Chapter 2

Overview of System Features and Components

This chapter discusses the differences in system architecture of IBM and compatible systems and explains memory structure and use. It also discusses how to obtain the service manuals necessary to maintain and upgrade your computer.

Types of Systems

Many types of IBM and compatible systems are on the market today. Most systems are similar to one another, but a few important differences in system architecture have become more apparent as operating environments such as Windows and OS/2 have increased in popularity. Operating systems such as OS/2 1.x require at least a 286 CPU platform on which to run. OS/2 2.x requires at least a 386 CPU. Environments such as Windows offer different capabilities and operating modes based on the capabilities of the hardware platform on which you run it. Knowing and understanding the differences in these hardware platforms will enable you to plan, install, and utilize modern operating systems and applications to use the hardware optimally.

All IBM and compatible systems can be broken down into two basic system types, or classes, of hardware:

- PC/XT class systems
- AT class systems

The term *PC* stands for Personal Computer, of course, while *XT* stands for eXTended. The XT is basically a PC system that includes a hard disk for storage in addition to the floppy drive(s) found in the normal PC system. These systems have an 8-bit 8088 processor and an 8-bit Industry Standard Architecture (ISA) Bus for system expansion. The *bus* is the name given to expansion slots where additional plug-in circuit boards can be installed. The 8-bit designation comes from the fact that the ISA Bus found in the PC/XT class systems can only send or receive 8-bits of data in a single cycle. The data in an 8-bit bus is sent along eight wires simultaneously in parallel.

More advanced systems are said to be *AT class,* which indicates that they follow certain standards first set forth in the IBM AT system. *AT* stands for Advanced Technology, which is the designation IBM applied to systems that first included more advanced 16-bit (and later 32- and 64-bit) processors and expansion slots. AT class systems must have any processor compatible with the Intel 286 or higher processors (including the 386, 486, and Pentium processors) and must have a 16-bit or greater expansion slot system. The bus architecture is central to AT compatibility; PC/XT class systems with upgraded processor boards that do not include the 16-bit or greater expansion bus do not qualify as true AT systems. The first AT systems have a 16-bit version of the ISA Bus, which is an extension of the original 8-bit ISA Bus found in the PC/XT class systems. Eventually a number of expansion slot or bus designs were developed for AT class systems, including those listed here:

- 16-bit ISA Bus
- 16/32-bit Enhanced ISA (EISA) Bus
- 16/32-bit PS/2 Micro Channel Architecture (MCA) Bus
- 16-bit Personal Computer Memory Card International Association (PCMCIA) Bus
- 16/32/64-bit Video Local (VL) Bus
- 32/64-bit Peripheral Component Interconnect (PCI) Bus

A system with any of these types of expansion slots is by definition an AT class system, regardless of the actual processor used. AT-type systems with 386 or higher processors have special capabilities not found in the first generation of 286-based ATs. The 386 and higher systems have distinct capabilities regarding memory addressing, memory management, and possible 32-bit-wide access to data. Most systems with 386DX or higher chips have 32-bit slots to take full advantage of the 32-bit data-transfer capabilities.

The ISA and MCA architectures were developed by IBM and copied by other manufacturers for use in compatible systems. Other expansion bus designs were independently derived by other companies. For years the ISA Bus dominated the IBM-compatible marketplace. When the 32-bit 386DX processor debuted, however, there arose a need for a 32-bit expansion slot design to match. IBM took the high road and developed the Micro Channel Architecture Bus, which has outstanding technical capabilities compared to the previous ISA designs. Unfortunately, IBM has had a difficult time marketing the MCA Bus due to problems with the high cost of manufacturing MCA motherboards and adapter cards, as well as the perceived notion that MCA is proprietary. Although it is not, IBM has not succeeded in marketing it as the new bus of choice, and it has remained largely a feature of IBM systems only. The rest of the marketplace has for the most part ignored MCA, although a few companies have produced MCA-compatible systems and many companies produce MCA expansion adapters.

Compaq, for example, was the primary architect of the Extended Industry Standard Architecture Bus. Realizing the difficulty IBM had in marketing its new MCA Bus, Compaq decided that the best approach would be to give the bus design away rather than to keep it as a Compaq-only feature. They feared a repeat of what IBM was going through in trying to get the MCA Bus accepted throughout the industry. After all, how many companies would market expansion cards for a new bus unique to Compaq systems? Compaq decided that others should share in their new design, and they contacted a number of other system manufacturers to see if they were interested in participating. This led to the EISA consortium, which in September 1988 debuted the Compaq-designed expansion bus: Extended Industry Standard Architecture (EISA). The system is a 32-bit slot for use with 386DX or higher systems.

Speculators said that EISA was developed to circumvent the royalties IBM charges competitors who use the ISA or MCA slot design in their systems. This speculation was false because EISA is an extension of the IBM-developed ISA Bus, and manufacturers of EISA systems must pay IBM the same licensing fees as do manufacturers of ISA or MCA systems. EISA was developed not to circumvent licensing fees, but to show technological leadership and to enable Compaq and other companies to have some design freedom and control over their systems. Whether EISA, an alternative to the IBM-designed MCA, becomes a useful standard depends on the popularity of systems that use the slot.

Unfortunately, EISA never achieved great popularity and sold in far smaller numbers than did MCA systems. There are fewer EISA expansion adapters than MCA adapters, as well. This failure in the marketplace occurred for several reasons. One is the high cost of integrating the EISA Bus into a system. The special EISA Bus controller chips add several hundred dollars to the cost of a motherboard. In fact, having EISA slots onboard can double the cost of the motherboard. Another reason for the relative failure of EISA was the fact that the performance it offered was actually greater than most peripherals it could be connected to! This incompatibility in performance was also true for MCA. The available hard disks and other peripherals could not transfer data as fast as the 16-bit ISA Bus could handle, so why use EISA, a still faster bus? Memory had already found its way off the standard bus and was normally installed directly on the motherboard via SIMMs (Single In-line Memory Modules). EISA complicated system installation and configuration whenever standard ISA boards were mixed with EISA boards. The standard ISA boards could not be controlled by the EISA configuration program required to configure the jumper and switchless EISA cards. In the years following EISA's introduction, it found a niche in high-end server systems because of the bus's increased bandwidth. For standard workstations, however, the EISA Bus has been superseded by VL-Bus and PCI.

The newest trend in expansion slots is the *local bus*. This type of bus is connected closely or directly to the processor. A problem with ISA and EISA is that the bus speed was locked in at 8.33 MHz, which was far slower than the processors. MCA offered greater performance, but it was still limited compared to the advancements in processors. What was needed were expansion slots that could talk directly to the processor, at processor

speed, using all the bits the processor could handle. The first of the local buses to achieve popularity was the Video Local Bus, so named because it actually was designed for video adapters. The VL-Bus was created initially by NEC Corporation, who sought to include it in their systems to allow much faster video adapter functionality. Because NEC Corporation saw strength in numbers, they decided to give away the VL-Bus technology and to make it an industry standard. The Video Electronics Standards Association was formed and split from NEC to control the new VL-Bus and other standards. The inexpensive design and high performance of the VL-Bus made it a popular addition to the ISA Bus and even to some EISA systems. VL-Bus was defined as an extension connector to the ISA or EISA Bus and could be found only in systems with those buses.

Peripheral Component Interconnect Bus was created by Intel to be a new generation bus, offering local bus performance while also offering processor independence and multiple processor capabilities. Like so many of the other bus creators, Intel formed an independent organization to make the PCI Bus an industry standard in which all could participate. The PCI Committee was formed to administer this new bus and to control its destiny. Due to the superior design and performance of PCI, it has rapidly become the bus of choice in the highest performance systems. Over the next few years, we will probably see PCI unseat the ISA Bus and become the dominant bus architecture.

Chapter 5, "Bus Slots and Specifications," has more in-depth information on these and other PC system buses, including technical information, such as pinouts, performance specifications, bus operation and theory, and so on.

Table 2.1 summarizes the primary differences between a standard PC (or XT) system and an AT system. This information distinguishes between these systems and includes all IBM and compatible models.

Table 2.1 Differences between PC/XT and AT Systems

System Attributes	PC/XT Type	AT Type
Supported processors	All Intel 80xx	286 or higher
Processor modes	Real	Real or Protected (Virtual Real on 386+)
Expansion-slot width	8-bit	16/32/64-bit
Slot type	ISA	ISA, EISA, MCA, PCMCIA, VL-Bus, PCI
Hardware interrupts	8	16 or more
DMA channels	4	8 or more
Maximum RAM	1 megabyte	16 or 4096 megabytes
Floppy controller	250 kHz Data Rate	250/300/500/1000 kHz Data Rate
Standard boot drive	360K or 720K	1.2M/1.44M/2.88M
Keyboard interface	Unidirectional	Bidirectional
CMOS setup/clock	No	Yes
Serial port UART	8250B	16450/16550A

This table highlights the primary differences between PC and AT architecture. Using this information, you can properly categorize virtually any system as a PC type or an AT type. A Compaq Deskpro, for example, is a PC system, and the Deskpro 286 and Deskpro 386 are AT-type systems. IBM's XT Model 286 is actually an AT-type system. The AT&T 6300 qualifies as a PC-type system, and the 6310 is an AT-type system.

You usually can identify PC and XT types of systems by their Intel-design 8088 or 8086 processors; many possibilities are available, however. Some systems have the NEC V-20 or V-30 processors, but these processors are functionally identical to the Intel chips. A few PC or XT systems have a 286 or 386 processor for increased performance. These systems have only 8-bit slots of the same system-bus design featured in the original IBM PC. The design of these slots includes only half the total DMA and hardware interrupts of a true AT design, which severely limits the use of expansion slots by different adapter boards that require the use of these resources. This type of system can run most software that runs under MS-DOS, but is limited in more advanced operating systems such as OS/2. This type of system cannot run OS/2 or any software designed to run under OS/2, nor can it run Windows 3.1 or greater. These systems also cannot have more than 1 megabyte of processor-addressable memory, of which only 640K is available for user programs and data.

You usually can identify AT systems by their Intel-design 286, 386, or higher processors. Some AT systems differ in the types of slots included on the main system board. The earlier standard called for 8/16-bit ISA slots compatible with the original IBM PC and AT. Other standards such as EISA, MCA, PCMCIA, VL-Bus, and PCI also would be found only in AT class systems. Most of these systems today would use 486 or Pentium processors.

PC systems usually have double-density (DD) floppy controllers, but AT systems must have a controller capable of high-density (HD) and double-density operation. Almost all current systems also have a controller capable of extra-high density (ED). These systems can run the 2.88M floppy drive. Because of the different controller types, the boot drive on a PC system must be the DD, 5 1/4-inch 360K or 3 1/2-inch 720K drives, but the AT needs the 5 1/4-inch 1.2M or the 3 1/2-inch 1.44M or 2.88M drives for proper operation. You can use a double-density disk drive as the boot drive in an AT system; the problem is that your boot drive is *supposed* to be a high-density drive. Many applications that run on only AT-type systems are packaged on high-density disks. The OS/2 operating system, for example, is packaged on high-density disks and cannot be loaded from double-density disks. The capability to boot and run OS/2 is a basic AT-compatibility test.

A subtle difference between PC/XT and AT systems is in the keyboard interface. AT systems use a bidirectional keyboard interface with an Intel 8042 processor "running the show." This processor has ROM built-in and can be considered a part of the total system ROM package. The PC/XT systems used an 8255 Programmable Peripheral Interface (PPI) chip, which supports only a unidirectional interface. A keyboard can be configured to work with only one of the interface designs. With many keyboards, you can alter the way the keyboard interfaces by flipping a switch on the bottom of the keyboard. Others, such as IBM's Enhanced 101-key keyboard, detect which type of system they are plugged into and switch automatically. The older XT and AT keyboards work with only the type of system for which they were designed.

The AT architecture uses CMOS memory and a real-time clock; the PC-type systems usually don't. (An exception is the PS/2 Model 30, which has a real-time clock even though it is an XT class system.) A *real-time clock* is the built-in clock implemented by a special CMOS memory chip on the motherboard in an AT system. You can have a clock added on some expansion adapters in a PC system, but DOS does not recognize the clock unless a special program is run first. The CMOS memory in the AT system also stores the system's basic configuration. On a PC- or XT-type system, all these basic configuration options (such as the amount of installed memory, the number and types of floppy drives and hard disks, and the type of video adapter) are set by using switches and jumpers on the motherboard and various adapters.

The serial-port control chip, Universal Asynchronous Receiver/Transmitter (UART), is a National Semiconductor 8250B for the PC-type systems; AT systems use the newer NS 16450 or 16550A chips. Because these chips differ in subtle ways, the BIOS software must be designed for a specific chip. In the AT BIOS, designed for the 16450 and 16550A chips, using the older 8250B chip can result in strange problems, such as lost characters at high transmission speeds.

Some differences (such as the expansion slots, the hardware interrupts, and the DMA channel availability) are absolute. Other differences, such as which processors are supported, are less absolute. The AT systems, however, must use the 286 or higher; the PC systems can use the entire Intel family of chips, from the 8086 on up. Other parameters are less absolute. Your own system might not follow the true standard properly. If your system does not follow all criteria listed for it, especially if it is an AT-type system, you can expect compatibility and operational problems.

Documentation

One of the biggest problems in troubleshooting, servicing, or upgrading a system is proper documentation. As with the system units, IBM has set the standard for the type of documentation a manufacturer makes available. Some compatible manufacturers duplicate the size and content of IBM's manuals, and other manufacturers provide no documentation at all. Generally, the type of documentation provided for a system is proportionate to the size of the manufacturing company. (Large companies can afford to produce good documentation.) Some of this documentation, unfortunately, is essential for even the most basic troubleshooting and upgrading tasks. Other documentation is necessary only for software and hardware developers with special requirements.

Types of Documentation

Four types of documents are available for each system. Some manuals cover an entire range of systems, which can save money and shelf space. You can get the following types of manuals:

- Guide-To-Operations (GTO) manuals (called quick-reference manuals for the PS/2)
- Technical-Reference (TR) manuals

- Hardware-Maintenance Service (HMS) manuals
- Hardware-Maintenance Reference (HMR) manuals

A Guide-To-Operations manual is included in the purchase of a system. For PS/2 systems, these manuals have been changed to Quick-Reference manuals. They contain basic instructions for system setup, operation, testing, relocation, and option installation. A customer-level basic diagnostics disk (usually called a Diagnostics and Setup Disk) normally is included with a system. For PS/2 machines, a special disk—the Reference Disk—contains the setup and configuration programs, as well as both customer-level and technician-level diagnostics.

For PC and XT types of systems, you can find listings of all the jumper and switch settings for the motherboard. These settings specify the number of floppy disk drives, math-chip use, memory use, type of video adapter, and other items. For AT systems, the basic diagnostics disk also has the SETUP routine (used to set the date and time), installed memory, installed disk drives, and installed video adapters. This information is saved by the SETUP program into CMOS battery backed-up memory. For PS/2 systems, the included disk (called the Reference Disk) contains the special Programmable Option-Select (POS) configuration routine and a hidden version of advanced diagnostics.

Technical-Reference Manuals

The Technical-Reference manuals provide system-specific hardware and software interface information for the system. The manuals are intended for people who design hardware and software products to operate with these systems or for people who must integrate other hardware and software into a system. Three types of Technical-Reference manuals are available: one is a Technical-Reference manual for a particular system; another covers all options and adapters; and a third covers the ROM BIOS interface. For PS/2 systems, one Hardware Interface Technical-Reference manual covers all PS/2 systems with updates for newer systems as they become available.

Each system has a separate Technical-Reference manual or an update to the Hardware Interface Technical-Reference manual. These publications provide basic interface and design information for the system units. They include information about the system board, math coprocessor, power supply, video subsystem, keyboard, instruction sets, and other features of the system. You need this information for integrating and installing aftermarket floppy and hard disk drives, memory boards, keyboards, network adapters, or virtually anything you want to plug into your system. This manual often contains schematic diagrams showing the circuit layout of the motherboard and pinouts for the various connectors and jumpers. It also includes listings of the floppy and hard disk drive tables, which show the range of drives that can be installed on a particular system. Power specifications for the power supply are also in this manual. You need these figures in order to determine whether the system has adequate current to power a particular add-on device.

The Options and Adapters Technical-Reference manual begins with a starter manual augmented with supplements. The basic manual covers a few IBM adapter cards, and supplements for new adapters and options are issued continually. These publications provide interface and design information about the options and adapters available for the various systems. This information includes a hardware description, programming considerations, interface specifications, and BIOS information.

The third manual is the BIOS Interface Technical-Reference manual. This publication provides basic input-output system (BIOS) interface information. This compendium covers every BIOS that has been available in IBM's systems. The manual is designed for developers of hardware or software products that operate with the IBM PC and PS/2 products.

Hardware-Maintenance Manuals

Each hardware-maintenance library consists of two manuals: a Hardware-Maintenance Service manual and a Hardware-Maintenance Reference manual. These are real service manuals that are written for service technicians. Although their intended audience is the professional service technician, they are very easy to follow and useful even for amateur technicians or enthusiasts. IBM and local computer retail outlets use these manuals for diagnosis and service.

For IBM systems, two sets of manuals are available. One set covers the PC, XT, Portable PC, AT, and PS/2 Model 25 and Model 30. The other manual set covers the PS/2 systems except Model 25 and Model 30: these systems are considered old PC or XT systems, rather than true PS/2 systems.

Manuals are purchased in starter form and then updated with supplements covering new systems and options. The PS/2 Model 25 and Model 30, for example, are covered by supplements that update the PC Maintenance Library; the PS/2 Model 80 is covered by a supplement to the PS/2 Maintenance Library.

The basic Hardware-Maintenance Service manual for the PC or PS/2 contains all the information you need to troubleshoot and diagnose a failing system. This book contains special flowcharts that IBM calls *Maintenance-Analysis Procedures* (MAPs), which can help you find a correct diagnosis in a step-by-step manner. It contains information about jumper positions and switch settings, a detailed parts catalog, and disks containing the advanced diagnostics. The Hardware-Maintenance Service manual is an essential part of a troubleshooter's toolkit.

Many technicians with troubleshooting experience never need to use MAPs. When they have a tough problem, however, MAPs help them organize a troubleshooting session. MAPs tell you to check the switch and jumper settings before the cables, to check the cables before replacing the drive or controller, and so on. This type of information is extremely valuable and can be generalized to a range of systems.

The basic Hardware-Maintenance Reference manual for the PC or PS/2 contains general information about the systems. It describes the diagnostic procedures and Field-Replaceable Unit (FRU) locations, system adjustments, and component removal and

installation. The information in it is useful primarily to users with no experience in disassembling and reassembling a system or to users who have difficulty identifying components within the system. Most people do not need this manual after the first time they take down a system for service.

Obtaining Documentation

You cannot accurately troubleshoot or upgrade a system without a Technical-Reference manual. Because of the specific nature of the information in this type of manual, it will most likely have to be obtained from the manufacturer of the system. The IBM AT Technical Reference Manual, for example, is useless to a person with a Compaq Deskpro 486. A person with a Deskpro 486 must get the specific manual for that machine from Compaq.

A service manual is also a necessary item, but is not available from most manufacturers. This type of manual is not nearly as system-specific as a Technical-Reference manual; because of that, the service manuals put out by IBM work well for most compatibles. Some information, such as the parts catalog, is specific to IBM systems and does not apply to compatibles, but most of the IBM service manuals have general information.

Many knowledgeable reviewers use the IBM Advanced Diagnostics, included with the Hardware-Maintenance Service manual, as an acid test for compatibility. If the system truly is compatible, it should pass the tests with flying colors. (Most systems pass.) Many manufacturers do not have or sell a book or disk equivalent to the IBM Hardware-Maintenance Service manual. Compaq, for example, has a service manual, but does not sell it or any parts to anyone who is not a Compaq-authorized dealer. Servicing or upgrading these systems therefore is more costly, and limited by how much your dealer helps you. Buyers are fortunate that sufficient third-party diagnostics work with most compatible systems such as the Compaq systems.

To get hardware-service documentation, contact the dealer who sold you the system and then, if necessary, contact the manufacturer. (Contacting the manufacturer is often more efficient because dealers rarely stock these items.) You can get any IBM manuals easily from IBM. To order the IBM manuals, call this toll-free number:

1-800-IBM-PCTB (1-800-426-7282)

TB is the abbreviation for Technical Books. The service is active Monday through Friday, from 8 a.m. to 8 p.m. Eastern time. When you call, you can request copies of the *Technical Directory*—a catalog listing all part numbers and prices of available documentation. You also can inquire about the availability of technical-reference or service documentation covering newly announced products that might not be listed in the current directory.

The process of obtaining other manufacturers' manuals might (or might not) be so easy. Most larger-name companies run responsible service and support operations that provide technical documentation. Others either do not have or are unwilling to part with such documentation, to protect their service departments or their dealers' service departments

from competition. Contact the manufacturer directly, and the manufacturer can direct you to the correct department so that you can inquire about this information.

Summary

Apart from the overall similarity between IBM computers and their compatibles, important differences in system architecture exist. IBM and compatible computers can be broken down into PC/XT and AT categories. This chapter explained their differences, and a discussion about how to obtain the service manuals necessary for maintaining and upgrading your computer ended the chapter.