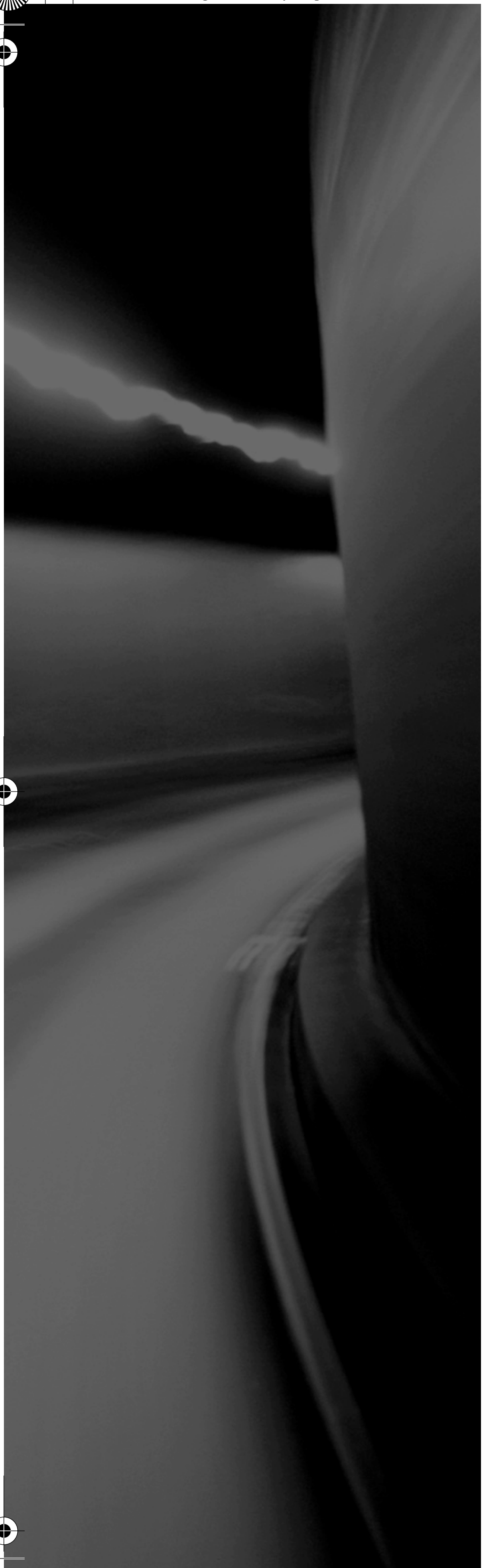
Chapter 1

Personal Computer Components

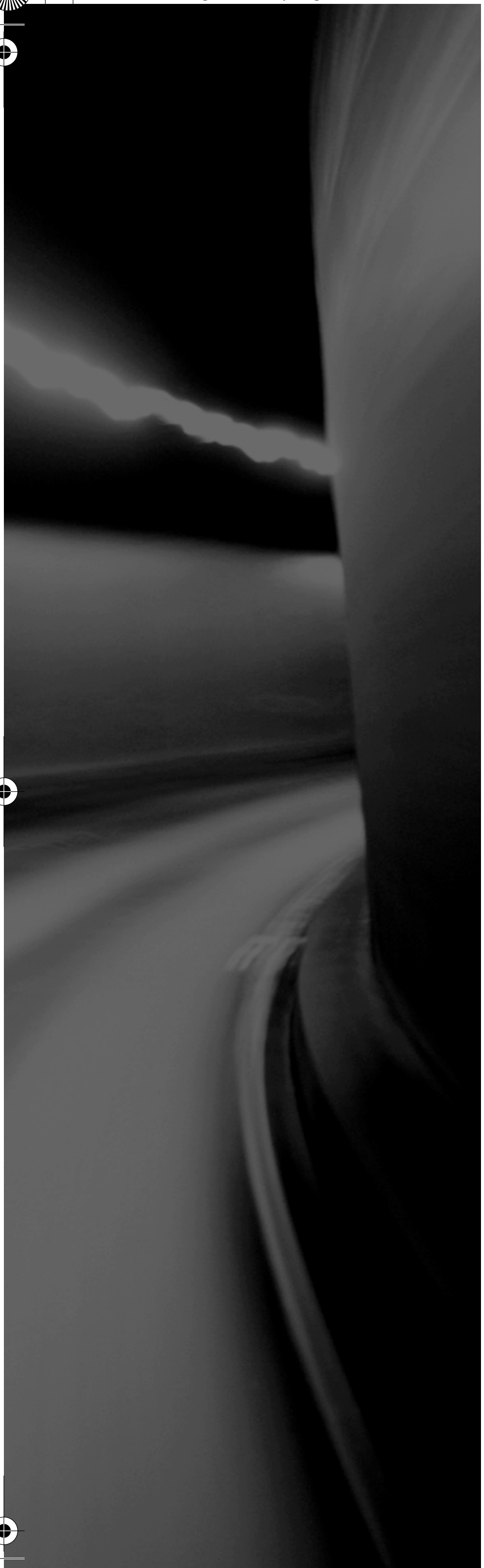
COMPTIA A+ ESSENTIALS EXAM OBJECTIVES COVERED IN THIS CHAPTER:

✓ **1.1 Identify the fundamental principles of using personal computers**

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

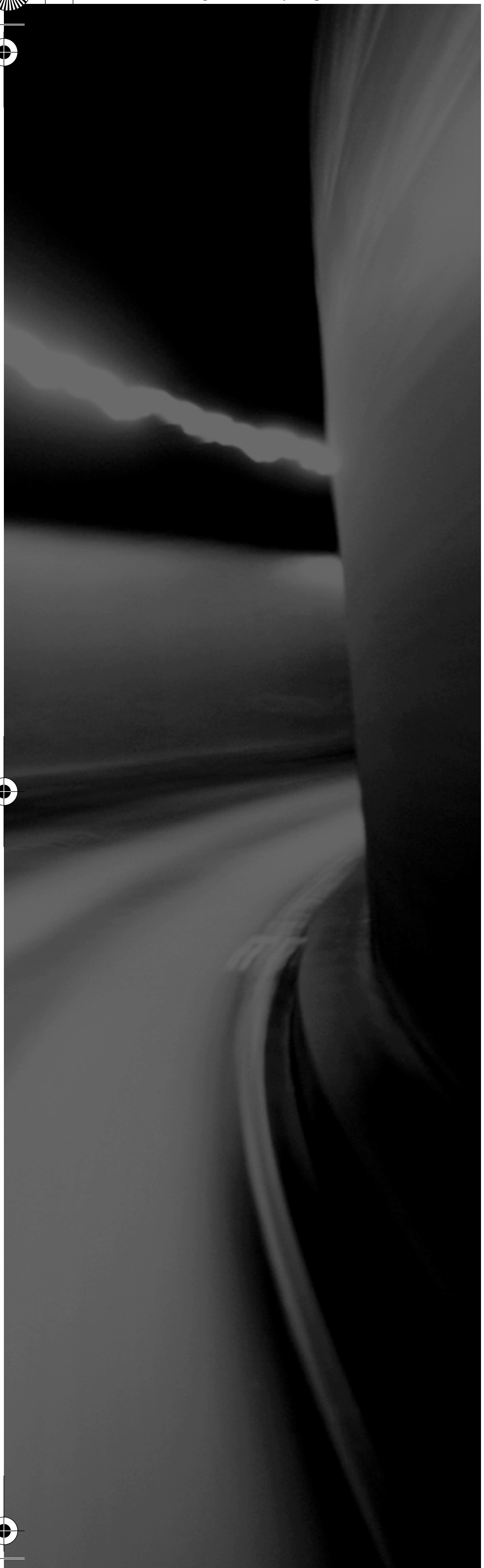


- Identify the names, purposes, and characteristics of power supplies, for example: AC adapter, ATX, proprietary, voltage
- Identify the names purposes and characteristics of processor / CPUs
  - CPU chips (e.g., AMD, Intel)
  - CPU technologies
  - Hyperthreading
  - Dual core
  - Throttling
  - Micro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



        - Multimedia
        - I / O (SCSI, serial, USB, Parallel)
        - Communications, including network and modem
    - Identify the names, purposes, and characteristics of ports and cables, for example: USB 1.1 and 2.0, parallel, serial, IEEE 1394 / firewire, RJ45 and RJ11, PS2 / MINI-DIN, centronics (e.g., mini, 36) multimedia (e.g., 1 / 8 connector, MIDSI COAX, SPDIF)
    - Identify the names, purposes, and characteristics of cooling systems, for example heat sinks, CPU and case fans, liquid cooling systems, thermal compound

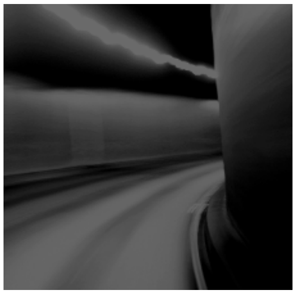
- ✓ **1.2 Install, configure, optimize, and upgrade personal computer components**
    - Add, remove, and configure internal and external storage devices
    - Drive preparation of internal storage devices, including format / file systems and imaging technology
    - Install display devices
    - Add, remove, and configure basic input and multimedia devices
- ✓ **1.3 Identify tools, diagnostic procedures, and troubleshooting techniques for personal computer components**
    - Recognize the basic aspects of troubleshooting theory, for example:
        - Perform backups before making changes
        - Assess a problem systematically and divide large problems into smaller components to be analyzed individually
        - Verify even the obvious, determine whether the problem is something simple and make no assumptions
        - Research ideas and establish priorities
        - Document findings, actions, and outcomes
    - Identify and apply basic diagnostic procedures and troubleshooting techniques, for example:
        - Identify the problem, including questioning user and identifying user changes to computer
        - Analyze the problem, including potential causes and make an initial determination of software and / or hardware problems



   - Test related components, including inspection, connections, hardware / software configurations, device manager, and consult vendor documentation
   - Evaluate results and take additional steps if needed, such as consultation, use of alternate resources, manuals
   - Document activities and outcomes
- Recognize and isolate issues with display, power, basic input devices, storage, memory, thermal, POST errors (e.g., BIOS, hardware)
- Apply basic troubleshooting techniques to check for problems (e.g., thermal issues, error codes, power, connections, including cables and / or pins, compatibility, functionality, software / drivers) with components, for example:
   - Motherboards
   - Power supply
   - Processor / CPUs
   - Memory
   - Display devices
   - Input devices
   - Adapter cards
- Recognize the names, purposes, characteristics, and appropriate application of tools, for example: BIOS, self-test, hard drive self-test, and software diagnostics test

✓ **1.4 Perform preventative maintenance on personal computer components**

- Identify and apply basic aspects of preventative maintenance theory, for example:
   - Visual / audio inspection
   - Driver / firmware updates
   - Scheduling preventative maintenance
   - Use of appropriate repair tools and cleaning materials
   - Ensuring proper environment
- Identify and apply common preventative maintenance techniques for devices, such as input devices and batteries



This chapter covers a lot of material—in fact, it could easily be a book in and of itself. One of the things that CompTIA is notorious for is having overlap between domains and exams, and the A+ is no exception. This domain is weighted at 21 percent (tied for highest) of the Essentials exam, and a great deal of the material covered here also appears in other domains (not to mention in the Technician exams).

Because of this, you'll want to make sure you're comfortable with the information presented in this chapter before going on to any others. As a doctor must be intimately acquainted with human anatomy, so a computer technician must understand the physical and functional structure of a personal computer.

Identify Principles of Personal Computers

Any PC is a complex machine. It could be described as a melting pot of various technologies and products, manufactured by a host of companies in many different countries. This diversity is a great advantage because it gives the PC its versatility. However, these components don't always "melt" together into a unified whole without the help of a technician. The different products—whether they're hard disks, modems, sound cards, or memory boards—must share one processor and one motherboard and therefore must be designed to work in harmony. For this reason, configuration of the computer components is especially emphasized on the A+ Essentials exam, and nearly one-third of the exam's question pool pertains to the objectives reviewed in this chapter.

Before sitting for the exam, you'll need to have a working knowledge of the components that make up a computer and their function within the system as a whole. The exam will test your knowledge of the types of components and their functions. The objective of this chapter is to review and identify the main components and their functions.

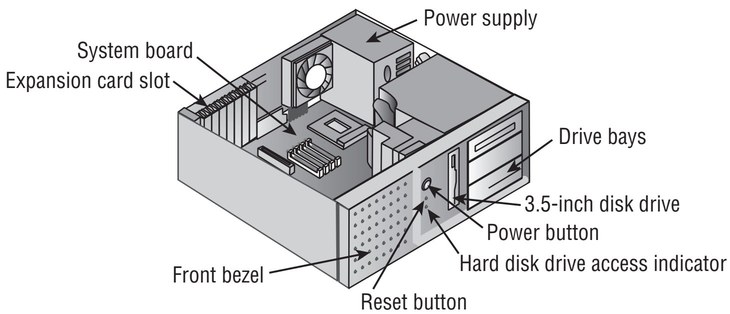
To pass the exam, you must be able to recognize these components and understand their relationship to one another.

Critical Information

This first objective blends together many diverse topic areas as they relate to PCs. Figure 1.1 shows a typical PC, its components, and their locations.

For this objective, you need to know about 10 key component categories: storage devices, motherboards, power supplies, processor/CPUs, memory, display devices, input devices, adapter cards, ports and cables, and cooling systems. Each of these is discussed in the sections that follow.

FIGURE 1.1 Typical PC components



Storage Devices

Storage media hold the data being accessed, as well as the files the system needs to operate and data that needs to be saved. The various types of storage differ in terms of capacity, access time, and the physical type of media being used.

Hard-Disk Systems

Hard disks reside inside the computer (usually) and can hold more information than other forms of storage. The hard-disk system contains three critical components: the controller, the hard disk, and the host adapter. The controller controls the drive, the hard disk provides a physical medium to store the data, and the host adapter is the translator.

NOTE: CompTIA favors the acronym HDD for *hard disk drive*.

Floppy Drives

A floppy disk drive (referred to by CompTIA as FDD) is a magnetic storage medium that uses a floppy disk made of thin plastic enclosed in a protective casing. The floppy disk itself (or *floppy*, as it's often called) enables the information to be transported from one computer to another easily. The downside of a floppy disk drive is its limited storage capacity. Floppy disks are limited to a maximum capacity of 2.88MB, but the most common type of floppy in use today holds only 1.44MB. Table 1.1 lists the various floppy disks and their capacity. All of these except the 1.44MB-capacity model are obsolete, and it isn't far behind.

CD-ROM Drives

CD-ROM stands for Compact Disc Read-Only Memory. The CD-ROM is used for long-term storage of data. CD-ROMs are read-only, meaning that once information is written to a CD, it can't be erased or changed. Access time for CD-ROMs is considerably slower than for a hard drive. CDs normally hold 650MB of data and use the ISO 9660 standard, which allows them to be used in multiple platforms.

TABLE 1.1 Floppy Disk Capacities

Floppy Drive Size	Common Designation	Number of Tracks	Capacity
$5\frac{1}{4}$″	Double-sided, Double-density	40	360KB
$5\frac{1}{2}$″	Double-sided, High-density	80	1.2MB
$3\frac{1}{2}$	Double-sided, Double-density	80	720KB
$3\frac{1}{2}$″	Double-sided, High-density	80	1.44MB
$3\frac{1}{2}$″	Double-sided, Ultra High Density	80	2.88MB

DVD-ROM Drives

Because DVD-ROMs use slightly different technology than CD-ROMs, they can store up to 1.6GB of data. This makes them a better choice for distributing large software bundles. Many software packages today are so huge that they take multiple CD-ROMs to hold all the installation and reference files. A single DVD-ROM, in a double-sided, double-layered configuration, can hold as much as 17GB (as much as 26 regular CD-ROMs).

Zip Drives and Jaz Drives

Iomega's Zip and Jaz drives are detachable, external hard disks that are used to store a large volume (around 100MB for the Zip, 1GB and 2GB for the Jaz) of data on a single, floppy-sized disk. The drives connect to either a parallel port or a special interface card. The major use of Zip and Jaz drives is to transport large amounts of data from place to place. This used to be accomplished with several floppies.

Tape Backup Devices

Another form of storage device is the tape backup. Tape backup devices can be installed internally or externally and use a magnetic tape medium instead of disks for storage. They hold much more data than any other medium but are also much slower. They're primarily used for archival storage.

Optical Drives

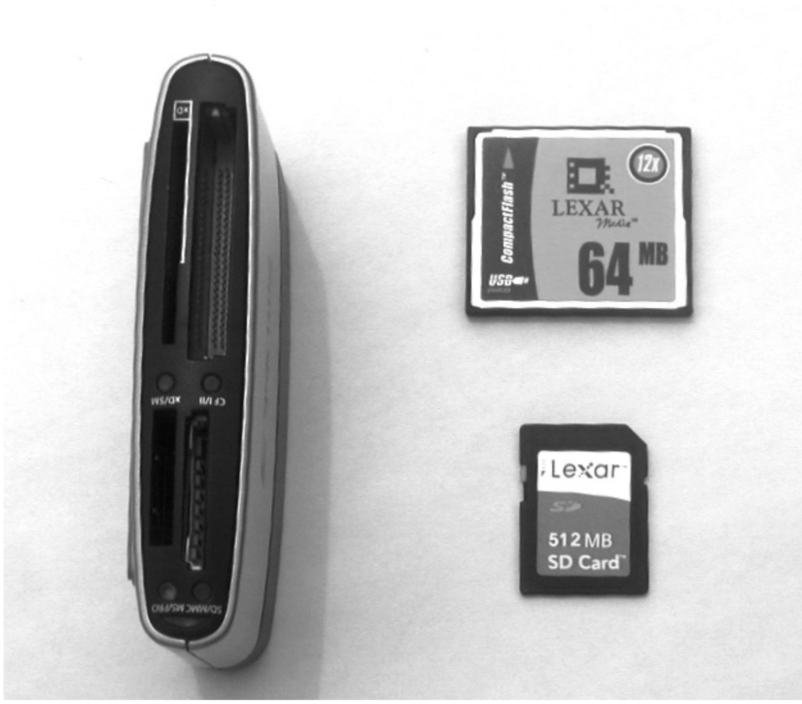
Optical drives work by using a laser rather than magnetism to change the characteristics of the storage medium.

Flash Drives (and SD Cards)

Flash drives have been growing in popularity for years and replacing floppy disks due to their capacity and small size. Flash is ideally suited for use not only with computers, but also with many other things—digital cameras, MP3 players, and so on.

Although the CompTIA objective lists flash and SecureDigital (SD) cards separately, in reality, SD cards are just one type of flash; there are many others. Figure 1.2 shows a CompactFlash card (larger of the two) and an SD card (the smaller of the two) along with an 8-in-1 card reader/writer. The reader shown connects to the USB port and then interacts with CompactFlash, CompactFlash II, Memory Stick, Memory Stick PRO, SmartMedia, xD-Picture Cards, SD, and MultiMediaCards.

FIGURE 1.2 CompactFlash and SD cards together with a reader

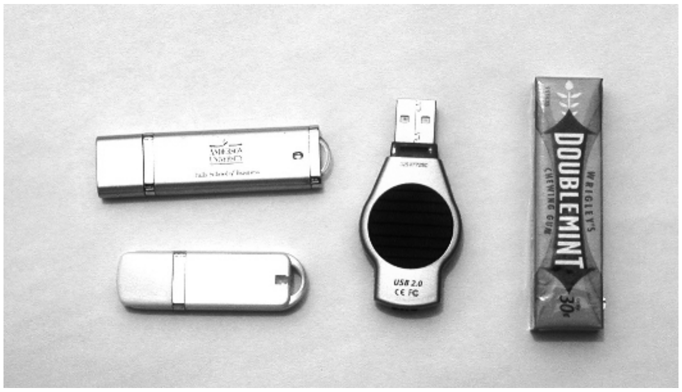


You can find flash cards in any of these formats available in a variety of sizes (16MB, 128MB, 256MB, and so on). The size of the flash card does place some limitation on the maximum capacity of the media, but most cards on the market are below that maximum. The maximum capacity for CompactFlash, for example, is 8GB, whereas for an SD card it's 1GB.

Thumb Drives

Thumb drives are USB flash drives that have become extremely popular for transporting files. Figure 1.3 shows three thumb drives (also known as *keychain drives*) next to a pack of gum for size comparison.

FIGURE 1.3 Three thumb drives together with a pack of gum



Like other flash drives, you can find these in a number of different size capacities. The maximum storage capacity for this media is 2GB. Many models include a write-protect switch to keep you from accidentally overwriting files stored on the drive. All include an LED to show when they're connected to the USB port. Other names for thumb drives include travel drives, flash drives, jump drives, and a host of others.

External Hard Drives

A number of vendors are now making external hard drives. These often connect to the computer through the USB port, but can also connect through the network (and be shared by other users) or other connections. While some are intended for expansion, many are marketed for the purpose of "mirroring" data on the internal drive(s) and often incorporate a push-button switch that starts a backup.

Motherboards

The motherboard is the backbone of a computer. The components of the motherboard provide basic services needed for the machine to operate and provide a platform for devices such as the processor, memory, disk drives, and expansion devices. For this objective, you should study the types of motherboards, their ports and memory, the types of CPU sockets, and the types of expansion slots.

System Board Form Factors

Form factor refers to the size and shape of a component. There are four popular motherboard form factors for desktop PCs: AT, ATX, BTX, and NLX.

AT AT is an older style of motherboard. A slightly more modern variant of it is the baby AT, which is similar but smaller. Its key features are a two-piece power-supply connector, ribbon cables that connect the I/O ports to the board, and an AT-style keyboard connector. The expansion slots are parallel to the wide edge of the board. See Figure 1.4.

FIGURE 1.4 An AT-style motherboard

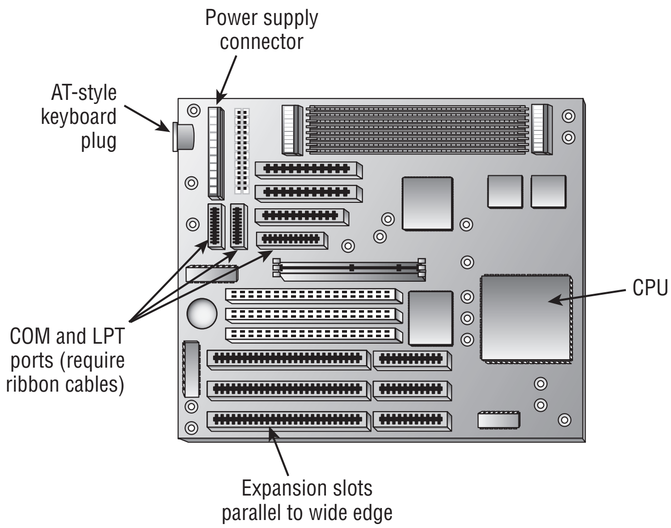
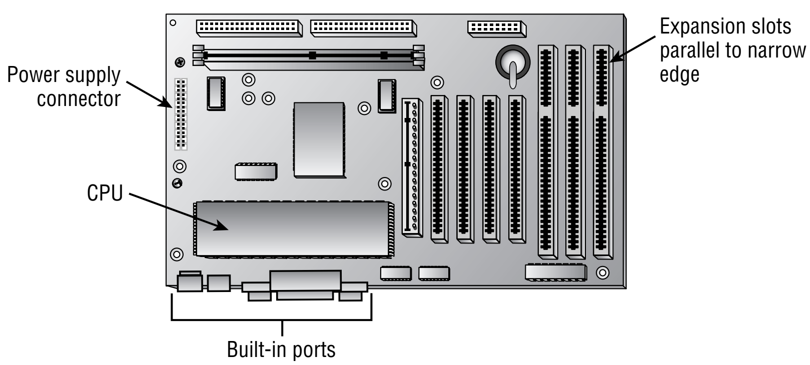


FIGURE 1.5 An ATX-style motherboard



ATX Most system boards today use the ATX form factor. It contains many design improvements over the AT, including I/O ports built directly into the side of the motherboard, the CPU positioned such that the power-supply fan helps cool it, and the ability for the PC to be turned on and off via software. It uses a PS/2 style-connector for the keyboard. The expansion slots are parallel to the narrow edge of the board. See Figure 1.5.

BTX The Balanced Technology Extended (BTX) motherboard was designed by Intel to deal with issues surrounding ATX (heat, power consumption, and so on). The BTX motherboard is larger than ATX, so there is more room for integrated components; there is also an optimized airflow path and a low-profile option.

Although the standard has been around for a number of years, it isn't expected to become popular in the market until at least 2007.

NLX An acronym for New, Low profile eXtended, this form factor is used in low-profile case types. It incorporates expansion slots that are placed on a *riser board* to accommodate the reduction in case size. However, this design adds another component to troubleshoot.

Buses

A *bus* is a set of signal pathways that allows information and signals to travel between components inside or outside a computer. A motherboard has several buses, each with its own speed and width.

The *external data bus*, also called the *system bus*, connects the CPU to the chipset. On modern systems, it's 64-bit. The *address bus* connects the RAM to the CPU. On modern systems, it's 64-bit.

The *expansion bus* connects the I/O ports and expansion slots to the chipset. There are usually several different expansion buses on a motherboard. Expansion buses can be broken into two broad categories: internal and external. Internal expansion buses include Industry Standard Architecture (ISA), Peripheral Component Interconnect (PCI), and Accelerated Graphics Port (AGP); they're for circuit boards. External expansion buses include serial, parallel, Universal Serial Bus (USB), FireWire, and infrared. The following sections explain some of the most common buses.

NOTE: There are many obsolete bus types, including Video Electronics Standards Association Local Bus (VESA local bus, or VL-Bus), Microchannel Architecture (MCA), and enhanced ISA (EISA). These were not on the last iteration of the A+ test and should not appear on this one either.

ISA

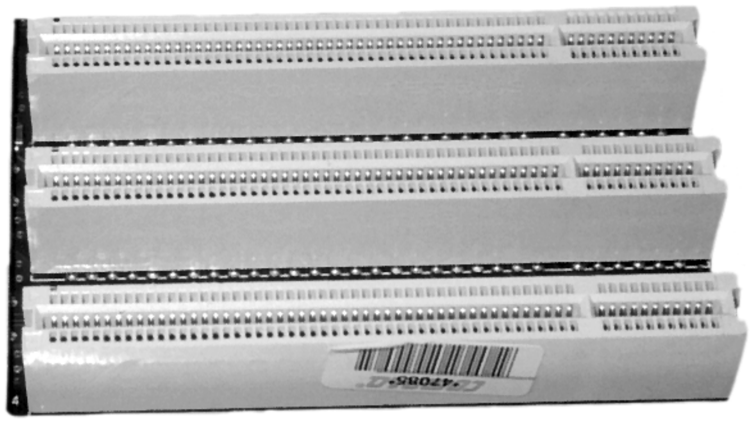
This is a 16-bit bus (originally 8-bit on the oldest computers) that operates at 8MHz. Its slots are usually black. New motherboards may not have this type of slot, because the ISA bus is old technology and is being phased out.

Besides the slow speed and narrow width, another drawback of the ISA bus is that each ISA device requires separate system resources, including separate Interrupt Requests (IRQs). In a heavily loaded system, this can cause an IRQ shortage. (PCI slots, in contrast, can share some resources.)

PCI

The PCI bus is a fast (33MHz), wide (32-bit or 64-bit) expansion bus that is the modern standard in motherboards today for general-purpose expansion devices. Its slots are typically white. PCI devices can share IRQs and other system resources with one another in some cases. All modern motherboards have at least three PCI slots. Figure 1.6 shows some PCI slots.

FIGURE 1.6 PCI bus connectors

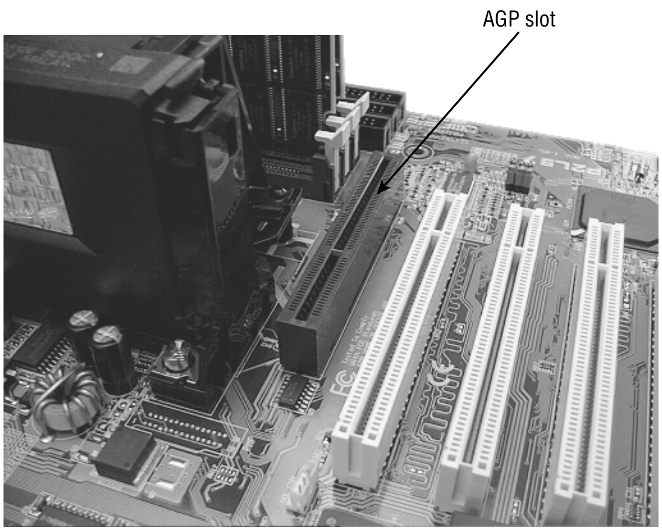


AGP

As systems got faster, PC game players wanted games that had better graphics, more realism, and more speed. However, as the computers got faster, the video technology couldn't seem to keep up, even with the PCI bus. The AGP bus was developed to meet this need.

The AGP slot is usually brown, and there is only one. It's a 32-bit or 64-bit bus, and it runs very fast (66MHz or faster). It's used exclusively for the video card. If you use a PCI video card, the AGP slot remains empty. See Figure 1.7.

FIGURE 1.7 An AGP slot on a motherboard



PCIE

PCI Express (PCIE , PCI-E, or PCIe) uses a network of serial interconnects that operate at high speed. It's based on the PCI system; most existing systems can be easily converted to PCIE. Intended as a replacement for AGP and PCI, PCIE has the capability of being faster than AGP, while maintaining the flexibility of PCI. There are currently six different speed levels and they correspond to AGP speeds: 1X, 2X, 4X, 8X, 16X, and 32X.

AMR AND CNR

Audio Modem Riser (AMR) was originally created to speed manufacturing (and certification) by separating the analog circuitry (modem and analog audio) onto its own card. Over time, this has been replaced by CNR (Communications Network Riser), which includes the capabilities of AMR and allows the motherboard chipset to be designed with additional integrated features.

LEGACY PARALLEL AND SERIAL

These buses are called *legacy* because they're old technology and are being phased out. The legacy serial port, also called an RS-232 port, is a 9-pin or 25-pin male connector. It sends data one bit at a time and is usually limited to about 115Kbps in speed.

The legacy parallel port transfers data 8 bits at a time. It's a 25-pin female connector. A system typically has only one parallel port, but because many printers are now coming with USB interfaces, this is no longer the inconvenience that it used to be.

USB

USB is a newer expansion bus type that is used almost exclusively for external devices. All motherboards today have at least two USB ports. Some of the advantages of USB include hot-plugging and the capability for up to 127 USB devices to share a single set of system resources. USB 1.1 runs at 12Mbps, and USB 2.0 runs at 480Mbps. Because USB is a serial interface, its width is 1 bit.

IEEE 1394/FIREWIRE

Some newer motherboards have a built-in IEEE 1394/FireWire port, although this port is more typically found on a PCI expansion board. It transfers data at 400Mbps and supports up to 63 chained devices on a single set of resources. It's hot-pluggable, like USB. Figure 1.8 shows the connections on a FireWire card.

FIGURE 1.8 FireWire connections

Motherboard RAM Slots

RAM is discussed extensively in the “Memory” section later in this chapter. For now, know that the RAM and the RAM slots on the motherboard must match.

Processor Sockets

Table 1.2 lists the various CPU slots and sockets you may find in a motherboard and explains which CPUs will fit into them. CPUs are covered in detail in the “Processor/CPUs” section of this chapter.

TABLE 1.2 Processor Sockets and Slots

Slot/Socket	CPU Used
Slot 1	Pentium II
Slot 2	Pentium III
Slot A	AMD Athlon
Socket A	AMD Athlon
Socket 7	Pentium (second and third generation), AMD K6
Socket 8	Pentium Pro
Socket 423	Pentium 4
Socket 478	Pentium 4
Socket 370	Pentium III

On-Motherboard Cache

On older motherboards, the L2 cache is on its own RAM-like stick made of very fast static random access memory (SRAM). It’s known as *cache on a stick (COAST)*. On newer systems, the L2 cache is built into the CPU packaging.

Some newer systems also have an L3 cache, which is an external cache on the motherboard that sits between the CPU and RAM.

IDE and SCSI On-Motherboard Interfaces

Most motherboards include two Integrated Drive Electronics (IDE) channels but don’t include built-in Small Computer System Interface (SCSI). A consideration when choosing a motherboard for IDE is that it needs to support the desired level of UltraDMA to match the capabilities of the hard drive you want to use.

Chipsets

The *chipset* is the set of controller chips that monitors and directs the traffic on the motherboard between the buses. It usually consists of two or more chips. Motherboards use two basic chipset designs: the *north/south bridge chipset* and the *hub chipset*.

North/south bridge is the older of the two. The north bridge connects the system bus to the other relatively fast buses (AGP and PCI). The south bridge connects ISA, IDE, and USB. A third chip, SuperIO, connects the legacy parallel and serial ports.

The hub chipset includes a memory controller hub (equivalent to the north bridge), an I/O controller hub (equivalent to the south bridge), and a SuperIO chip.

CMOS

You can adjust a computer's base-level settings through a Basic Input/Output System (BIOS) Setup program, which you access by pressing a certain key at startup, such as F1 or Delete (depending on the system). Another name for this setup program is CMOS Setup. The most common settings to adjust in CMOS include port settings (parallel, serial, USB), drive types, boot sequence, date and time, and virus/security protections.

ACCESSING CMOS SETUP

Your PC keeps these settings in a special memory chip called the Complementary Metallic Oxide Semiconductor (CMOS) chip. The CMOS chip must have a constant source of power to keep its settings. To prevent the loss of data, motherboard manufacturers include a small battery to power the CMOS memory. On modern systems, this is a coin-style battery, about the same diameter of a dime and about 1/4 inch thick.

You can press a certain key or group of keys to access the setup program during the power on self-test (POST). This utility allows you to change the configuration through a group of menus. There are many different CMOS Setup programs, depending on the BIOS make and manufacturer, so it's impossible to provide specifics here; instead, we'll look at capabilities.

LOAD SETUP DEFAULTS

The purpose of this setting is to configure the PC back to the default settings set by the factory. If you make changes to your settings and the machine becomes disabled, in most cases, selecting this menu item returns the machine to a usable state. You may then try different settings until you achieve your desired configuration. This is an important setting to know about before making any other changes.

DATE AND TIME

One of the most basic things you can change in CMOS Setup is the system date and time. You can also change this from within the operating system.

CPU SETTINGS

In most modern systems, the BIOS detects the CPU's type and speed automatically, so any CPU setting in CMOS Setup is likely to be read-only.

MEMORY SPEED/PARITY

Most systems today detect the RAM amount and speed automatically. Some motherboards can use different types of RAM, such as parity and nonparity, or different speeds, and the CMOS Setup program may provide the opportunity to change those settings. Increasingly, however, RAM is becoming a read-only part of CMOS Setup programs.

POWER MANAGEMENT

The Power Management settings determine the way the PC will act after it has been idle for certain time periods. For example, you may have choices like Minimum, Maximum, and User Defined. The Minimum and Maximum settings control the HDD Off After, Doze Mode, Standby Mode, and Suspend Mode settings with predefined parameters. If you select User Defined, you must manually configure these settings to your personal preferences.

NOTE

Laptops have even more power settings because of the need to conserve battery power. Chapter 2 focuses on laptops and portable devices.

PORTS AND PERIPHERALS

In CMOS Setup, you can enable or disable integrated components, such as built-in video cards, sound cards, or network cards. You may disable them in order to replace them with different models on expansion boards, for example.

You can also disable the on-board I/O ports for the motherboard, including parallel, serial, and USB. Depending on the utility, there may also be settings that enable or disable USB keyboard usage, Wake On LAN, or other special features.

In addition to enabling or disabling legacy parallel ports, you can also assign an operational mode to the port. Table 1.3 lists the common modes for a parallel port. When you're troubleshooting parallel port problems, sometimes trying a different mode will help.

TABLE 1.3 Printer or Parallel Port Settings

Setting	Description	Use
EPP (enhanced parallel port)	Supports bidirectional communication and high transfer rates	Newer ink-jet and laser printers that can utilize bidirectional communication, and scanners
ECP (enhanced capabilities port)	Supports bidirectional communication and high transfer rates	Newer ink-jet and laser printers that can utilize bidirectional communication, connectivity devices, and scanners
SPP (standard parallel port)	Supports bidirectional communication	Older ink-jet and laser printers and slower scanners

PASSWORDS

In most CMOS Setup programs, you can set a supervisor password. Doing so requires a password to be entered in order to use the CMOS Setup program, effectively locking out users from making changes to it. You may also be able to set a user password, which restricts the PC from booting unless the password is entered.

To reset a forgotten password, you can remove the CMOS battery to reset everything. There also may be a Reset jumper on the motherboard.

VIRUS PROTECTION

Some CMOS Setup programs have a rudimentary virus-protection mechanism that prevents applications from writing to the boot sector of a disk without your permission. If this setting is turned on, and you install a new operating system, a confirmation box may appear at some point, warning you that the operating system's Setup program is trying to write to the boot sector. Let it.

HDD AUTO DETECTION

Some CMOS Setup programs have a feature that polls the IDE channels and provides information about the IDE devices attached to them. You can use this feature to gather the settings for a hard disk. However, most hard disks these days are fully Plug and Play, so they automatically report themselves to the CMOS Setup.

DRIVE CONFIGURATION

You can specify how many floppy drives are installed and what types they are. Floppy drives aren't automatically detected. The settings needed for a floppy drive are size ($3\frac{1}{2}$-inch or $5\frac{1}{4}$-inch) and density (double-density or high-density). You can also set each floppy drive to be enabled or disabled from being bootable. Almost all floppy drives today are high-density $3\frac{1}{2}$-inch.

Hard drives, on the other hand, can be auto-detected by most systems if the IDE setting is set to Auto. The settings detected may include the drive's capacity; its geometry (cylinders, heads, and sectors); and its preferred PIO (Programmed Input/Output), direct memory access (DMA), or UltraDMA operating mode. You can also configure a hard drive by entering its CHS values manually, but doing so is almost never necessary anymore.

> **NOTE** CHS stands for *cylinders, heads, and sectors*. This is also called the *drive geometry*, because together these three numbers determine how much data the disk can hold. Most CMOS Setup programs are able to automatically detect the CHS values.

BOOT SEQUENCE

Each system has a default boot order, which is the order in which it checks the drives for a valid operating system to boot. Usually, this order is set for floppy first, then hard disk, and finally CD-ROM, but these components can be placed in any boot order. For example, you might set CD-ROM first to boot from a Windows XP Setup disk on a system that already contained an operating system.

EXITING THE CMOS SETUP

The CMOS Setup program includes an Exit command, with options including Save Changes and Discard Changes. In most programs, Esc is a shortcut for exiting and discarding changes, and F10 is a common shortcut for exiting and saving changes.

Firmware

Any software that is built into a hardware device is called *firmware*. Firmware is typically in flash ROM and can be updated as newer versions become available. An example of firmware is the software in a laser printer that controls it and allows you to interact with it at the console (usually through a limited menu of options).

Daughterboards

Any boards added to the motherboard to expand its capabilities are known as *daughterboards* ("daughters" of the "mother"). A common use is to insert one daughterboard (also called *daughter boards*) into the motherboard and allow expansion cards to then be inserted into it sideways, thus saving space.

Power Supplies

The device in the computer that provides the power is the *power supply*. A power supply converts 110-volt AC current into the voltages a computer needs to operate. On an AT motherboard, these are +5 volts DC, –5 volts DC, +12 volts DC, and –12 volts DC. Components in modern PCs don't use the negative voltages; they're provided for backward compatibility only. On an ATX motherboard, an additional voltage is provided: +3.3 volts DC.

Power-supply problems are usually easy to troubleshoot. The system doesn't respond in any way when the power is turned on. When this happens, open the case, remove the power supply, and replace it with a new one.

Be aware that different cases have different types of on/off switches. The process of replacing a power supply is a lot easier if you purchase a replacement with the same mechanism. Even so, remember to document exactly how the power supply was connected to the on/off switch before you remove it.

Power supplies contain transformers and capacitors that carry *lethal* amounts of current. They aren't meant to be serviced. *Do not* attempt to open them or do any work on them. Figure 1.9 shows a generic power supply.

A power supply has a rated output capacity in watts, and when you fill a system with power-hungry devices, you must make sure that maximum capacity isn't exceeded. Otherwise, problems with power can occur, creating lockups or spontaneous reboots.

To determine the wattage a device draws, multiply voltage by current. For example, if a device uses 5 amps of +3.3V and 0.7 amps of +12V, a total of 25 watts is consumed. Do this calculation for every device installed. Most devices have labels that state their power requirements. Some devices don't have power labels; for such devices, use the numbers in Table 1.4 for estimations.

FIGURE 1.9 A power supply

NOTE As a general rule, you should have a large enough power supply for all the slots in the computer with the most likely devices that will be installed. In other words, you should calculate the power-supply capacity from what is possible and not just what is currently on the motherboard.

TABLE 1.4 Estimating Power Consumption

Component	Watts Consumed, for Estimating Purposes
Motherboard	20–30 watts
CPU	30–70 watts (faster CPU, more watts)
AGP video card	20–50 watts
PCI circuit boards	5 watts each
ISA circuit boards	10 watts each
Floppy drive	5 watts
CD drive	10–25 watts

TABLE 1.4 Estimating Power Consumption *(continued)*

Component	Watts Consumed, for Estimating Purposes
RAM	8 watts per 128MB
IDE hard drive	5–15 watts
SCSI hard drive	10–40 watts

Processor/CPUs

The *central processing unit (CPU)* is a processor chip consisting of an array of millions of integrated circuits. Its purpose is to accept, perform calculations on, and eject numeric data. It's considered the "brain" of the computer because it's the part that performs the mathematical operations required for all other activity.

There are two form factors for CPU chips: pin grid array (PGA) and single edge contact cartridge (SECC). The PGA style is a flat square or rectangular ceramic chip with an array of pins in the bottom. The actual CPU is a tiny silicon wafer embedded inside that ceramic chip. The SECC style is a circuit board with the silicon wafer mounted on it. The circuit board is then surrounded by a plastic cartridge for protection; the circuit board sticks out of the cartridge along one edge. This edge fits into a slot in the motherboard.

All CPUs today require cooling because they generate heat as they operate. The cooling can be either active or passive. A *passive heat sink* is a block of heat-conductive material that sits close to the CPU and wicks away the heat into the air. An *active heat sink* contains a fan that pulls the hot air away from the CPU.

NOTE

One way to determine which CPU your computer is using is to open the case and view the numbers stamped on the CPU. However, some passive heat sinks are glued to the CPU, so the numbers may not be visible without removing it. Another way to determine a computer's CPU is to save your work, exit any open programs, and restart the computer. Watch closely as the computer returns to its normal state. You should see a notation that tells you what chip you're using. The General tab of the System Properties in Windows may also report the CPU speed. Later versions of Windows will also report the CPU speed in the System Information tool.

External Speed (Clock Speed)

The *clock speed*, or *external speed*, is the speed at which the motherboard communicates with the CPU. It's determined by the motherboard, and its cadence is set by a quartz crystal (the system crystal) that generates regular electrical pulses.

Internal Speed

The *internal speed* is the maximum speed at which the CPU can perform its internal operations. This may be the same as the motherboard's speed (the external speed), but it's more likely to be a multiple of it. For example, a CPU may have an internal speed of 1.3GHz but an external speed of 133MHz. That means for every tick of the system crystal's clock, the CPU has 10 internal ticks of its own clock.

Cache Memory

A *cache* is an area of extremely fast memory used to store data that is waiting to enter or exit the CPU. The *Level 1 cache*, also known as the *L1* or *front-side cache*, holds data that is waiting to enter the CPU. On modern systems, the L1 cache is built into the CPU. The *Level 2 cache*, also known as the *L2* or *back-side cache*, holds data that is exiting the CPU and is waiting to return to RAM. On modern systems, the L2 cache is in the same packaging as the CPU but on a separate chip. On older systems, the L2 cache was on a separate circuit board installed in the motherboard, and was sometimes called COAST.

The Bus

The processor's ability to communicate with the rest of the system's components relies on the supporting circuitry. The system board's underlying circuitry is called the *bus*. The computer's bus moves information into and out of the processor and other devices. A bus allows all devices to communicate with each other. The motherboard has several buses. The *external data bus* carries information to and from the CPU and is the fastest bus on the system. The *address bus* typically runs at the same speed as the external data bus and carries data to and from RAM. The PCI, AGP, and ISA interfaces also have their own buses with their own widths and speeds.

The CPU must be compatible with the motherboard in the following ways:

Physical connectivity The CPU must be in the right kind of package to fit into the motherboard.

Speed The motherboard's chipset dictates its external data-bus speed; the CPU must be capable of operating at that external speed.

Instruction set The motherboard's chipset contains an instruction set for communicating with the CPU; the CPU must understand the commands in that set. For example, a motherboard designed for an AMD Athlon CPU can't accept an Intel Pentium CPU, because the instruction set is different.

Voltage The CPU requires that a certain voltage of power be supplied to it via the motherboard's interface. This can be anywhere from +5V for a very old CPU down to around +2.1V for a modern one. The wrong voltage can ruin the CPU.

There are several ways of differentiating one CPU from another. The following sections explain specifications according to type, speed, voltage, and cache memory.

CPU Speed

The CPU's speed is the frequency at which it executes instructions. This frequency is measured in millions of cycles per second, or megahertz (MHz); or billions of cycles per second, or gigahertz (GHz).

The CPU has an internal and an external speed. The external speed corresponds with the motherboard's speed, based on its system crystal. The system crystal pulses, generating a cadence at which operations occur on the motherboard. Each pulse is called a clock tick. The CPU's internal speed is usually a multiple of that, so that multiple operations occur internally per clock tick. A CPU's speed as described in its specifications is its internal speed.

CPU Cache

Each CPU has at least two caches: L1 and L2. The L1 cache is built into the CPU on modern systems. It's the front-side cache, where data waits to enter the CPU. The L2 cache, or back-side cache, is where data exiting the CPU waits. On modern systems, the L2 cache is within the CPU's packaging but not integrated into the CPU's die. On older systems, the L2 cache was on a separate set of chips on the motherboard. You can compare one CPU to another according to the size of its L1 and L2 caches.

On some CPUs, the L2 cache operates at the same speed as the CPU; on others, the cache speed is only half the CPU speed. Chips with full-speed L2 caches have better performance.

Some newer systems also have an *L3 cache*, which is external to the CPU. It sits between the CPU and RAM to optimize data transfer between them.

CPU Voltage

A CPU's voltage is the amount of electricity provided to it by the motherboard. Older CPUs have higher voltages (around +5V); newer ones have lower voltages (less than +2V in some cases).

One reason a given motherboard can't support many different CPUs is that it must provide the correct voltage. To get around this issue, some motherboards have *voltage regulator modules (VRMs)* that are able to change the voltage based on the CPU.

CPU Manufacturers

The market leader in the manufacture of chips is Intel Corporation, with Advanced Micro Devices (AMD) gaining market share in the home PC market. Other competitors include Motorola and IBM.

INTEL PROCESSORS

The first commercially successful Intel CPU was the 8086, developed in the late 1970s. It was used in the IBM XT, one of the early home and business personal computers. Other early Intel CPUs included the 80286, 80386, and 80486. You may find it useful to learn about the specifications of these CPUs for your own knowledge, but they aren't covered on the current A+ exam.

PENTIUM

Intel introduced the Pentium processor in 1993. This processor has 3.1 million transistors using a 64-bit data path, a 32-bit address bus, and a 16KB on-chip cache, and it comes in speeds from 60MHz to 200MHz. With the release of the Pentium chips, *dual pipelining* was introduced (also called *superscalar architecture*), allowing the chip to process two operations at once.

The term *Pentium* refers to three separate CPUs: first-generation, second-generation, and MMX. First-generation Pentiums were 273-pin PGA CPUs (Socket 4) drawing +5V. They ran at 60MHz or 66MHz. The second-generation Pentiums were 296-pin models (Socket 5 or Socket 7) drawing +3.3V. They ran at between 75Mhz and 200MHz. Third-generation (MMX) Pentiums, released in 1997, added multimedia extensions (MMX) to help the CPU work with graphic-intensive games. They used Socket 7 sockets, drew +2.8V, and ran at 166MHz to 233MHz. Due to the voltage difference between the Pentium MMX CPU and other Socket 7 CPUs, the MMX CPU required a motherboard that either was specifically for that CPU or had a VRM that could take the voltage down to that level.

PENTIUM PRO

The Pentium Pro, released in 1995, came between the second- and third-generation Pentiums. Physically, the Pentium Pro was a PGA-style, rectangular chip with 387 pins, using a Socket 8 socket drawing +3V. It was designed primarily for server usage, and was optimized for 32-bit operating systems. On a 16-bit OS like Windows 3.1, the Pentium Pro ran more slowly than a Pentium, so it failed to gain widespread consumer support.

The Pentium Pro included *quad pipelining*, which processed four operations at once. It was also the first CPU to include an on-chip L2 cache. Another advantage of the Pentium Pro was *dynamic processing*, which allowed it to run instructions out of order whenever it was waiting for something else to happen.

NOTE

Throttling is a term CompTIA expects you to know for the exam. With throttling, you artificially reduce the amount of resource available. Although commonly used with bandwidth to prevent one user from absorbing all the resources on a network, it can also be applied to processors and applications. In many senses, throttling in this manner is the opposite of *overclocking*—where you attempt to get the processor to run at a speed higher than it's marked by using a faster bus speed or some other trick.

PENTIUM II

Intel next released the Pentium II: This chip's speeds ranged from 233MHz to over 400MHz. It was introduced in 1997 and was designed to be a multimedia chip with special on-chip multimedia instructions and high-speed cache memory. It has 32KB of L1 cache, dynamic execution, and MMX technology. The Pentium II uses an SECC to attach to the motherboard instead of the standard PGA package used with the earlier processor types.

When released, the Pentium II was designed for single-processor-only applications. Intel also released a separate processor, known as the Pentium II Xeon, to fill the need for multiprocessor applications such as servers. The Xeon's primary advantage is a huge L2 cache (up to 2MB) that runs at the same speed as the CPU. The Xeon uses a special size of SECC-style slot called Slot 2.

Different voltages have been used for the Pentium II over its lifespan, ranging from +2.8V to +2.0V. When you're using a Pentium II, it's important that the motherboard provide the correct voltage to it. This can be achieved with a VRM on the motherboard that detects the CPU's needs and adjusts the voltage provided.

CELERON

To offer a less-costly alternative and to keep its large market share, Intel released the Celeron. In some cases, the Celeron was priced as low as half the retail price of the Pentium II. Because it was developed after the Pentium II, it benefited from some advancements and in certain aspects outperformed its more expensive counterpart. Intel has also named its low-budget Pentium III CPUs Celeron.

The Celeron CPU has come in several package types, including a 370-pin PGA socket (Socket 370) and an SECC variant called single edge processor (SEP) that is similar to the circuit board inside an SECC cartridge but without the plastic outer shell.

PENTIUM III

The Pentium III was released in 1999 and uses the same SECC connector as its predecessor, the Pentium II. It included 70 new instructions and a processor serial number (PSN), a unique number electronically encoded into the processor. This number can be used to uniquely identify a system during Internet transactions.

The Pentium III has two styles: an SECC-style cartridge called SECC2, and a PGA-style chip with 370 pins. The Pentium III PGA chip has the CPU chip mounted on the top rather than the bottom of the ceramic square; it's called a flip chip (FC), or FC-PGA.

NOTE

Like the Pentium II, the Pentium III has a multiprocessor Xeon version as well.

PENTIUM 4

The Pentium 4 was released in 2002. It runs on a motherboard with a fast system bus (between 400MHz and 800MHz) and provides some incremental improvements over the Pentium III. It's a PGA-style CPU.

One of the improvements the Pentium 4 offers is *hyperthreading* technology. This feature enables the computer to multitask more efficiently between CPU-demanding applications.

NOTE

Dual-core processors, available from Intel as well as AMD, essentially combine two processors into one chip. Instead of adding two processors to a machine (making it a multiprocessor system), you have one chip splitting operations and essentially performing as if it's two processors in order to get better performance.

SUMMARY OF INTEL PROCESSORS

Table 1.5 provides a summary of the history of the Intel processors. Table 1.6 shows the physical characteristics of Pentium-class (and higher-class) processors.

TABLE 1.5 The Intel Family of Processors

Chip	Year Added	Data Bus Width (in Bits)	Address Bus Width (in Bits)	Speed (in MHz)
8080	1974	8	8	2
8086	1978	16	20	5–10
8088	1979	8	20	4.77
80286	1982	16	24	8–12
386DX	1985	32	32	16–33
386SX	1988	32	24	16–20
486DX	1989	32	32	25–50
486SX	1991	32	32	16–33
487SX	1991	32	32	16–33
486DX2	1991	32	32	33–66
486DX4	1992	32	32	75–100
Pentium	1993	32	32	60–166
Pentium Pro	1995	64	32	150–200
Pentium II	1997	64	64	233–300
Pentium II Xeon	1998	64	64	400–600
Celeron	1999	64	64	400–600
Pentium III	1999	64	64	350–1000
Pentium III Xeon	1999	64	64	350–1000
Pentium 4	2002	64	64	1000–3000

NOTE: A Pentium 4 Extreme Edition was released in 2003. Featuring a dual-core processor as its biggest modification over the Pentium 4, it's targeted for the gaming user.

TABLE 1.6 Physical Characteristics of Pentium-Class Processors

Processor	Speeds (MHz)	Socket	Pins	Voltage
Pentium-P5 (first generation)	60–66	4	273	+5V
Pentium-P54C (second generation)	75–200	5 or 7	296	+3.3V
Pentium-P55C (third generation)	166–233	7	321	+2.8V
Pentium Pro	150–200	8	387	+3V
Pentium II	233–450	SECC	N/A	+2.0V–+2.8V
Pentium III	450–1130	SECC2 or Socket 370	370	+2.0V
Pentium 4	1300–3000 (at this writing)	Socket 423 or Socket 478	423 or 478	+1.53V–+1.75V

INTEL CLONES AND OTHERS

Intel *clones* are processors that are based on the *x*86 architecture and are produced by other vendors; the most notable is AMD. AMD's competitor to the Pentium II is the K6. The original K6 ran at between 166MHz and 300MHz. The K6-2, at 266MHz to 475MHz, added 3DNow! Technology for improved multimedia. The K6-3, at 400MHz to 450MHz, adds a full-speed L2 cache. Because all the K6 chips are PGA, whereas Pentiums are SECC, you need a special motherboard for the K6 chips designed specifically for them.

AMD's competitor to the Pentium III is the Athlon. It uses an SECC-style slot called Slot A that is physically the same but not pin-compatible with Intel-style Slot 1 SECC. AMD also has a low-budget version called the Duron that has less L2 cache.

Memory

To pass the A+ exam and be a productive computer technician, you must be familiar with memory. Not only will you be tested on this subject, but one of the most common upgrades performed on a PC is adding memory. Adding memory is a simple task, but before you can add memory you must have the correct type. When we say *memory*, we are most often referring to Random Access Memory (RAM). However, there are other types of memory. We'll discuss them all in this section. Be familiar with the various types and their usage.

Physical Memory

Physically, memory is a collection of integrated circuits that store data and program information as patterns of 1s and 0s (on and off states) in the chip. Most memory chips require constant power (also called a constant *refresh*) to maintain those patterns of 1s and 0s. If power is lost, all those tiny switches revert back to the off position, effectively erasing the data from memory. Some memory types, however, don't require a refresh.

There are many types of RAM. In this section, we examine each type in detail.

SRAM

Static RAM (SRAM) stores whatever is placed in it until it's changed. Unlike dynamic RAM (DRAM), it doesn't require constant electrical refreshing. Another name for it is nonvolatile RAM (NVRAM). It's expensive, so it isn't typically used for the main memory in a system.

DRAM

DRAM is an improvement over SRAM. DRAM uses a different approach to storing the 1s and 0s. Instead of using transistors, DRAM stores information as charges in very small capacitors. If a charge exists in a capacitor, it's interpreted as a 1. The absence of a charge is interpreted as a 0.

Because DRAM uses capacitors instead of switches, it needs to use a constant refresh signal to keep the information in memory. DRAM requires more power than SRAM for refresh signals and, therefore, is mostly found in desktop computers.

DRAM technology allows several memory units, called *cells*, to be packed to a high density. Therefore, these chips can hold very large amounts of information. Most PCs today use DRAM of one type or another.

Let's take a brief look at some of the different types of DRAM:

Fast page mode (FPM) An older type of RAM (almost always 72-pin SIMM packaging) that isn't synchronized in speed with the motherboard. It's rated in nanoseconds of delay, with lower numbers being better (for example, 60ns). FPM is now obsolete.

Extended data out (EDO) Like FPM, an older type of RAM, usually in 72-pin SIMM form. It performs a bit better than normal FPM RAM because it needs to be refreshed less frequently. Like FPM, it's now obsolete.

Synchronous DRAM (SDRAM) Synchronized to the speed of the motherboard's system bus. Synchronizing the speed of the systems prevents the address bus from having to wait for the memory because of different clock speeds. SDRAM typically comes in the form of 168-pin DIMMs or 184-pin RIMMs.

Double data rate (DDR) SDRAM/DDR2 Essentially, clock-doubled SDRAM. The memory chip can perform reads and writes on both sides of any clock cycle (the up, or start, and the down, or ending), thus doubling the effective memory executions per second. So, if you're using DDR SDRAM with a 100MHz memory bus, the memory will execute reads and writes at 200MHz and transfer the data to the processor at 100MHz. The advantage of DDR over regular SDRAM is increased throughput and thus increased overall system speed.

The next generation of DDR SDRAM is DDR2 (double data rate 2). This allows for two accesses per clock cycle and effectively doubles the speed of the memory.

RAMBUS A relatively new and extremely fast (up to 800MHz) technology that uses, for the most part, a new methodology in memory system design. RAMBUS (also known as direct Rambus) is a memory bus that transfers data at 800MHz. RAMBUS memory models (often called Rambus inline memory modules [RIMMs]), like DDR SDRAM, can transfer data on both the rising and falling edges of a clock cycle. That feature, combined with the 16-bit bus for efficient transfer of data, results in the ultra-high memory transfer rate (800MHz) and the high bandwidth of up to 1.6GBps.

Memory Chip Package Types

Memory chips come in many different types of packages. The ones most frequently encountered are discussed in the following sections.

DUAL INLINE PACKAGE (DIP)

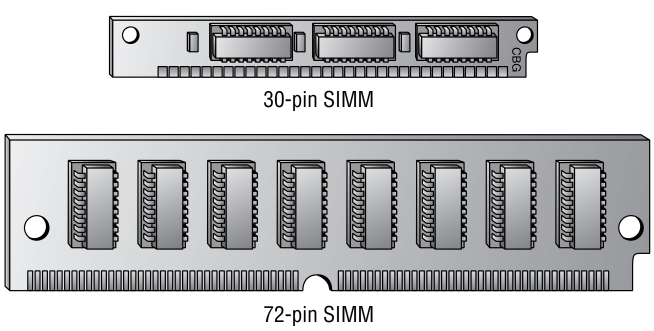
Dual inline package (DIP) memory is so named because the individual RAM chips use the DIP-style package for the memory module. Older computers, such as the IBM AT, arranged these small chips like rows of caskets in a small memory "graveyard." This type of memory has long been obsolete.

SIMMS

Single inline memory modules (SIMMs) were developed because DIPs took up too much real estate on the logic board. Someone got the idea to put several DIP chips on a small circuit board and then make that board easily removable.

Each of these RAM circuit boards is a *stick* of RAM. There are two sizes of SIMMs: 30-pin and 72-pin. The 30-pin are older, 8-bit sticks. The 72-pin are 32-bit sticks. Figure 1.10 shows one of each. SIMMs are called *single* because they're single-sided. When you count the number of pins (the metal tabs) along the bottom, there are 30 or 72 of them. In contrast, DIMMs (dual inline memory modules) are double-sided; for example, a 168-pin DIMM has 84 pins on each side.

FIGURE 1.10 Single inline memory modules (SIMMs)



DIMMS AND RIMMS

DIMMs are double-sided memory chips used in modern systems (Pentium and higher). They typically have 168 pins and are 64 bits in width. Figure 1.11 shows a DIMM.

A RIMM is just like a DIMM, except it's a Rambus DRAM stick, has 184 pins, and is slightly longer in size.

SODIMMS AND MICRODIMMS

Portable computers (notebooks and subnotebooks) require smaller sticks of RAM because of their smaller size. Two types are small outline DIMM (SoDIMM) and MicroDIMM.

Parity and Nonparity RAM

Some sticks of RAM have a parity bit on them for error correction. The parity bit works by adding up the number of 1s in a particular row of data in RAM (for example, 32-bit RAM has 32 individual binary digits). It then adds either 1 or 0 to that total to make it come out even. When retrieving the data from RAM, it re-adds the 1s again, and if the parity bit doesn't come out the same, it knows an error has occurred.

You can identify a parity SIMM by counting the number of chips on the stick. If there are nine, it's parity RAM. If there are eight, it's nonparity.

When do you choose parity RAM? Usually the motherboard requires either parity or non-parity; a few motherboards will accept either. Nowadays parity RAM is rarely needed because advances in RAM technology have created reliable RAM that seldom makes errors.

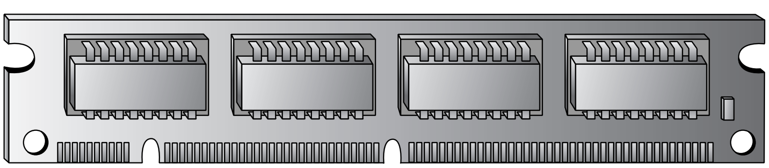
One type of parity RAM is error correction code (ECC). This is a now-obsolete type of parity RAM. Most RAM today is non-ECC.

RAM Banks and Bit Width

As explained earlier, 30-pin SIMMs are 8-bit, 72-pin SIMMs are 32-bit, and DIMMs are 64-bit. The motherboard has an address bus that carries data from the RAM to the CPU and chipset. It has a certain width. On Pentium and higher systems, it's 64-bit; on earlier systems, it's 32-bit (386 and 486) or less (286 and below). A bank of RAM is a single stick or a group of sticks where the collective bit width adds up to the width of the address bus.

For example, on a Pentium motherboard, a single bank consists of a single 64-bit DIMM or a pair of two 32-bit SIMMs. For a 486 motherboard, a single bank is a single 32-bit SIMM or four 8-bit SIMMs.

FIGURE 1.11 Dual inline memory module (DIMM)



Video RAM

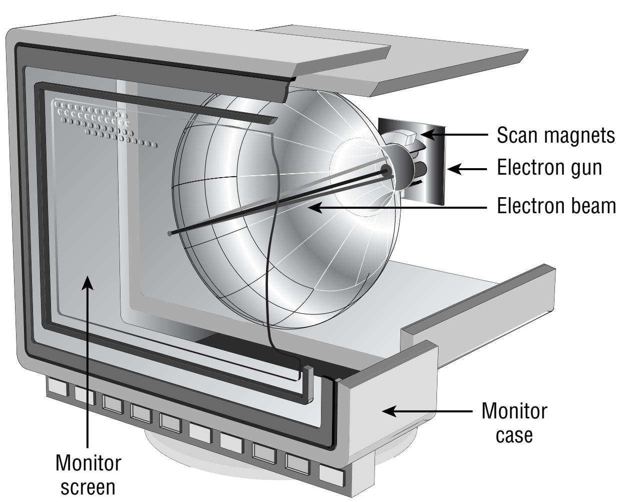
Video memory (also called *video RAM [VRAM]*) is used to store image data for processing by the video adapter. The more video memory an adapter has, the better the quality of image that it can display. Also, more VRAM allows the adapter to display a higher resolution of image.

Display Devices

Display systems convert computer signals into text and pictures and display them on a television-like screen. Several different types of computer displays are used today, including the TV. All of them use either the same *cathode ray tube* (*CRT*) technology found in television sets or the *liquid crystal display* (*LCD*) technology found on all laptop, notebook, and palmtop computers.

In a CRT, a device called an *electron gun* shoots electrons toward the back of the monitor screen (see Figure 1.12). The back of the screen is coated with special chemicals (called *phosphors*) that glow when electrons strike them. This beam of electrons scans the monitor from left to right and top to bottom to create the image.

FIGURE 1.12 How a CRT monitor works



There are two ways of measuring a monitor's image quality: dot pitch and refresh (scan) rate. A monitor's *dot pitch* is the distance between two dots of the same color on the monitor. Usually given in fractions of a millimeter (mm), it tells how sharp the picture is. The lower the number, the closer together the pixels are, and thus the sharper the image. An average dot pitch is 0.28mm.

A monitor's *refresh rate* specifies how many times in one second the scanning beam of electrons redraws the screen. The phosphors stay bright for only a fraction of a second, so they must constantly be hit with electrons to stay lit. Given in draws per second, or hertz (Hz), the refresh rate specifies how much energy is being put into keeping the screen lit. Most people notice a flicker in the display at refresh rates of 75Hz or lower because the phosphors begin to decay to black before they're revived; increasing the refresh rate can help reduce eyestrain by reducing the flickering.

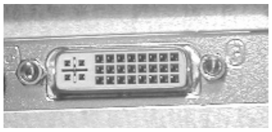
The *resolution* of a monitor is the number of horizontal and vertical pixels that are displayed. Most monitors allow for two or more resolutions, and you can pick the one to use in the desktop settings of the operating system. The vertical hold (V-hold) settings can be tweaked to make the image appear properly in the monitor. Connectors commonly used to connect the display device include the following:

VGA This is the traditional connector, which is shaped like a D and has three rows of five pins each, for a total of 15 pins. This is also often called the DB-15 connector.

NOTE: A 9-pin VGA connector does exist, but it's very uncommon.

Digital video interface (DVI) There are several types of DVI pin configurations, but all connectors are D-shaped. The wiring differs based on whether the connector is single linked or dual linked (extra pins are used for the dual link). DVI differs from everything else in that it includes both digital and analog signals at the same time, which makes it popular for LCD and plasma TVs. Figure 1.13 shows a DVI connector.

FIGURE 1.13 One of several possible DVI connectors



High definition multimedia interface (HDMi) These connectors are used to connect compatible digital items (DVD players, for example). The Type A connector has 19 pins and is backward compatible with DVI. Type B connectors have 29 pins and aren't backward compatible with DVI, but they support greater resolutions.

S-Video The S-Video connector looks much like a PS/2 connector, except that it has four conductors. These are also known as Y/C connectors; they break the signal into two components (luminance and chrominance) instead of carrying them in a single signal.

Component/RGB Component connectors are similar to what you use to connect video recorders and other items to televisions. They have RCA jacks and use red, green, and blue signals.

Liquid Crystal Displays

Two major types of LCDs are used in laptops today: *active matrix* screens and *passive matrix* screens. Their main differences lie in the quality of the image. Both types use some kind of lighting behind the LCD panel to make the screen easier to view.

Passive matrix A passive matrix screen uses a row of transistors across the top of the screen and a column of them down the side. It sends pulses to each pixel at the intersections of each row and column combination, telling it what to display.

Passive matrix displays are becoming obsolete because they're less bright and have poorer refresh rates and image quality than active matrix displays. However, they use less power than active matrix displays do.

Active matrix An active matrix screen uses a separate transistor for each individual pixel in the display, resulting in higher refresh rates and brighter display quality. These screens use more power, however, because of the increased number of transistors that must be powered. Almost all notebook PCs today use active matrix. A variant called thin-film transistor (TFT) uses multiple transistors per pixel, resulting in even better display quality.

Display System Problems

There are two types of video problems: no video and bad video. *No video* means no image appears on the screen when the computer is powered up. *Bad video* means the quality is substandard for the type of display system being used.

NO VIDEO

Any number of things can cause a blank screen. The first three are the most common: the power is off, the monitor's cable is unplugged, or the contrast or brightness is turned down.

If you've checked the power as well as the brightness and contrast settings, then the problem could be a bad video card or a bad monitor. Most monitors these days display a *Working* message briefly when you turn them on, so you can ascertain that the monitor is working and that an amber light appears on the front. When the PC starts up, the light on the front of the monitor changes from amber to green, indicating that the monitor is receiving a signal.

If the monitor is working but not receiving a signal from the PC, the video card may be bad. However, no video can also mean a problem with the motherboard, RAM, or CPU, so it isn't a given that the video card is at fault when no video appears.

Malfunctioning monitors are usually not worth fixing, because the cost of the labor involved exceeds the cost of a brand-new monitor. In addition, it may be difficult to find a technician to work on a monitor, because it isn't part of most standard PC technician training programs (due to the risk of electric shock from the high-voltage capacitor inside the monitor).

BAD VIDEO

A monitor that doesn't display one of the three basic colors (red, green, or blue) probably has a bad cable, a bent or broken pin, or a loose connection at either the PC or the monitor. This is the case because different pins on the connectors—and wires in the cable—control different colors.

Color problems may also result from the monitor being out of adjustment. With most new monitors, this is an easy problem to fix. Old monitors had to be partially disassembled to change these settings; new monitors have push-button control panels for changing these settings.

Exposure to a magnetic field can cause swirls and fuzziness even in high-quality monitors. The Earth generates magnetic fields, as do unshielded speakers and power surges. Most monitors have metal shields that can protect against magnetic fields. But eventually these shields can become polluted by taking on the same magnetic field as the Earth, so they becomes useless. To solve this problem, these monitors have a built-in feature known as *Degauss*; it removes the effects of the magnetic field by creating a stronger magnetic field with opposite polarity that gradually fades to a field of zero. A special Degauss button or feature in the monitor's on-screen software activates it. You need only press it when the picture starts to deteriorate. The image will shake momentarily during the Degauss cycle and then return to normal.

TIP If you have a monitor that shows bad distortion, and changing the settings or Degaussing has no effect, then look for magnetic interference caused by nearby florescent lights or large power sources.

Input Devices

A virtually unlimited number of types of input devices can be connected to a PC. In addition to the standard keyboard and mouse, there are bar-code readers, digital cameras, microphones, biometric devices, touch screens, and a plethora of others. Many today connect through the USB or FireWire port, using instructions from the vendor. However, you must know about other types of connections for the A+ exam.

Keyboard connectors allow for the direct connection of the keyboard to the motherboard. There are now essentially three types of keyboard connectors: AT, PS/2, and USB.

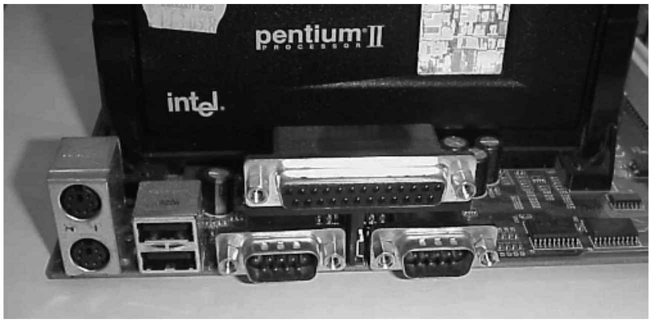
AT connectors are round, about 1/2 inch in diameter, and have five sockets in the DIN-5 configuration. They're found on AT motherboards. The second style, PS/2 connectors, are smaller and look just like a PS/2 mouse connector; these are found on ATX motherboards. USB keyboards are rapidly growing in popularity and allow you to connect to any available USB port (front, back, side, etc.).

A mouse connector is a PS/2-style connector; on an ATX it's built into the side of the motherboard, and on an AT a small ribbon cable connects a back-mountable port to the motherboard.

Peripheral Ports and Connectors

PCs were developed to perform calculations on data. In order for the PC to be useful, there must be a way to get the data into and out of the computer. To accomplish this, several ports are available. The four most common types of ports are the serial, parallel, USB, and game ports. Figure 1.14 shows some typical ports built into an ATX motherboard.

FIGURE 1.14 Built-in ports on a motherboard



These ports are connected to the motherboard using small ribbon cables on an AT system, or they're built directly into the side of the motherboard on an ATX system.

Adapter Cards

Adapter cards are also known by many other names, including *circuit boards/cards* and *expansion boards/cards*. In all cases, adapter cards are circuit boards that fit into expansion slots in the motherboard. They can include modems, network interface cards, sound cards, and many other types of devices.

Adapter cards are purchased to match an available expansion slot in the motherboard. PCI is the most common type of expansion slot for an adapter card in today's PCs. ISA slots are nearly obsolete, and AGP slots are used only for video cards.

Expansion slots are used to install various devices in the computer to expand its capabilities. Some expansion devices that may be installed in these slots include video, network, sound, and disk interface cards.

Expansion slots come in three main types: ISA, PCI, and AGP. Each type is different in appearance and function, as you'll learn in future chapters. You should be able to visually identify the different expansion slots on the motherboard:

ISA expansion slots If you're repairing a computer made before 1997, chances are the motherboard in your computer has a few ISA slots. These slots are usually brown and are separated into two unequal lengths. Computers made after 1997 generally include a few ISA slots for backward compatibility with old expansion cards.

PCI expansion slots Most computers made today contain primarily PCI slots. They're easily recognizable, because they're short (around 3 inches long) and are usually white. PCI slots can usually be found in any computer that has a Pentium-class processor or higher.

AGP expansion slots AGP slots are becoming more popular. In the past, if you wanted to use a high-speed, accelerated 3D graphics video card, you had to install the card into an existing PCI or ISA slot. AGP slots were designed to be a direct connection between the video circuitry and the PC's memory. They're also easily recognizable because they're usually brown and located right next to the PCI slots on the motherboard. Figure 1.15 shows an example of an AGP slot, along with a PCI slot for comparison. Notice the difference in length between the two.

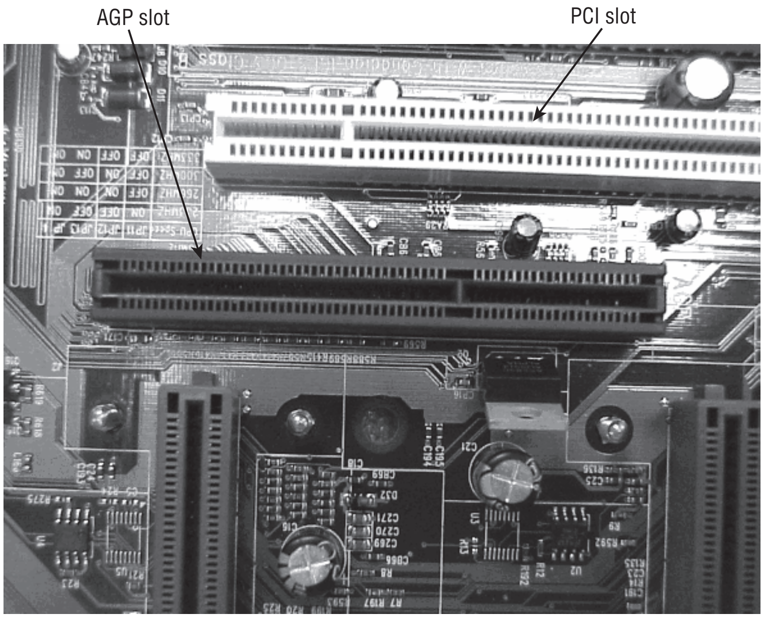
PCIE expansion slots PCIE combines the functionality of PCI with AGP and was discussed earlier in this chapter.

Ports and Cables

A computer's peripheral ports are the physical connectors found outside the computer. Cables of various types are designed to plug into these ports and create a connection between the PC and the external devices that may be attached to it. A successful IT technician should have an in-depth knowledge of ports and cables.

Because the peripheral components need to be upgraded frequently, either to keep pace with technological change or to replace broken devices, the test requires a well-rounded familiarity with the ports and their associated cabling.

FIGURE 1.15 An AGP slot compared to a PCI slot



Unless a peripheral device connects directly to the motherboard, it must use a port. Ports can be distinguished from one another by three factors:

Bits of data simultaneously conveyed A s*erial cable* carries only one bit at a time. A *parallel cable* carries multiple bits at a time (usually eight).

Data transmission speed This is expressed in kilobits or megabits per second and refers to the overall data throughput.

Type of connector A wide variety of connectors are used in PCs today, including the DB-style (as with legacy parallel and serial ports and VGA monitors), Centronics style (as with printers and some SCSI devices), and USB.

Parallel vs. Serial

A cable (and its port) can be either parallel or serial, and it isn't always immediately obvious from looking which is which. For example, both parallel and serial cables can use the DB-25 style of connector.

Both parallel and serial cables have multiple wires inside them, but they use them for different purposes. A parallel cable uses eight wires to carry bits of data in each direction, plus extra wires for signaling and traffic control. A serial cable uses only one wire to carry data in each direction; all the rest of its wires are for signaling and traffic control.

Transmission Speed

Neither parallel nor serial is intrinsically faster than the other. There are both fast and slow parallel and serial connections. For example, a legacy serial port such as for an external modem carries data fairly slowly (about 115Kbps), but a USB cable (also serial) carries data very quickly (up to 12Mbps for USB 1.1, and even faster for USB 2.0).

Connector Types

The following are common connector types:

DB A D-shaped connector with a metal ring around a set of pins. Named for the number of pins/holes used: DB-25, DB-9, DB-15, and so on. Can be either parallel or serial. Common uses: VGA video, legacy serial devices such as external modems, and parallel printer cables (the connector on the PC only; the printer end uses Centronics).

RJ Registered jack; a plastic plug with small metal tabs, like a telephone cord plug. Numbering is used in the naming: RJ-11 has two metal tabs, and RJ-14 has four. Both are used for telephone systems. RJ-45 has eight tabs and is used for Ethernet 10BaseT/100BaseT networking. Always serial.

BNC Stands for Bayonet-Neill Connector or British Naval Connector. A metal wire surrounded by shielding, like a cable television connector. Used for 10Base2 Ethernet networking. Always serial.

Centronics A plastic block with metal tabs flat against it, surrounded by a D-shaped metal ring. Used to connect a parallel printer cable to the printer, and also for some SCSI devices. Always parallel.

Ribbon connector A rectangular block consisting of a set of square holes that connect to pins on a circuit board. Used to connect floppy drives, IDE drives, and some SCSI devices to their controllers. Always parallel.

PS/2 (mini-DIN) A round connector with six small pins inside, commonly used to connect keyboards on ATX motherboards or PS/2 style mice.

DIN A larger round connector with five rather large pins inside, used for connecting the keyboard on an AT motherboard.

USB A flat rectangular connector, used with USB interfaces.

Cabling

Cables are used to connect two or more entities together. They're usually constructed of several wires encased in a rubberized outer coating. The wires are soldered to modular connectors at both ends. These connectors allow the cables to be quickly attached to the devices they connect.

Cables may be either shielded or unshielded. This refers to shielding against electromagnetic interference (EMI); it has nothing to do with whether the cable is shielded against dirt or water.

A list of common cable types used in PCs, their descriptions, their maximum effective lengths, and their most common uses is given in Table 1.7. The F or M in a connector's designation is for female (holes) or male (pins).

TABLE 1.7 Common PC Cable Descriptions

Application	1st Connector	2nd Connector	Max. Length
Null modem	DB-9F	DB-9F	25 feet
Null modem	DB-25F	DB-25F	25 feet
RS-232 (modem cable)	DB-9F	DB-25M	25 feet
RS-232 (modem cable)	DB-25F	DB-25M	25 feet
Parallel printer	DB-25M	Centronics 36M	10 feet
External SCSI cable	Centronics 50M	Centronics 50M	10 feet (total SCSI bus length)
VGA extension cable	DB-15M	DB-15M	3 feet
UTP Ethernet cable	RJ-45M	RJ-45M	100 meters
Thinnet Ethernet cable	BNC-M	BNC-M	100 meters
Telephone wall cable	RJ-11M or RJ-14M	RJ-11M or RJ-14M	N/A

One cable that deserves special mention is the null modem cable. It allows two computers to communicate with each other without using a modem. This cable has its transmit and receive wires crossed at both ends, so when one entity transmits on its TD line, the other entity receives it on its RD line.

Unshielded twisted pair (UTP) is the most common type of cable used for network cabling. There are various categories of network cabling; the category required for 10BaseT/100BaseT networking is Category 5, often shortened to Cat 5. There is also a Cat 5e cable type, which is used for higher-speed Ethernet such as Gigabit Ethernet.

Cooling Systems

The cooling system consists of the fan in the power supply, the fan or heat sink on the CPU, and any additional heat sinks or fans in the case. If a system is inadequately cooled, lockups and spontaneous reboots may occur.

Liquid-cooled cases are now available that use circulating water rather than fans to keep components cool. These cases are typically more expensive than standard ones and may be more difficult for an untrained technician to work on, but they result in an almost completely silent system.

Air cooling is the most common cooling method used in PCs. CPUs typically have *active heat sinks*, which are heat sinks that include an electric fan that constantly channels heat away.

A CPU that is running too hot may benefit from a better cooling fan. The heat sink portion is a block of spikes that channel heat away from the CPU.

Most *passive heat sinks* (that is, heat sinks that don't include a fan) are attached to the CPU using a glue-like thermal compound. This makes the connection between the heat sink and the CPU more seamless and direct. Thermal compound can be used on active heat sinks too, but generally it isn't because of the possibility that the fan may stop working and need to be replaced.

In addition to the main fan in the power supply, you can also install additional cooling fans in a case to help circulate air through the case.

Exam Essentials

Know what the BIOS does. This is a ROM chip on the motherboard. It contains the BIOS software that tells the processor how to interact with the hardware in the computer. The BIOS chip tells the motherboard how to start up, check itself and its components, and pass off control to the operating system.

Know the different types of memory. DRAM is dynamic random access memory. SRAM is static random access memory. ROM stands for read-only memory, and it's normally used to store the computer's BIOS. CMOS is a special kind of memory that holds the BIOS configuration settings.

Know the CPU package types. Pin grid array (PGA) is a square or rectangular ceramic chip with pins in the bottom. Single edge contact cartridge (SECC) is a plastic cartridge that fits into a slot in the motherboard.

Know what RJ-45 connectors are used for. You're likely to be asked what type of connector would be used to attach a network connector to a wall jack.

Know what PS2/mini-DIN connectors are used for. You're likely to be asked what type of connector would be used to connect a keyboard or mouse to the back of a PC.

Know what RJ-11 connectors are used for. You're likely to be asked what type of connector would be used to connect a modem to a telephone jack.

Understand parallel versus serial. Parallel cables carry data eight bits at a time; serial cables carry it one bit at a time.

Understand the differences between PCI, ISA, and AGP. Know the bus widths and speeds, and be able to select the best bus type for a given device.

Know what factors go into making memory compatible with a PC. These factors can include physical size, capacity, technology, speed, and compatibility with existing RAM in the system.

Be able to calculate the wattage requirements of power supplies. Given the voltage and amperage draws for a group of devices, determine the wattage of a power supply required to support them.

Understand the processor's job. The processor is the brain of the PC. Most actions performed by the PC require use of the processor to accomplish their task.

Understand the differences between the classes of Pentium chips. The Intel Pentium has gone through several changes since its release. You'll need to understand the differences between the various classes in terms of their physical packaging, speeds, voltages, and caches.

Know what a VRM is. A voltage regulator module (VRM) on a motherboard allows it to change the voltage that it provides to the CPU to accommodate a wider range of CPUs.

Know the differences between RAM types. Make sure you can differentiate between all the acronyms, such as SRAM, DRAM, SDRAM, DDR SDRAM, EDO DRAM, and so on.

Understand the different RAM packaging. Be able to differentiate between SIMMs and DIMMs, including the number of pins each has and their bit widths.

Know the purpose of parity in RAM. Understand how a parity bit is used for error correction.

Know the motherboard form factors. Understand the differences between AT, ATX, and NLX.

Distinguish between ISA, PCI, and AGP. Know their bus widths and maximum speeds, and that they're all used for expansion boards inside the PC.

Distinguish between I/O ports on a motherboard. Know the different types of ports, such as USB, IEEE 1394, legacy parallel, and legacy serial.

Know the sizes and shapes of CPU slots/sockets. Be able to specify what type of socket or slot various CPUs require.

Know what the CMOS Setup utility does. The CMOS Setup utility allows you to configure the characteristics of certain portions of the PC.

Be familiar with the common menu items listed. Knowing these common menu items and their function can greatly aid troubleshooting.

Understand the different printer port settings. Although there is no good rule of thumb on which of these settings will fix a communication error, in most cases you can resolve the issue by systematically trying the different settings.

Install, Configure, and Optimize PC Components

Knowing about personal computer components is only part of the requirements for this exam. You must also know how to install, configure, and optimize them. The components in question for this part of the exam are storage devices (internal and external), display devices, and input/multimedia devices.

Critical Information

To know how to interact with the components in question, you must understand something about system modules not already covered, as well as IDE and SCSI. Although these two acronyms popped up on occasion earlier, we didn't dwell on them because it wouldn't have done them justice to discuss them in only a sentence or two.

This section looks at some system modules that didn't fit in to the discussion earlier, as well as the differences between IDE and SCSI, and focuses on these two technologies.

NOTE There is a great deal of overlap between this objective and its counterpart in Chapter 9. You're strongly encouraged to read Chapter 9 (this domain is a requirement on every technician exam) as you study for this part of the exam.

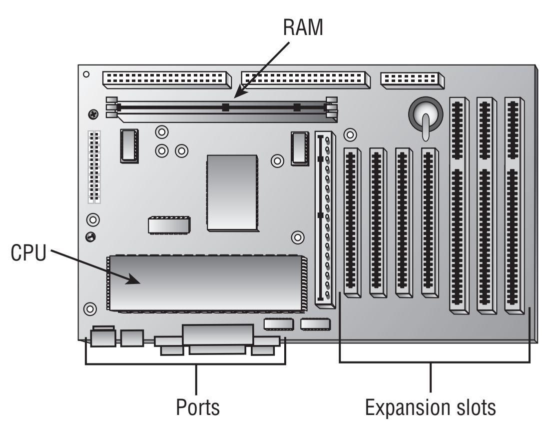
Concepts and Modules

The system modules described in this section are either essential computer components or available on the market as optional equipment. Each has a distinct and practical function. To troubleshoot and repair computers, you must be familiar with the components and their function when operating. Each component provides a specific function to the operation of the computer.

System Board

The spine of the computer is the *system board*, or *motherboard*. This component is made of green or brown fiberglass and is placed in the bottom or side of the case. It's the most important component in the computer because it connects all the other components of a PC together. Figure 1.16 shows a typical PC system board, as seen from above. On the system board you'll find the CPU, underlying circuitry, expansion slots, video components, RAM slots, and a variety of other chips.

FIGURE 1.16 A typical system board



INTEGRATED COMPONENTS

Some motherboards have some of the peripheral devices built in, such as video, sound, and/or networking. These are referred to as *integrated system boards*. Such boards are cost-effective because they don't require a separate video card, sound card, and so on. The built-in components can be disabled through BIOS Setup if they should ever malfunction or need to be replaced by newer models.

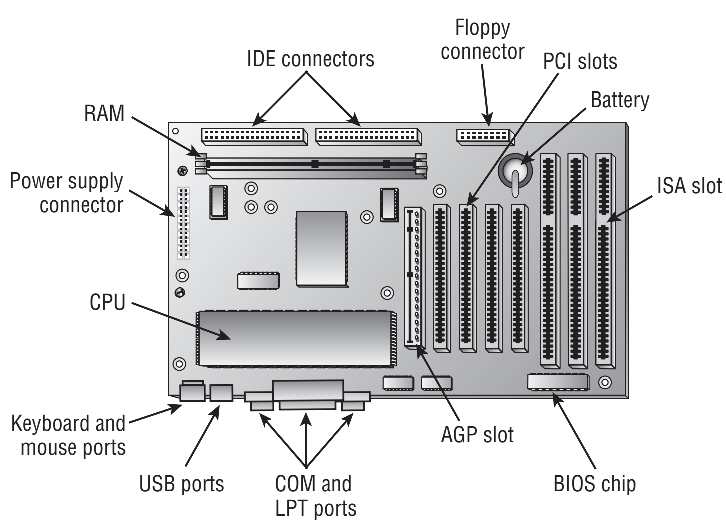
SYSTEM BOARD COMPONENTS

Motherboards include components that provide basic functionality to the computer. The following components are found on a typical motherboard:

- Expansion slots
- Memory (RAM) slots
- CPU slot or socket
- Power connector
- Floppy and IDE drive connectors
- Keyboard and mouse connectors
- Peripheral port connectors (COM, LPT, USB)
- BIOS chip
- Battery

Figure 1.17 illustrates many of the components found on a typical motherboard.

FIGURE 1.17 Components on a motherboard

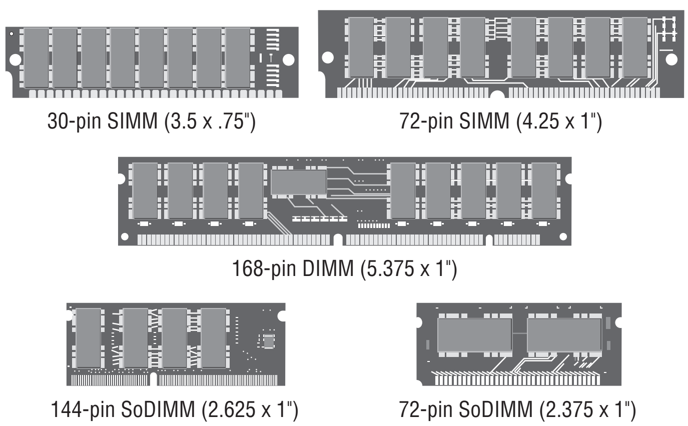


Many of these components were discussed previously. Those that were not include the following:

Memory slots Memory, or RAM, slots contain the memory chips. There are many and varied types of memory for PCs today. We'll further discuss memory later in this chapter. PCs use memory chips arranged on a small circuit board. These circuit boards are called *single inline memory modules* (*SIMMs*) or *dual inline memory modules* (*DIMMs*). DIMMs utilize memory chips on both sides of the circuit board, whereas SIMMs utilize memory chips on a single side. There is also a high-speed type of RAM called *Rambus dynamic RAM (RDRAM),* which comes on circuit boards called *RIMMs*.

Along with chip placement, memory modules also differ in the number of conductors, or pins, that the particular module uses. The number of pins used directly affects the overall size of the memory slot. Slot sizes include 30-pin, 72-pin, 168-pin, and 184-pin. Laptop memory comes in smaller form factors known as *small outline DIMMs* (*SoDIMMs*). Figure 1.18 shows the form factors for the most popular memory chips. Notice that they basically look the same, but the memory module sizes are different.

FIGURE 1.18 Various memory module form factors



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

Central processing unit (CPU) and processor slots The CPU slot permits the attachment of the CPU to the motherboard, allowing the CPU to use the other components of the system. There are many different types of processors, which means many types of CPU slots.

The CPU slot can take on several different forms. In the past, the CPU slot was a rectangular box called a PGA socket, with many small holes to accommodate the pins on the bottom of the chip. With the release of new and more-powerful chips, additional holes were added, changing the configuration of the slot and its designator or number. Figure 1.19 shows a typical PGA-type CPU socket.

With the release of the Pentium II, the architecture of the slot went from a rectangle to more of an expansion-slot style of interface called an SECC. This style of CPU slot includes Slot 1 and Slot 2 for Intel CPUs, and Slot A for Athlon (AMD) CPUs. This type of slot looks much like an expansion slot, but it's located in a different place on the motherboard than the other expansion slots.

To see which socket type is used for which processors, examine Table 1.8.

FIGURE 1.19 A PGA CPU socket

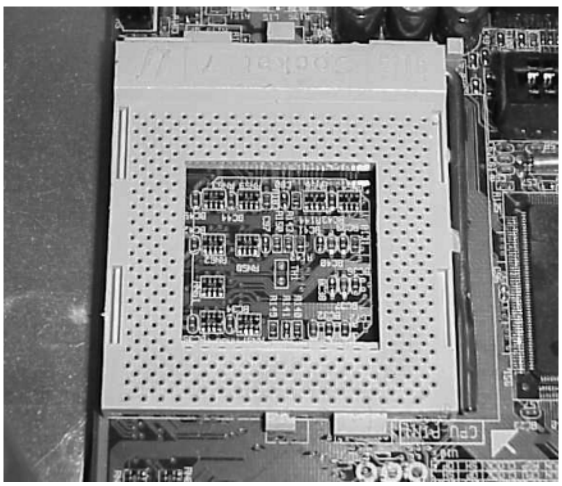


TABLE 1.8 Socket Types and the Processors They Support

Connector Type	Processor
Socket 1	486 SX/SX2, 486 DX/DX2, 486 DX4 Overdrive
Socket 2	486 SX/SX2, 486 DX/DX2, 486 DX4 Overdrive, 486 Pentium Overdrive
Socket 3	486 SX/SX2, 486 DX/DX2, 486 DX4 486 Pentium Overdrive
Socket 4	Pentium 60/66, Pentium 60/66 Overdrive
Socket 5	Pentium 75-133, Pentium 75+ Overdrive
Socket 6	DX4, 486 Pentium Overdrive
Socket 7	Pentium 75-200, Pentium 75+ Overdrive

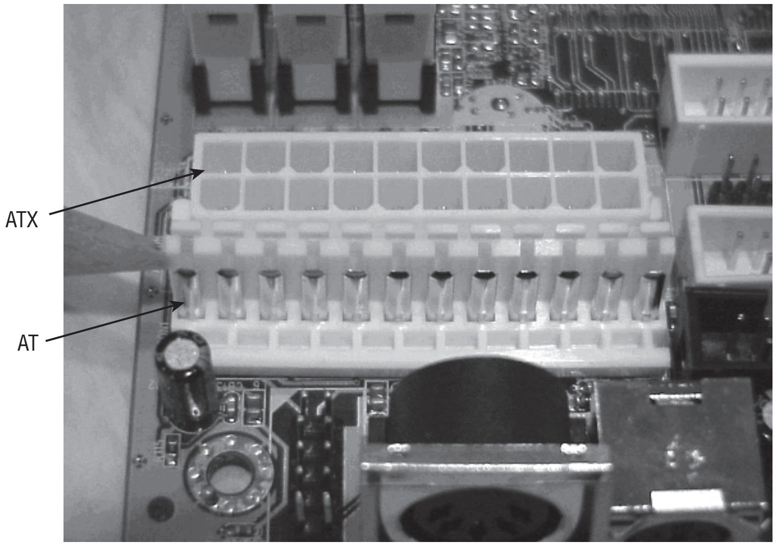
TABLE 1.8 Socket Types and the Processors They Support *(continued)*

Connector Type	Processor
Socket 8	Pentium Pro
Socket 370	Pentium III
Socket 423	Pentium 4
SECC (Type I), Slot 1	Pentium II
SECC2 (Type II), Slot 2	Pentium III
Slot A	Athlon

Power connectors A power connector allows the motherboard to be connected to the power supply. As you saw in Figures 1.4 and 1.5, the power supply connector is different for AT versus ATX systems. On an ATX, there is a single power connector consisting of a block of 20 holes (in two rows). On an AT, there is a block consisting of 12 pins sticking up; these pins are covered by two connectors with six holes each.

Figure 1.20 shows a very versatile motherboard that happens to have both kinds, so you can compare. The upper connector is for ATX, and the lower one is for AT.

FIGURE 1.20 Power connectors on a motherboard



On-board floppy and IDE connectors With the exception of diskless workstations, every PC made today uses some type of disk drive to store data and programs until they're needed. Disk drives need a connection to the motherboard in order for the computer to utilize the disk drive. These connections are known as *drive interfaces*. There are two primary types: *floppy drive interfaces* and *IDE interfaces*. Floppy drive interfaces allow floppy disk drives to be connected to the motherboard, and, similarly, IDE interfaces do the same for hard disks, CD drives, and other IDE-based drives. When you see them on the motherboard, these interfaces are said to be *on board*, as opposed to being on an expansion card, known as *off board*. The interfaces consist of circuitry and a port. A few motherboards also have SCSI interfaces that can be used for connecting drives.

Battery Your PC has to keep certain settings when it's turned off and its power cord is unplugged. These settings include the date, time, hard-drive configuration, and memory.

Your PC stores the settings in a special memory chip called the CMOS chip. To retain these settings, the CMOS chip requires power constantly. To prevent the CMOS chip from losing its charge, a small battery is located on the motherboard.

SYSTEM BOARD FORM FACTORS

Form factor refers to the size and shape of a component. Most system boards today use the ATX form factor (refer back to Figure 1.5). Some of its key features are its orientation of the expansion slots parallel to the narrow edge of the board, a one-piece power connector from the power supply, the built-in I/O ports on the side, and the orientation of the CPU in such a position that the power-supply fan helps to cool it.

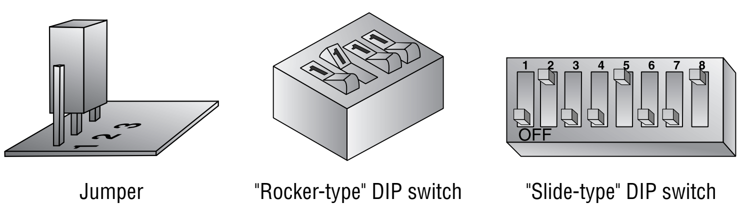
An older, alternative form factor for a system board is the baby AT style (refer back to Figure 1.4). This type uses a two-piece power supply connector, uses ribbon cables to connect ports to the board, and orients the expansion slots parallel to the wide edge of the board.

A case is generally designed to hold one or the other of these motherboard form factors, and a power supply is designed to work with one or the other; therefore those three components must be chosen as a group.

JUMPERS AND DIP SWITCHES

Jumpers and DIP switches are used to configure various hardware options on the motherboard. Processors use different voltages and multipliers to achieve their target voltage and frequency. You must set these parameters on the motherboard by changing the jumper or DIP-switch settings. Figure 1.21 shows a jumper and two types of DIP switches. Individual jumpers are often labeled with the moniker *JP*x (where *x* is the number of the jumper).

FIGURE 1.21 A jumper set and DIP switches



Cases

The *case* is the metal or plastic box in which the motherboard, power supply, disk drives, and other internal components are installed. A case is typically—but not always—purchased with a power supply already installed.

Choosing the right case for the motherboard is important. Recall from the preceding sections that motherboards come in two form factors: ATX and AT. Each requires a different style of case and a different type of power supply.

One case may also be distinguished from another in terms of its orientation. A desktop case lies with its widest side flat on the desk; a tower case stands up on end.

Finally, one case differs from another in terms of the number of drive bays it has. For example, within the broad category of *tower* cases are mini-towers (typically with two large and two small drive bays), mid-towers, and full towers (typically with four large and three small drive bays). However, there is little standardization of the number of drive bays that constitute a particular size; one manufacturer's full tower may have more or fewer bays than another's.

Although it isn't common, you may occasionally encounter a slim-line case, which is a desktop-orientation case that is shorter and thinner than a normal one—so short that normal expansion boards won't fit perpendicular to the motherboard. In such cases a *riser card* is installed, which sits perpendicular to the motherboard and contains expansion slots. The expansion cards can then be oriented parallel to the motherboard when installed.

IDE Devices

IDE drives are the most common type of hard drive found in computers. But IDE is much more than a hard drive interface; it's also a popular interface for many other drive types, including CD-ROM, DVD, and Zip. IDE drives are the most prevalent in the industry today. IDE drives are easy to install and configure, and they provide acceptable performance for most applications. Their ease of use relates to their most identifiable feature—the controller is located on the drive itself.

IDE TECHNOLOGIES

The design of the IDE is simple: Put the controller right on the drive, and use a relatively short ribbon cable to connect the drive/controller to the IDE interface. This offers the benefits of decreasing signal loss (thus increasing reliability) and making the drive easier to install. The IDE interface can be an expansion board, or it can be built into the motherboard, as is the case on almost all systems today.

IDE generically refers to any drive that has a built-in controller. The IDE we know today is more properly called AT IDE; two previous types of IDE (MCA IDE and XT IDE) are obsolete and incompatible with it.

There have been many revisions of the IDE standard over the years, and each one is designated with a certain AT attachment (ATA) number—ATA-1 through ATA-8. Drives that support ATA-2 and higher are generically referred to as enhanced IDE (EIDE).

With ATA-3, a technology called ATA Packet Interface (ATAPI) was introduced to help deal with IDE devices other than hard disks. ATAPI enables the BIOS to recognize an IDE CD-ROM drive, for example, or a tape backup or Zip drive.

Starting with ATA-4, a new technology was introduced called UltraDMA, supporting transfer modes of up to 33MBps.

ATA-5 supports UltraDMA/66, with transfer modes of up to 66MBps. To achieve this high rate, the drive must have a special 80-wire ribbon cable, and the motherboard or IDE controller card must support ATA-5.

ATA-6 supports UltraDMA/100, with transfer modes of up to 100MBps.

NOTE If an ATA-5 or ATA-6 drive is used with a normal 40-wire cable or is used on a system that doesn't support the higher modes, it reverts to the ATA-4 performance level.

ATA-7 supports UltraDMA/133, with transfer modes of up to 150MBps and serial ATA (discussed later).

ATA-8 made only minor revisions to ATA-7 and also supports UltraDMA/133, with transfer modes of up to 150MBps and serial ATA.

IDE PROS AND CONS

The primary benefit of IDE is that it's nearly universally supported. Almost every motherboard has IDE connectors. In addition, IDE devices are typically the cheapest and most readily available type.

A typical motherboard has two IDE connectors, and each connector can support up to two drives on the same cable. That means you're limited to four IDE devices per system unless you add an expansion board containing another IDE interface. In contrast, with SCSI you can have up to seven drives per interface (or even more on some types of SCSI).

Performance also may suffer when IDE devices share an interface. When you're burning CDs, for example, if the reading and writing CD drives are both on the same cable, errors may occur. SCSI drives are much more efficient with this type of transfer.

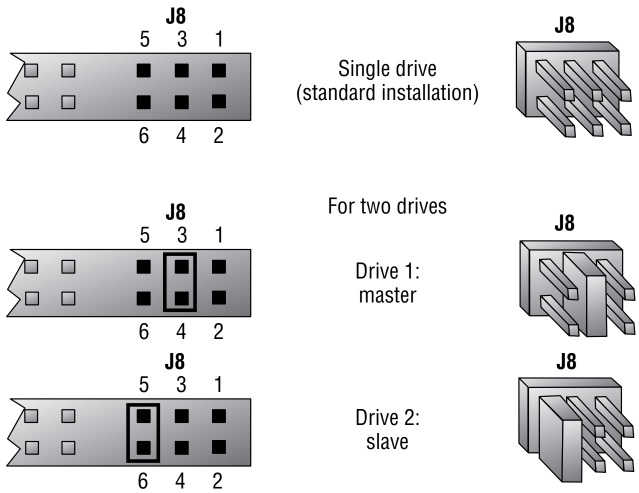
INSTALLATION AND CONFIGURATION

To install an IDE drive, do the following:

1. Set the master/slave jumper on the drive.
2. Install the drive in the drive bay.
3. Connect the power-supply cable.
4. Connect the ribbon cable to the drive and to the motherboard or IDE expansion board.
5. Configure the drive in BIOS Setup if it isn't automatically detected.
6. Partition and format the drive using the operating system.

Each IDE interface can have only one *master* drive on it. If there are two drives on a single cable, one of them must be the *slave* drive. This setting is accomplished via a jumper on the drive. Some drives have a separate setting for Single (that is, master with no slave) and Master (that is, master with a slave); others use the Master setting generically to refer to either case. Figure 1.22 shows a typical master/slave jumper scenario, but different drives may have different jumper positions to represent each state.

FIGURE 1.22 Master/slave jumpers



Most BIOS Setup programs today support Plug and Play, so they detect the new drive automatically at startup. If this doesn't work, the drive may not be installed correctly, the jumper settings may be wrong, or the BIOS Setup may have the IDE interface set to None rather than Auto. Enter BIOS Setup, and find out. Setting the IDE interface to Auto and then allowing the BIOS to detect the drive is usually all that is required.

In BIOS Setup for the drive, you might have the option of selecting a DMA or programmed input/output (PIO) setting for the drive. Both are methods for improving drive performance by allowing the drive to write directly to RAM, bypassing the CPU when possible. For modern drives that support UltraDMA, neither of these settings is necessary or desirable.

Now that your drive is installed, you can proceed to partition and format it for the operating system you've chosen. Then, finally, you can install your operating system of choice.

For a Windows 2000 or XP system, allow the Windows Setup program to partition and format the drive, or use the Disk Management utility in Windows to perform those tasks. To access Disk Management, from the Control Panel, choose Administrative Tools and then choose Computer Management.

SATA and PATA

Serial ATA (SATA) came out as a standard recently and was first adopted in desktops and then laptops. Whereas ATA had always been an interface that sends 16 bits at a time, SATA sends only one bit at a time. The benefit is that the cable used can be much smaller, and faster cycling can actually increase performance.

Parallel ATA (PATA) is the name retroactively given to the ATA/IDE standards when SATA became available. PATA uses a normal 40-pin connector, whereas SATA uses a 7-pin connector.

SCSI Devices

The *Small Computer System Interface* (*SCSI*) is a type of subsystem that is both highly flexible and robust. The range of devices that can use SCSI technology includes hard disk drives, scanners, tape drives, and CD-ROM drives. This is why it's so flexible, but also why its standards are so complex.

SCSI (pronounced "scuzzy") is a technology developed and standardized by the American National Standards Institute (ANSI). The standard specifies a universal, parallel, system-level interface for connecting up to eight devices (including the controller) on a single shared cable, called the *SCSI bus*. One of the many benefits of SCSI is that it's a very fast, flexible interface. You can buy a SCSI disk and install it in a Mac, a PC, or virtually any computer if a SCSI adapter is available.

SCSI is used for more than just drives. There are also SCSI scanners, tape backup units, and even printers.

SCSI CONNECTORS

SCSI devices can be either internal or external to the computer. Eight-bit SCSI-1 and SCSI-2 internal devices use a SCSI A cable, a 50-pin ribbon cable similar to that of an IDE drive. Sixteen-bit SCSI uses a SCSI P cable, with 68 wires and a DB-style connector. There is also an 80-pin internal connector called SCA used for some high-end SCSI devices.

External SCSI connectors depend on the type. SCSI-1 uses a 50-pin Centronics connector, as with a parallel printer. SCSI-2 uses a 25-, 50-, or 68-pin female DB-style connector. SCSI-3 uses a 68- or 80-pin female DB-style connector.

IDS AND TERMINATION

To configure SCSI, you must assign a unique device number (often called a *SCSI address*) to each device on the SCSI bus. These numbers are configured through either jumpers or DIP switches. When the computer needs to send data to the device, it sends a signal on the wire addressed to that number.

A device called a *terminator* (technically a *terminating resistor pack*) must be installed at both ends of the bus to keep the signals "on the bus." The device then responds with a signal that contains the device number that sent the information and the data itself. The terminator can be built into the device and activated/deactivated with a jumper, or it can be a separate block or connector hooked onto the device when termination is required.

Termination can be either active or passive. A *passive terminator* works with resistors driven by the small amount of electricity that travels through the SCSI bus. *Active termination* uses voltage regulators inside the terminator. Active termination is much better, and you should use it whenever you have fast, wide, or Ultra SCSI devices on the chain and/or more than two SCSI devices on the chain. It may not be obvious from looking at a terminator whether it's active or passive.

TYPES OF SCSI

The original implementation of SCSI was just called "SCSI" at its inception. However, as new implementations came out, the original was referred to as *SCSI-1*. This implementation is characterized by its 5Mbps transfer rate, its Centronics 50 or DB-25 female connectors, and its 8-bit bus width. SCSI-1 had some problems, however. Some devices wouldn't operate correctly when they were on the same SCSI bus as other devices. The main problem was that the ANSI SCSI standard was so new, vendors chose to implement it differently. These differences were the primary source of conflicts.

The first improvement that was designed into *SCSI-2* was a wider bus. The new specification specified both 8-bit and 16-bit buses. The larger of the two specifications is known as *Wide SCSI-2*. It improved data throughput for large data transfers. Another important change was to improve upon the now-limiting 5Mbps transfer rate. The *Fast SCSI-2* specification allowed for a 10Mbps transfer rate, thus allowing transfers twice as fast as SCSI-1. So, Wide SCSI-2 transfers data 16 bits at a time, and Fast SCSI-2 transfers data 8 bits at a time but twice as fast (at 10Mbps).

SCSI-3, also known as *Ultra SCSI*, comes in two widths: 8-bit (narrow) and 16-bit (wide), and three speeds: 20Mbps, 40Mbps, and 80Mbps. See Table 1.9.

TABLE 1.9 SCSI-3 Speeds

SCSI-3 Type	Narrow (8-Bit)	Wide (16-Bit)
Ultra 1	20MBps	40MBps
Ultra 2	40MBps	80MBps
Ultra 3	80MBps	160MBps

SCSI-3 also provides ways to increase the maximum distance for the chain. Standard SCSI is also known as single-ended (SE) SCSI, and it can go about 10 feet. Low-voltage differential (LVD) SCSI is a variant with higher speeds and longer maximum distances, up to 39 feet. LVD and SE can work together on the same chain, but all will revert to SE limitations in that case.

High-voltage differential (HVD) is a special type of SCSI incompatible with the other two types. It has a maximum distance of 82 feet and must have a special HVD terminator.

SCSI DEVICE INSTALLATION AND CONFIGURATION

Installing SCSI devices is more complex than installing an IDE drive. The main issues with installing SCSI devices are cabling, termination, and addressing.

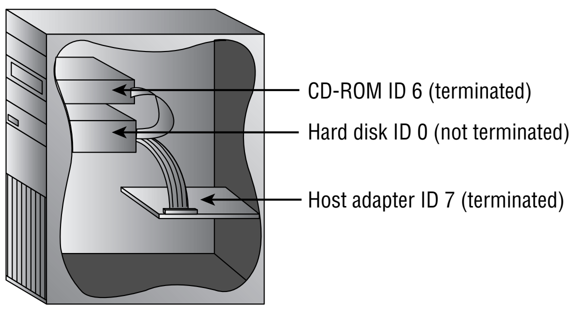
We'll discuss termination and cabling together because they're closely tied. There are two types of cabling:

- *Internal cabling* uses a 50-wire ribbon cable with several keyed connectors on them. These connectors are attached to the devices in the computer (the order is unimportant), with one connector connecting to the adapter.
- *External cabling* uses thick, shielded cables that run from adapter to device to device in a fashion known as *daisy-chaining*. Each device has two ports on it (most of the time). When hooking up external SCSI devices, you run a cable from the adapter to the first device. Then, you run a cable from the first device to the second device, from the second to the third, and so on.

Because there are two types of cabling devices, you have three ways to connect them. The methods differ by where the devices are located and whether the adapter has the terminator installed. The guide to remember here is that *both ends* of the bus must be terminated. Let's look briefly at the three connection methods:

Internal devices only When you have only internal SCSI devices, you connect the cable to the adapter and to every SCSI device in the computer. You then install the terminating resistors on the adapter and terminate the last drive in the chain. All other devices are unterminated. This is demonstrated in Figure 1.23.

FIGURE 1.23 Cabling internal SCSI devices only

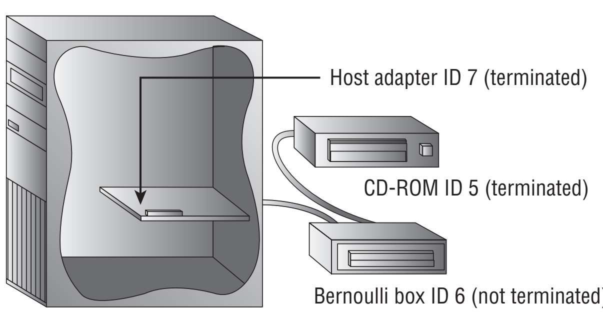


NOTE

Some devices and adapters don't use terminating resistor packs; instead, you use a jumper or DIP switch to activate or deactivate SCSI termination on such devices. Check the documentation to find out what type your device uses.

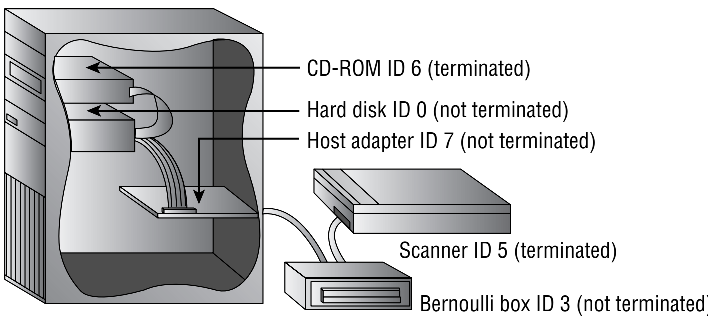
External devices only In the next situation, you have external devices only, as shown in Figure 1.24. By external devices, we mean that each has its own power supply. You connect the devices in the same manner in which you connected internal devices, but in this method you use several very short (less than 0.5 meters) *stub* cables to run between the devices in a daisy chain (rather than one long cable with several connectors). The effect is the same. The adapter and the last device in the chain (which has only one stub cable attached to it) must be terminated.

FIGURE 1.24 Cabling external SCSI devices only



Both internal and external devices Finally, there's the hybrid situation in which you have both internal and external devices (Figure 1.25). Most adapters have connectors for both internal and external SCSI devices—if yours doesn't have both, you'll need to see if anybody makes one that will work with your devices. For adapters that do have both types of connectors, you connect your internal devices to the ribbon cable and attach the cable to the adapter. Then, you daisy-chain your external devices off the external port. You terminate the last device on each chain, leaving the adapter unterminated.

FIGURE 1.25 Cabling internal and external SCSI devices together



NOTE: Even though the third technique described is the technically correct way to install termination for the hybrid situation (in which you have both internal and external devices), some adapter cards still need to have terminators installed.

Each device must also have a unique SCSI ID number. This number can be assigned by the jumper (with internal devices) or with a rotary switch (on external devices). You start by assigning your adapter an address. This can be any number from 0 to 7 on an 8-bit bus, 0 to 15 on a 16-bit bus, and 0 to 31 on a 32-bit bus, as long as no other device is using that ID.

Here are some recommendations that are commonly accepted by the PC community. Remember that these are guidelines, not rules:

- Generally speaking, give slower devices higher priority so they can access the bus whenever they need it. Lower numbers are higher priority.
- Set the bootable (or first) hard disk to ID 0.
- Set the CD-ROM to ID 3.

After the devices are cabled and terminated, you have to get the PC to recognize the SCSI adapter and its devices. The SCSI adapter manages all SCSI device resource allocation, so generally all that is required is to make sure the operating system is able to see the SCSI adapter. This involves installing a Windows driver for the adapter in Windows, for example, or a real-mode driver in `CONFIG.SYS` for MS-DOS.

However, if you want to boot from a SCSI drive, the system must be able to read from that drive in order to load the operating system; you must enable the SCSI adapter's own BIOS extension so that the PC can read from it at startup without a driver. Check the documentation for the adapter; sometimes the BIOS Setup program for the SCSI adapter is activated via a function key at startup.

Once the drive is installed and talking to the computer, you can high-level-format the media and install the operating system.

TIP

If there are problems, double-check the termination and ID numbers. If everything looks correct, try changing the ID numbers one at a time. SCSI addressing is a gray area where many problems arise.

RAID

RAID stands for Redundant Array of Independent Disks. It's a way of combining the storage power of more than one hard disk for a special purpose such as increased performance or fault tolerance. RAID is more commonly done with SCSI drives, but it can be done with IDE drives.

There are several types of RAID:

RAID 0 Also known as *disk striping*. This is technically not RAID, because it doesn't provide fault tolerance. Data is written across multiple drives, so one drive can be reading or writing while the next drive's read-write head is moving. This makes for faster data access. However, if any one of the drives fails, all content is lost.

RAID 1 Also known as *disk mirroring*. This is a method of producing fault tolerance by writing all data simultaneously to two separate drives. If one drive fails, the other contains all the data and can be switched to. However, disk mirroring doesn't help access speed, and the cost is double that of a single drive.

RAID 5 Combines the benefits of both RAID 0 and RAID 1. It uses a parity block distributed across all the drives in the array, in addition to striping the data across them. That way, if one drive fails, the parity information can be used to recover what was on the failed drive. A minimum of three drives is required.

TIP

RAID works the same with SCSI as it does with IDE drives.

Upgrading Storage Devices

There are three major topic areas beneath objective 1.2: storage devices, display devices, and input/multimedia devices. The information given thus far covers all you should need to know to work with storage devices.

Upgrading Display Devices

Before connecting or disconnecting a monitor, ensure that the power to both the PC and the monitor is off. Then, connect a VGA (DB-15) cable from the monitor to the PC's video card, and connect the monitor's power cord to an AC outlet.

Other than the power supply, one of the most dangerous components to try to repair is the monitor, or CRT monitor. We recommend that you *not* try to repair monitors. To avoid the extremely hazardous environment contained inside the monitor—it can retain a high-voltage charge for hours after it's been turned off—take it to a certified monitor technician or television repair shop. The repair shop or certified technician will know and understand the proper procedures to discharge the monitor, which involves attaching a resistor to the flyback transformer's charging capacitor to release the high-voltage electrical charge that builds up during use. They will also be able to determine whether the monitor can be repaired or needs to be replaced. Remember, the monitor works in its own extremely protective environment (the monitor case) and may not respond well to your desire to try to open it. The CRT is vacuum-sealed. Be extremely careful when handling it—if you break the glass, the CRT will implode, which can send glass in any direction.

Even though we recommend not repairing monitors, the A+ exam does test your knowledge of the safety practices to use when you need to do so. If you have to open a monitor, you must first discharge the high-voltage charge on it using a high-voltage probe. This probe has a very large needle, a gauge that indicates volts, and a wire with an alligator clip. Attach the alligator clip to a ground (usually the round pin on the power cord). Slip the probe needle under the high-voltage cup on the monitor. You'll see the gauge spike to around 15,000 volts and slowly reduce to zero. When it reaches zero, you may remove the high-voltage probe and service the high-voltage components of the monitor.

Upgrading Input/Multimedia Devices

Input devices (of which multimedia devices are a subset) were discussed earlier in this chapter. Aside from following the manufacturer's instructions and the material already covered, there is nothing additional you need to know for this objective.

Exam Essentials

Know how many pins an IDE cable has. An IDE cable has 40 pins. You're likely to be asked to choose a cable in a scenario question simply by knowing how many pins the drive requires.

Know how a controller works in a master/slave environment. When you have a master and a slave, only one of the two controllers controls data transfers. You're likely to be asked a scenario question that relates to this environment.

Know what devices besides hard drives use IDE interfaces. With the popularity of IDE technology, manufacturers have introduced tape drives and CD-ROMs that use IDE interfaces.

Know the transfer rates of the different types of SCSI architectures. The different types of SCSI controllers and their supporting devices support throughput ranging from 5Mbps to 160Mbps. You should be familiar with these types and their throughput.

Understand SCSI IDs. SCSI IDs are a critical concept to understand. Not only is this information necessary for the exam, but you also must be able to configure SCSI ID numbers in order to install a SCSI device.

Understand termination. You must not only understand what termination does, but also know how to implement it for the exam and know how to install a SCSI device.

Know the difference between SE, LVD, and HVD. Make sure you know which will coexist (SE and LVD) and what benefits LVD and HVD offer over SE.

Understand RAID levels. Know that RAID 0 is performance enhancement with no fault tolerance, RAID 1 is fault tolerance with no performance enhancement, and RAID 5 offers fault tolerance and enhances performance.

Identify Tools and Diagnostics for PC Components

When you're troubleshooting hardware, there are a few common problems that any experienced technician should know about. These common issues usually have simple solutions. Knowing these problems and their solutions will make you a more efficient troubleshooter.

Critical Information

Most computer technicians spend a great deal of time troubleshooting and repairing systems. This objective tests your knowledge of basic troubleshooting procedures. To study for it, you'll need to familiarize yourself with common problems and solutions related to motherboards, hard disks, RAM, cooling, and the other major system components.

Basic Aspects of Troubleshooting

Although everyone approaches troubleshooting from a different perspective, a few things should remain constant. Among them is a basic appreciation for data. Any hardware component can be replaced, but data often can't be. For that reason, it's important to always perform backups before making any changes.

It's important to assess every problem systematically and try to isolate the root cause. You always start out with an issue and whittle away at it until you can get down to the point where you can pinpoint the problem—this often means eliminating, or verifying, the obvious.

You must establish priorities—one user being unable to print to the printer of their choice isn't as important as a floor full of accountants unable to run payroll. Prioritize every job and escalate it (or de-escalate it) as you need to.

Last, but perhaps most important, document everything—not just that there was a problem, but also the solution you found, the actions you tried, and the outcomes of each.

Basic Diagnostic Procedures

Just as all artists have their own style, all technicians have their own way to troubleshoot. Some people use their instincts; others rely on advice from other people. The most common troubleshooting tips can be condensed into a step-by-step process. You try each step, in order. If the first step doesn't narrow down the problem, you move on to the next step.

In this section, we'll look at each step in the troubleshooting process.

Step 1: Define the Problem

If you can't define the problem, you can't begin to solve it. You can define the problem by asking questions of the user. Here are a few questions to ask the user to aid in determining what the problem is, exactly:

Can you show me the problem? This question is one of the best. It allows the user to show you exactly where and when they experience the problem.

How often does this happen? This question establishes whether this problem is a one-time occurrence that can be solved with a reboot, or whether a specific sequence of events causes the problem to happen. The latter usually indicates a more serious problem that may require software installation or hardware replacement.

Has any new hardware been installed recently? New hardware can mean compatibility problems with existing devices. Some Plug and Play devices install with the same resource settings as an existing device. This can cause both devices to become disabled.

Have any other changes been made to the computer recently? If the answer is "Yes," ask if the user can remember approximately when the change was made. Then ask them approximately when the problem started. If the two dates seem related, then there's a good chance that the problem is related to the change. If it's a new hardware component, check to see that the hardware component was installed correctly.

Step 2: Check the Simple Stuff First

This step is the one that most experienced technicians overlook. Often, computer problems are the result of something simple. Technicians overlook these problems because they're so simple that the technicians assume they *couldn't* be the problem. Some examples of simple problems are shown here:

Is it plugged in? And plugged in on both ends? Cables must be plugged in on *both ends* in order to function correctly. Cables can easily be tripped over and inadvertently pulled from their sockets.

Is it turned on? This one seems the most obvious, but we've all fallen victim to it at one point or another. Computers and their peripherals must be turned on in order to function. Most have power switches with LEDs that glow when the power is turned on.

Is the system ready? Computers must be ready before they can be used. *Ready* means the system is ready to accept commands from the user. An indication that a computer is ready is when the operating system screens come up and the computer presents you with a menu or a command prompt. If that computer uses a graphical interface, the computer is ready when the mouse pointer appears. Printers are ready when the On Line or Ready light on the front panel is lit.

Do the chips and cables need to be reseated? You can solve some of the strangest problems (random hang-ups or errors) by opening the case and pressing down on each socketed chip. This remedies the chip-creep problem discussed later in this chapter. In addition, you should reseat any cables to make sure that they're making good contact.

Step 3: Check to See If It's User Error

This error is common but preventable. The indication that a problem is due to user error is when a user says they can't perform some very common computer task, such as printing or saving a file. As soon you hear these words, you should begin asking questions to determine if it's simply a matter of teaching the user the correct procedure. A good question to ask following their statement of the problem is, "Were you *ever* able to perform that task?" If they answer "No" to this question, it means they're probably doing the procedure wrong. If they answer "Yes," you must move on to another set of questions.

THE SOCIAL SIDE OF TROUBLESHOOTING

When you're looking for clues as to the nature of a problem, no one can give you more information than the person who was there when it happened. They can tell you what led up to the problem, what software was running, and the exact nature of the problem ("It happened when I tried to print"), and they can help you re-create the problem, if possible.

Use questioning techniques that are neutral in nature. Instead of saying, "What were you doing when it broke?" be more compassionate and say, "What was going on when the computer decided not to work?" It sounds silly, but these types of changes can make your job a lot easier!

Step 4: Restart the Computer

It's amazing how often a simple computer restart can solve a problem. Restarting the computer clears the memory and starts the computer with a clean slate. Whenever we perform phone support, we always ask the customer to restart the computer and try again. If restarting doesn't work, try powering down the system completely and then powering it up again (rebooting). More often than not, that will solve the problem.

Step 5: Determine If the Problem Is Hardware- or Software-Related

This step is important because it determines what part of the computer you should focus your troubleshooting skills on. Each part requires different skills and different tools.

To determine if a problem is hardware- or software-related, you can do a few things to narrow down the issue. For instance, does the problem manifest itself when the user uses a particular piece of hardware (a modem, for example)? If it does, the problem is more than likely hardware-related.

This step relies on personal experience more than any of the other steps do. You'll without a doubt run into strange software problems. Each one has a particular solution. Some may even require reinstallation of the software or the entire operating system.

Step 6: If the Problem Is Hardware-Related, Determine Which Component Is Failing

Hardware problems are pretty easy to figure out. If the modem doesn't work, and you know it isn't a software problem, the modem is probably the piece of hardware that needs to be replaced.

With some of the newer computers, several components are integrated into the motherboard. If you troubleshoot the computer and find a hardware component to be bad, there's a good chance that the bad component is integrated into the motherboard (for example, the parallel port circuitry) and the whole motherboard must be replaced—an expensive proposition, to be sure.

Step 7: Check Service Information Sources

As you may (or may not) have figured out by now, we're fond of old sayings. Another old saying applies here: "If all else fails, read the instructions." The service manuals are your instructions for troubleshooting and service information. Almost every computer and peripheral made today has service documentation in the form of books, service CD-ROMs, and websites. The latter of the three is growing in popularity as more and more service centers get connections to the Internet.

Step 8: If It Ain't Broke…

When doctors take the Hippocratic oath, they promise to not make their patients any sicker than they already were. Technicians should take a similar oath. It all boils down to, "If it ain't broke, don't fix it." When you troubleshoot, make one change at a time. If the change doesn't solve the problem, revert the computer to its previous state before making a different change.

Step 9: Ask for Help

If you don't know the answer, ask one of your fellow technicians. They may have run across the problem you're having and know the solution.

This solution does involve a little humility. You must admit that you don't know the answer. It's said that the beginning of wisdom is "I don't know." If you ask questions, you'll get answers, and you'll learn from the answers. Making mistakes is valuable as well, as long as you learn from them.

NOTE Throughout my career in the computer business, the reluctance to share information has been the thing that most concerns me about this industry. As computer professionals, we are valued due to the extent of our knowledge. Some of us intend to keep our value high by limiting the flow of knowledge to others. My position is different than that of those tight-lipped people. I like to help and to teach. This factor has been my best asset as I climbed from the help desk to become an IS manager. The most amusing thing is that despite my impressive title, many certifications, and two published technical books, I still ask for advice and help on a daily basis. If I don't know the answer, I ask, and it doesn't bother me a bit. If I know, and I'm asked, I share and try to bring the other person to the understanding that I have of that particular subject. One of the greatest assets you can have is another opinion or another person to bounce ideas off.

Recognizing and Isolating Issues

Your value as a technician increases as you gain experience, because of the reduced time it takes you to accomplish common repairs. Your ability to troubleshoot by past experiences and gut feelings will make you more efficient and more valuable, which in turn will allow you to advance and earn a better income. This section will give you some guidelines you can use to evaluate common hardware issues that you're sure to face.

POST Routines

Every computer has a diagnostic program built into its BIOS called the *power on self-test* (*POST*). When you turn on the computer, it executes this set of diagnostics. Many steps are involved the POST, but they happen very quickly, they're invisible to the user, and they vary among BIOS versions. The steps include checking the CPU, checking the RAM, checking for the presence of a video card, and so on. The main reason to be aware of the POST's existence is that if it encounters a problem, the boot process stops. Being able to determine at what point the problem occurred can help you troubleshoot.

One way to determine the source of a problem is to listen for a *beep code*. This is a series of beeps from the computer's speaker. The number, duration, and pattern of the beeps can sometimes tell you what component is causing the problem. However, the beeps differ depending on the BIOS manufacturer and version, so you must look up the beep code in a chart for your particular BIOS. Different BIOS manufacturers use the beeping differently. AMI BIOS, for example, relies on a raw number of beeps, and uses patterns of short and long beeps.

Another way to determine a problem during the POST routine is to use a *POST card*. This is a circuit board that fits into an ISA or PCI expansion slot in the motherboard and reports numeric codes as the boot process progresses. Each of those codes corresponds to a particular component being checked. If the POST card stops at a certain number, you can look up that number in the manual that came with the card to determine the problem.

NOTE BIOS Central is a website containing charts detailing the beep codes and POST error codes for many different BIOS manufacturers: `www.bioscentral.com/`.

Applying Basic Troubleshooting Techniques

The following sections offer discussions of the basic items to check for common problems.

Motherboard and CPU Problems

Most motherboard and CPU problems manifest themselves by the system appearing completely dead. However, "completely dead" can be a symptom of a wide variety of problems, not only with the CPU or motherboard but also with the RAM or the power supply. So, a POST card (described in the preceding section) may be helpful in narrowing down the exact component that is faulty.

When a motherboard fails, it's usually because it has been damaged. Most technicians can't repair motherboard damage; the motherboard must be replaced. Motherboards can become damaged due to physical trauma, exposure to electrostatic discharge (ESD), or short-circuiting. To minimize the risk of these damages, observe the following rules:

- Handle a motherboard as little as possible, and keep it in an antistatic bag whenever it's removed from the PC case.
- Keep all liquids well away from the motherboard, because water can cause a short circuit.
- Wear an antistatic wrist strap when handling or touching a motherboard.
- When installing a motherboard in a case, make sure you use brass stand-offs with paper washers to prevent any stray solder around the screw holes from causing a short circuit with the metal of the screw.

A CPU may fail because of physical trauma or short-circuiting, but the most common cause for a CPU not to work is failure to install it properly. With a PGA-style CPU, ensure that the CPU is oriented correctly in the socket. With an SECC-style CPU, make sure the CPU is completely inserted into its slot.

I/O Ports and Cables

I/O ports include legacy parallel and serial, USB, and FireWire ports, all of which are used to connect external peripherals to the motherboard. When a port doesn't appear to be functioning, check the following:

- Cables are snugly connected.
- The port has not been disabled in BIOS Setup.
- The port has not been disabled in Device Manager in Windows.
- No pins are broken or bent on the male end of the port or of the cable being plugged into it.

If you suspect that the cable, rather than the port, may be the problem, swap out the cable with a known-good one. If you don't have an extra cable, you can test the existing cable with a multimeter by setting it to ohms and checking the resistance between one end of the cable and the other.

Use a pin-out diagram, if available, to determine which pin matches up to which at the other end. There is often—but not always—an inverse relationship between the ends. In other words, at one end pin 1 is at the left, and at the other end it's at the right on the same row of pins.

Cooling Issues

A PC that works for a few minutes and then locks up is probably experiencing overheating due to a heat sink or fan not functioning properly. To troubleshoot overheating, first check all fans inside the PC to ensure they're operating, and make sure any heat sinks are firmly attached to their chips.

In a properly designed, properly assembled PC case, air flows in a specific path from the power-supply fan through the vent holes. Cases are designed to cool by making the air flow in a certain way. Therefore, operating a PC with the cover removed can make a PC more susceptible to overheating, even though it's "getting more air."

Similarly, operating a PC with empty expansion-slot backplates removed can inhibit a PC's ability to cool itself properly because the extra holes change the airflow pattern from what was intended by its design.

Although CPUs are the most common component to overheat, occasionally chips on other devices, particularly video cards, may also overheat. Extra heat sinks or fans may be installed to cool these chips.

Case Issues

A PC case holds the drives in its bays, holds the power supply, and has lights and buttons on the front. For the first two of those functions, make sure that the drives and the power supply are tightly fastened in the case with screws.

If one of the lights or buttons on the front of the PC isn't functioning, remove the cover and check the wires that run from the back of that button/light to the motherboard. If the wire has become detached, reattach it. Refer to the motherboard manual or the writing on the motherboard itself to determine what goes where.

Hard-Disk System Problems

Hard-disk system problems usually stem from one of three causes:

- The adapter (that is, the IDE or SCSI interface) is bad.
- The disk is bad.
- The adapter and disk are connected incorrectly.

The first and last causes are easy to identify, because in either case the symptom will be obvious: The drive won't work. You won't be able to get the computer to communicate with the disk drive.

However, if the problem is a bad disk drive, the symptoms aren't as obvious. As long as the BIOS POST routines can communicate with the disk drive, they're usually satisfied. But the POST routines may not uncover problems related to storing information. Even with healthy POST results, you may find that you're permitted to save information to a bad disk, but when you try to read it back, you get errors. Or the computer may not boot as quickly as it used to, because the disk drive can't read the boot information successfully every time.

In some cases, reformatting the drive can solve the problems described in the preceding paragraph. In other cases, reformatting brings the drive back to life only for a short while. The bottom line is that read and write problems usually indicate that the drive is malfunctioning and should be replaced soon.

WARNING

Never low-level-format IDE or SCSI drives! They're low-level-formatted from the factory, and you may cause problems by using low-level utilities on these types of drives.

Modem Problems

The most common peripheral problems are those related to modem communications. The symptoms of these problems include the following:

- The modem won't dial.
- The modem keeps hanging up in the middle of the communications session.
- The modem spits out strange characters to the terminal screen.

If the modem won't dial, first check that it has been configured correctly in Windows, including its resource assignments.

Some modems work only under Windows because some of their functions rely on Windows software; these are called *Winmodems* or *software modems*. If such a modem doesn't work immediately upon installation, try running the Setup software that came with the modem.

If the configuration is correct, and Windows recognizes the modem, it should work for dial-up networking connections.

AT COMMANDS

When you're using a terminal application such as HyperTerminal, it's important to use the correct initialization commands. These are the commands sent to the modem by the communications program to initialize it. These commands tell the modem such things as how many rings to wait before answering, how long to wait after the last keystroke was detected for it to disconnect, and at what speed to communicate.

Modem initialization commands are known as the *Hayes command set* or the *AT command set*, because each Hayes modem command starts with the letters `AT` (presumably calling the modem to ATtention).

Each `AT` command does something different. The letters `AT` by themselves ask the modem if it's ready to receive commands. If it returns *OK*, the modem is ready to communicate. If you receive *Error*, there is an internal modem problem that may need to be resolved before communication can take place.

Table 1.10 lists a few of the most common `AT` commands, their functions, and the problems they can solve. You can send these commands to the modem by opening a terminal program like Windows Terminal or HyperTerminal and typing them in. All commands should return *OK* if they're successful.

TABLE 1.10 Common `AT` Commands

Command	Function	Usage
`AT`	Tells the modem that what follows the letters `AT` is a command that should be interpreted	Used to precede most commands.
`ATDT` *nnnnnnn*	Dials the number *nnnnnnn* as a tone-dialed number	Used to dial the number of another modem if the phone line is set up for tone dialing.
`ATDP` *nnnnnnn*	Dials the number *nnnnnnn* as a pulse-dialed number	Used to dial the number of another modem if the phone line is set up for rotary dialing.
`ATA`	Answers an incoming call manually	Places the line off-hook and starts to negotiate communication with the modem on the other end.

TABLE 1.10 Common AT Commands *(continued)*

Command	Function	Usage
ATH0 (or +++ and then ATH0)	Tells the modem to hang up immediately	Places the line on-hook and stops communication. (Note: The 0 in this command is a zero, not the letter *O*.)
AT&F	Resets the modem to factory default settings	This setting works as the initialization string when others don't. If you have problems with modems hanging up in the middle of a session or failing to establish connections, use this string by itself to initialize the modem.
ATZ	Resets the modem to power-up defaults	Almost as good as AT&F, but may not work if power-up defaults have been changed with S-registers.
ATS0-*n*	Waits *n* rings before answering a call	Sets the default number of rings that the modem will detect before taking the modem off-hook and negotiating a connection. (Note: The 0 in this command is a zero, not the letter *O*.)
ATS6-*n*	Waits *n* seconds for a dial tone before dialing	If the phone line is slow to give a dial tone, you may have to set this register to a number higher than 2.
,	Pauses briefly	When placed in a string of AT commands, the comma causes a pause to occur. Used to separate the number for an outside line (many businesses use 9 to connect to an outside line) and the real phone number (for example, 9,555-1234).
*70 or 1170	Turns off call waiting	The click you hear when you have call waiting (a feature offered by the phone company) will interrupt modem communication and cause the connection to be lost. To disable call waiting for a modem call, place these commands in the dialing string like so: *70,555-1234. Call waiting will resume after the call is hung up.

TABLE 1.10 Common AT Commands *(continued)*

Command	Function	Usage
CONNECT	Displays when a successful connection has been made	You may have to wait some time before this message is displayed. If this message isn't displayed, the modem couldn't negotiate a connection with the modem on the other end of the line, possibly due to line noise.
BUSY	Displays when the number dialed is busy	If this message is displayed, some programs wait a certain amount of time and try again to dial.
RING	Displays when the modem has detected a ringing line	When someone is calling your modem, the modem displays this message in the communications program. You type **ATA** to answer the call.

If two computers can connect, but they both receive garbage on their screens, there's a good chance that the computers don't agree on the communications settings. Settings such as data bits, parity, stop bits, and compression must all agree in order for communication to take place.

Keyboard and Mouse Problems

Usually, keyboard problems are environmental. Keyboards get dirty, and the keys start to stick.

NOTE: If a keyboard is malfunctioning (for example, sending the wrong characters to the display), it's most cost effective to replace it rather than spend hours attempting to fix it, because keyboards are fairly inexpensive.

One way to clean a keyboard is with the keyboard cleaner sold by electronics supply stores. This cleaner foams up quickly and doesn't leave a residue behind. Spray it liberally on the keyboard and keys. Work the cleaner in between the keys with a stiff toothbrush. Blow away the excess with a strong blast of compressed air. Repeat until the keyboard functions properly. If you have to clean a keyboard that's had a soft drink spilled on it, remove the key caps before you perform the cleaning procedure; doing so makes it easier to reach the sticky plungers.

TIP: Remember that most of the dollars spent on systems are for labor. If you spend an hour cleaning a $12.00 keyboard, then you have probably just cost your company $20.00. Knowing how to fix certain things doesn't necessarily mean that you *should* fix them. Always evaluate your workload, the cost of replacement, and the estimated cost of the repair before deciding on a course of action.

Similarly, most mouse problems, such as the pointer failing to move in one direction or the other, or the pointer jumping around onscreen, are due to dirt building up inside the mouse. To clean a standard mouse, remove the plate on the bottom of the mouse that holds the ball in place; then, remove the ball, and clean the inside chamber with an alcohol-dipped cotton swab. Clean the ball itself with mild soap and water. Don't use alcohol on the ball, because it tends to dry out the rubber.

Display-System Problems

Display problems were discussed earlier in this chapter. As a general rule, there are two types of video problems: no video and bad video, both of which were previously discussed.

Floppy and Other Removable Disk-Drive Problems

Most floppy-drive problems result from bad media. Your first troubleshooting technique with floppy-drive issues should be to try a new disk.

One of the most common problems that develops with floppy drives is misaligned read/write heads. The symptoms are fairly easy to recognize—you can read and write to a floppy on one machine but not on any others. This is normally caused by the mechanical arm in the floppy drive becoming misaligned. When the disk was formatted, it wasn't properly positioned on the drive, thus preventing other floppy drives from reading it.

Numerous commercial tools are available to realign floppy drive read/write heads. They use a floppy drive that has been preformatted to reposition the mechanical arm. In most cases, though, this fix is temporary—the arm will move out of place again fairly soon. Given the inexpensive nature of the problem, the best solution is to spend a few dollars and replace the drive.

Another problem you may encounter is a phantom directory listing. For example, suppose you display the contents of a floppy disk, and then you swap to another floppy disk but the listing stays the same. This is almost always a result of a faulty ribbon cable; a particular wire in the ribbon cable signals when a disk swap has taken place, and when that wire breaks, this error occurs.

Sound-Card Problems

Sound cards are traditionally one of the most problem-ridden components in a PC. They demand a lot of PC resources and are notorious for being inflexible in their configuration. The most common problems related to sound cards involve resource conflicts (IRQ, DMA, or I/O address). The problem is much less pronounced on PCI than on ISA cards.

Luckily, most sound-card vendors are aware of the problems and ship very good diagnostic utilities to help resolve them. Use your PC troubleshooting skills to determine the conflict, and then reconfigure until you find an acceptable set of resources that aren't in use.

Some sound cards aren't completely Plug and Play–compatible. Windows may detect that new hardware has been installed but be unable to identify the new hardware as a working sound card. To fix this problem, run the Setup software that came with the sound card.

CD-ROM/DVD Issues

CD-ROM and DVD problems are normally media-related. Although compact disc technology is much more reliable than floppy disks, it's not perfect. Another factor to consider is the cleanliness of the disc. On many occasions, if a disc is unreadable, cleaning it with an approved cleaner and a lint-free cleaning towel will fix the problem.

If the operating system doesn't see the drive, start troubleshooting by determining whether the drive is receiving power. If the tray will eject, you can assume there is power to it. Next, check BIOS Setup (for IDE drives) to make sure the drive has been detected. If not, check the master/slave jumper on the drive, and make sure the IDE adapter is set to Auto, CD-ROM, or ATAPI in BIOS Setup.

In order to play movies, a DVD drive must have MPEG-decoding capability. This is usually accomplished via an expansion board, but it may be built into the video card or sound card, or it may be a software decoder. If DVD data discs will play but movies won't, suspect a problem with the MPEG decoding.

If a CD-RW or DVD drive works normally as a regular CD-ROM drive but doesn't perform its special capability (doesn't read DVD discs, or doesn't write to blank CDs), perhaps software needs to be installed to work with it. For example, with CD-RW drives, unless you're using an operating system such as Windows XP that supports CD writing, you must install CD-writing software in order to write to CDs.

Network Interface Card Problems

In general, network interface cards (NICs) are added to a PC via an expansion slot. The most common issue that prevents network connectivity is a bad or unplugged patch cable.

Cleaning crews and the rollers on the bottoms of chairs are the most common threats to a patch cable. In most cases, wall jacks are placed 4 to 10 feet away from the desktop. The patch cables are normally lying exposed under the user's desk, and from time to time damage is done to the cable, or it's inadvertently snagged and unplugged. When you troubleshoot a network adapter, start with the most rudimentary explanations first. Make sure the patch cable is tightly plugged in, and then look at the card and see if any lights are on. If there are lights on, use the NIC's documentation to help troubleshoot. More often than not, shutting down the machine, unplugging the patch and power cables for a moment, and then reattaching them and rebooting the PC will fix an unresponsive NIC.

NOTE

Although this isn't on the test, it's useful information: Wake On LAN cards have more problems than standard network cards. In our opinion, this is because they're always on. In some cases, you'll be unable to get the card working again unless you unplug the PC's power supply and reset the card.

BIOS Issues

Computer BIOSes don't go bad; they just become out-of-date. This isn't necessarily a critical issue—they will continue to support the hardware that came with the box. It *does*, however, become an issue when the BIOS doesn't support some component that you would like to install—a larger hard drive, for instance.

Most of today's BIOSes are written to an EEPROM and can be updated through the use of software. Each manufacturer has its own method for accomplishing this. Check out the documentation for complete details.

WARNING If you make a mistake in the upgrade process, the computer can become unbootable. If this happens, your only option may be to ship the box to a manufacturer-approved service center. Be careful!

Power-Supply Problems

Power-supply problems are usually easy to troubleshoot. The system doesn't respond in any way when the power is turned on. When this happens, open the case, remove the power supply, and replace it with a new one.

Be aware that different cases have different types of on/off switches. The process of replacing a power supply is a lot easier if you purchase a replacement with the same mechanism. Even so, remember to document exactly how the power supply was connected to the on/off switch before you remove it.

Miscellaneous Problems

Some common problems don't fit well into categories. This section lists some common hardware issues you'll be faced with.

DISLODGED CHIPS AND CARDS

The inside of a computer is a harsh environment. The temperature inside the case of some Pentium computers is well over 100° F! When you turn on your computer, it heats up. Turn it off, and it cools down. After several hundred such cycles, some components can't handle the stress and begin to move out of their sockets. This phenomenon is known as *chip creep*, and it can be really frustrating.

Chip creep can affect any socketed device, including ICs, RAM chips, and expansion cards. The solution to chip creep is simple: open the case, and reseat the devices. It's surprising how often this is the solution to phantom problems of all sorts.

Another important item worth mentioning is an unresponsive but freshly unboxed PC. With the introduction of the Type II and Type II-style of processors, the number of dead boxes increased dramatically. In fact, at that time I was leading a 2,000-unit migration for a large financial institution. As with any large migration, time and manpower were in short supply. The average dead PC ratio was about 1 out of every 20. When about 10 DOAs had stacked up, I stayed after work one night to assess the problem. After checking the power supply, RAM, and cables on these integrated systems, an examination of the chip provided me with the fix. These large, top-heavy processors can become dislodged during shipment. Shortly thereafter, manufacturers began using a heavier attachment point for the slot style of processor, which has helped tremendously.

ENVIRONMENTAL PROBLEMS

Computers are like human beings. They have similar tolerances to heat and cold. In general, anything comfortable to us is comfortable to computers. They need lots of clean, moving air to keep them functioning.

Dirt, grime, paint, smoke, and other airborne particles can become caked on the inside of the components. This is most common in automotive and manufacturing environments. The contaminants create a film that coats the components, causing them to overheat and/or conduct electricity on their surface. Blowing out these exposed systems with a can of condensed air from time to time can prevent damage to the components. While you're cleaning the components, be sure to clean any cooling fans in the power supply or on the heat sink.

NOTE: To clean the power-supply fan, blow the air from the inside of the case. When you do this, the fan will blow the contaminants out the cooling vents. If you spray from the vents toward the inside of the box, you'll be blowing the dust and grime inside the case or back into the fan motor.

One way to ensure that the environment has the least possible effect on your computer is to always leave the *blanks* in the empty slots on the back of your box. These pieces of metal are designed to keep dirt, dust, and other foreign matter from the inside of the computer. They also maintain proper airflow within the case to ensure that the computer doesn't overheat.

Applying the Appropriate Tools

Just as a mechanic must have the appropriate tools in their toolbox to be able to fix an automobile, you must have the right tools in your arsenal to be able to fix computer problems. Fortunately, many of the tools are included with the computer; you just need to know which ones to turn to. If there is a problem with the boot process, check the BIOS. If there is a problem with the hard drive, run diagnostic utilities on it.

The most important tool you have in your toolbox is common sense. Not only should you use it to determine which tool to use while working on a personal computer, but you should also use it to pick the correct answers on the A+ exam.

Exam Essentials

Be familiar with the purpose of POST routines. The POST routines perform entry-level hardware troubleshooting as a PC starts. Be familiar with the abilities of the POST and its use.

Be able to diagnose port problems. When a port isn't functioning, make sure you know the steps to take to ensure that it's physically connected, enabled in BIOS, and recognized in Windows.

Know how to troubleshoot hard-disk system problems. Be aware of the common causes of hard-disk problems, including improper jumper configuration, BIOS Setup, and formatting/partitioning issues.

Identify problems that can result from overheating. Overheating can cause spontaneous rebooting or shutdown. It's often caused by nonfunctioning cooling fans or improper airflow through the PC.

Be able to determine the cause of display-system problems. The most common display problems relate to power, brightness, or contrast. Adjusting the monitor controls should be your first step when troubleshooting.

Recognize the symptoms of floppy-drive problems. Most floppy-drive problems result from bad media. Your first troubleshooting technique with floppy-drive issues should be to try a new disk.

Know how to troubleshoot sound-card problems. Sound cards demand a lot of PC resources and are notorious for being inflexible in their configuration. The most common problems related to sound cards involve resource conflicts (IRQ, DMA, or I/O address).

Learn to identify BIOS issues. BIOS issues are related to the inability to support hardware. In most cases, a program or flash upgrade is available to update the BIOS so that components can be supported.

Recognize power-supply problems. Become familiar with the symptoms of a dead, failing, or overloaded power supply.

Know the symptoms of dislodged chips and cards. Dislodged components are the most common issues you'll face. Become familiar with the symptoms and their fixes.

Know the basic steps of troubleshooting. Troubleshooting is a process of trial and error. For the exam and your career, use this system to diagnose and repair hardware-related issues.

Check your information sources. Service manuals are your instructions for troubleshooting and service information. Almost every computer and peripheral made today has service documentation in the form of books, service CD-ROMs, and websites.

Ask for help. If you don't know the answer, ask one of your fellow technicians. They may have run across the problem you're having and know the solution. This is one thing we feel very strongly about. Don't be embarrassed to ask, and don't be too tight-lipped to help others.

Perform Preventative Maintenance on Personal Computers

This section outlines some preventive maintenance products and procedures. Preventive maintenance is one of the most overlooked ways to reduce the cost of ownership in any environment.

Critical Information

Cleaning a computer system is the most important part of maintaining it. Computer components get dirty. Dirt reduces their operating efficiency and, ultimately, their life. Cleaning them is definitely important. But cleaning them with the right cleaning compounds is equally important. Using the wrong compounds can leave residue behind that is more harmful than the dirt you're trying to remove!

Most computer cases and monitor cases can be cleaned using mild soap and water on a clean, lint-free cloth. Make sure the power is off before you put anything wet near a computer. Dampen (don't soak) a cloth with a mild soap solution, and wipe the dirt and dust from the case. Then, wipe the moisture from the case with a dry, lint-free cloth. Anything with a plastic or metal case can be cleaned in this manner.

WARNING Don't drip liquid into any vent holes on equipment. CRTs in particular have vent holes in the top.

To clean a monitor screen, use glass cleaner designed specifically for monitors, and a soft cloth. Don't use commercial window cleaner, because the chemicals in it can ruin the antiglare coating on some monitors.

To clean a keyboard, use canned air to blow debris out from under keys, and use towelettes designed for use with computers to keep the key tops clean. If you spill anything on a keyboard, you can clean it by soaking it in distilled, *demineralized water*. The minerals and impurities have been removed from this type of water, so it won't leave any traces of residue that might interfere with the proper operation of the keyboard after cleaning. Make sure you let the keyboard dry for at least 48 hours before using it.

The electronic connectors of computer equipment, on the other hand, should never touch water. Instead, use a swab moistened in distilled, *denatured isopropyl alcohol* (also known as electronics cleaner and found in electronics stores) to clean contacts. Doing so will take the oxidation off the copper contacts.

A good way to remove dust and dirt from the inside of the computer is to use compressed air. Blow the dust from inside the computer using a stream of compressed air. However, be sure you do this outdoors, so you don't blow dust all over your work area or yourself. You can also use a vacuum, but it must be designed specifically for electronics—such models don't generate ESD, and have a finer filter than normal.

To prevent a computer from becoming dirty in the first place, control its environment. Make sure there is adequate ventilation in the work area and that the dust level isn't excessive. To avoid ESD, you should maintain 50 to 80 percent humidity in the room where the computer is operating.

One unique challenge when cleaning printers is spilled toner. It sticks to everything and should not be breathed. Use a vacuum designed specifically for electronics. A normal vacuum's filter isn't fine enough to catch all the particles, so the toner may be circulated into the air.

TIP If you get toner on your clothes, use a magnet to get it out (toner is half iron).

Removable media devices such as floppy and CD drives don't usually need to be cleaned during preventive maintenance. Clean one only if you're experiencing problems with it. Cleaning kits sold in computer stores provide the needed supplies. Usually, cleaning a floppy drive involves a dummy floppy disk made of semi-abrasive material. When you insert the disk in the drive, the drive spins it, and the abrasive action on the read-write head removes any debris.

An uninterruptible power supply (UPS) should be checked periodically as part of the preventive maintenance routine to make sure that its battery is operational. Most UPSs have a Test button you can press to simulate a power outage.

Remember, preventive maintenance is more than just manipulating hardware; it also encompasses running software utilities on a regular basis to keep the filesystem fit. These utilities can include Disk Defragmenter, ScanDisk, Check Disk, and Disk Cleanup.

Exam Essentials

Know what can be used to clean computer components. Many types of cleaning solutions can be used to perform these procedures. Be familiar with which option is best for each component. Which ones can be cleaned with water? Which ones require alcohol? Which ones need canned air?

Know why the proper cleaning solutions should be used. Using the wrong cleaning solution can damage components. Along with choosing the right cleaning solution, understand why the unchosen solutions are inappropriate for a particular component.

Review Questions

1. What two types of expansion slots are found on all modern motherboards? What is a third, older type that might or might not also be present?
2. Name three features that distinguish an ATX motherboard from an AT motherboard.
3. What are PGA and SECC? Which of those types is the Socket 423 used with the Pentium 4?
4. What voltages does a typical power supply provide to the motherboard?
5. On modern systems, what is the relationship between a CPU's internal and external speeds?
6. Which cache is also known as the back-side cache?
7. What is the purpose of a VRM on a motherboard?
8. What is the purpose of a parity bit on a SIMM?
9. Would the POST test identify a problem with RAM?
10. If a legacy serial port is physically fine but does not show up in Windows' Device Manager, how might you enable it?

Answers to Review Questions

1. PCI and AGP. The third type is ISA.
2. Possible answers include: (1) position of CPU, (2) expansion slot orientation, (3) built-in ports on the side, (4) one-piece power supply connector, (5) physical size and shape of the motherboard, and (6) type of keyboard connector.
3. They are the two types of slots/sockets for CPUs in motherboards. PGA is the type with a grid of holes into which pins fit on a flat chip. SECC is the type that accepts a circuit board surrounded by a cartridge. Whenever you see *socket* in the name, it's always a PGA type. SECC types have *slot* in the name.
4. +5V, -5V, +12V, and -12V for all power supplies, plus +3.3V for an ATX power supply.
5. The internal speed is a multiple of the external speed.
6. The L2 cache
7. To provide different voltages for different CPUs
8. Error correction
9. Yes. One of the components the POST checks is the RAM.
10. It may be disabled in BIOS Setup; try enabling it there.