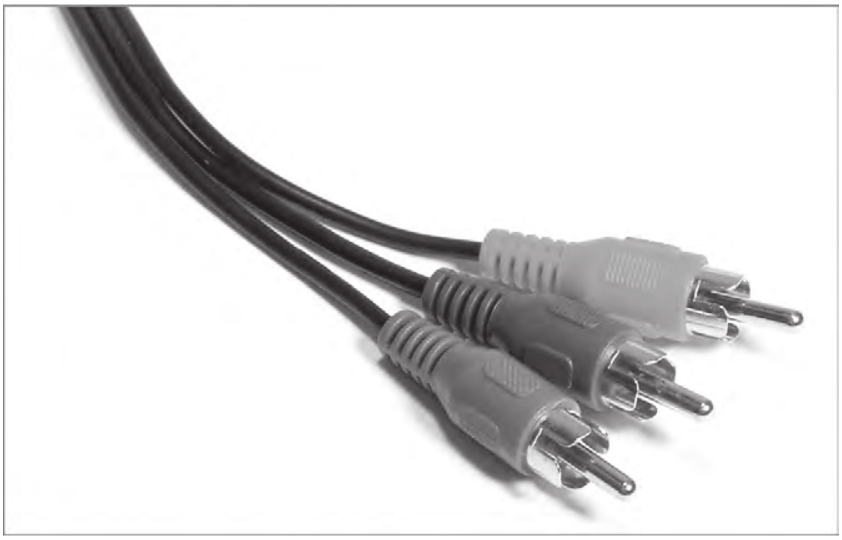
FIGURE 3.38 Type D HDMI interface

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*. However, unlike RGB separation, which requires full-bandwidth red, green, and blue signals as well as a fourth pathway for synchronization, the most popular implementation of component video uses one uncompressed signal and two compressed signals, reducing the overall bandwidth needed. These signals are delivered over coax either as red, green, and blue color-coded RCA plugs or similarly coded *BNC* connectors, the latter being seen mostly in broadcast-quality applications.

The uncompressed signal is called luma (Y), which is essentially the colorless version of the original signal that represents the "brightness" of the source feed as a grayscale image. The component-video source also creates two compressed color-difference signals known as Pb and Pr. These two chrominance (chroma, for short) signals are also known as B – Y and R – Y, respectively, because they are created by subtracting out the luma from the blue and red source signals. It might make sense, then, that the analog technology presented here is most often referred to and labeled as YPbPr. A digital version of this technology, usually found on high-end devices, replaces analog's Pb and Pr with Cb and Cr, respectively, and is most often labeled YCbCr. Figure 3.39 shows the three RCA connectors of a component video cable.

FIGURE 3.39 A component video cable



NOTE

As a slightly technical aside, luma is a gamma-correcting, nonlinear display concept related to but not equivalent to luminance, which is a linear, non-gamma-corrected measure of light intensity. Display devices perform nonlinear gamma decompression, which means a complementary nonlinear gamma compression (correction) must have been performed by the transmitter for the resulting image to be displayed properly. Thus, *luma*, not *luminance*, is the appropriate term when discussing component video. Furthermore, although *Y* is commonly used to represent luma, it actually stands for luminance. As a result, if you ever see a reference to Y′PbPr or Y′CbCr, the Y-prime refers correctly to luma. The more common, yet less correct, *Y* is used here to refer to luma.

Note that in the foregoing discussion, there is no mention of a green component-video signal. In fact, the often green-colored lead in the component-video cable carries the luma. There is no need for a separate green color-difference signal. Essentially, the luma signal is used as a colorless map for the detail of the image. The receiving display device adds the luma signal from the Y lead back to the blue and red color-difference signals that were received on the Pb and Pr leads, re-creating compressed versions of the full blue and red source signals. Whatever details in the luma version of the image have weak representation in the blue and red versions of the image are inferred to be green.

Therefore, you can conclude that by providing one full signal (Y) and two compressed signals (Pb and Pr) that are related to the full signal (Pb = B – Y and Pr = R – Y), you can transmit roughly the same information as three full signals (R, G, and B) but with less bandwidth. Incidentally, component video is capable of transmitting HD video at full 1080p (1920×1080, progressive-scan) resolution. However, the output device is at the mercy of the video source, which often is not manufactured to push 1080p over component outputs.

S-video

S-video is a component video technology that, in its basic form, combines the two chroma signals into one, resulting in video quality not quite as high as that of YPbPr. This is because the R, G, and B signals are harder to approximate after the Pb and Pr signals have been combined. One example of an S-video connector, shown in Figure 3.40, 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 luma and one chroma (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 3.40 A 7-pin S-video port

The 6-pin and 7-pin versions add composite video leads, which are discussed next. Some 7-pin ports use the extra pins to provide full Y, Pb, and Pr leads with four ground leads, making those implementations of S-video equivalent to component video. ATI has used 8-, 9-, and 10-pin versions of the connector that include such added features as an S-video input path in addition to output (from the perspective of the video source), 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 all luma and chroma leads into one. Composite video is truly the bottom of the analog-video barrel. However, the National Television System Committee (NTSC) signal received by over-the-air antennas or by cable-TV feeds is composite video, making it a very common video signal. Unfortunately, once the four signals are combined into one, the display equipment has no way of faithfully splitting them back out, leading to less than optimal quality but great cost efficiency.

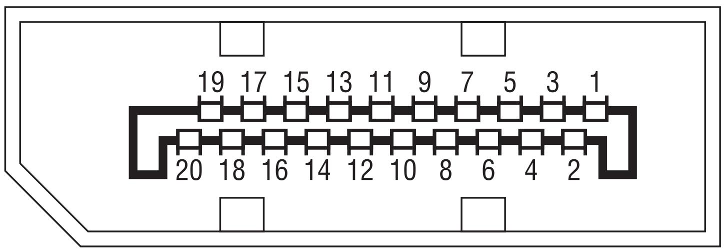
A single yellow RCA jack, the composite video jack is rather common on computers and home and industrial video components. While still fairly decent in video quality, composite video is more susceptible to undesirable video phenomena and artifacts, such as aliasing, cross coloration, and dot crawl. If you have a three-connector cable on your home video equipment, such as a DVD player connected to a TV, odds are the tips will be yellow, red, and white. The red and white leads are for left and right stereo audio; the yellow lead is your composite video.

DisplayPort

DisplayPort is a royalty-free digital display interface from the Video Electronics Standards Association (VESA) that uses less power than other digital interfaces and VGA. A simple adapter allows HDMI and DVI voltages to be lowered to those required by DisplayPort because it is functionally similar to HDMI and DVI. DisplayPort cables can extend 3 meters unless an active cable powers the run, in which case the cable can extend to 33 meters.

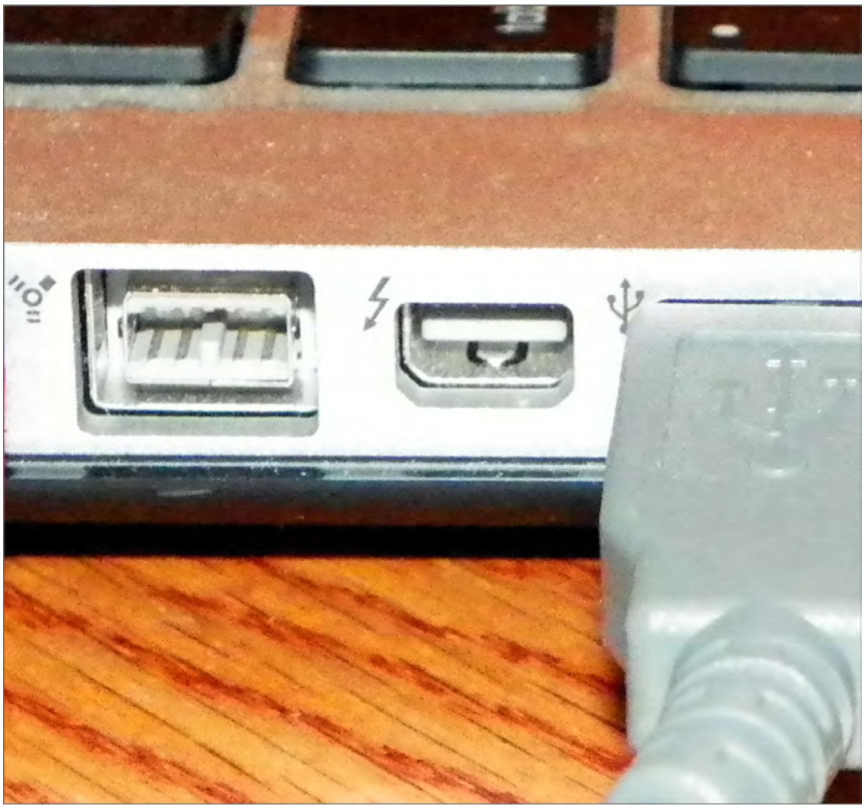
The DisplayPort connector latches itself to the receptacle with two tiny hooks in the same way that micro-B USB connectors do. Figure 3.41 shows an illustration of the DisplayPort 20-pin interface. Note the keying of the connector in the bottom left of the diagram.

FIGURE 3.41 A full-size DisplayPort connector



The full-size DisplayPort is being usurped by a smaller compatible version called Thunderbolt, created in collaboration between Intel and Apple. Thunderbolt combines PCI Express with the DisplayPort technology. The Thunderbolt cable is a powered active cable extending as far as 3m and was designed to be less expensive than an active version of the full-size DisplayPort cable of the same length. Figure 3.42 shows a Thunderbolt interface on an Apple MacBook Pro. Note the standard lightning-bolt insignia by the port. To the left of the Thunderbolt port in the image is a 9-pin IEEE 1394b (FireWire) beta port. Despite its diminutive size, the Thunderbolt port has 20 pins around its connector bar, like its larger DisplayPort cousin. Of course, the functions of all the pins do not directly correspond between the two interface types because Thunderbolt adds PCIe functionality.

FIGURE 3.42 A Thunderbolt connector



Coaxial

Two main forms of coaxial cable are used to deliver video from a source to a monitor or television. One of them is terminated by RCA or BNC plugs and tends to serve a single frequency, while the other is terminated by F connectors, those seen in cable television (CATV) settings, and tends to require tuning/demodulation equipment to choose the frequency to display. The terms that refer to whether a single frequency or multiple frequencies are carried over a cable are *baseband* and *broadband*, respectively. Figure 3.43 shows an example of the F connector most commonly used in home and business CATV installations. This is a 75-ohm form of coax known as RG-6.

Ethernet

With the capability of today's data networks, both compressed and even uncompressed audio and video can be digitized and sent over an IP network in packet form. The physical and data-link connectivity is often implemented through devices that connect through a standard Ethernet network. Care must be taken that this new application for the network does not obstruct the normal flow of data or even the possibly recently added voice over IP (VoIP) traffic. As with VoIP applications, quality of service (QoS) must be implemented and supported throughout the data network or audio/video (A/V) quality will surely suffer.

FIGURE 3.43 A CATV F connector and coaxial cable

Input Devices

An *input device* is one that transfers information from 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 from their default boot-up state. The following sections detail different classes of input devices and a hub, of sorts, used for switching between the most common of these devices. We will also demonstrate the similarities shared by devices that provide input to computer systems as well as their differences. Installation considerations will be presented where appropriate. The following input devices are covered in the following sections:

- Mouse
- Keyboard
- Barcode reader
- Multimedia devices
- Biometric devices
- Touchscreen
- KVM switch
- Scanner
- Gamepads and joysticks
- Digitizer

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 onscreen cursor motion. Many variations of the mouse exist, including trackballs, tablets, touchpads, and pointing sticks. Figure 3.44 illustrates the most recognizable form of the mouse.

FIGURE 3.44 A computer mouse

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 a Cartesian plane and transmitted the results to the software interface. This method of motion detection remains available today, although it's fairly unpopular.

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. Certain surfaces don't lend themselves well to standard laser-mouse functionality, but a higher resolution version exists that can even track across the surface of glass. The mouse today can be wired to the computer system or connected wirelessly. 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 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 term *right-click*. Today, the mouse is commonly found to have a wheel on top to aid in scrolling and other specialty movement. 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 and can alarm the unsuspecting user the first time they grab such a mouse the wrong way.

Touch pads—flat panels below the spacebar—and pointing sticks—eraser-like protrusions in the middle of the keyboard—are found mainly on laptops. A trackball, however, is more like an inverted mouse, so let's look at how they compare to each other. Both devices place the buttons on the top, which is where your fingers will be. A mouse places its tracking mechanism on the bottom, requiring that you move the entire assembly as an analogue for how you want the cursor on the screen to move. In contrast, a trackball places the tracking mechanism, usually a ball that is larger than that of a mouse, on the top with the buttons. In doing so, you have a device that need not be moved around on the desktop and can work in tight spaces and on surfaces that would be incompatible with the use of a mouse. The better trackballs place the ball and buttons in such a configuration that your hand rests ergonomically on the device, allowing effortless control of the onscreen cursor.

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. Fewer still would even know how. The US English keyboard places keys in the same orientation as the QWERTY typewriter keyboards, which were developed in the 1860s.

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. At the discretion of the programmer, any given application might require the use of only one of the two sets of numeric keys or allow the use of either. The IBM PC/AT keyboard had only 84 keys, lacking separate cursor-movement keys. These functions were superimposed on the numeric keypad only. The Num Lock key had to be toggled to switch between cursor movement and the numeric keypad. The 101-key keyboard did include these separate keys but still kept the Num Lock arrangement as well, and the popular 104-key Windows keyboard added Windows-specific keys to those 101 keys.

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 laptop 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 or function 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, including simply displaying the character printed on the key.

In addition to the layout for a standard keyboard, other keyboard layouts exist, some not nearly as popular, however. For example, without changing the order of the keys, an ergonomic keyboard is designed to feel more comfortable to users as they type. To accomplish that goal, manufacturers split the keyboard down the middle, angling keys on each side downward from the center.

The Dvorak Simplified Keyboard, patented in 1936, was designed to reduce fatigue in the hands of typists by placing characters that are more commonly used in the home row, among other physiologic enhancements. The QWERTY layout was designed to keep the hammers of a typewriter from becoming entangled. Although the Dvorak keyboard makes logical sense, especially with the decline in manufacturing and sales of the classic typewriter, the QWERTY keyboard remains dominant. One reason the Dvorak keyboard has failed to take over might be the loss of productivity to a touch-typist as they retrain on the new format.

Real World Scenario

Installing Your Mouse and Keyboard

In the early days of the mouse for the PC, the original AT keyboard was still in use. The 9-pin D-sub RS-232 serial ports the mouse used looked nothing like the 5-pin DIN to which the keyboard attached. Not long thereafter, the PS/2 product line blurred the distinction; indeed, it removed it. With both interfaces being matching 6-pin mini-DIN connectors, care was paramount during installation. Standard industry color coding has simplified the installation process, but the ports are still easily interchanged during blind insertion. If you have visibility of the ports, remembering that the keyboard interface is coded purple and the mouse green takes much of the guesswork out of analyzing icons stamped into or printed on the case. Of course, graduation to USB-attached devices alleviates the hassle. Consult the accompanying documentation for the installation of all types of wireless input devices.

Scanner

One of the earliest input devices aside from the keyboard and mouse was the *scanner*. Before USB, scanners would routinely connect to computers through a SCSI bus, alongside external drives. Many models supported parallel attachment in the place of a printer, which was helpful for simpler systems with no SCSI interfaces; almost all computers had parallel ports in those days. Look for a menu item in applications capable of scanning that specifies TWAIN, the generic term for the class of drivers associated with scanners, such as Select TWAIN Source. This selection allows you to choose among multiple scanners before initiating the scan job.

More affordable scanners were handheld devices that relied on included or specialty software to intelligently stitch together the scanned ribbons into one cohesive image. Although more easily afforded today, flatbed scanners were once reserved for the computing elite. Regardless of the caliber of scanner, they all use light to reflect off of a surface and measure the relative reflections of the different dots that make up the grid the scanner is able to detect. The tighter the grid (the more dots per inch [DPI] supported), the higher resolution the resulting image. Charge coupled devices (CCDs) are a common choice in today's scanners. CCDs convert light they receive into electrical impulses that is then forwarded to the software producing the scan for further processing into an image that is a facsimile of the original object being scanned.

A flatbed scanner evokes the concept of a copier with the paper handling and printing mechanisms missing. This image is not far off, which is why copiers make wonderful scanners, as long as they can produce a digital image file. It's also why multifunction devices are so prolific; it takes very little to outfit a printer with a scanner component to be used for input to the computer and as a fax-scanning device. Inbound faxes can be printed, or the same digital interface that the scanner uses can be used to transfer the image electronically to software in the computer. Figure 3.45 shows the top flatbed scanner portion of a laser multifunction device that provides a way to print, scan, and fax.

FIGURE 3.45 A flatbed scanner

Figure 3.46 shows you one of numerous brands of portable document scanners. These handy little devices are scarcely more than a foot long and can make short work of scanning anything from a business card to a gas receipt to an 8.5″ × 11″ lodging folio. The associated software that comes with these scanners performs optical character recognition (OCR) and can recognize the orientation of the text and glean pertinent information from the documents scanned to populate the internal database. From this database, you can produce reports for such purposes as expenses, invoicing, and taxes. This model also offers the option to create a PDF during the scan instead.

FIGURE 3.46 A portable document scanner

Barcode Reader

A *barcode reader* (or barcode *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. Barcode readers can use LEDs or lasers as light sources and can scan one- or two-dimensional barcodes.

Using a Barcode Reader in the VoIP Industry

The VoIP industry relies on barcode readers to quickly scan in the MAC addresses of hundreds or thousands of desk sets from labels on their neatly stacked boxes before their deployment. Depending on the brand of equipment, the MAC addresses might be read in to populate a spreadsheet that is later used as input to the call management system during the identification of which directory numbers will be assigned to which physical devices. The same job done by hand could have untold issues caused by user error.

Barcode 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, or "wedge," 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, WiFi, and more.

With today's smartphone technology being what it is, the built-in cameras can act as scanners, and the scanning app can interpret what the camera sees. In this way, Universal Product Code (UPC) barcodes and Quick Response (QR) codes and other 2D matrix barcodes can be input and processed. The smartphone can then use its Internet access to launch the application associated with the text, such as a web browser or an email client. A QR code is an encoded image that allows the scanning application to decode large amounts of text and can be used to represent simple text or popular strings, such as a website's URL, a phone number, a GEO location, an email address, or an SMS message. Figure 3.47 is a simple QR code that will direct a QR-code reader app to the `www.sybex.com` website.

FIGURE 3.47 A QR code

Digitizer

One way to faithfully reproduce incredibly good artwork in digital form for computer use is to place the analog artwork on top of a sensor and use a stylus to trace the artwork after choosing an onscreen "crayon" or "pen." The end result can be a work of art almost as good as the original. The device used to trace an analog source, turning it into a digital representation, is a *digitizer*. Digitizing, in fact, is the act of turning any analog source—artwork, audio, video, slides and photographs—into a binary bit stream. As an input device, however, a digitizer or *digitizing tablet* takes pen strokes in the analog world and turns them into a digital rendering through the software controlling the digitizer. These devices are also commonly used to annotate presentations with the option to save or discard the annotations with each presentation. Figure 3.48 shows an example of a USB-attached digitizing tablet with choice of pen or mouse for input.

FIGURE 3.48 A digitizing tablet

Biometric Devices

Any device that measures one or more physical or behavioral features of an organism is considered a *biometric device*, or literally, a device that measures life. When the same device forwards this biometric information to the computer, it becomes an input device. The list includes fingerprint scanners, retinal and iris scanners, voice recognition devices, and facial recognition devices, to name a few. A computer can use this input to authenticate the user based on preestablished biometric information captured during user setup. Even cipher locks that authenticate personnel before allowing entry to secure environments can be replaced with biometric devices.

Because there are many manufacturers of biometric devices, the installation of any particular model is best performed while consulting that company's documentation. If the device is not built into the computer, at a minimum some form of interface, such as USB, must be used to attach the device, and software must be installed to lock the system until authentication occurs. Many offerings allow multiple forms of authentication to be required in sequence. An example of a highly secure approach to authentication with multiple factors would be a biometric scan, followed by a challenge that requires a code from a token card, followed finally by the opportunity to enter a password. This "something you are, something you have, and something you know" technique works to secure some of the world's most sensitive installations. Further discussion of the concept of multifactor authentication is beyond the scope of this book.

Touchscreens

Touchscreen 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 the mouse, simultaneously in movement and in click. With onscreen keyboards, the external keyboard can be retired as well. However, standard computer systems are not the only application for touchscreen enhancement. This technology can also be seen in PDAs and smartphones, point-of-sale venues for such things as PIN entry and signature capture, handheld and bar-mounted games, ATMs, remote controls, appliances, and vehicles. The list continues to grow as technology advances.

For touchscreens, a handful of solutions exist for converting 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. The two most popular with handheld devices are *resistive* and *capacitive*. Capacitive interfaces are generally smoother to the touch than resistive interfaces and can be controlled by the pad of the finger or a special stylus that mimics this soft part of the fingertip. Resistive interfaces usually have to be controlled by the fingernail or a plastic or metal stylus. In any event, the sensory system is added onto a standard monitor at some point, whether in the field by the user or in a more seamless fashion by the manufacturer.

Installing monitors with touch capability on standard computers entails not only attachment to the graphics adapter, but also attachment to a serial interface. The most popular of these has become the USB port, much as it has for the mouse and keyboard.

Calibration is required upon first configuration and whenever there appears to be a misinterpretation by the system as to where the user has touched the screen. This calibration entails displaying a pattern that the user has to touch at certain points to let the system know where these landmarks are perceived to be.

KVM Switch

A KVM switch isn't an input device, but it allows you to switch between sets of input devices. The *KVM switch* is named after the devices among which it allows you to switch. The initials stand for keyboard, video, and mouse. KVM switches come in a variety of models. You can select the switch that accommodates the type of interfaces your components require. For example, your keyboard and mouse might attach with mini-DIN connectors or with USB connectors; your monitor might attach with a VGA, DVI, or HDMI connector.

The purpose of the switch is to allow you to have multiple systems attached to the same keyboard, monitor, and mouse. You can use these three devices with only one system at a time. Some switches have a dial that you turn to select which system attaches to the components, while others feature buttons for each system connected. Common uses of KVM switches include using the same components alternately for a desktop computer and a laptop docking station or having a server room with multiple servers but no need to interface with them simultaneously.

Figure 3.49 shows a four-system VGA/USB switch with analog audio switching as well. If DVI or PS/2 attachments are desired, for example, adapters are required. The buttons on the front (right side of the image) switch the common console connections (on the left side of the image) among the four systems, only three of which are currently attached. A maximum of one of the four LEDs beside the corresponding buttons is lit at a time, only for the system currently in control.

FIGURE 3.49 A KVM switch

Gamepads and Joysticks

As long as there have been gaming applications for the personal computer, there have been standard and specialty controllers for some of those games. For the rest, the keyboard and mouse could be or had to be used for controlling the game. Two popular types of controllers have been the generic *joystick*, a controller with one or more buttons and a stick of varying length and girth, and the often proprietary *gamepad*, usually comprising function and directional buttons specific to the gaming console in use. Standardized PC connections have included the DA15 game port, also known as the joystick port, the DB25/DE9 serial port, and the USB port. Figure 3.50 shows a wired joystick connected through the wireless controller for the Nintendo Wii video game console.

FIGURE 3.50 A proprietary gamepad

Multimedia Input Devices

Multimedia input devices vary in functionality based on the type of input being gathered. Two broad categories of multimedia input are audio and video. Digital motion and still cameras are incredibly popular as a replacement for similar video products that do not transfer information to a computer, making sharing and collaboration so much easier than before. The following sections present information on these multimedia input devices:

- Web cams
- MIDI-enabled devices
- Digital cameras and camcorders

Web Cams

Years ago, owing to the continued growth in the Internet's popularity, video camera-only devices, known as *web cams*, started their climb in esteem. Today, anyone who does a fair amount of instant messaging, whether professional or personal, has likely used or at least been introduced to web cams, often used in conjunction with messaging user interfaces.

Web cams make great security devices as well. Users can keep an eye on loved ones or property from anywhere that Internet access is offered. Care must be taken, however, because the security that the web cam is intended to provide can backfire on the user if the web cam is not set up properly. Anyone who happens upon the web interface for the device can control its actions if there is no authentication enabled. Some web cams provide an activity light when someone is using the camera to watch whatever it's pointed at. Nevertheless, it is possible to decouple the camera's operation and that of its light.

A web cam connects directly to the computer through an I/O interface, such as USB or WiFi, and does not have any self-contained recording mechanism. Its sole purpose is to transfer its captured video directly to the host computer, usually for further transfer over the Internet, hence the term *web*. Web cams that have built-in wired and wireless NIC interfaces for direct network attachment are prevalent as well. A now maturing evolution of the web cam for laptops resulted in manufacturers building the device into the bezel of the display. Connectivity is generally through an internal USB or FireWire interface.

MIDI Devices

Microphones, audio playback, and audio synthesizing devices are common input components connected to a sound card or serial port so that audio from these devices can be collected and processed. As an example, consider Musical Instrument Digital Interface (*MIDI*) devices, called controllers, which create messages describing, and thus synthesizing, the user's intended musical performance. These devices do not make sound that is recorded directly; they are merely designed to somewhat realistically fabricate the music the instruments they represent might produce. MIDI files, therefore, are much smaller than files that contain digitized audio waveforms.

Modern MIDI controllers use 5-pin DIN connectors that look like the original AT keyboard connector. Controllers can be interconnected in one of two ways. The original method is to provide devices with two ports, an input and an output port, and daisy-chain them in a ring. This arrangement introduces a delay caused by devices processing and retransmitting messages that were not destined for them but instead for devices downstream from them. One solution is to replace the output port with one that merely replicates the input signal. If the receiving device is the intended destination, then the unnecessarily repeated message is ignored by downstream recipients. Otherwise, the actual recipient receives its message with far less delay. The second method of connection is another solution that reduces delay. A device with one input and multiple outputs interconnects many devices directly.

Regardless of the controller interconnection method, computers can receive MIDI controllers directly, such as through a sound card with a built-in MIDI interface or through the use of an external MIDI interface that originally connected to the computer's game port. Today, USB and FireWire ports are more commonly used. Ethernet-attached interfaces also exist and require very little processing power to convert the MIDI messages into Ethernet frames.

Digital Cameras and Camcorders

A *digital camera* is a device that takes still pictures and records them to digital media of some sort for later access. A *camcorder* is a video capture device that performs a similar function to that of the digital camera, but for moving video. Most of today's multimedia recording devices perform the functions of both the digital camera and the digital camcorder. Depending on the device, both pictures and video can be stored on the same or different media within the same device. In fact, the most basic smartphone can perform both of these functions, often with exceptional quality.

Early versions of digital cameras relied on the storage media of the day, 3.5″ floppy diskettes, for instance. Eventually, models with internal flash memory were developed, which led to hybrid models that also featured a memory card slot, resulting in the flexibility to grow the camera's storage capacity as the technology produced larger cards.

A similar evolution occurred in the world of camcorders. Originally, camcorders required one of a variety of analog tape formats to record on. This gave way to digital tape formats and then to burnable optical discs, hard disk drives, and today's high-capacity flash storage. Once a removable memory card was added on, the possibilities for what can be recorded and how much became nearly endless. Figure 3.51 shows a digital camcorder on the left and a digital camera on the right.

FIGURE 3.51 A digital camera and camcorder

The mechanism by which the digital information is transferred to a computer varies somewhat among these devices. In some cases, a cable—USB, for instance—can be attached between the device and the computer. A drive icon might then appear in Windows Explorer, or you might have a specific application for access to the content. In other cases, removable media was recorded on and this media can be removed and transferred directly to a reader on the computer system, be it an optical drive or card reader. Certain manufacturers have developed docking stations for their product line. The dock can remain attached to the computer system, and the device can be interfaced to the dock, usually by simply sitting it down on the docking station. In some cases, these stations also charge the device while it is docked.

Output Devices

The process for the installation and configuration of certain output devices varies almost as widely as the number of models within a given category. Nevertheless, certain high-level steps must be taken with nearly each such device. The devices in the following sections are each covered in eye-opening detail elsewhere in this book; two of the three have chapters dedicated to them alone:

- Printers (Chapter 10, "Installing and Configuring Printers")
- Speakers
- Display devices (Chapter 4)

The following sections introduce each of the device categories and any specific issues that exist with their installation and configuration without delving too deeply yet.

Printers

Often immediately behind your monitor in output-device importance, the one or more printers you have attached to your computer become invaluable when you need to produce a hard copy for distribution or for inclusion in a report, for instance. Chapter 10 will detail the various families of printer, such as impact, inkjet, and laser, as well as the details involved in their installation, including connectivity and driver installation. This chapter gives you copious information regarding the interfaces used today and throughout personal-computing history, such as parallel, serial, SCSI, USB, and FireWire.

Speakers

The various audio-related discussions in this chapter present concepts surrounding speakers and their connection to the computer or other device, such as surround-sound processors or A/V receivers. Your operating system's audio controls have settings that can be manipulated, sometimes in very complex ways, to produce software configurations that derive the best performance from the speakers you have installed.

Display Devices

The next chapter presents a wide array of pertinent information on this subject. This chapter also contains considerable interface and cabling information on video display technology. As output devices, the connectivity of display devices can be fixed, with a single type of connection to a video source, or variable, sometimes supporting the connection of multiple sources through similar or different interfaces. In the latter case, input selection is generally a fairly simple process, most often accessible directly from the display device's remote control. In the case of interfaces that have options, such as HDMI, a small amount of onscreen configuration might be in order. In most cases, however, configuration is Plug and Play in nature.

Summary

In this chapter, you learned about various types of expansion cards, the interfaces they are known for, and the peripherals they connect to. The fact that some interfaces have gone through an evolution, changing appearance and capabilities at times, was also presented. No discussion of expansion cards and interfaces would be complete without adding in details of the cables needed, if any, to connect the cards to the peripherals; the discussion in this chapter is no exception.

This chapter also surveyed the details of peripherals from an output vs. input perspective, including specifics on the connections for display devices. Well-known input devices, such as the mouse and keyboard, and less conventional yet popular input devices were also examined in this chapter. You also learned about the KVM switch, a device that allows you to share input devices among computers. The adapter cards highlighted in this chapter fall into four broad categories: video, multimedia, I/O, and communications.

Other output devices were presented, with substantial detail of some and a topical look at others that are covered in more detail elsewhere in this book.

Exam Essentials

Familiarize yourself with installation and configuration of expansion cards. The variety of expansion cards available leads to the need to know the similarities and differences among them. For example, they all need to insert into the system using an expansion slot. They all perform a specific function or set of functions, based on their type, but not all cards are configured the same way. Some require more configuration than others, while some require no installer interaction at all.

Recognize and understand different peripheral connectors. Expansion cards and motherboards have external connectivity interfaces. The interfaces have connectors that adhere to some sort of standard for interconnecting with a cable or external device. Knowing these specific characteristics can help you differentiate among the capabilities of the interfaces available to you.

Recognize and be able to describe display connectors specifically. Although a type of peripheral connector, display connectors are in a class all their own. Technologies