Motherboards

In this chapter, you will learn how to

- Explain how motherboards work
- Identify the types of motherboards
- Explain chipset varieties
- Upgrade and install motherboards
- Troubleshoot motherboard problems

The *motherboard* provides the foundation for the personal computer. Every piece of hardware, from the CPU to the lowliest expansion card, directly or indirectly plugs into the motherboard. The motherboard contains the wires—called *traces*—that make up the buses of the system. It holds the vast majority of the ports used by the peripherals, and it distributes the power from the power supply (Figure 9-1). Without the motherboard, you literally have no PC.

Historical/Conceptual

How Motherboards Work

Three variable and interrelated characteristics define modern motherboards: form factor, chipset, and components. The *form factor* determines the physical size of the motherboard as well as the general location of components and ports. The *chipset* defines the type of processor and RAM the motherboard requires and determines to a degree the built-in devices the motherboard supports, including the expansion slots. Finally, the built-in components determine the core functionality of the system.

Any good tech should be able to make a recommendation to a client about a particular motherboard simply by perusing the specs. Because the motherboard determines function, expansion, and stability for the whole PC, it's essential that you know your motherboards!

Figure 9-1
Traces visible beneath the CPU socket on a motherboard
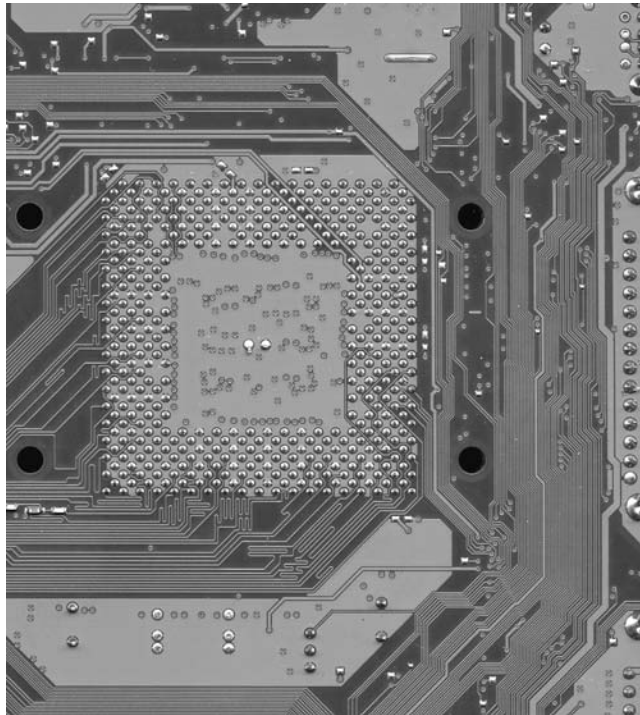
Form Factors

Form factors are industry-standardized shapes and layouts that enable motherboards to work with cases and power supplies. A single form factor applies to all three components. All motherboards come in a basic rectangular or square shape, but vary in overall size and in the layout of built-in components (Figure 9-2). You need to install a motherboard in a case designed to fit it, so the ports and slot openings on the back fit correctly.

The power supply and the motherboard need matching connectors, and different form factors define different connections. Given that the term "form factor" applies to the case, motherboard, and power supply—the three parts of the PC most responsible for moving air around inside the PC—the form factor also defines how the air moves around in the case.

To perform motherboard upgrades and provide knowledgeable recommendations to clients, techs need to know their form factors. The PC industry has adopted—and dropped—a number of form factors over the years with such names as AT, ATX, and BTX. Let's start with the granddaddy of all PC form factors, AT.
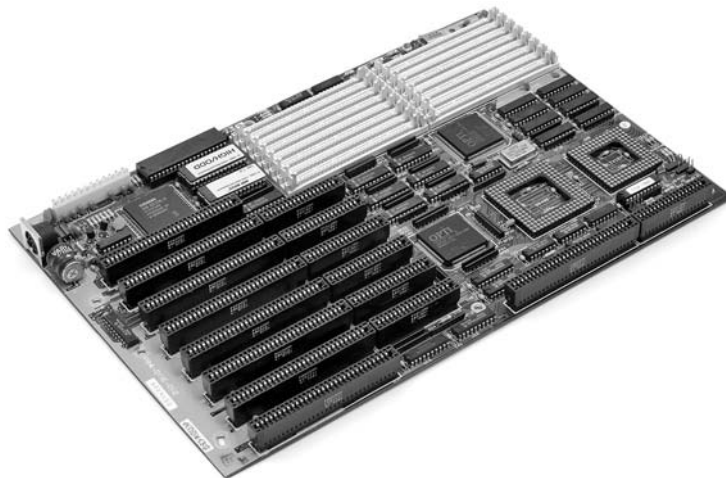
AT Form Factor

The *AT* form factor (Figure 9-3), invented by IBM in the early 1980s, was the predominant form factor for motherboards through the mid-1990s. AT is now obsolete.

Figure 9-2
Typical mother-
board

Figure 9-3
AT-style mother-
board

The AT motherboard had a few size variations (see Figure 9-4), ranging from large to very large. The original AT motherboard was huge, around 12 inches wide by 13 inches deep. PC technology was new and needed lots of space for the various chips necessary to run the components of the PC.

NOTE All AT motherboards had a split power socket called *P8/P9*. You can see the white P8/P9 socket near the keyboard port in Figures 9-3 and 9-4.

Figure 9-4
AT motherboard
(bottom) and
Baby AT mother-
board (top)
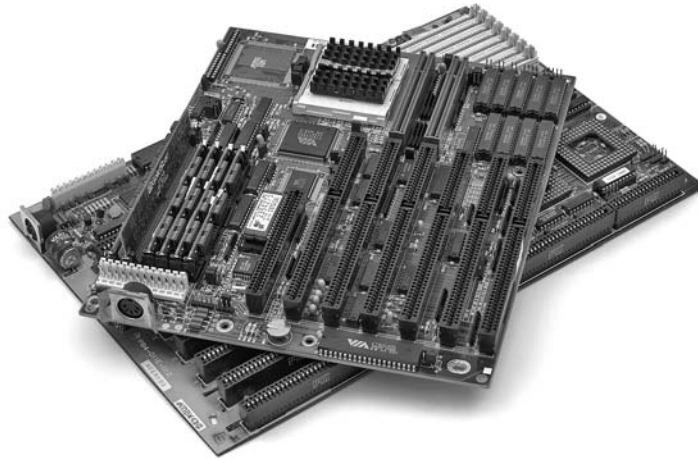
The single greatest problem with AT motherboards was the lack of external ports. When PCs were first invented, the only devices plugged into the average PC were a monitor and a keyboard. That's what the AT was designed to handle—the only dedicated connector on an AT motherboard was the keyboard port (Figure 9-5).

Figure 9-5
Keyboard con-
nector on the
back of an AT
motherboard
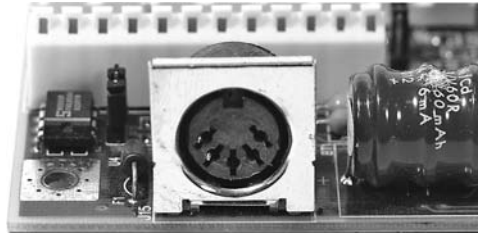
Over the years, the number of devices plugged into the back of the PC has grown tremendously. Your average PC today has a keyboard, a mouse, a printer, some speakers, a monitor, and—if your system's like mine—four to six USB devices connected to it at any given time. These added components created a demand for a new type of form factor, one with more dedicated connectors for more devices. Many attempts were made to create a new standard form factor. Invariably, these new form factors integrated dedicated connectors for at least the mouse and printer, and many even added connectors for video, sound, and phone lines.

One variation from the AT form factor that enjoyed a degree of success was the *slimline* form factor. The first slimline form factor was known as *LPX* (defined in some sources as *low profile extended*, although there's some disagreement). It was replaced by the *NLX* form factor. (NLX apparently stands for nothing, by the way. It's just a cool

grouping of letters.) The LPX and NLX form factors met the demands of the slimline market by providing a central riser slot to enable the insertion of a special *riser card* (Figure 9-6) or, as it's sometimes called, a *daughterboard*. Expansion cards then fit into the riser card horizontally. Combining built-in connections with a riser card enabled manufacturers to produce PCs shorter than 4 inches.

Figure 9-6
Riser card on an older mother-board

The main problem with form factors such as LPX and NLX was their inflexibility. Certainly, no problem occurred with dedicated connections for such devices as mice or printers, but the new form factors also added connectors for such devices as video and sound—devices that were prone to obsolescence, making the motherboard out of date the moment a new type of video or sound card came into popularity.

Essentials

ATX Form Factor

There continued to be a tremendous demand for a new form factor: a form factor that had more standard connectors and also was flexible enough for possible changes in technology. This demand led to the creation of the ATX form factor in 1995 (Figure 9-7). ATX got off to a slow start, but by around 1998, ATX overtook AT to become the most common form factor used today.

ATX is distinct from AT in the lack of an AT keyboard port, replaced with a rear panel that has all necessary ports built in. Note the mini-DIN (PS/2) keyboard and mouse ports at the left of Figure 9-8, standard features on almost all ATX boards. You recall those from Chapter 2, "The Visible PC," right?
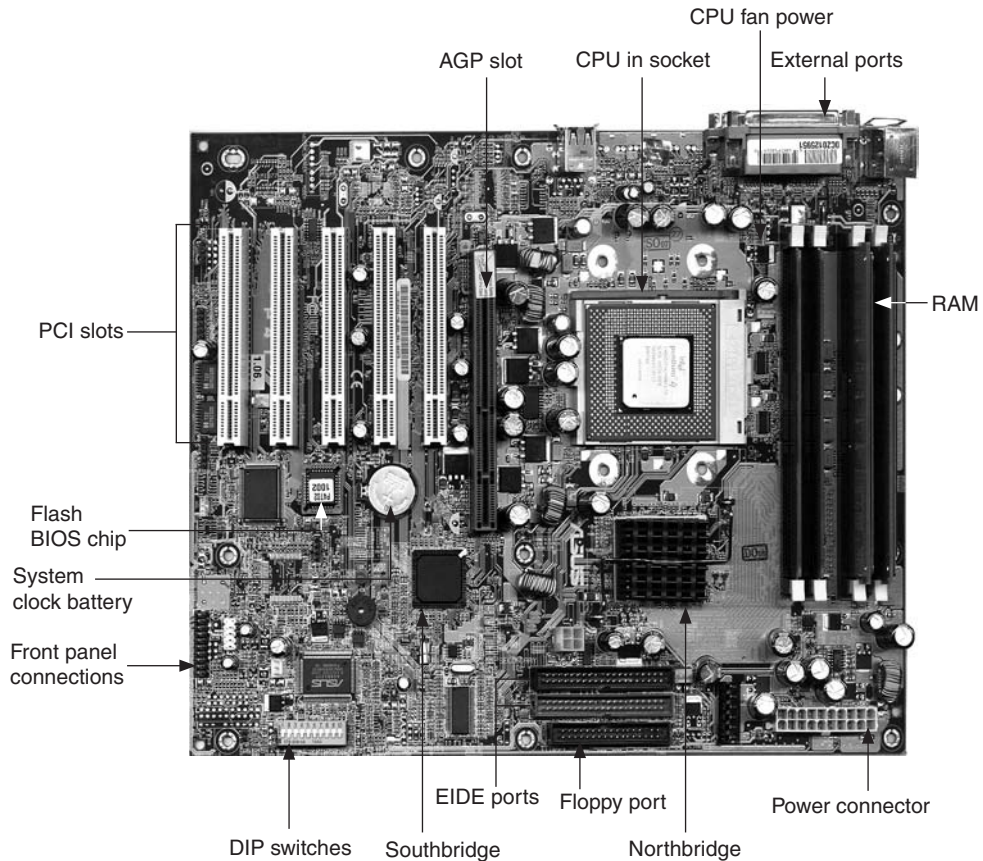
Figure 9-7   Early ATX motherboard

Figure 9-8
ATX ports

The ATX form factor includes many improvements over AT. The position of the power supply allows better air movement. The CPU and RAM are placed to provide easier access, and the rearrangement of components prevents long expansion cards from colliding with the CPU or Northbridge. Other improvements, such as placing the RAM closer to the Northbridge and CPU than on AT boards, offer users enhanced performance as well. The shorter the wires, the easier to shield them and make them capable of handling

double or quadruple the clock speed of the motherboard. Figure 9-9 shows AT and ATX motherboards—note the radical differences in placement of internal connections.

Figure 9-9
AT (left) and ATX (right) mother-boards for quick visual comparison
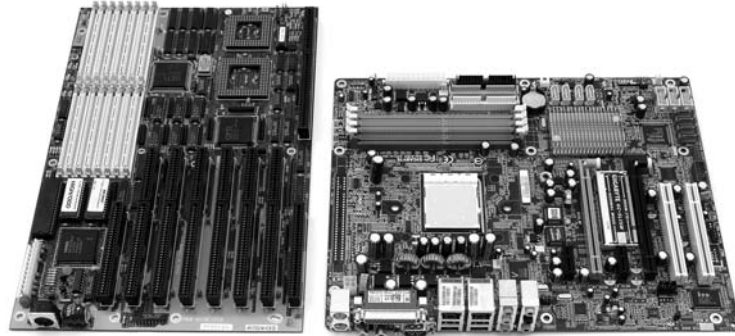
ATX motherboards use a feature called *soft power*. This means they can use software to turn the PC on and off. The physical manifestation of soft power is the power switch. Instead of the thick power cord used in AT systems, an ATX power switch is little more than a pair of small wires leading to the motherboard. We delve into this in more detail in Chapter 10, "Power Supplies."

The success of ATX has spawned two form factor subtypes for specialty uses. The *microATX* motherboard (Figure 9-10) floats in at a svelte 9.6 by 9.6 inches or about 30 percent smaller than standard ATX, yet uses the standard ATX connections. A micro-ATX motherboard fits into a standard ATX case or in the much smaller microATX cases. Note that not all microATX motherboards have the same physical size. You'll sometimes see microATX motherboards referred to with the Greek symbol for micro, as in μATX.

Figure 9-10
A microATX motherboard
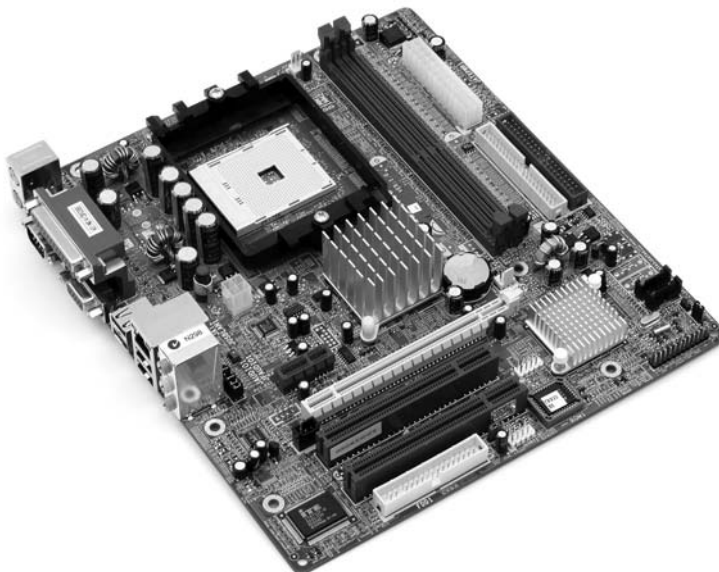
In 1999, Intel created a variant of the microATX called the FlexATX. *FlexATX* motherboards have maximum dimensions of just 9 by 7.5 inches, which makes them the smallest motherboards in the ATX standard. Although FlexATX motherboards can use a standard ATX power supply, most FlexATX systems use a special FlexATX-only power supply. This diminutive power supply fits into tight FlexATX cases.

> **NOTE** Many techs and Web sites use the term *mini-ATX* to refer to motherboards smaller than a full ATX board. This is technically incorrect. The specifications for these small boards use only the terms *microATX* and *FlexATX*.

Keep in mind that each main type of form factor requires its own case. AT motherboards go into AT cases, NLX motherboards go into NLX cases, and ATX motherboards go into ATX cases. You cannot replace one form factor with another without purchasing a new case (Figure 9-11). The exception to this rule is that larger form factor ATX cases can handle any smaller-sized form factor motherboards.

Figure 9-11
That's not going
to fit!

BTX Form Factor

Even though ATX addressed ventilation, faster CPUs and powerful graphics cards create phenomenal amounts of heat, motivating the PC industry to create the "coolest" new form factor used today—the *Balanced Technology eXtended* (*BTX*) form factor (Figure 9-12). BTX defines three subtypes: standard BTX, *microBTX*, and *picoBTX*, designed to replace ATX, microATX, and FlexATX, respectively.

Figure 9-12
A microBTX
motherboard

At first glance, BTX looks like ATX, but notice that the I/O ports and the expansion slots have switched sides. You can't put a BTX motherboard in an ATX case. BTX does not change the power connection, so there's no such thing as a BTX power supply.

NOTE Many manufacturers sell what they call BTX power supplies. These are actually marketing gimmicks. See Chapter 10, "Power Supplies," for details.

Everything in the BTX form factor is designed to improve cooling. BTX cases vent cool air in from the front and warm air out the back. CPUs are moved to the front of the motherboard so they get cool air coming in from the front of the case. BTX defines a special heat sink and fan assembly called the *thermal unit*. The thermal unit's fan blows the hot CPU air directly out the back of the case, as opposed to the ATX method of just blowing the air into the case.

The BTX standard is clearly a much cooler option than ATX, but the PC industry tends to take its time when making big changes such as moving to a new form factor. As a result, BTX has not yet made much of an impact in the industry, and BTX motherboards, cases, and thermal units are still fairly rare. BTX could take off to become the next big thing or disappear in a cloud of disinterest—only time will tell.

Proprietary Form Factors

Several major PC makers, including Dell and Sony, make motherboards that work only with their cases. These *proprietary* motherboards enable these companies to create systems that stand out from the generic ones and, not coincidentally, push you to get service and upgrades from their authorized dealers. Some of the features you'll see in proprietary systems are riser boards like you see with the NLX form factor—part of a motherboard

separate from the main one, but connected by a cable of some sort—and unique power connections. Proprietary motherboards drive techs crazy because replacement parts tend to cost more and are not readily available.

Chipset

Every motherboard has a chipset. The chipset determines the type of processor the motherboard accepts, the type and capacity of RAM, and the sort of internal and external devices that the motherboard supports. As you learned in earlier chapters, the chips in a PC's chipset serve as electronic interfaces through which the CPU, RAM, and input/output devices interact. Chipsets vary in features, performance, and stability, so they factor hugely in the purchase or recommendation of a particular motherboard. Good techs know their chipsets!

Because the chipset facilitates communication between the CPU and other devices in the system, its component chips are relatively centrally located on the motherboard (Figure 9-13). Most modern chipsets are composed of two primary chips: the Northbridge and the Southbridge.

Figure 9-13
Northbridge
(under the fan)
and Southbridge
(lower right,
labeled VIA)
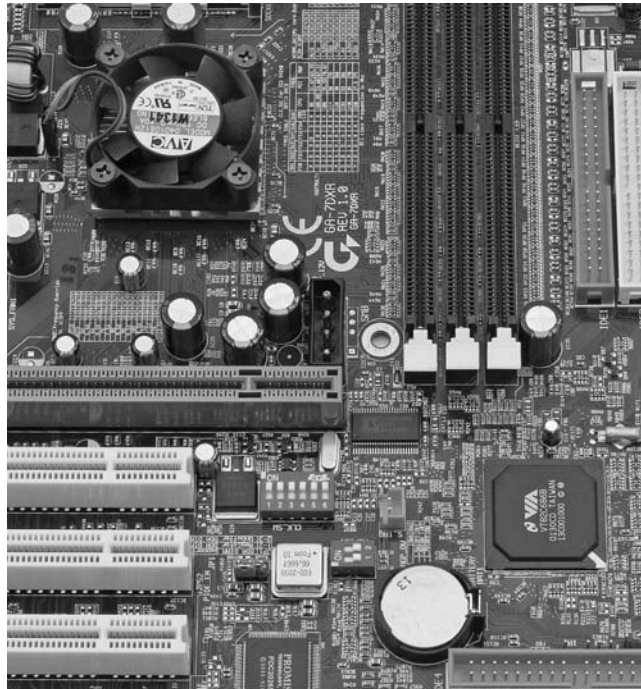
The Northbridge chip on traditional Intel-based motherboards helps the CPU work with RAM, as mentioned in earlier chapters. On newer AMD and Intel-based motherboards, however, the Northbridge does not work directly with RAM, but instead provides the communication with the video card. The CPU has taken on the role of the

memory controller. Current Northbridge chips do a lot and thus get pretty hot, so they get their own heat sink and fan assembly.

The Southbridge handles some expansion devices and mass storage drives, such as hard drives. Most Southbridge chips don't need extra cooling, leaving the chip exposed or passively cooled with only a heat sink. This makes the Southbridge a great place to see the manufacturer of the chipset, such as Intel.

Many motherboards support very old technologies such as floppy drives, infrared connections, parallel ports, and modems. Although supporting these old devices was once part of the Southbridge's job, hardly any modern chipsets still support these devices. Motherboard manufacturers add a third chip called the *Super I/O chip* to handle these chores. Figure 9-14 shows a typical Super I/O chip.

Figure 9-14
Super I/O chip
on ASUS
motherboard

NOTE Super I/O chips work with chipsets but are not part of the chipset. Motherboard makers purchase them separate from chipsets.

The system ROM chip provides part of the BIOS for the chipset, but only at a barebones, generic level. The chipset still needs support for the rest of the things it can do. So how do expansion devices get BIOS? From software drivers, of course, and the same holds true for modern chipsets. You have to load the proper drivers for the specific OS to support all of the features of today's chipsets. Without software drivers, you'll never create a stable, fully functional PC. All motherboards ship with a CD-ROM disc with drivers, support programs, and extra-special goodies such as anti-virus software (Figure 9-15).

There are a limited number of chipset makers. The dominant chipset vendors today are Intel and NVIDIA, although several other companies continue to produce chipsets, such as AMD through its ATI brand. Motherboard manufacturers incorporate the chipsets into motherboards that match the feature set of the chipset. Chipset companies rise and fall every few years, with one company seeming to hold the hot position for a while until another company comes along to unseat them.

NOTE In an average year, chipset makers collectively produce around one hundred new chipset models for the PC market.

Figure 9-15
Driver disc
for ASUS
motherboard

Chipset makers don't always use the terms Northbridge and Southbridge. Chipsets for AMD-based motherboards tend to use the terms, but Intel-based motherboards prefer to say *Memory Controller Hub* (*MCH*) for the Northbridge and *I/O Controller Hub* (*ICH*) for the Southbridge. With the launch of the X58 Express Chipset, Intel has further refined their terminology, calling the Northbridge simply the *I/O Hub* (*IOH*) since the memory controller is located on the CPU. Sometimes Intel refers to the Southbridge as the *Legacy I/O Controller Hub*. Regardless of the official name, Northbridge and Southbridge are the commonly used terms. Figure 9-16 shows a schematic with typical chipset chores for a VIA K8T900 chipset.

It would be impossible to provide an inclusive chipset chart here that wouldn't be obsolete by the time you pick this book up off the shelf at your local tech pub (doesn't everybody have one of those?), but Table 9-1 gives you an idea of what to look for as you research motherboards for recommendations and purchases.

So why do good techs need to know the hot chipsets in detail? The chipset defines almost every motherboard feature short of the CPU itself. Techs love to discuss chipsets and expect a fellow tech to know the differences between one chipset and another. You also need to be able to recommend a motherboard that suits a client's needs.

Motherboard Components

The connections and capabilities of a motherboard sometimes differ from those of the chipset the motherboard uses. This disparity happens for a couple of reasons. First, a particular chipset may support eight USB ports, but to keep costs down, the manufacturer might include only four ports. Second, a motherboard maker may choose to install extra features—ones not supported by the chipset—by adding additional chips. A common example is a motherboard that supports FireWire. Other technologies you
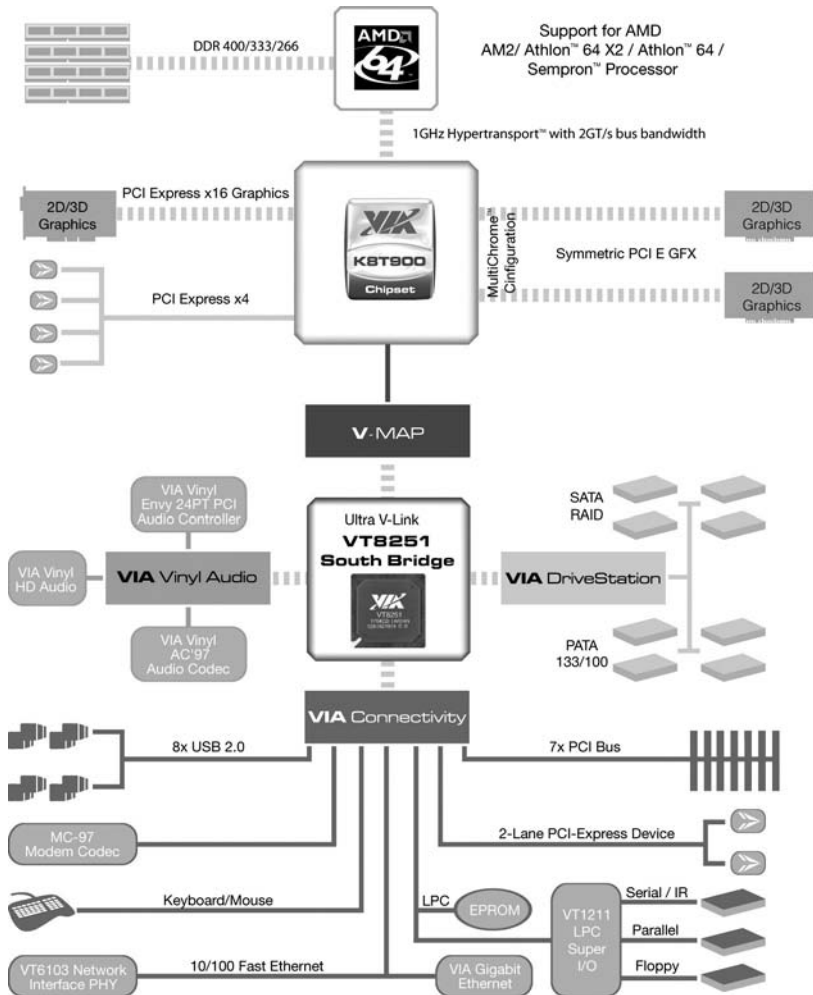
Figure 9-16 Schematic of a modern chipset (*image courtesy of VIA Technologies*)

might find are built-in sound, hard drive RAID controllers, and AMR or CNR slots for modems, network cards, and more.

USB/FireWire

Most chipsets support USB, and most motherboards come with FireWire as well, but it seems no two motherboards offer the same port arrangement. My motherboard supports eight USB ports and two FireWire ports, for example, but if you look on the back of the motherboard, you'll only see four USB ports and one FireWire port. So, where are the other ports? Well, this motherboard has special connectors for the other ports,

Chipset	North-bridge	Southbridge	CPU	CPU Interconnect	CPU RAM Interface	Northbridge RAM Interface	North-bridge PCIe	South-bridge PCIe	SATA	RAID	USB	Integrated Video
Intel X58 Express Chipset	Intel 82X58 Express Chipset I/O Hub (IOH)	Intel 82801JIB ICH10, Intel 82801JIR ICH10R, Intel 82801JID ICH10D, or Intel 82801JIDO ICH10D	LGA1366: Core i7	QuickPath Interconnect (6.4 GT/s, 4.8 GT/s)	Yes, triple-channel DDR3 (24 GB max)	No	1x16, 2x16, or 4x8	6x1	6	Yes: 0,1,5,10	12 Hi-Speed	No
Intel Q45 Express Chipset	Intel 82Q45 Graphics and Memory Controller Hub (GMCH)	Intel 82801JIB ICH10, Intel 82801JIR ICH10R, Intel 82801JID ICH10D, or Intel 82801JIDO ICH10D	LGA775: Core2 Duo, Core2 Quad	Frontside bus (1333 MHz, 1066 MHz, 800 MHz)	No	Yes, dual-channel DDR2 (16 GB max) or DDR3 (8 GB max)	1x16	6x1	6	Yes: 0,1,5,10	12 Hi-Speed	Yes
Intel Q965 Express Chipset	Intel 82Q965 Graphics and Memory Controller Hub (GMCH)	Intel 82801HB ICH8 or Intel 82801HR ICH8R	LGA775: Core2 Duo, Pentium D, Pentium 4 supporting hyper-threading technology	Frontside bus (1066 MHz, 800 MHz, 533 MHz)	No	Yes, dual-channel DDR2 (8 GB max)	1x16	6x1	6	Yes: 0,1,5,10	10 Hi-Speed	Yes
NVIDIA nForce 980a SLI	NVIDIA nForce 980a SLI	N/A[1]	AM3, AM2+, AM2: Phenom X4, Phenom X3, Phenom II X4, Phenom II X3, Athlon X2, Athlon	HyperTransport 3.0 (5.2 GT/s, 2 GT/s, 1.6 GT/s)	Yes, dual-channel DDR3 (16 GB max)	No	3x16, 2x16, 1x16, 2x8, or 4x8 + 4x1	N/A[1]	6	Yes: 0,1, 0+1,5	12 Hi-Speed	No

NVIDIA GeForce 9400 mGPU	N/A¹	LGA775: Pentium D, Core 2 Quad, Core 2 Extreme, Core 2 Duo, Celeron D	Frontside bus (1333 MHz, 1066 MHz, 800 MHz)	No	Yes, dual channel, DDR2 (16 GB max) or DDR3 (8 GB max)	1x16 + 4x1	N/A¹	6	Yes: 0, 1, 0+1, 5	12 Hi-Speed	Yes
AMD 770 Chipset	AMD SB600 or AMD SB700	AM2, AM2+: Phenom X4, Phenom X3, Athlon FX, Athlon X2, Athlon, Sempron	HyperTransport 3.0 (5.2 GT/s, 2 GT/s, 1.6 GT/s)	Yes, dual-channel DDR2 (8 GB max)	No	1x16	6x1	6	Yes: 0, 1, 10	12 Hi-Speed	No
AMD 790GX Chipset	AMD SB750	AM2+: Phenom X4, Phenom X3, Athlon FX, Athlon X2, Athlon, Sempron	HyperTransport 3.0 (5.2 GT/s, 2 GT/s)	Yes, dual-channel DDR2 (16 GB max)	No	1x16 or 2x16	6x1	6	Yes: 0, 1, 5, 10	12 Hi-Speed	Yes

¹. NVIDIA does not make a Northbridge/Southbridge distinction with their chipsets.

Table 9-1   Chipset Comparison Chart

and the motherboard comes with the dongles you need to connect them (Figure 9-17). These dongles typically use an extra slot on the back of the case.

Figure 9-17
USB/FireWire
dongle

These dongle connectors are standardized, so many cases have built-in front USB/ FireWire ports that have dongles attached. This is very handy for USB or FireWire devices you might want to plug and unplug frequently, such as thumb drives or digital cameras. You can also buy add-on front USB and FireWire devices that go into a 3.5-inch drive bay (Figure 9-18).

Figure 9-18
Front USB and
FireWire drive
bay device

Sound

Quite a few motherboards come with onboard sound chips. These sound chips are usually pretty low quality compared to even a lower-end sound card, but onboard sound is cheap and doesn't take up a slot. These connectors are identical to the ones used on sound cards, so we'll save more discussion for Chapter 20, "Multimedia."

RAID

RAID stands for *redundant array of independent* (*or inexpensive*) *disks* and is very common on motherboards. There are many types of RAID, but the RAID on motherboards usually only supports *mirroring* (the process of using two drives to hold the same data, which is good for safety, because if one drive dies, the other still has all of the data)

or *striping* (making two drives act as one drive by spreading data across them, which is good for speed). RAID is a very cool but complex topic that's discussed in detail in Chapter 11, "Hard Drive Technologies."

AMR/CNR

The U.S. Federal Communications Commission (FCC) must certify any electronic device to ensure that it does not transmit unwanted electronic signals. This process is a bit expensive, so in the very late 1990s, Intel came up with a special slot called the *audio modem riser* (*AMR*), shown in Figure 9-19. An AMR slot was designed to take specialized AMR devices (modems, sound cards, and network cards). An AMR device would get one FCC certification and then be used on as many motherboards as the manufacturer wanted without going through the FCC certification process again. AMR was quickly replaced with the more advanced *communications and networking riser* (*CNR*). Many motherboard manufacturers used these slots in the early 2000s, but they've lost popularity because most motherboard makers simply use onboard networking and sound.

Figure 9-19
AMR slot
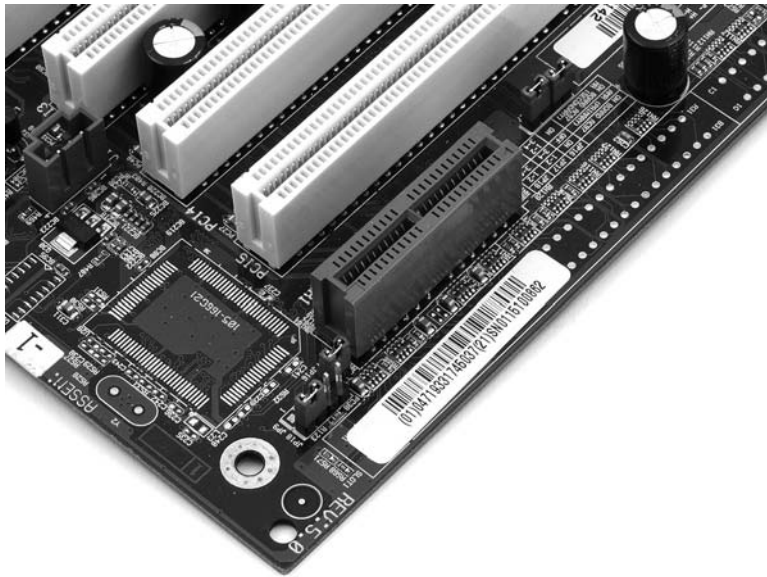
Practical Application

Upgrading and Installing Motherboards

To most techs, the concept of adding or replacing a motherboard can be extremely intimidating. It really shouldn't be; motherboard installation is a common and necessary part of PC repair. It is inexpensive and easy, although it can sometimes be a little

tedious and messy because of the large number of parts involved. This section covers the process of installation and replacement and shows you some of the tricks that make this necessary process easy to handle.

Choosing the Motherboard and Case

Choosing a motherboard and case can prove quite a challenge for any tech, whether newly minted or a seasoned veteran. You first have to figure out the type of motherboard you want, such as AMD- or Intel-based. Then you need to think about the form factor, which of course influences the type of case you'll need. Third, how rich in features is the motherboard and how tough is it to configure? You have to read the motherboard manual to find out. Finally, you need to select the case that matches your space needs, budget, and form factor. Now look at each step in a little more detail.

EXAM TIP Being able to select and install a motherboard appropriate for a client or customer is something every CompTIA A+ technician should know.

First, determine what motherboard you need. What CPU are you using? Will the motherboard work with that CPU? Because most of us buy the CPU and the motherboard at the same time, make the seller guarantee that the CPU will work with the motherboard. If you can, choose a motherboard that works with much higher speeds than the CPU you can afford; that way you can upgrade later. How much RAM do you intend to install? Are extra RAM sockets available for future upgrades?

A number of excellent motherboard manufacturers are available today. Some of the more popular brands are abit, ASUS, BIOSTAR, DFI, GIGABYTE, Intel, MSI, and Shuttle. Your supplier may also have some lesser-known but perfectly acceptable brands of motherboards. As long as the supplier has an easy return policy, it's perfectly fine to try one of these.

Second, make sure you're getting a form factor that works with your case. Don't try to put a regular ATX motherboard into a microATX case!

Third, all motherboards come with a technical manual, better known as the *motherboard book* (Figure 9-20). You must have this book! This book is your primary source for all of the critical information about the motherboard. If you set up CPU or RAM timings incorrectly in CMOS, for example, and you have a dead PC, where would you find the CMOS clear jumper? Where do you plug in the speaker? Even if you let someone else install the motherboard, insist on the motherboard book; you will need it.

NOTE If you have a motherboard with no manual, you can usually find a copy of the manual in Adobe Acrobat (.pdf) format online at the manufacturer's Web site. It's a good idea to grab and print a copy to keep with the motherboard. I often tape a copy (either hard copy or burned onto a CD) of the manual in the case where I installed the motherboard. Just don't cover any vents!

Fourth, pick your case carefully. Cases come in six basic sizes: slimline, desktop, mini-tower, mid-tower, tower, and cube. Slimline and desktop models generally sit on

Figure 9-20
Motherboard box
and book

the desk, beneath the monitor. The various tower cases usually occupy a bit of floor space next to the desk. The mini-tower and mid-tower cases are the most popular choices. Make sure you get a case that fits your motherboard—many microATX and all Flex-ATX cases are too small for a regular ATX motherboard. Cube cases generally require a specific motherboard, so be prepared to buy both pieces at once. A quick test-fit before you buy saves a lot of return trips to the supplier.

NOTE Manufacturers have created a couple of other case form factors, most notably the all-in-one style of the Apple iMac and the super-small nettops. The all-in-one design incorporates the computer into the monitor to provide a svelte setup. The nettops cram super small components, such as you'd normally find in tiny laptops, into various interestingly shaped boxes.

I don't mention these as comparable to the six standard case types, simply because you can't go out and easily buy the components to create one on your own. You might have to service such computers. For tips on servicing, see Chapter 21, "Portable Computing."

**Figure 9-21**
Removable face

Cases come with many options, but three more common options point to a better case. One option is a removable face (Figure 9-21)—many cheaper cases screw the face into the metal frame with wood screws. A removable face makes disassembly much easier.

Another option is a detachable motherboard mount. Clearly, the motherboard has to be attached to the case in some fashion. In better cases,

this is handled by a removable tray or plate (Figure 9-22). This enables you to attach the motherboard to the case separately, saving you from sticking your arms into the case to turn screws.

Figure 9-22
Motherboard tray
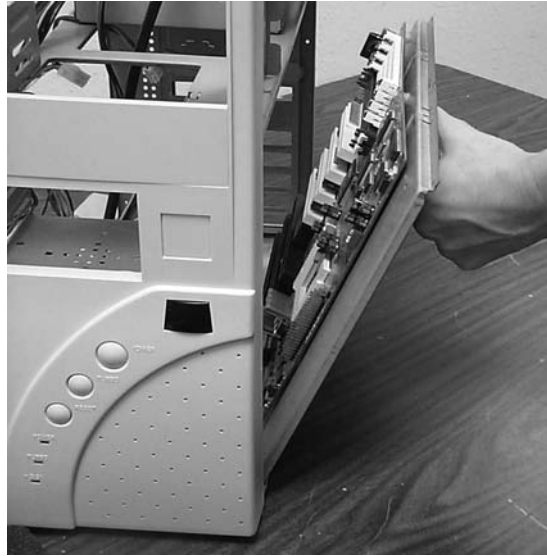
The third option, front-mounted ports for USB, FireWire, and headphones, can make using a PC much easier. Better cases offer these ports, although you can also get add-on components that fit into the increasingly useless floppy drive bay to bring added front connectivity to the PC. Figure 9-23 shows a case with both types of front connectors.

Power supplies often come with the case. Watch out for "really good deal" cases because that invariably points to a cheap or missing power supply. You also need to verify that the power supply has sufficient wattage. This issue is handled in Chapter 10, "Power Supplies."

Building a Recommendation

Family, friends, and potential clients often solicit the advice of a tech when they're thinking about upgrading their PC. This solicitation puts you on the spot to make not just any old recommendation but one that works with the needs and budget of the potential upgrader. To do this successfully, you need to manage expectations and ask the right questions.

1. What does the upgrader want to do that compels him or her to upgrade? Write it down! Some of the common motivations for upgrading are to play that hot new game or to take advantage of new technology. What's the minimum system needed to run tomorrow's action games? What do you need to make multimedia sing? Does the motherboard need to have FireWire and high-speed USB built in to accommodate digital video and better printers?

Figure 9-23
Case with both
front-mounted
ports and an add-
on flash memory
card reader

2. How much of the current system does the upgrader want to save? Upgrading
a motherboard can very quickly turn into a complete system rebuild. What
form factor is the old case? If it's a microATX case, that constrains the
motherboards you can use with it to microATX or the smaller FlexATX. If the
desired motherboard is a full-sized ATX board, you'll need to get a new case.
Does the new motherboard possess the same type of CPU socket as the old
motherboard? If not, that's a sure sign you'll need to upgrade the CPU as well.
What about RAM? If the old motherboard was using DDR SDRAM, and the
new motherboard requires DDR2 SDRAM, you'll need to replace the RAM. If
you need to upgrade the memory, it is best to know how many channels the
new RAM interface supports, because performance is best when all channels are
populated.

What if the old motherboard was using an AGP graphics accelerator that the
new motherboard does not support, but you don't want to splurge on a PCI
Express graphics accelerator right now? In this situation you might want to
consider moving to a motherboard with integrated graphics. What's great about
integrated graphics is that if the motherboard also possesses a ×16 PCI Express
slot, you can upgrade to a more powerful discreet graphics accelerator later.

3. Once you've gathered information on motivation and assessed the current PC of the upgrader, it's time to get down to business: field trip time! This is a great excuse to get to the computer store and check out the latest motherboards and gadgets. Don't forget to jot down notes and prices while you're there. By the end of the field trip, you should have the information to give the upgrader an honest assessment of what an upgrade will entail, at least in monetary terms. Be honest—in other words, don't just tell upgraders what you think they want to hear—and you won't get in trouble.

Installing the Motherboard

If you're replacing a motherboard, first remove the old motherboard. Begin by removing all of the cards. Also remove anything else that might impede removal or installation of the motherboard, such as hard or floppy drives. Keep track of your screws—the best idea is to return the screws to their mounting holes temporarily, at least until you can reinstall the parts. Sometimes you even have to remove the power supply temporarily to enable access to the motherboard. Document the position of the little wires for the speaker, power switch, and reset button in case you need to reinstall them.

EXAM TIP The CompTIA A+ Essentials exam will test you on the basics of installing a motherboard, so you need to know this section for both exams.

Unscrew the motherboard. *It will not simply lift out.* The motherboard mounts to the case via small connectors called *standouts* that slide into keyed slots or screw into the bottom of the case (Figure 9-24). Screws then go into the standouts to hold the motherboard in place. Be sure to place the standouts properly before installing the new motherboard.

Figure 9-24
Standout in a case, ready for the motherboard

CAUTION Watch out for ESD here! Remember that it's very easy to damage or destroy a CPU and RAM with a little electrostatic discharge. It's also fairly easy to damage the motherboard with ESD. Wear your anti-static wrist strap.

A lot of techs install the CPU, CPU fan, and RAM into the motherboard before installing the motherboard into the case. This helps in several ways, especially with a new system. First, you want to make certain that the CPU and RAM work well with the motherboard and with each other—without that, you have no hope of setting up a stable system. Second, installing these components first prevents the phenomenon of *flexing* the motherboard. Some cases don't provide quite enough support for the motherboard, and pushing in RAM can make the board bend. Third, attaching a CPU fan can be a bear of a task, one that's considerably easier to do on a table top than within the confines of a case. Finally, on motherboards that require you to set jumpers or switches, you can much more easily read the tiny information stenciled on the PCB before you add the shadows from the case. If necessary, set any jumpers and switches for the specific CPU according to information from the motherboard manual.

Once you install the CPU, RAM, fans, and so on, you're ready to install the motherboard into the case. When you insert the new motherboard, do not assume that you will put the screws and standouts in the same place as they were in your old motherboard. When it comes to the placement of screws and standouts, only one rule applies: anywhere it fits. Do not be afraid to be a little tough here! Installing motherboards can be a wiggling, twisting, knuckle-scraping process.

CAUTION Pay attention to the location of the standouts if you're swapping a motherboard. If you leave a screw-type standout beneath a spot on the motherboard where you can't add a screw and then apply power to the motherboard, you run the risk of shorting the motherboard.

Once you get the motherboard mounted in the case, with the CPU and RAM properly installed, it's time to insert the power connections and test it. A POST card can be helpful with the system test because you won't have to add the speaker, a video card, monitor, and keyboard to verify that the system is booting. If you have a POST card, start the system, and watch to see if the POST takes place—you should see a number of POST codes before the POST stops. If you don't have a POST card, install a keyboard, speaker, video card, and monitor. Boot the system and see if the BIOS information shows up on the screen. If it does, you're probably okay. If it doesn't, it's time to refer to the motherboard book to see where you made a mistake.
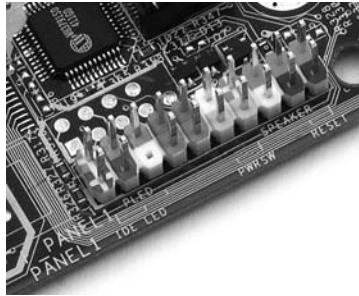
Wires, Wires, Wires

The last part of motherboard installation is connecting the LEDs, buttons, and front-mounted ports on the front of the box. These usually include the following:

- Soft power
- Reset button
- Speaker

- Hard drive activity LED
- Power LED
- USB
- FireWire
- Sound

Figure 9-25
Motherboard wire connections labeled on the motherboard

These wires have specific pin connections to the motherboard. Although you can refer to the motherboard book for their location, usually a quick inspection of the motherboard will suffice for an experienced tech (Figure 9-25).

You need to follow a few rules when installing these wires. First, the lights are LEDs, not light bulbs; they have a positive and negative side. If they don't work one way, turn the connector around and try the other. Second, when in doubt, guess. Incorrect installation only results in the device not working; it won't damage the computer. Refer to the motherboard book for the correct installation. The third and last rule is that, with the exception of the soft power switch on an ATX system, you do not need any of these wires for the computer to run. Many techs often simply ignore these wires, although this would not be something I'd do to any system but my own.

No hard-and-fast rule exists for determining the function of each wire. Often the function of each wire is printed on the connector (Figure 9-26). If not, track each wire to the LED or switch to determine its function.

Figure 9-26
Sample of case wires
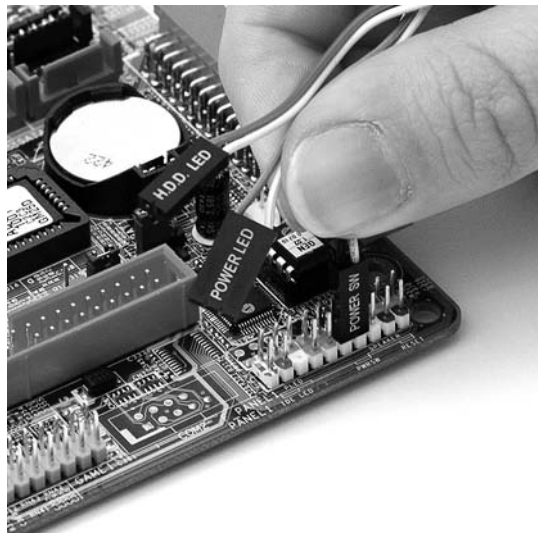
Troubleshooting Motherboards

Motherboards fail. Not often, but motherboards and motherboard components can die from many causes: time, dust, cat hair, or simply slight manufacturing defects made worse by the millions of amps of current sluicing through the motherboard traces. Installing cards, electrostatic discharge, flexing the motherboard one time too many when swapping out RAM or drives—any of these factors can cause a motherboard to fail. The motherboard is a hard-working, often abused component of the PC. Unfortunately for the common tech, troubleshooting a motherboard problem can be difficult and time consuming. Let's wrap this chapter with a look at symptoms of a failing motherboard, techniques for troubleshooting, and the options you have when you discover a motherboard problem.

Symptoms

Motherboard failures commonly fall into three types: catastrophic, component, and ethereal. With a *catastrophic failure*, the PC just won't boot. This sort of problem happens to brand-new systems because of manufacturing defects—often called a *burn-in failure*—and to any system that gets a shock of electrostatic discharge. Burn-in failure is uncommon and usually happens in the first 30 days of use. Swap out the motherboard for a replacement and you should be fine. If you accidentally zap your motherboard when inserting a card or moving wires around, be chagrined. Change your daring ways and wear an anti-static wrist strap!

Component failure happens rarely and appears as flaky connections between a device and motherboard, or as intermittent problems. A hard drive plugged into a faulty controller on the motherboard, for example, might show up in CMOS autodetect but be inaccessible in Windows. Another example is a serial controller that worked fine for months until a big storm took out the external modem hooked to it, and doesn't work anymore, even with a replacement modem.

The most difficult of the three types of symptoms to diagnose are those I call *ethereal* symptoms. Stuff just doesn't work all of the time. The PC reboots itself. You get a Blue Screen of Death (BSoD) in the midst of heavy computing, such as right before you smack the villain and rescue the damsel. What can cause such symptoms? If you answered any of the following, you win the prize:

- Faulty component
- Buggy device driver
- Buggy application software
- Slight corruption of the operating system
- Power supply problems

Err…you get the picture.

What a nightmare scenario to troubleshoot! The Way of the Tech knows paths through such perils, though, so let's turn to troubleshooting techniques now.

Techniques

To troubleshoot a potential motherboard failure requires time, patience, and organization. Some problems will certainly be quicker to solve than others. If the hard drive doesn't work as expected, as in the previous example, check the settings on the drive. Try a different drive. Try the same drive with a different motherboard to verify that it's a good drive. Like every other troubleshooting technique, all you try to do with motherboard testing is to isolate the problem by eliminating potential factors.

This three-part system—check, replace, verify good component—works for the simpler and the more complicated motherboard problems. You can even apply the same technique to ethereal-type problems that might be anything, but you should add one more verb: *document*. Take notes on the individual components you test so you don't repeat efforts or waste time. Plus, taking notes can lead to the establishment of patterns. Being able to re-create a system crash by performing certain actions in a specific order can often lead you to the root of the problem. Document your actions. Motherboard testing is time-consuming enough without adding inefficiency.

Options

Once you determine that the motherboard has problems, you have several options for fixing the three types of failures. If you have a catastrophic failure, you must replace the motherboard. Even if it works somewhat, don't mess around. The motherboard should provide bedrock stability for the system. If it's even remotely buggy or problematic, get rid of it!

If you have a component failure, you can often replace the component with an add-on card that will be as good as or better than the failed device. Adaptec, for example, makes fine cards that can replace the built-in SATA ports on the motherboard (Figure 9-27).

Figure 9-27
Adaptec PCIe
SATA card
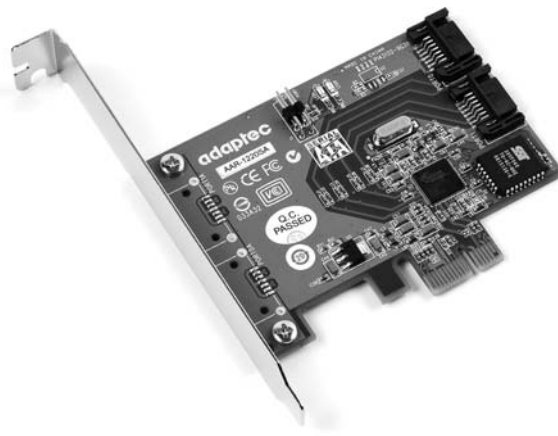
CAUTION If you've lost components because of ESD or a power surge, you would most likely be better off replacing the motherboard. The damage you *can't* see can definitely sneak up to bite you and create system instability.

If your component failure is more a technology issue than physical damage, you can try upgrading the BIOS on the motherboard. As you'll recall from Chapter 7 on BIOS and CMOS, every motherboard comes with a small set of code that enables the CPU to communicate properly with the devices built into the motherboard. You can quite readily upgrade this programming by *flashing the BIOS*: running a small command-line program to write new BIOS in the flash ROM chip. Refer to Chapter 7, "BIOS and CMOS," for the details on flashing.

NOTE Flashing the BIOS for a motherboard can fix a lot of system stability problems and provide better implementation of built-in technology. What it cannot do for your system is improve the hardware. If AMD comes out with a new, improved, lower-voltage Athlon 64, for example, and your motherboard cannot scale down the voltage properly, you cannot use that CPU—even if it fits in your motherboard's Socket AM2. No amount of BIOS flashing can change the hardware built into your motherboard.

Finally, if you have an ethereal, ghost-in-the-machine type of problem that you have finally determined to be motherboard related, you have only a couple of options for fixing the problem. You can flash the BIOS in a desperate attempt to correct whatever it is, which sometimes does work and is less expensive than the other option. Or you can replace the motherboard.

Beyond A+

Shuttle Form Factor

In the early 2000s, Shuttle started making a very interesting line of tiny cube-shaped PCs called XPCs that became an overnight sensation and continue to be popular today (Figure 9-28). These boxes use a tiny, proprietary form factor motherboard, called *Shuttle Form Factor*, installed in a proprietary case with a proprietary power supply. Originally, these systems were sold *barebones*, meaning they came with only a motherboard, case, and power supply. You had to supply a CPU, RAM, video card, keyboard, mouse, and monitor. Shuttle now produces a full line of computers.

NOTE Many companies followed Shuttle's lead and started making cube or cube-like small cases. You'll hear these cases commonly referred to as *small form factor* (*SFF*), but there's no industry-wide standard. Some SFF cases accommodate microATX and FlexATX motherboards.

Figure 9-28
Shuttle XPC
(*photo courtesy of Shuttle Computer Group, Inc.*)

Mini-ITX

If you really want to get small, check out Mini-ITX (Figure 9-29). Developed by VIA Technologies in 2001, Mini-ITX has a maximum size of only 17 centimeters by 17 centimeters. Most Mini-ITX systems feature low-power processors such as the Intel Atom or the VIA C7. Many new enthusiast-grade Mini-ITX motherboards support more powerful processors such as the Intel Core2 Duo or the AMD Phenom.

Figure 9-29
Mini-ITX
motherboard

NOTE Watch out for all of the pretty colors on today's motherboards. To catch the consumer's eye, a lot of motherboard manufacturers have started making wildly colorful motherboard components. There is no universally accepted standard for connection colors on the inside of a motherboard.

Chapter Review Questions

1. Which of the following form factors dominates the PC industry?

   A. AT

   B. ATX

   C. BTX

   D. CTX

2. Which of the following form factors offers the best cooling?

   A. AT

   B. ATX

   C. BTX

   D. CTX

3. On older Intel-based motherboards, which chip enables the CPU to interact with RAM?

   A. Memorybridge

   B. Northbridge

   C. Southbridge

   D. Super I/O

4. Brian bought a new motherboard that advertised support for eight USB ports. When he pulled the motherboard out of the box, though, he found that it only had four USB ports. What's likely the issue here?

   A. The extra four USB ports will connect to the front of the case or via a dongle to an expansion slot.

   B. The extra four USB ports require an add-on expansion card.

   C. The FireWire port will have a splitter that makes it four USB ports.

   D. The motherboard chipset might support eight USB ports, but the manufacturer only included four ports.

5. Martin bought a new motherboard to replace his older ATX motherboard. As he left the shop, the tech on duty called after him, "Check your standouts!" What could the tech have meant?

   A. Standouts are the connectors on the motherboard for the front panel buttons, such as the on/off switch and reset button.

   B. Standouts are the metal edges on some cases that aren't rolled.

   C. Standouts are the metal connectors that attach the motherboard to the case.

   D. Standouts are the dongles that enable a motherboard to support more than four USB ports.

6. Amanda bought a new system that, right in the middle of an important presentation, gave her a Blue Screen of Death. Now her system won't boot at all, not even to CMOS. After extensive troubleshooting, she determined that the motherboard was at fault and replaced it. Now the system runs fine. What was the most likely cause of the problem?

   A. Burn-in failure

   B. Electrostatic discharge

   C. Component failure

   D. Power supply failure

7. Solon has a very buggy computer that keeps locking up at odd moments and rebooting spontaneously. He suspects the motherboard. How should he test it?

   A. Check settings and verify good components.

   B. Verify good components and document all testing.

   C. Replace the motherboard first to see if the problems disappear.

   D. Check settings, verify good components, replace components, and document all testing.

8. Depending on the age of the motherboard, the Northbridge chip provides either communication with the RAM or communication with what component?

   A. Hard drive

   B. Memory controller

   C. Onboard networking

   D. Video card

9. When Jane proudly displayed her new motherboard, the senior tech scratched his beard and asked, "What kind of ICH has she got?" What could he possibly be asking about?

   A. The AMR slot

   B. The CNR slot

   C. The Northbridge

   D. The Southbridge

10. What companies dominate the chipset market? (Select two.)

    A. ATI

    B. Intel

    C. NVIDIA

    D. SiS

Answers

  1. **B.** Almost all modern motherboards follow the ATX form factor.

  2. **C.** Although not widely adopted by the industry, BTX motherboards offer superior cooling to ATX systems.

  3. **B.** The Northbridge enables communication between the CPU and RAM.

  4. **A.** The extra four USB ports most likely connect to the front of the case or via a dongle to an expansion slot.

  5. **C.** Standouts are the metal connectors that attach the motherboard to the case.

  6. **A.** Although all of the answers are plausible, the best answer here is that her system suffered burn-in failure.

  7. **D.** Solon needs to check settings, verify good components, replace components, and document all testing.

  8. **D.** On older motherboards, the Northbridge handled RAM. Newer CPUs have the memory controller built in, so the Northbridge handles the communication with the video card.

  9. **D.** Intel calls their Southbridge chips the I/O Controller Hub (ICH) on many of their chipsets.

10. **B, C.** Intel and NVIDIA produce the vast majority of the chipsets used in personal computers.