



PC Server 720

User's Reference

Note

Before using this information and the product it supports, be sure to read the general information under “Notices” on page 108.

First Edition (July, 1995)

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This *User's Reference* provides an overview of the technologies and features that make up your server. It is intended for anyone who has an interest in learning more about the IBM PC Server 720.

This book does not provide specific instructions for performing procedures. That information is in your *Setup* booklet or your *User's Handbook*.

How This Book is Organized

Chapter 1, "Introducing Your IBM PC Server 720," provides an overview of the features and expansion capabilities of the IBM PC Server 720. This chapter also includes the system specifications.

Chapter 2, "Server Performance," contains information about server performance, and includes tips on improving server performance.

Chapter 3, "Microprocessors and Memory," explains microprocessors, and discusses the types of microprocessors and memory in your server.

Chapter 4, "Bus Architectures," provides information about the bus architectures in your server. These include the Corollary C-bus II multiprocessing bus, the PCI bus, and the Micro Channel bus.

Chapter 5, "Data Storage Devices," explains the data storage capabilities of your server. It includes information about the direct access storage devices (DASD) that you can install, such as diskette drives, hard disk drives, CD-ROM drives, and tape drives.

Chapter 6, "SCSI Subsystem," discusses the small computer system interface (SCSI) subsystem and its advantages.

Chapter 7, "Disk Arrays," contains information about the RAID (redundant array of independent disks) adapter that comes standard in some models of the IBM PC Server 720. It also provides an overview of disk array technology and RAID levels, as well as the advantages of each level.

Chapter 8, “Configuration,” provides information about the configuration process and describes the system configuration programs provided with your server.

Chapter 9, “Input/Output Ports and Connectors,” discusses the integrated serial, parallel, keyboard, mouse, video, and SCSI-2 input/output (I/O) ports on the IBM PC Server 720. This chapter also includes detailed pin assignments for each I/O connector, to help you determine if a device is compatible with your server.

Chapter 10, “Video Subsystem,” contains information about the super video graphics array (SVGA) controller and video device drivers. This chapter also includes details about some of the displays that you can attach to your server.

Chapter 11, “Security Features,” explains securing network hardware, securing data on the network, and the selectable-drive startup feature.

Appendix A, “Product Warranties and Notices,” contains product warranties and special notices, such as a list of trademarks used in this book.

See the glossary in the back of this book for definitions of technical terms. An index is also provided.

Related Publications

The *IBM PC Server 720 Setup* booklet and the *IBM PC Server 720 User's Handbook* that come with this reference contain detailed information about setting up, configuring, using, installing options in, and troubleshooting your server. See the "About This Book" section in the front of the *User's Handbook* for a complete description of what that book contains.

The documentation included in the ServerGuide package contains information and instructions about installing the operating systems and other software provided on the ServerGuide compact discs.

The *IBM Personal System/2 Hardware Maintenance Manual Supplement* is available for purchase. It contains a parts catalog, error codes, and advanced diagnostic procedures. This manual is intended for trained service technicians. Diagnostic diskettes are not included.

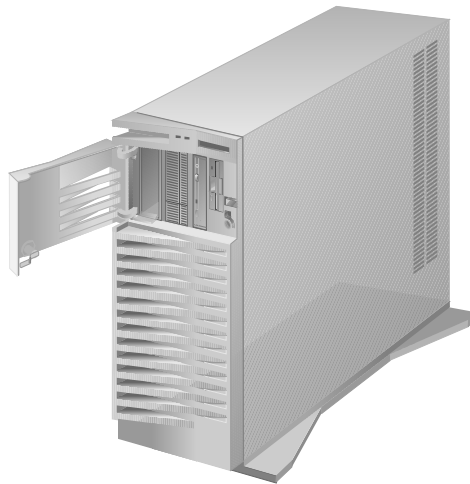
For a complete listing of publications available in the U.S. and Puerto Rico, call 1-800-426-7282. In Canada, call 1-800-465-1234. In all other countries, contact the IBM support organization that services your area, your IBM marketing representative, or your IBM authorized reseller.

Chapter 1. Introducing Your IBM PC Server 720

The IBM PC Server 720 is a high-performance, symmetric-multiprocessing (SMP) server. It is ideally suited for networking environments that require superior microprocessor performance, efficient memory management, flexibility, and large amounts of reliable data storage.

Performance, ease of use, reliability, and expansion capabilities were key considerations during the design of your server. These design features make it possible for you to customize the system hardware to meet your needs today, while providing flexible expansion capabilities for the future.

Your IBM PC Server 720 comes with a three-year warranty, a 30-day money-back guarantee, the IBM ServerGuide package, and IBM PC Server Startup Support. The PC Server Startup Support program provides comprehensive telephone assistance for the installation of your hardware *and* your software during your first 90 days.



Features at a Glance

<p>Microprocessor</p> <ul style="list-style-type: none"> • Intel Pentium with 16KB of internal cache • Expandable to six processor boards <p>Cache Memory</p> <ul style="list-style-type: none"> • On each processor board: <ul style="list-style-type: none"> – 16KB of level-1 cache – 512KB of level-2 cache – 192 byte level-3 cache buffer <p>Memory</p> <ul style="list-style-type: none"> • 64MB expandable to 1GB • Industry standard, 4-byte, 60 ns, ECC • 16 memory sockets per card • 4-way interleaved • Second memory card available as an option <p>Diskette Drive</p> <ul style="list-style-type: none"> • Standard: One 3.5-inch, 2.88MB • Optional (internal): <ul style="list-style-type: none"> – 3.5-inch, 1.44MB – 3.5-inch, 2.88MB – 5.25-inch, 360KB – 5.25-inch, 1.2MB <p>CD-ROM Drive:</p> <ul style="list-style-type: none"> • Standard: SCSI-2 CD-ROM <p>Keyboard</p> <ul style="list-style-type: none"> • Standard: 101-key <p>Mouse</p> <ul style="list-style-type: none"> • Standard: IBM Mouse 	<p>Expansion Bays and Slots</p> <ul style="list-style-type: none"> • Seven 32-bit combination PCI/Micro Channel slots • 22 drive bays, 18 of them hot-swap <p>Video</p> <ul style="list-style-type: none"> • SVGA controller • Compatibility: <ul style="list-style-type: none"> – Video graphics array (VGA) – Enhanced graphics adapter (EGA) – Color graphics adapter (CGA) – Multicolor graphics array (MCGA) <p>Hard Disk Drive</p> <ul style="list-style-type: none"> • Number of drives and drive capacities are model dependent • Can support up to twenty hard disk drives <p>Security Features</p> <ul style="list-style-type: none"> • Door lock • LogicLock with active security • U-bolt enabled • Selectable drive-startup • Cable cover (optional) <p>Information Panel</p> <ul style="list-style-type: none"> • Two 16-character lines • LCD display of diagnostic and status information • 4-button keypad for scrolling through the diagnostic and status information 	<p>Integrated Functions</p> <ul style="list-style-type: none"> • Vital product data (VPD) • LED usability support • Video connector • Two serial connectors • Parallel connector • Mouse connector • Keyboard connector • Battery-backed clock and time/date calendar <p>Power Supply</p> <ul style="list-style-type: none"> • 470 watt with automatic range voltage selection (115–230 V ac) • Built-in overload and surge protection • Power supply upgrade expansion option <ul style="list-style-type: none"> – 220 watt automatic range voltage selection add-on – Built-in overload and surge protection <p>SCSI-2 Controller</p> <ul style="list-style-type: none"> • IBM PC Server SCSI-2 Fast/Wide PCI Adapter on non-disk-array models • IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A on disk-array models <p>Upgradable POST and BIOS</p> <ul style="list-style-type: none"> • Two 256KB flash ROMs
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What Your IBM PC Server 720 Offers

The unique design of your PC Server 720 takes advantage of advancements in symmetric multiprocessing (SMP), data storage, disk-array technologies, and memory management. Your server combines:

- Impressive performance using an innovative approach to symmetric multiprocessing

Your server supports up to six processor boards. Each processor board contains its own Pentium microprocessor.

- Large data-storage and hot-swap capabilities

All models of the PC Server 720 support up to twenty hard disk drives, and you can configure up to 18 of them as hot-swappable drives. This *hot-swap* feature enables you to remove and replace hard disk drives without turning off the server.

- Integrated disk-array subsystem

Although many operating systems provide software fault tolerance, IBM provides hardware fault tolerance through the IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A. This redundant array of independent disks (RAID) adapter comes as a standard feature in the disk-array models, and it supports RAID levels 0, 1, and 5.

- Large system memory

The 256-bit memory bus in your server supports up to 1 GB (GB equals approximately 1 000 000 000 bytes) of system memory. The system memory is 4-way interleaved, and is shared among all processor boards.

Your IBM PC Server 720 is designed to be cost effective, powerful, and flexible. It uses both peripheral component interconnect (PCI) and Micro Channel bus architectures, to provide compatibility with a wide range of existing hardware devices and software applications.

IBM ServerGuide

The IBM ServerGuide package contains several compact discs (CDs). These CDs contain menu-driven programs that make it easy for you to install your operating system, network program, and systems-management software. These CDs also contain online publications and a performance tuning program. Refer to the documentation packaged with the ServerGuide CDs for more detailed information.

IBM NetFinity

The IBM ServerGuide package that comes with your server gives you the option of installing IBM NetFinity. NetFinity is an integrated systems-management program that enables you to use several of the built-in systems-management features in your server. To find out more about NetFinity and how it can help you, view the demonstration program provided in the ServerGuide package and read its accompanying information.

IBM PC Server Startup Support

The IBM PC Server Startup Support program provides comprehensive telephone assistance 24 hours a day, seven days a week during your first 90 days after installation.

IBM provides you direct access to trained specialists who can assist you with the setup, installation, and configuration of your server. Assistance is available for IBM and non-IBM network operating systems, network interface adapters, and other optional peripherals. To receive a current listing of the network products supported by the IBM PC Server Startup Support program, call the IBM Automated Fax System in the U.S. at 1-800-426-3395 and ask for document number 16125. For more information about this exceptional program, or for assistance with the installation of your server:

- In the U.S., call 1-800-772-2227.
- In Canada, call 1-800-565-3344.
- In all other countries, contact the IBM support organization that services your area, your IBM marketing representative, or your IBM authorized reseller.

Reliability, Availability, and Serviceability Features

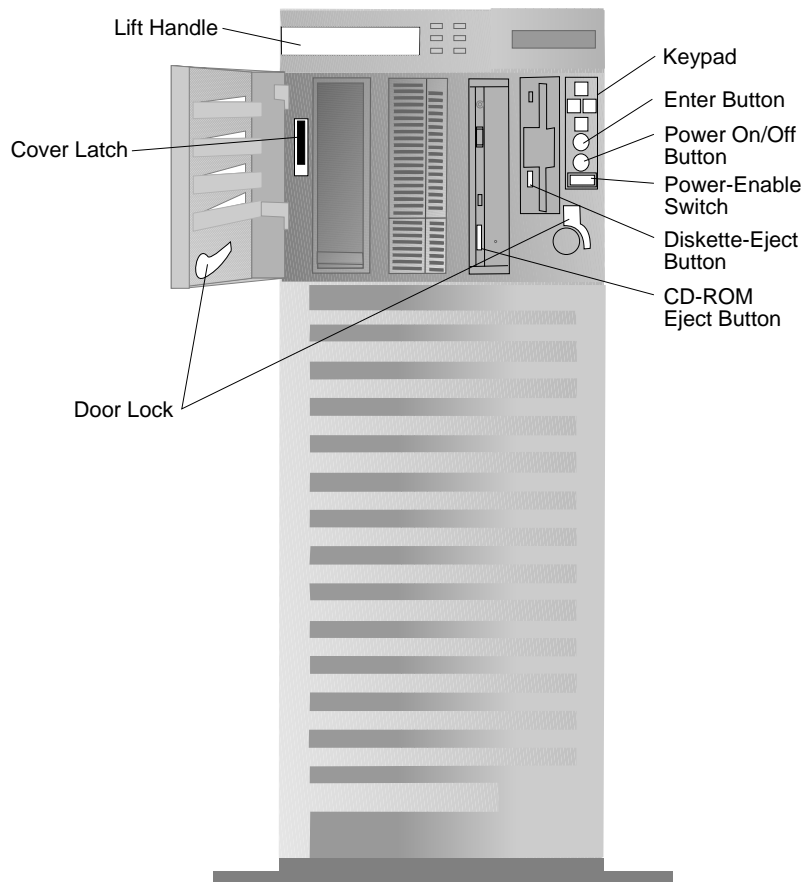
Three of the most important factors in server design are *reliability*, *availability*, and *serviceability* (RAS). These factors ensure the integrity of the data stored on your server; that your server is available when you want to use it; and that should a failure occur, you can easily diagnose and repair the failure with minimal inconvenience.

The following is an abbreviated list of the built-in RAS features on the IBM PC Server 720. Many of these features are explained in later chapters of this reference manual, or in your *User's Handbook*.

- Automatic configuration using the system programs
- Power-on self-test (POST) and Fast POST
- 24-hour customer support center
- Built-in temperature and voltage monitoring
- Three variable-speed cooling fans with error-sensing capability
- Hot-swap drive bays (18)
- Error checking and correcting (ECC) memory and bus
- Disk mirroring (some models)
- System error logging
- Menu-driven diagnostic programs
- Error codes and messages
- Upgradable POST and BIOS code
- Information panel
- Remote maintenance support
- Remote power-on support
- Automatic restart after a power failure
- Parity checking on the SCSI bus, Micro Channel bus, PCI bus, keyboard interface, and serial ports
- Vital product data (VPD), including serial number information and replacement part numbers, is stored in nonvolatile memory. (This information makes remote maintenance of your server easier and more efficient.)

Server Controls

The most commonly used controls on the front of the server appear in the following illustration.



Door Lock: You can lock the door on your server to deter tampering with the internal components.

Cover Latch: Before you can remove the front cover, you must lift up this latch.

Lift Handle: When you lift up on this handle, you can maneuver the server on its built-in rear roller.

Keypad: The four buttons on this keypad enable you to scroll through the diagnostic data and other system information that appears on the information panel.

Enter Button: Press this button to select an option from the top line of the information panel.

Power On/Off Button: Press this button to manually turn the server on or off. To turn off the server and perform a systematic shutdown of the software, press and hold this button until instructions appear on the information panel; then follow the instructions on the information panel.

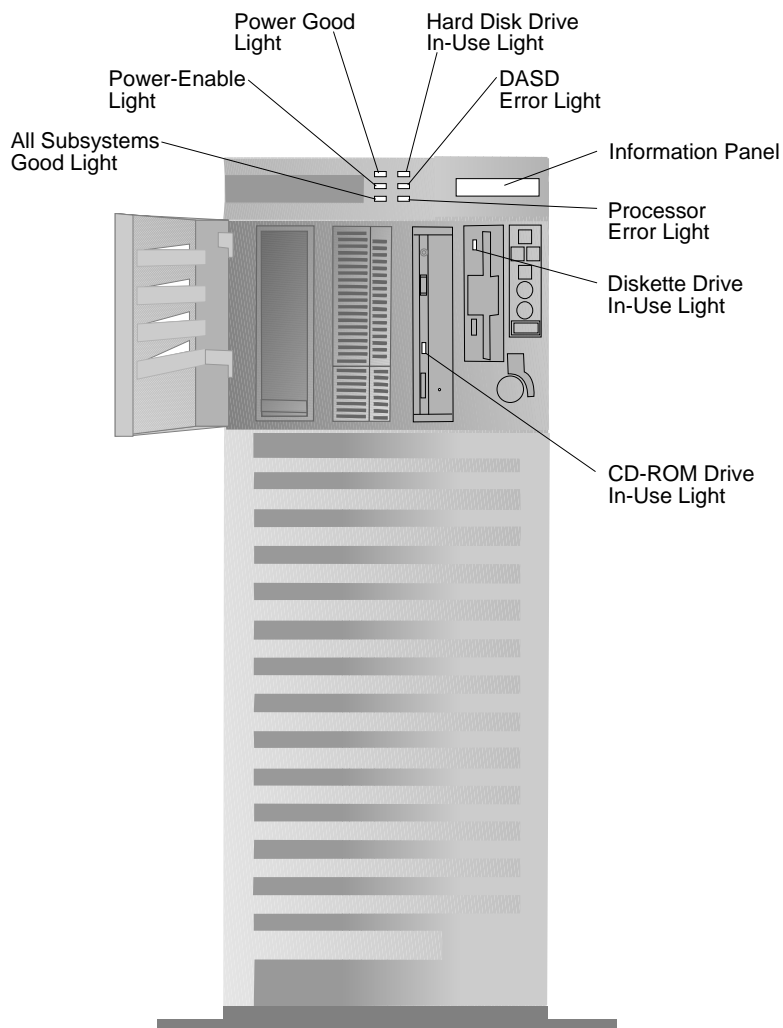
Power-Enable Switch: Keep this switch in the on position (pressed in) to enable the remote power-on and power-off features. This switch must be in the on position (pressed in) before you can turn on the server.

Diskette-Eject Button: Press this button to remove a diskette from the drive.

CD-ROM Eject Button: Press this button to eject the CD-ROM tray from its drive so that you can insert or remove a CD.

Status Indicators

The most commonly used status indicators on the front of the server appear in the following illustration.



All Subsystems Good Light: This green light indicates that all subsystems are functioning properly.

Power-Enable Light: This green light indicates that the power-enable switch is in the on position.

Power Good Light: This green light indicates that the power supply is functioning properly.

Hard Disk In-Use Light: Normally, this amber light is on when the server is writing to or reading from the hard disk. However, on disk-array models, this light is operating-system dependent.

DASD Error Light: This amber light indicates that an error occurred in the direct access storage device (DASD) subsystem.

Information Panel: Diagnostic data and other system information appear on this liquid crystal display (LCD) panel. This LCD panel remains functional even when the video controller and other system-board logic are not functioning.

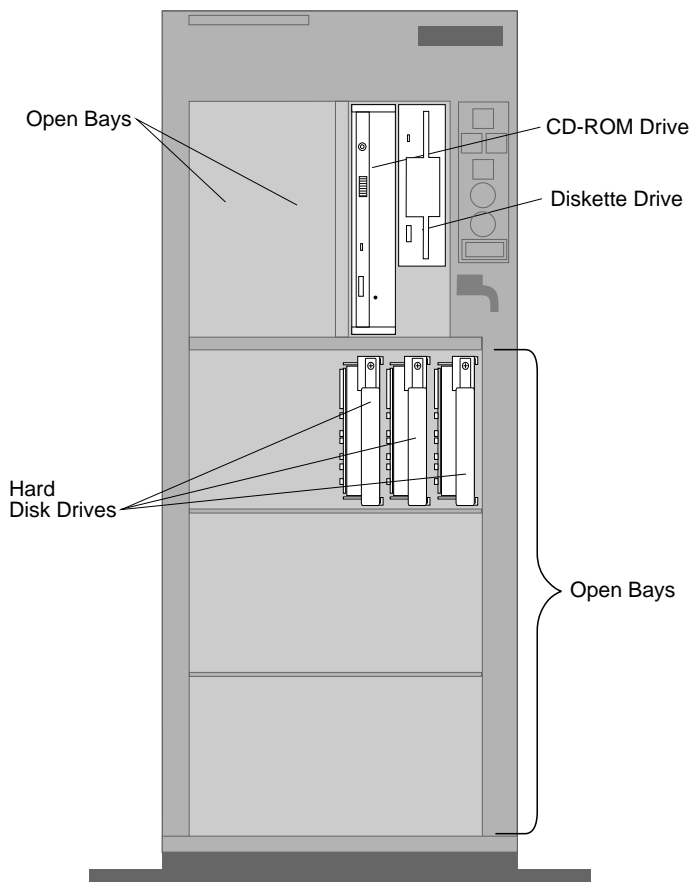
Processor Error Light: This amber light indicates that an error occurred in the processor complex.

Diskette Drive In-Use Light: This light is on whenever the diskette drive is accessed.

CD-ROM Drive In-Use Light: This light is on whenever the compact disc read-only memory (CD-ROM) drive is accessed.

Expansion Bays

The following illustration shows the location of the expansion bays in your server.



Hard Disk Drives: The number of preinstalled drives and their capacities vary by model.

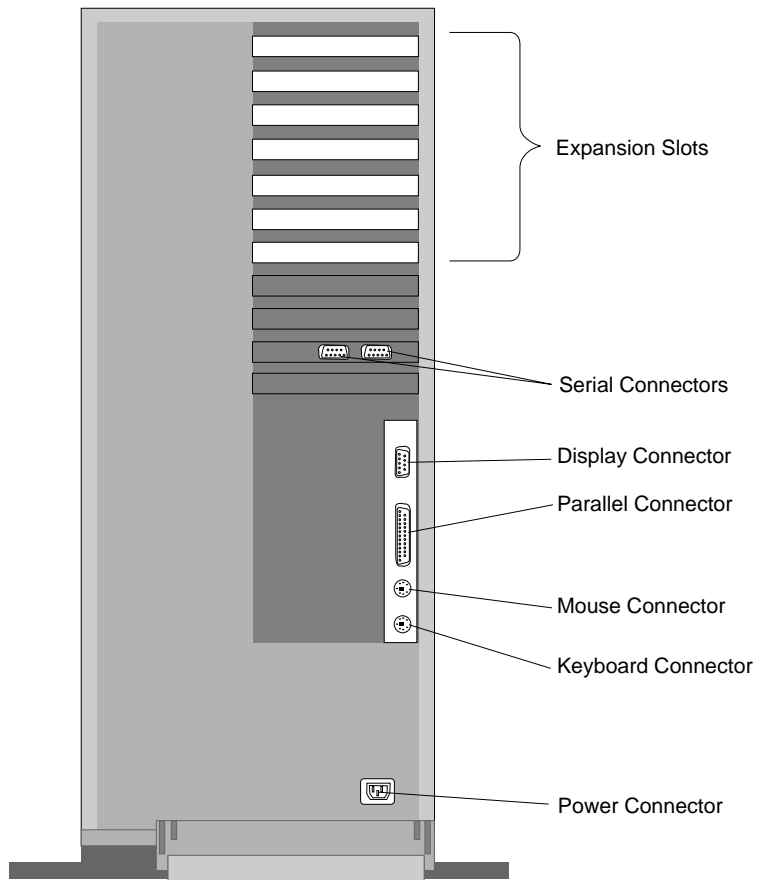
Open Bays: The open drive bays support up to 20 internal drives. The open bay next to the CD-ROM drive can accept a tape drive or rewritable optical drive instead of a hard disk drive. For installation instructions and information on the types of drives that you can install in each bay, refer to the “Installing Options” chapter in your *User's Handbook*.

CD-ROM Drive: A 5.25-inch, SCSI-2 CD-ROM drive comes standard in all PC Server 720 models. For information about inserting CDs and using the CD-ROM drive, refer to your *Setup* booklet or your *User's Handbook*.

Diskette Drive: The 3.5-inch, 2.88MB diskette drive uses 1MB, 2MB, and 4MB diskettes.

Expansion Slots and Input/Output Ports

The expansion slots and the input/output connectors (ports) on the rear of the server are shown here.



Expansion Slots: The PC Server 720 has seven expansion slots accessible from the rear of the server. A SCSI-2 adapter comes preinstalled in one of the expansion slots. The six remaining slots are available for expansion. You can add PCI or Micro Channel adapters to provide communication, specialized graphics, and sound. Many adapters provide bus-master capabilities, which enable the adapters to perform operations without interrupting the system microprocessor.



Serial Connectors: Two 9-pin serial connectors (A and B) are provided. The serial signal cable for a modem or other serial device usually connects here. If you are using a 25-pin signal cable, you need a 9-pin-to-25-pin adapter cable.



Display Connector: The display signal cable attaches to this 15-pin connector.



Parallel Connector: This is where the signal cable for a parallel printer or other parallel device connects to your server.



Mouse Connector: This is where the mouse cable connects to the server. This port sometimes is called an auxiliary-device or pointing-device port.



Keyboard Connector: The cable from your keyboard connects here.

Power Connector: The system power cord connects here.

International Capabilities

As always, your IBM server meets stringent world wide certifications for power, electromagnetic compatibility (EMC), and safety. It is suitable for use worldwide. The voltage-sensing feature allows the server to automatically set itself to match differing power sources, because electric power can vary from country to country.

Language is another factor to consider. Your server can use special editions of operating systems that let the system and keyboard operate in a variety of languages. With the appropriate adapter, those same operating systems let you view ideographic characters on your display, such as those used in Chinese and Japanese.



Operating-System Support

You can use your server in a variety of environments to do many different tasks. To meet the requirements of these environments, your server supports several operating systems.

Some operating systems, such as OS/2 for SMP, Microsoft Windows NT, and SCO/UNIX, support the multiple-microprocessor capability of your server.

IBM and other manufacturers of operating systems, network programs, and application programs periodically make software updates available. These updates provide enhancements and corrections for the off-the-shelf versions of the software. To ensure that the software you install on your server functions properly, contact the manufacturers of the software that you intend to install and obtain the most current software updates.

If you intend to install an IBM operating system or network program, such as OS/2 for SMP or OS/2 LAN Server, you can obtain the most current software updates from the IBM Personal Software Solutions Center. These software updates are called ServicePaks or corrective-service diskettes (CSDs). In the U.S., you can call the IBM Personal Software Solutions Center at 1-800-992-4777.

For the latest information about the SMP operating systems supported by your PC Server 720:

- In the U.S., call 1-800-772-2227.
- In Canada, call 1-800-565-3344.
- In all other countries, contact the IBM support organization that services your area, your IBM marketing representative, or your IBM authorized reseller.

Specifications

<p>Size</p> <ul style="list-style-type: none"> • Depth: 755 mm (29.7 in.) • Height: 622 mm (24.5 in.) • Width: 353 mm (13.9 in.) • Depth with cable cover: 807 mm (31.8 in.) <p>Weight</p> <ul style="list-style-type: none"> • Configured with one hard disk drive: 31.3 kg (69 lb) <p>Environment</p> <ul style="list-style-type: none"> • Air temperature <ul style="list-style-type: none"> - System on: 10° to 35° C (50° to 95° F) Altitude: 0 to 914 m (3000 ft.) - System on: 10° to 32° C (50° to 90° F) Altitude: 914 m (3000 ft.) to 2133 m (7000 ft.) - System off: 10° to 43° C (50° to 110° F) Maximum Altitude: 2133 m (7000 ft.) - Storage: 1° to 60° C (34° to 140° F) • Humidity <ul style="list-style-type: none"> - System on: 8% to 80% - System off: 8% to 80% • Maximum altitude: 2133 m (7000 ft) 	<p>Heat Output</p> <ul style="list-style-type: none"> • Approximate heat output in British Thermal Units (BTU) per hour <ul style="list-style-type: none"> - Minimum configuration: 150 BTU (44 watts) - Maximum configuration: 3,924 BTU (1150 watts) <p>Electrical Input</p> <ul style="list-style-type: none"> • Sine-wave input (50 to 60 Hz) is required • Input voltage <ul style="list-style-type: none"> - Low range <ul style="list-style-type: none"> - Minimum: 90 V ac - Maximum: 137 V ac - High range <ul style="list-style-type: none"> - Minimum: 180 V ac - Maximum: 265 V ac - Input kilovolt-amperes (kVA) approximately <ul style="list-style-type: none"> - Minimum configuration as shipped: 0.16 kVA - Maximum configuration: 1.15 kVA <p>Total Power Available for Drives</p> <ul style="list-style-type: none"> • Nominal operating current allowed (base with expansion upgrade) <ul style="list-style-type: none"> - +5 V dc line: 7.5 A base/20.5 A with upgrade - +12 V dc line: 4.7 A base/17.5 A with upgrade 	<p>Acoustical Noise Emission Values¹</p> <ul style="list-style-type: none"> • Average sound pressure levels at operator position <ul style="list-style-type: none"> - No hard disk drive <ul style="list-style-type: none"> - 44 dB operating - 44 dB idle - Four, 2GB hard disk drives <ul style="list-style-type: none"> - 46 dB operating - 46 dB idle • Average sound pressure at bystander position (1 meter) <ul style="list-style-type: none"> - No hard disk drive <ul style="list-style-type: none"> - 40 dB operating - 40 dB idle - Four, 2GB hard disk drives <ul style="list-style-type: none"> - 42 dB operating - 41 dB idle • Declared (upper limit) sound power levels <ul style="list-style-type: none"> - No hard disk drive <ul style="list-style-type: none"> - 6.0 bels operating - 6.0 bels idle - Four, 2GB hard disk drives <ul style="list-style-type: none"> - 6.1 bels operating - 6.1 bels idle
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¹ The air-cooling system adjusts the fan speed based on the thermal needs of the server. Acoustical levels are measured in controlled acoustical environments according to the American National Standards Institute (ANSI) procedure S12.10 and ISO 7779, and are reported in accordance with ISO 9296. Sound pressure levels in your location might exceed the average values stated because of room reflections and other nearby noise. The declared sound power levels indicate an upper limit, below which a large proportion of machines operate.

Chapter 2. Server Performance

Your productivity and satisfaction, as well as the productivity and satisfaction of everyone on your network, depends on server performance. Many factors can influence this performance, including the configuration of the hardware, application workloads, operating-system configuration parameters, and the server operating environment.

The information in this chapter can help you avoid potential performance bottlenecks, and includes suggestions to help you maximize the performance of your server.

Understanding Server Performance

You can optimize the performance of your server by balancing the performance of its main components. These include:

- Network and application programs
- Network adapter
- System memory
- System microprocessor
- Hard disk subsystem (disk controller and drives)

The ServerGuide CD that comes with your server contains a performance tuning utility program. This utility program enables you to customize the programmable registers in your system so that your applications can run faster than before. Refer to the information that comes with the ServerGuide package for more information about using the performance tuning utility program.

Network and Application Programs

Most complex programs allow you to change specific parameters to improve performance in a network environment. Always check the documentation that comes with your software to determine which parameters affect performance, and which parameters you can change to increase performance.

The original parameter settings provided by network programs usually support a network with 12 to 18 concurrent users. If you have a larger network, or increase the size of a network, you will

probably need to adjust some of these settings to maintain adequate performance.

Make sure that you record the original settings before you make any changes. In the unlikely event that performance decreases, you can change the settings back to their original values. Also document changes by making remarks, such as the date and reason for the changes, above or below the values that you change. This information can save you valuable time if you need to make additional adjustments.

Network Adapter

Before you can use the IBM PC Server 720 on a network, you must install a network adapter. The appropriate network adapter for your server depends on the type of network you have (broadband, baseband, token-ring, Ethernet, and so on). IBM offers a wide variety of network adapters. For up-to-date information about the adapters available, contact your IBM authorized reseller or marketing representative.

Some network adapters, such as the bus-master network adapters, are best suited for use in network servers. The primary value of using a bus-master network adapter is added capacity or, in the case of a heavily loaded server, improved performance.

Bus-master network adapters provide a higher throughput rate, because they handle most of the network processing and leave the system microprocessor free for other tasks. When you use a bus-master network adapter, the network throughput is less dependent on the type of system microprocessor and more dependent on the network adapter design and the network software.

Adding a faster network adapter provides additional throughput. The total number of transactions that the server processes per second increases, and the application response time decreases. However, keep in mind that this reduction in response time is limited. As you add more users, the effects of the faster network adapter are offset by the increase in data-space access and write-data processing (which reduces the disk-cache-hit rate and

overall server performance). See “Cache Memory” on page 30 for more information.

System Memory

When you have a large network or you increase the size of a small network, you might need to install additional memory to maintain adequate performance. This additional memory might be needed to support additional application programs, buffers, or control blocks.

The PC Server 720 supports up to 1 GB (GB equals approximately 1 000 000 000 bytes) of system memory. Your server comes with one memory card that supports up to 512MB (MB equals approximately 1 000 000 bytes) of memory. For additional memory expansion, you can install the optional memory card, which also supports up to 512MB of memory.

System Microprocessor

One way to optimize the performance of your server is to install an additional microprocessor. The design of the PC Server 720 supports up to six processor boards. By installing an additional processor board, you add more than just a microprocessor, because each processor board has:

- Its own microprocessor
- Its own memory controller
- An internal, 16KB level-1, write-back cache
- An external, 512KB level-2, write-back cache
- An external, 192 byte level-3 cache buffer
- Global access to all I/O devices

Another way to improve system microprocessor performance is to lighten its load by using bus masters. Bus masters can handle tasks, such as network processing or data transfers, and provide relief for an overloaded system microprocessor. See “Bus Master Implementation” on page 36 for more information.

Hard Disk Subsystem

An IBM SCSI-2 bus-master controller is a standard feature in your server. This controller can significantly increase performance by handling the processing of SCSI commands and data transfers, leaving the system microprocessor free to handle other tasks.

You can install up to 18 hot-swap hard disk drives to increase disk storage and performance.

Some models of the PC Server 720 come with an IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A as a standard feature. This RAID adapter enables you to configure a disk array.

Disk arrays use multiple hard disk drives to provide faster input and output rates than a single large-capacity drive. Because the files are stored on individually addressable disks, they can be found more quickly during read requests. As always, the amount of performance improvement depends on the application programs that you run on the server and the type of array that you configure. (See Chapter 7, “Disk Arrays” on page 59, for more information.)

Estimating Server Performance and Capacity

There is no simple method of evaluating your server performance for all environments. The hardware, software, applications, workloads, and number of users all affect server performance.

When you are ready to do a performance evaluation, use a systematic approach, such as the following:

- Define the functional requirements of the server for your working environment.
- Define what you consider to be adequate performance, such as response times, transaction rates, and number of users.
- Understand what factors affect server performance.
- Decide what an approximate configuration of applications for your work environment would be.

- Measure the current performance of your server using a variety of application configurations. Use the performance results to locate bottlenecks and to determine which configuration provides sufficient performance today and allows room for growth.
- Ensure that the performance of the server will remain acceptable if one of the components fails.

Improving Server Performance

Before you begin to experiment with applying upgrades or enhancements to improve performance, remember that the subsystem that causes a bottleneck depends largely on the applications you are using.

Try to determine which subsystem is the most likely bottleneck for your environment, then concentrate on obtaining improvements for components within that subsystem. Some changes might improve the performance of one application, but degrade the performance for other applications. If this occurs, you will need to assess the trade-offs.

Once you understand the factors that affect server performance, you can use a methodical approach to improving it. A good example of this type of approach is:

1. Measure the current server performance.
2. Identify the performance bottlenecks.
3. Upgrade components that cause the bottlenecks.
4. Measure the new performance of the server.

For example, if the bottleneck is memory, you could install additional memory; if it's the microprocessor, you could install additional processor boards; if it's the hard disk subsystem, you could install additional hard disk drives or create a disk array. You can replace slow network adapters with faster ones, or you can install additional adapters, and so on.

Chapter 3. Microprocessors and Memory

The processing center of your server contains devices that run programs and store data used by programs. These devices include the microprocessor and the components of the memory subsystem.

Microprocessor

The *microprocessor* is an integrated circuit that performs most of the control and computing functions of your server. An Intel Pentium microprocessor is installed on the processor board in your IBM PC Server 720.

Your server supports up to six processor boards. Depending upon your model, you can install up to five more microprocessors in your server. Additional microprocessors enhance performance and provide symmetric multiprocessing (SMP) capability.

Microprocessor Clock

The rate at which the microprocessor performs its basic operations is called the *clock speed*. Examples of basic operations include fetching an instruction from memory, decoding it, executing it, writing the result to memory, and so on. The process of executing an instruction always consists of several basic operations. The design of the microprocessor determines the maximum clock speed at which it can operate reliably, and the design of the server determines the optimal clock speed for the server. Clock speed is measured in megahertz (MHz). A *clock cycle* is the time unit that measures how long the microprocessor takes to perform a basic operation at a given clock speed. Clock cycles are measured in nanoseconds (ns) and are inversely related to the clock speed. For example, at a clock speed of 25 MHz, one clock cycle takes 40 ns; at a clock speed of 100 MHz, one clock cycle takes 10 ns. The microprocessor in your server operates at two different clock speeds: one speed for transferring data into and out of the microprocessor and a faster speed for operations within the microprocessor.

Microprocessor Performance

The Pentium microprocessor gains its high performance through its *superscalar* design. Superscalar is the term given to microprocessor

architectures that allow more than one instruction to be executed in one clock cycle.

The Pentium microprocessor contains three *execution units*; and each execution unit can issue an instruction in one clock cycle. Each execution unit contains a *pipeline*. In a pipeline, multiple instructions are in various stages of execution. For example, while one instruction is fetched, two are decoded, another is executed, and the results of another are written to memory. This parallelism potentially speeds up instruction execution by a factor of 15 when compared to a microprocessor that is running at the same speed, but does not use multiple execution units and pipelining.

In practice, the speedup is much less. In many clock cycles, the microprocessor will not issue an instruction. Memory accesses, even to very fast cache memory, take multiple cycles to complete. Some instructions spend many clock cycles in the execution stage of a pipeline. Still, performance is substantially improved.

Microprocessor Registers and Interfaces

The microprocessor needs data or instructions, or both, for each basic operation. Instructions and data are copied from memory into data-storage locations known as *registers*, in the microprocessor. The microprocessor can read from and write to its registers very quickly. Registers also store the results of processing operations until the results are needed for other operations or are written to memory.

The microprocessor *data interface* is the connection between the microprocessor and the data bus. The width of the data bus determines which type of adapters (16-bit or 32-bit) the server supports. Your server has a 32-bit data bus, and it uses a microprocessor that has a 64-bit data interface that supports both 16-bit and 32-bit adapters.

The set of instructions that the microprocessor can perform determines whether a particular program will run in the server. Programs written for a 32-bit interface require only that the microprocessor be capable of decoding and performing 32-bit instructions. The width of the data bus does not affect software compatibility.

The size of the microprocessor *address interface*, which is the connection between the microprocessor and the address bus, determines the width of the address bus and the amount of physical memory the microprocessor can address. The Pentium microprocessor in your server has a 32-bit address interface and can address up to 4GB of physical memory. (Physical memory is described in “Physical Memory and Virtual Memory” on page 29.)

Real Mode and Protected Mode

The microprocessor has a *real mode* with a 1MB address space. The real mode is the default condition for the microprocessor; the microprocessor is always in the real mode after the server is turned on and before any operating system is started. The real mode does not support virtual memory (see “Physical Memory and Virtual Memory” on page 29).

The microprocessor also has a *protected mode* that supports virtual memory and allows the microprocessor to address more than 1MB of memory. In protected mode in a multitasking environment, the microprocessor manages the memory so that each program is protected from interference from other programs running at the same time.

The operating system you install determines whether the microprocessor stays in the real mode or is switched to the protected mode. For example, when the server runs DOS, the microprocessor stays in the real mode. DOS makes only limited use of the capabilities provided by the protected mode. When the IBM Operating System/2 (OS/2) starts, it switches the microprocessor to the protected mode. The OS/2 operating system uses the virtual memory and multitasking capabilities provided by the protected mode of the microprocessor.

Note: The OS/2 operating system has a real mode and a protect mode. These operating-system modes are not related to the real mode and protected mode of the microprocessor.

Numeric Computing

The microprocessor in your server has an execution unit that performs only floating-point arithmetic and mathematical instructions. This execution unit, called the *floating-point unit (FPU)*, executes the types of instructions previously executed by the separate math coprocessors used in earlier personal computers. These instructions, generally called *numeric instructions*, perform basic floating-point arithmetic and a variety of mathematical functions.

The control circuits within the microprocessor pass data and instructions to the FPU, which then performs the mathematical operations. The two other execution units, called *integer units*, can execute instructions concurrently with the FPU. The FPU is pipelined, so several floating-point instructions can be in various stages of execution simultaneously.

Programs that require extensive mathematical calculations run much faster when the FPU performs the calculations, because the FPU is designed specifically for that purpose. A program that is intended to use the FPU must contain specific instructions that are recognized by the FPU. Otherwise, the program will not activate the FPU, and the integer units will perform the calculations.

Memory Subsystem

The *memory subsystem* consists of the memory controller, random access memory and read-only memory, physical memory and virtual memory, and cache memory.

Memory Controller

The memory controller is a device on the processor board that controls access to system memory by the microprocessor and I/O devices. Registers in the memory controller contain information about the amount and type of memory that is installed in the server. During a system reset, the POST routine writes this information into the registers.

A 32-bit *direct-memory-access* (DMA) controller is integrated onto the processor board in your PC Server 720. This DMA controller is a *bus master* that manages all DMA data transfers between system memory and I/O devices. (See “Bus Master Implementation” on page 36 for more information.)

Direct Memory Access

Direct memory access is a method used to transfer large amounts of data between system memory and I/O devices without the assistance of the microprocessor. DMA is more efficient than *programmed I/O*, in which the microprocessor reads the data from the sending device, and then writes it to the receiving device. In DMA data transfers, data can bypass the system microprocessor as it moves between system memory and I/O devices. DMA improves server performance because the microprocessor does not have to interrupt its processing activities to manage data transfers.

Transferring data between system memory and an I/O device requires two steps. First, the microprocessor gives the DMA controller the location, destination, and amount of data that is to be transferred. Then the DMA controller transfers the data, allowing the microprocessor to continue with other processing tasks.

When a device needs to use the bus to send or receive data, it competes with all the other devices that are trying to gain control of the bus, in a process known as *arbitration*. The DMA controller does not arbitrate for control of the bus; instead, the I/O device that is sending or receiving data (the *DMA subordinate*) participates in arbitration. The DMA controller takes control of the bus when the central-arbitration-control point grants the request of the DMA subordinate. For more information about bus masters, subordinates, and arbitration, see “Bus Master Implementation” on page 36.

The functions of the memory controller vary and can include memory interleaving, which is a method of reducing the time the microprocessor has to wait for system memory to respond during memory I/O operations.

Memory Interleaving

Some microprocessors are so fast that system memory cannot respond to read and write requests as quickly as the microprocessor can send them. To reduce the time that the microprocessor spends waiting for system memory to respond, your server uses *4-way interleaved memory*.

In servers that use *noninterleaved memory*, the speed of memory I/O operations is limited by the speed at which system memory can respond. The speed of a memory I/O operation is measured in microprocessor clock cycles. Therefore, the microprocessor clock speed determines the minimum time required for a memory I/O operation.

Random Access Memory and Read-Only Memory

Random access memory (RAM) is used for temporary storage of data and instructions during processing. RAM is contained in memory components known as *single inline memory modules* (also called SIMMs). It is *volatile* memory, which means that to retain its contents, it must be constantly refreshed by an electrical current. While the server is turned off, no current is supplied to the single inline memory modules, so no data is retained in RAM.

Your server supports up to 1GB of 60 ns error correcting code (ECC) memory. You can add memory to your server by installing 8MB, 16MB, or 32MB single inline memory modules.

In addition to volatile RAM, the system board has a small area of *nonvolatile RAM* (NVRAM). Using a small current from the system battery, NVRAM retains its contents while the server is turned off. Your power-on password, the time and date, and the system configuration information are stored in NVRAM.

Read-only memory (ROM) is used for storage of programs that the server uses for startup procedures and other internal operations. These programs are permanently encoded in the ROM module. ROM is *nonvolatile* memory, and retains its contents when the server is turned off.

Generally, the contents of a ROM module cannot be modified. However, the type of ROM modules in your server can be reprogrammed. *Electrically erasable programmable ROM (EEPROM)* modules (or *flash memory*) can be reprogrammed while they are in the server. For example, the POST and BIOS code in your server is stored in flash memory so that it can be updated whenever enhancements are made. (The disk-array models also have an EEPROM on the SCSI-2 RAID adapter that stores the disk array configuration information.)

Physical Memory and Virtual Memory

Physical memory consists of all the writable memory locations in the server, most of which are in single inline memory modules. Portions of the physical memory are reserved for the operating system, for the power-on self-test, and for the video data that is being displayed. The part of physical memory available for instructions and data that the server uses to run programs is *system memory*.

Virtual memory is memory that *appears* to be allocated to application programs. The operating system uses a portion of the hard disk as virtual memory, swapping data and instructions between the hard disk and physical memory. The portion of the hard disk used for virtual memory is often called *swap space*. The amount of swap space on the disk determines the amount of available virtual memory, which is typically much larger than the actual amount of installed physical memory.

Virtual memory supports very large programs and *multitasking*. In multitasking, multiple programs run simultaneously. The memory requirements of these programs can exceed the amount of available physical memory. The operating system allocates the memory required by each program as virtual memory and manages the physical memory, swapping portions of each program's address space to the hard disk as required.

The maximum amount of physical memory that you can install in your server, and the maximum amount of virtual memory that the operating system can allocate, are determined by the microprocessor.

The width of the microprocessor address interface limits the amount of physical and virtual memory that the microprocessor can address. The microprocessor in your server has a 32-bit address interface and can address a maximum of 4GB of physical memory and 64TB (TB equals approximately 1 000 000 000 000 bytes) of virtual memory in the protected mode.

Cache Memory

Cache memory is high-speed memory, known as static random access memory (SRAM), that can respond to memory operations without imposing *wait states* on the microprocessor. A wait state is a period of time (one microprocessor clock cycle) during which the microprocessor suspends processing and waits for system memory to respond to a read or write operation. Wait states cause the server to operate less efficiently than it would if the microprocessor were able to continue processing data during read or write operations.

To reduce the time that the microprocessor spends waiting for system memory to respond, your server uses cache memory. Cache memory improves server performance by temporarily storing frequently used data and instructions in a *cache*, a small buffer between the microprocessor and system memory.

Each processor board in your server contains level-1, level-2, and level-3 cache. Cache performance depends on the size of the cache and the application programs you are running on your server.

Level-1 Cache

The level-1 cache, which is part of the microprocessor, consists of very fast RAM. This type of cache memory is also referred to as internal cache. The Pentium microprocessor on the processor board contains 16KB (KB equals approximately 1000 bytes) of internal level-1 cache (8KB of data and 8KB of instruction).

The level-1 cache stores the data and instructions most frequently used by the microprocessor in the current execution context. (The execution context is the executable code and associated data used by the program running on the microprocessor.) Because the microprocessor sends many fewer read and write requests to system memory, a level-1 cache enables a microprocessor to execute

programs much faster than if it had to access system memory for each request. When the execution context changes, the level-1 cache controller copies new data and instructions into the cache, replacing data and instructions that are no longer needed.

Server performance improves each time the microprocessor finds what it needs in the cache (a *cache hit*). The microprocessor is designed so that the cache hit rate is very high, and a penalty for a *cache miss* is minimized. A cache miss occurs when the information needed by the microprocessor is not available in the cache. In the case of a cache miss, the microprocessor must wait while the level-1 cache controller locates the information needed in the level-2 cache or system memory, and then copies the information into the cache. The cache controller on the processor board manages the use of the cache so that the number of cache hits far exceeds the number of cache misses.

Level-2 Cache

The processor board in your server comes with 512KB of parity-protected level-2 cache. The level-2 cache provides an intermediate level of storage between level-1 cache and system memory. Although level-2 cache accesses are slower than level-1 cache accesses, level-2 cache accesses are still much faster than system memory accesses.

In the case of a level-1 cache miss, the microprocessor can access the level-2 cache relatively quickly. If the microprocessor does not find what it needs in the level-2 cache (*a second-level cache miss*), the cache controller locates the data or instruction in the level-3 cache buffer or system memory; then copies it into one of the caches.

Level-3 Cache

The 192-byte level-3 cache buffer on the processor board stores the most recent data discarded by the level-2 cache. This buffer enhances the effectiveness of the level-2 cache by increasing the probability of a cache hit.

Write-Back and Write-Through Modes

For maximum performance, the IBM PC Server 720 caches are set to the write-back mode. In the write-back mode, the microprocessor

updates the cache in just over one clock cycle. After the microprocessor updates the cache, the cache controller updates system memory. The microprocessor is free to perform other operations while the cache controller updates system memory. Because the cache controller updates system memory, which is a relatively lengthy process, the microprocessor is free to perform other tasks; therefore, the write-back mode provides the best performance.

You can use the system programs to change the cache settings to the write-through mode. In the write-through mode, the microprocessor updates the caches and system memory. Because the microprocessor must write directly to system memory, which runs about five times slower than the cache, performance is substantially reduced.

Chapter 4. Bus Architectures

A *bus* is an electrical pathway for transferring signals and power among microprocessors, memory, adapters, and I/O devices. The signals include addresses, data, and control information.

Your PC Server 720 incorporates three bus architecture designs. These are:

- The Corollary C-bus II multiprocessing bus, which enables you to install up to six processor boards in your server and enables symmetric multiprocessing (SMP)
- The peripheral component interconnect (PCI) bus, which provides a high-throughput local bus
- The Micro Channel bus, which provides an expansion bus that supports PC compatibility and a wide range of adapters

Multiprocessing Bus Overview

The C-bus II multiprocessing bus is a 64-bit bus that provides symmetric multiprocessing capabilities. It supports up to six processor boards and has a peak-data-transfer rate of 400 megabytes-per-second (MBps).

Any processor board connected to the C-bus II multiprocessing bus can be assigned any application task, and all processor boards connected to this bus can globally access the system memory and the input/output (I/O) devices in the server.

The multiprocessor-to-PCI *bus bridge* connects the C-bus II multiprocessing bus to the PCI bus. This bus bridge provides a path through which the microprocessors can directly access PCI devices mapped anywhere in memory or address spaces.

PCI Bus Overview

The PCI bus is a 32-bit local bus that provides a high-speed data path between the processor boards and peripheral devices, such as the video and hard disk subsystems.

This powerful bus uses the burst mode for all data transfers. For 32-bit PCI devices, the PCI bus supports a peak-data-transfer rate of

132 MBps. The implementation of this industry-standard bus in your server supports PCI bus speeds up to 33 MHz, and allows PCI masters direct access to system memory.

The PCI bus coexists with the Micro Channel bus, which means that you can install up to seven PCI, Micro Channel, or a mixture of PCI and Micro Channel adapters in the expansion slots. The light-emitting diode (LED) next to each expansion slot signifies proper operation of the PCI device installed in the slot. Expansion slots 1 through 5 are the *secondary* PCI bus slots. Slots 6 and 7 are the *primary* PCI bus slots; you should install your high-performance PCI devices in these slots. Slot 8 contains the multiprocessor-to-PCI bus bridge.

An integrated circuit (chip) on the system board connects the PCI bus to the Micro Channel bus.

Micro Channel Bus Overview

In your server, the Micro Channel bus serves as an expansion bus. This 32-bit bus makes your server versatile and provides a wide range of design and application alternatives.

Like the PCI bus, the Micro Channel bus also supports burst data transfers, in which data is sent in multiple bytes with no intervention by the microprocessor. The Micro Channel bus also supports streaming-data transfers of up to 80 MBps. These methods of data transfer improve system performance and enable fast data transfers between devices.

PCI and Micro Channel Shared Features

The PCI and Micro Channel implementations in your PC Server 720 share some fundamental features. Your server uses configuration programs and files to automatically assign interrupt levels, I/O addresses, memory addresses, arbitration levels, and other system resources to the PCI and Micro Channel adapters in your server.

Both buses support burst data transfers; an address and multiple data words (each containing 32 bits) can be sent in each transfer.

The address specifies the location of the data to be sent; a bus command specifies the number of data words to send.

Each bus supports data transfers from only one device at a time. A *bus arbitration* mechanism determines which device can access a bus at a given time.

The PCI bus and the Micro Channel bus have several functions. In your server, each bus is used as an expansion bus, an address bus, and a data bus.

Expansion Bus

An expansion bus supports the addition of adapters to add new functions to your server. You can install a wide variety of PCI and Micro Channel adapters in the *expansion slots*, on the system board. The expansion slots provide paths for transferring data to and from the adapters.

Your server has seven expansion slots, which support both PCI and Micro Channel adapters. You can install up to seven PCI, Micro Channel, or a mixture of PCI and Micro Channel adapters in the PC Server 720 expansion slots. Slots 6 and 7 are the primary PCI bus slots. Install your high-performance PCI devices in these slots.

Address and Data Bus

When a device sends data, it identifies where the data is stored (source) and where it is to be sent (destination). Each location is identified by a unique number, known as an *address*. Each memory location and I/O device that is attached to a bus has an address. The sending device uses the bus as an address bus to send the target address to the receiving device. Then the sending device uses the bus as a data bus to send the data.

The width of a bus determines the size of the address space available to the bus. The PCI and Micro Channel buses each have a 32-bit address bus, enabling devices on the bus to address up to 2GB of memory.

The width of the data bus determines how much data can be transferred simultaneously. The PCI bus in your server provides a 32-bit data path. However, depending on the capacity of the sending and receiving devices, the Micro Channel bus in your server provides data-bus widths of 8, 16, and 32 bits. For example, when a 32-bit device transfers data to an 8-bit device, the 32-bit device must send the data in four 8-bit transfers. The full width of the 32-bit data bus is used only when both the sending device and the receiving device are 32 bits wide.

Bus Master Implementation

Both the PCI bus and the Micro Channel bus support *bus masters*. A bus master is a device or an adapter that can take control of (own) the bus. The system microprocessor is the first owner of the bus at system startup. Other bus masters receive ownership of the bus by halting the system microprocessor.

A bus master can have its own microprocessor, instruction cache, and memory. By taking over some of the work of the system microprocessor, bus masters create a multiprocessing environment and increase overall system performance.

Typical bus masters include:

- Memory and cache controllers
- Disk controllers
- DMA controllers
- Video controllers and adapters
- Network interface adapters

Once a bus master has control of the bus, it can issue bus commands to other devices on the bus. The target of a bus master, called a *subordinate*, executes bus commands issued by a bus master. Subordinates can initiate service requests, such as interrupts, but subordinates never own the bus.

A bus master can also be a subordinate, but, at a given time, it must be either a bus master or a subordinate. It cannot be both simultaneously.

PCI and Micro Channel Bus Arbitration

The PCI and Micro Channel bus architectures support *arbitration*, a process that determines which of two or more competing devices has control of the bus at any given time.

When multiple devices need to own a bus at the same time, these devices participate in arbitration. Every device that can arbitrate for control of the bus is assigned a priority level, known as an *arbitration level*, that is used to determine which device should control the bus next. The arbitration level for each device is contained in a software file. For Micro Channel devices, the software file is known as an *adapter description file (ADF)*.

Note: Devices that contend for control of a bus must not have the same arbitration level. Occasionally, arbitration-level conflicts occur between devices. When this occurs, you can use the system programs to change the arbitration level of one of the conflicting devices.

Both buses have *fairness features* to ensure that all devices get a turn to own the bus, even those having low priority levels. The fairness feature guarantees that none of the devices are locked out of the bus and that each device can gain control of the bus within a given amount of time. When you configure your server, you can disable the fairness feature for a device so that it controls the bus more than other devices. However, if you disable the fairness feature for a device, that device can monopolize the bus. Disabling the fairness feature for more than one device is risky. You could cause some devices for which the fairness feature is enabled to be completely locked out of the bus, including the microprocessor. Therefore, it is best to leave the fairness feature enabled for all devices.

The PCI and Micro Channel architectures each implement a *central-arbitration-control point*. This is where contending devices send their arbitration signals. The central-arbitration-control point does not actually decide which device should control the bus; contending devices make that determination among themselves, using arbitration logic that is programmed into the devices. However, it is the central-arbitration-control point that actually grants control after the decision is made.

Bus Parity Checking

The PCI and Micro Channel buses support *bus parity checking*, which is a method of verifying that data has not been changed during a data-transfer operation. Bus parity checking uses an extra bit, known as a *parity bit*, that is sent with each byte of data as it is transferred across the bus. The parity bit is set to 1 or 0 so that each byte has an odd number of 1's (if the server uses odd parity) or an even number of 1's (if the server uses even parity). If the parity (odd or even) of the received byte does not match the parity of the byte as it was sent, an error occurred during transmission and the receiving device can request the sending device to send the data again.

Bus parity checking is a common feature in servers. It is not 100% accurate, but it greatly reduces the chance for errors. It is essential for most operations because of fast I/O devices, complex I/O configurations, and large memory subsystems.

Features Unique to the Micro Channel Bus

The Micro Channel bus provides features not implemented in the PCI bus. These include the streaming-data procedure, channel-check reporting, and error logging.

Streaming-Data Procedure

The *streaming-data procedure* allows high-speed data transfers between bus masters and subordinates. This procedure supports high-speed transfers of large blocks of data for devices such as hard disk drives and network adapters.

The streaming-data procedure transfers blocks of sequentially stored data. In basic data-transfer operations, a target address is assigned for every byte of data that is transferred. The streaming-data procedure assigns a target address only to the first byte of data; the rest of the data in the block follows in sequence and is assigned to a sequential address. The streaming-data procedure supports a data-transfer rate of 80 MBps, which is four times as fast as basic data-transfer operations.

The Micro Channel bus has 32 data lines and 32 address lines. During streaming-data transfer operations, the 32 address lines are used only at the beginning of a transfer cycle; then, they remain idle for the rest of the cycle. The multiplexed streaming-data procedure uses the address bus as another 32-bit data bus, allowing data to be transferred 64 bits at a time.

Channel-Check Reporting and Error Logging

Errors can occur not only during data-transfer operations, but also while data is stored in system memory. The contents of a memory location can be changed accidentally, a memory module can be defective, or other hardware failures can occur in the server.

Your server uses *channel-check reporting* to detect hardware errors and *error logging* to record the errors. Service technicians can use these records to diagnose and correct problems in the server.

The channel-check reporting facility automatically locates random and intermittent errors while your server is operating. Information about any failing component is saved in the error log so that you can identify and replace the failing component.

Chapter 5. Data Storage Devices

IBM data storage devices and IBM external storage enclosures are available for use with your server. You can use these storage devices, along with a wide variety of industry-standard storage devices, to expand the data storage capacity of your server.

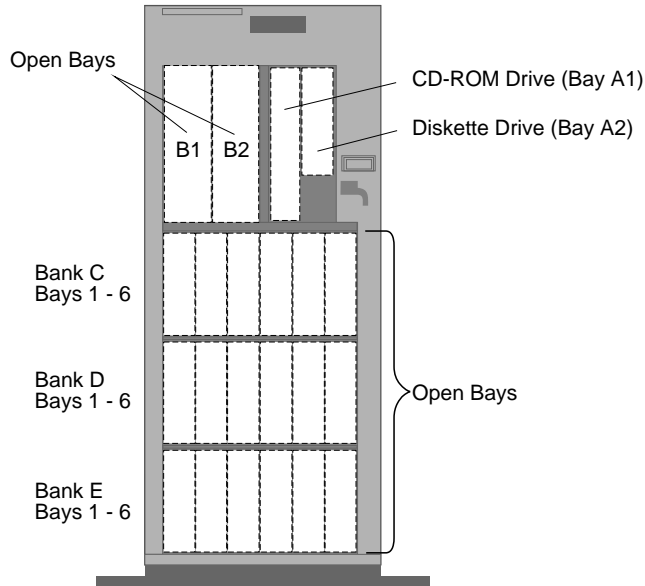
Hard Disk Subsystem

The IBM PC Server 720 comes with either an IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A or an IBM PC Server SCSI-2 Fast/Wide PCI Adapter preinstalled as a standard feature. Models that come with the RAID adapter preinstalled have a built-in, disk-array subsystem. If your server is a non-disk-array model, you can install an IBM RAID adapter and hard disk drives to create a disk-array subsystem. (See Chapter 7, “Disk Arrays” on page 59 for more information.)

The hot-swap capability for hard disk drive replacement, provided in all PC Server 720 models, enables you to correct failures without turning off the server.

Internal Bays

Your server comes with one 3.5-inch, 2.88MB diskette drive and one CD-ROM drive. The number of hard disk drives installed varies by model.



Hard Disk Drives: The number of preinstalled drives and their capacities vary by model.

Diskette Drive: The 3.5-inch, 2.88MB diskette drive installed in bay A2 uses 1MB, 2MB, and 4MB diskettes.

CD-ROM Drive: The 5.25-inch, SCSI-2 CD-ROM drive is installed vertically in bay A1.

Open Bays: Additional bays provide extensive storage expansion capability. For installation instructions and detailed information on the types of drives you can install in each bay, refer to your *User's Handbook*.

Direct Access Storage Devices

In a direct access storage device (DASD), the time required to access data is not dependent on the location of the data on the storage medium. Direct access storage devices include diskette drives, hard disk drives, CD-ROM drives, and rewritable optical drives. All of these devices, except hard disk drives, are removable-media drives.

Diskette Drives

The following 3.5-inch and 5.25-inch diskette drives are available for purchase as options.

3.5-Inch, 2.88MB Diskette Drive

This drive uses 3.5-inch diskettes with a formatted capacity of 720KB, 1.44MB, or 2.88MB. To prevent the loss of data, format 1MB diskettes to store 720KB of data, 2MB diskettes to store 1.44MB of data, and 4MB diskettes to store 2.88MB of data. This drive has a *media-sense* feature, which uses the small window at the bottom-right corner of the diskette to detect whether the diskette capacity is 1MB, 2MB, or 4MB.

The 2.88MB diskette drive is available in two models, one of which has a *removable-media security* feature to prevent the removal or insertion of diskettes by unauthorized persons.

3.5-Inch, 1.44MB Diskette Drive

This drive uses 3.5-inch diskettes with a formatted capacity of 720KB or 1.44MB. To prevent the loss of data, format 1MB diskettes to store 720KB of data and 2MB diskettes to store 1.44MB of data. The slim-high model of this drive includes the media-sense feature.

5.25-Inch, 1.2MB Diskette Drive

This drive uses 5.25-inch diskettes with a formatted capacity of 360KB or 1.2MB. Diskettes formatted on this drive to store 360KB of data might not be usable in 360KB diskette drives. An external model and an internal model are available. The internal model attaches to the diskette drive cable. The external model attaches to an adapter that you install in an expansion slot.

SCSI Hard Disk Drives

The SCSI-2 adapter in your server has two internal channels and one external channel. You can connect up to seven SCSI devices, including hard disk drives, CD-ROM drives, rewritable optical drives, and tape drives, to each channel of the SCSI-2 adapter. However, you can use only two of these three channels simultaneously.

IBM offers a wide variety of SCSI hard disk drives that you can install in your server or in an external storage enclosure. These drives comply with ANSI SCSI Standards X3.131-1986 and X3.131-1994.

Contact your IBM authorized reseller or marketing representative for a current list of the SCSI hard disk drives available for your PC Server 720.

CD-ROM Drive

The *compact disc-read only memory* (CD-ROM) drive uses a compact disc (CD) that the server can read from but not write to. You can view the data, but you cannot change or update the data.

All IBM CD-ROM drives use industry-standard 5.25-inch CDs with a capacity of approximately 650MB of data. Diskette drives, hard disk drives, and tape drives use a magnetic recording technique.

However, CD-ROM drives use an optical technique that records and reads data at a much higher density than magnetic recording can achieve.

The CD-ROM drive installed in your server complies with ANSI SCSI Standard X3.131-1986. This drive has an average access time of 20 ms, a data transfer rate of 300 kilobytes-per second (KBps), and a burst data transfer rate of 4.2 megabytes-per second (MBps).

Note: The average access time is the interval between the instant the call for data is initiated and the instant the delivery of data is completed.

The CD-ROM drive supports CD-ROM Extended Architecture (XA), which is a standard for interleaving different types of data such as video, audio, and text. This enables your server to support advanced multimedia applications.

Your CD-ROM drive also supports the Kodak Photo CD standard for recording pictures on CDs, and it is equipped with line output jacks and a volume-control dial.

Handle a CD by the edges only. Periodically clean your CDs by wiping them with a soft, lint-free cloth, from the center of the CD to the outer edge. Do not clean CDs in a circular pattern, because this can cause loss of data.

3.5-Inch Rewritable Optical Drive

The IBM 3.5-Inch Enhanced Rewritable Optical Drive complies with ANSI SCSI Standards X3.131-1986 and X3.131-1994. You can install this drive inside your server, or you can install it in an external storage enclosure.

This drive reads data at a rate of 640 KBps and writes data at a rate of 213 KBps. Its burst data-transfer rate is 7.25 MBps, and its average seek time is 40 ms.

This enhanced rewritable optical drive is a SCSI direct access storage device that can use the following types of removable, 3.5-inch optical cartridges:

- The IBM 128MB Rewritable Optical Cartridge has a formatted capacity of 127MB and can be written to and read from many times.
- The optical read-only memory (OROM) cartridge has a formatted capacity of 122MB and can be read from but not written to. Using an OROM cartridge is similar to using a compact disc. You can use an OROM cartridge to distribute almost any type of data and software, such as operating systems and multimedia application programs.
- The partial read-only memory (P-ROM) cartridge has a formatted capacity of 122MB. Any part of the cartridge (up to 122MB) can contain read-only data. You can format the remaining part of the cartridge, then write to or read from it many times.

You could use a P-ROM cartridge for testing or survey services. For example, you would enter the questions in the read-only part of the cartridge. The rest of the cartridge would provide space for read and write operations, so the test participants could enter their answers.

Tape Drives

Backing up the entire contents of a hard disk to diskettes can be very time-consuming and, in the case of a network server with multiple hard disks, can require hundreds of diskettes. A faster and more efficient way to back up the data is to use a tape-backup drive.

Tape drives provide a cost-effective way to back up your files. You can copy several billion bytes of data from the hard disks to a single tape. Data is stored in the same sequence as it was entered.

Four tape drives are available for use with your server. They are:

- 4/10GB 4 mm 3.5-Inch DAT Tape Option Kit
- 4/10GB 4 mm 5.25-Inch DAT Tape Option Kit
- 3445 External 5/10GB Tape Drive
- 24/48GB Internal Tape Autoloader

The 3.5-Inch and 5.25-Inch 4/10GB DAT Tape Drives

These two internal digital audio tape (DAT) drives use 4 mm tape cartridges and feature data compression, which allows you to store more data. The main difference between these drives is their external size.

The 3445 External 5/10GB Tape Drive

This tape-backup drive uses 8 mm tape cartridges and also offers the data compression feature. You can attach it to the external connector on the SCSI-2 adapter.

The 24/48GB Internal Tape Autoloader

You can install this autoloading tape-backup drive in an internal, 5.25-inch bay. It has six cartridges that can each store up to 8GB of data. In the native mode, this drive supports a data-transfer rate of 510 KBps, but this data-transfer rate doubles when the data-compression feature is used. This drive also supports burst-data transfers of 3 MBps in the asynchronous mode and 7.5 MBps in the synchronous mode. A convenient feature of this tape-backup drive is its ability to perform up to 8GB of backup every six days completely unattended.

IBM External SCSI Storage Enclosures

IBM offers three types of SCSI storage enclosures. These enclosures attach to the external connector on the SCSI-2 adapter. (You also need a SCSI Card-to-Option Cable to attach a storage enclosure to your server.)

Model 3510 SCSI Storage Enclosure

The Model 3510 accommodates one 3.5-inch half-high or slim-high SCSI hard disk drive, one rewritable optical drive, or one 5.25-inch CD-ROM drive. You can attach multiple storage enclosures to the same SCSI adapter.

A SCSI Card-to-Option Cable connects the controller to the first Model 3510. An Option-to-Option Cable then connects the first Model 3510 to the second Model 3510. The last Model 3510 requires an Option Interface Terminator, which comes with the SCSI Card-to-Option Cable and terminates that end of the SCSI bus. The maximum length of cable that you can attach to each SCSI controller is 6 meters (approximately 20 feet). For more information about maximum SCSI cable length, refer to your *User's Handbook*.

The Model 3510 has a 32-watt power supply, an external SCSI ID selector, and a push button power switch with power-on indicator.

Model 3511 External Storage Enclosure for SCSI Devices

This enclosure is quite different from the Model 3510. From the outside, this floor-standing enclosure looks like a PS/2 Model 95 computer. This enclosure can accommodate up to seven storage devices, such as hard disk drives.

The Model 3511 can hold up to five half-high or slim-high hard disk drives and one 2.3GB SCSI Tape Drive, providing excellent backup for your server. You also can install up to two removable-media drives, such as CD-ROM drives and rewritable optical drives.

The manual provided with the Model 3511 includes information about power supply considerations. To avoid overloading the power supply, follow the guidelines in the manual for the enclosure.

If you plan to install non-IBM SCSI devices, check with the drive manufacturer for the required power information.

Model 3516 Hot Swap Storage Expansion Enclosure

This is a mini tower that holds up to seven hot-swap hard disk drives. It ships without any drives, so you must install at least one drive before you attach the enclosure to the server.

To connect the enclosure to the external SCSI-2 connector on the server, you need a 68-pin to 68-pin external SCSI-2 cable.

Chapter 6. SCSI Subsystem

The *small computer system interface* (SCSI) enables the system to communicate with devices such as hard disk drives, read-and-write optical drives, CD-ROM drives, tape drives, scanners, and printers. Your IBM PC Server 720 comes with a SCSI-2 adapter (controller) preinstalled as a standard feature.

Disk-array models come with an IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A preinstalled. Non-disk-array models come with an IBM PC Server SCSI-2 Fast/Wide PCI Adapter preinstalled. Both of these bus master SCSI-2 adapters support:

- A variety of SCSI devices that conform to ANSI SCSI Standard X3.131-1986 or X3.131-1994.
- Devices compatible with the SCSI Common Command Set.
- Removing and replacing hard disk drives without turning off the server (hot-swapping).
- Multiple physical devices:

The IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A supports two channels with a maximum of seven SCSI physical devices per channel. This adapter has two 16-bit internal connectors and one 16-bit external connector. One of the internal connectors is permanently configured as Channel 1. You can configure the second internal connector or the external connector as Channel 2. You cannot use all three connectors simultaneously. For example, if you attach SCSI devices to both of the internal connectors, you cannot use the external connector.

The IBM PC Server SCSI-2 Fast/Wide PCI Adapter supports a maximum of 15 physical SCSI devices. This adapter has three connectors: an 8-bit internal connector, a 16-bit internal connector, and a 16-bit external connector. The 16-bit devices support SCSI IDs 0 to 15, while 8-bit devices support only IDs 0 to 7.

If you attach SCSI devices to both of the internal connectors, you cannot use the external connector.

- Functions unique to a particular SCSI device (when the device manufacturer provides the appropriate device driver that supports the unique function).

Advantages of the SCSI Subsystem

The SCSI standards define the interface through which the system communicates with different types of devices. Before the SCSI standards were developed, most physical devices required their own controllers (usually adapters). These adapters could support only one device or multiple devices of the same type. Because each device required support from the system microprocessor, every device added to the system increased the workload on the microprocessor. Also, because almost every device required its own adapter in a separate expansion slot, flexibility and growth were limited by the number of expansion slots in the system.

The SCSI subsystem produces significant improvements in system performance and flexibility over other I/O interfaces. Each SCSI device has a built-in *device controller* that interprets the SCSI command set. The SCSI standards define the commands and messages used in the interface.

Several devices can operate concurrently and share the interface. This means significantly higher data-transfer rates and faster, more efficient, I/O management for network servers. The SCSI controller (adapter) is the key component in the SCSI subsystem. You can connect internal and external physical devices to the same SCSI controller (adapter).

Types of Interfaces

The two most common types of interfaces for attaching devices to the server are *device-level* interfaces and *bus-level* interfaces. The small computer system interface is a bus-level interface.

Each device connected to a device-level interface has a controller that is mounted on a separate adapter, away from the physical device. Usually, there are limitations on the types of devices you can attach to the same controller. Functions such as formatting, head selection, and error detection are directed by the controller and not by the device itself. The device is limited to performing the mechanical operations of reading and writing data, and it can do only what the controller allows it to do.

With a bus-level interface, each device has its own device controller that provides the details of how to accomplish its tasks. This type of interface uses a standardized set of commands, the Common Command Set, to issue tasks to the devices, and each device controller determines how to accomplish these tasks.

The SCSI-2 adapter imposes few restrictions on the number and types of devices that you can attach to it. As new SCSI devices become available, there is no need to install new adapters. You can attach many different devices, such as hard disk drives, CD-ROM drives, scanners, and printers, to the same SCSI-2 adapter.

The SCSI standard allows great flexibility in the design of devices. Hardware manufacturers can develop SCSI devices to perform functions without requiring that the SCSI controller support those functions. Device drivers supplied by the device manufacturer provide support for the functions that are unique to the device.

SCSI Physical Configuration

The following describes a possible SCSI subsystem in the IBM PC Server 720:

- A cable connects the SCSI devices to the SCSI-2 adapter. This can be a SCSI cable inside the system that provides connectors for internal devices, or a SCSI cable (or series of cables) that connects to the external connector of the SCSI-2 adapter.
- You can attach one device or a combination of up to 15 internal and external devices to the SCSI-2 adapter, provided that the total length of the interface (connecting cables) does not exceed 6 meters (approximately 20 feet) for an 8-bit cable, or 3 meters (approximately 10 feet) for a 16-bit cable.
- The first external device connects to an external SCSI cable, and the external SCSI cable connects to the 68-pin external connector on the SCSI-2 adapter. Additional external devices connect to each other with SCSI option-to-option cables. The last external device must have a terminator. (If there is only one external device, it must have a terminator. See “Termination” on page 57 for more information.)
- The IBM PC Server SCSI-2 Fast/Wide PCI Adapter can support up to 15 physical devices. One of the two internal connectors is for an optional 8-bit cable, and the other internal connector is for the standard 16-bit cable. If you use both internal connectors, you cannot use the external connector.

Each device attached to the interface, including the SCSI-2 adapter itself, must conform to ANSI SCSI Standard X3.131-1986 or X3.131-1994. These standards specify the commands and the mechanical, electrical, and functional requirements that must be used by devices in the SCSI subsystem.

SCSI ID

The SCSI ID is also known as the *SCSI address* or *physical unit number (PUN)*. This address enables the SCSI controller to distinguish one device from another.

The SCSI controller can service only one device at a time. When more than one physical device is connected to the same SCSI controller, the devices compete for support from the SCSI controller. When this occurs, the SCSI controller gives each device a priority based on its SCSI ID. A SCSI device with a low-numbered SCSI ID (such as 0 or 1) has a lower priority than a SCSI device with a high-numbered SCSI ID (such as 5 or 6).

The SCSI-2 adapter (controller) in your server is preset to ID 7, and the SCSI CD-ROM drive in bay A1 is preset to ID 6. If your model came with one or more hard disk drives preinstalled, their SCSI IDs depend on where they are installed. (See “Assigning SCSI IDs” for information about how the backplane assigns SCSI IDs.)

Logical Units

In addition to the physical unit number (PUN), each SCSI device also has at least one *logical unit number (LUN)*. If a physical device supports no logical devices, its LUN is 0. Most SCSI devices support only LUN 0. However, some types of physical SCSI devices, such as *bridge controllers*, can support more than one logical device. The LUN identifies each device that is connected to the SCSI through its own device controller.

For example, a printer controller might support up to eight printers. The printer controller is a physical device, and each of the printers is a logical device. If the printer controller is set to ID 3, the ID of the first printer appears in the SCSI device configuration as PUN 3, LUN 0. The IDs of the other printers are PUN 3, LUN 1; PUN 3, LUN 2; and so on.

Assigning SCSI IDs

For the SCSI subsystem to function properly, each SCSI device installed in or attached to your server must have a unique SCSI ID.

When you install additional hot-swap drives in bays C1 to C6, the *backplane* (the printed circuit board behind bank C) automatically sets the SCSI IDs for the drives. The optional backplanes for banks D and E also are designed to automatically set the SCSI IDs for hot-swap drives.

The backplane behind bank C assigns the SCSI IDs as follows:

Bay	SCSI ID
C1	ID 0
C2	ID 1
C3	ID 2
C4	ID 3
C5	ID 4
C6	ID 5

Before you attach external SCSI devices or install a SCSI device in bay B, you must choose an ID for the device; then manually set the SCSI ID by following the instructions supplied with the device.

Your *User's Handbook* contains more information about setting SCSI IDs, and it also contains detailed information about the types of drives that you can install in your server.

Cabling

The SCSI subsystem in your server consists of a SCSI-2 controller, SCSI devices, and cabling. The cabling (interface) conforms to the SCSI standard. The 16-bit cable that comes standard in all PC Server 720 models has a set of 16 data lines, two data-parity lines, and various control lines. The optional 8-bit cable that you can attach to the IBM PC Server SCSI-2 Fast/Wide PCI Adapter (non-disk-array models) has a set of eight data lines, one data-parity line, and various control lines.

Note: A 16-bit to 8-bit SCSI internal converter connects the 8-bit CD-ROM drive to one of the 16-bit cable connectors.

The IBM PC Server SCSI-2 Fast/Wide PCI Adapter has one 8-bit internal cable connector, one 16-bit internal cable connector, and one 16-bit external cable connector. The IBM SCSI-2 Fast/Wide

Streaming-RAID Adapter/A has two 16-bit internal cable connectors and one 16-bit external connector.

The interface uses *daisy-chain cabling*, where each device except the last one (internal or external) has one cable going into it and another coming out of it. There are some limitations on the length of cabling that you can use. Information about these limitations is provided in “Termination,” but more detailed information is provided in your *User's Handbook*.

Termination

The SCSI standard defines the signals carried on the interface (cabling). To ensure the quality of these signals, a *terminator* must be present at both ends of the SCSI cabling. When both an internal cable and an external cable are present, the entire configuration is seen as one long bus. In this case, there are only two termination points, at the far ends of the internal and external cables.

The interface uses daisy-chain cabling, where each device except the last one (internal or external) has a cable going into it and another coming out of it. The last device has an incoming cable and a terminator.

In the PC Server 720, the backplane that the hot-swap drives plug into automatically sets the termination of the drives. Therefore, you do not need to install or remove terminators when you install or remove hot-swap drives. However, if you install a SCSI device in bay B, or you attach SCSI devices to the external SCSI-2 connector, you might need to adjust the termination so that the last device in the chain is terminated.

The maximum length of SCSI cable between the terminated ends of the cable must not exceed 6 meters (approximately 20 feet) for the optional 8-bit cable, and 3 meters (approximately 10 feet) for the standard 16-bit cable.

The following general rules apply to SCSI-device termination:

- If you install a SCSI device in bay B and you attach one or more external SCSI devices, you must terminate the devices at the ends of the internal and external cables.
- If you have only one external device, you must terminate that device.

Note: If you attach SCSI devices to the external connector on the SCSI-2 adapter, you can connect internal SCSI devices to only one of the internal SCSI connectors.

- For specific information about termination, use the instructions supplied with the device.

Refer to the "Installing Options" chapter of the *User's Handbook* for more information.

When you connect several hard disks together and configure the hard disk controller to access them in a predetermined pattern, you create a *disk array*. Disk arrays are used to increase security, performance, or reliability. They provide faster input and output rates than single large-capacity drives, because the files are stored on individually addressable disks and can be found more quickly during I/O requests.

The amount of security, performance, and improved reliability depends on the application programs that are running and the type of disk array you configure. The type of disk array you can configure depends on the data-storage patterns supported by your hard disk controller, operating system, and application programs.

Some PC Server 720 models come with an IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A as a standard feature. This redundant array of independent disk (RAID) adapter supports RAID levels 0, 1, and 5. If your server is a non-disk-array model, you can install an IBM RAID adapter and hard disk drives to create a disk-array subsystem.

Improved System Performance

When you group hard disk drives into a single logical drive, the RAID adapter can transfer data in parallel from the multiple drives in the array. This parallel transfer yields data-transfer rates that are many times higher than with non-arrayed drives. This increased speed makes the server better able to meet the *throughput* (the amount of work in a given amount of time) or productivity needs of the multiple-user network environment.

The ability to respond to multiple data requests provides not only an impressive increase in throughput, but also a decrease in response time. The combination of parallel transfers and simultaneous responses to multiple requests allows disk arrays to provide the highest level of performance in network environments.

RAID Technology

RAID is the technology of grouping several hard disk drives in a server into an *array* that you can define as a single logical drive. This logical drive then appears to the operating system as a single physical drive.

RAID technology provides access and data transfer rates beyond the physical limitations of existing hard disk drives, which greatly enhances the logical-drive capacity and performance.

In addition, if one of the physical drives in a RAID level-1 or RAID level-5 disk array fails, the system continues to run, with no operator intervention required. You can replace the failed drive without turning off the server (hot-swap), and the RAID adapter rebuilds the new drive contents from the information on the other drives. This rebuilding process takes place in the background with the system online. Once the drive contents are rebuilt, full performance and fault-tolerant functions are restored.

Note: Data stored in a failed level-0 logical drive is lost.

Logical Drives

The following information will help you understand how the server manages logical drives and how many you can define.

When you create an array, you group hard disk drives into one storage area. You can define this storage area as a single logical drive, or you can subdivide it into several logical drives. A logical drive in a disk array can be any size you choose within the size limitations of the array. The RAID adapter supports up to four independent arrays and a total of eight logical drives. You can combine a maximum of eight drives to form an array, and an array can span both channels.

If you have only one array, you can define it as a single logical drive, or you can divide it into as many as eight logical drives. If you have two or more arrays, each array can be one logical drive, or you can divide each array into multiple logical drives, as long as the total number of logical drives for the arrays is no more than eight.

The operating system considers each of these logical drives just as it does a physical hard disk drive. You can use the FDISK program (or its equivalent) to partition the logical drives in the same way that the operating system partitions a hard disk drive.

If you install an operating system, you can allow the installation program to determine how the FDISK program or its equivalent allots the space within a logical drive, or you can manipulate the program yourself to partition the available space. Refer to your operating system documentation for more information.

Additional Storage Capacity

When you add hard disk drives to your server, you must configure a new disk array before you can use the drives. You can reconfigure the existing disk array to include the capacity offered with the new drives, or you can group the new drives into their own array. You also can create an array with only one drive. Your server has space for up to 18 hot-swappable hard disk drives. You can install additional SCSI devices in bay B, but this bay does not support hot-swapping. Depending upon your configuration, you might need to install an additional SCSI adapter or cable.

Notes:

1. Before you reconfigure or redefine an existing array, be sure to back up your data. When you redefine an existing array, all data in that array is lost.
2. The RAID adapter automatically assigns RAID level 0 to all logical drives in an array containing only one hard disk drive.
3. If you install a drive in bay B, you can include it in an array if you have five or fewer drives installed in bank C, or if you have installed an additional SCSI adapter and SCSI cable.

Hard Disk Drive Capacities

Hard disk drive capacities influence the way you create disk arrays. Drives in the disk array can be of different capacities (1GB or 2GB, for example), but the RAID adapter treats them as if they all have the capacity of the *smallest* disk drive. For example, if you have four drives of 1GB, 1GB, 1GB, and 2GB grouped into one disk array,

the total capacity of the array is 1GB times 4, or 4GB, not the 5GB physically available.

If you add a smaller drive to an array of larger drives, such as a 1GB drive to a group containing three 2GB drives, the total capacity of that array is 4GB, not the 7GB physically available.

Disk-Array Classifications

With RAID technology, data is *striped* across an array of hard disk drives. This data-distribution technique complements the way the operating system requests data.

The six basic disk-array classifications are RAID-0 through RAID-5. The IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A supports three RAID levels: 0, 1, and 5.

RAID Level 0

RAID level 0 stripes the data across all the drives in the array. This offers substantial speed enhancement, but provides for no data redundancy. The RAID adapter automatically assigns RAID level 0 to all logical drives in an array containing only one hard disk drive.

A hard disk failure within the array results in loss of data in the logical drive assigned level 0, but *only in that logical drive*. If you have logical drives assigned RAID level 1 or 5 in the same array, they will not lose data.

When you replace the failed drive, the RAID adapter automatically rebuilds all the logical drives assigned RAID levels 5 and 1 onto that hard disk drive and defines the level-0 logical drive. However, the data that was in the failed level-0 logical drive is lost.

Though the risk of data loss is present, you might want to assign RAID level 0 to one of the logical drives to take advantage of the speed offered with this level. You could use this logical drive to enter data that you back up each day and for which safety is not of primary importance; that is, data that you can re-create easily. You also might want to use a level-0 logical drive when the work you are doing requires maximum capacity. Level 0 provides the largest

capacity of the three RAID levels offered, because no room is taken up for redundant data or data parity storage.

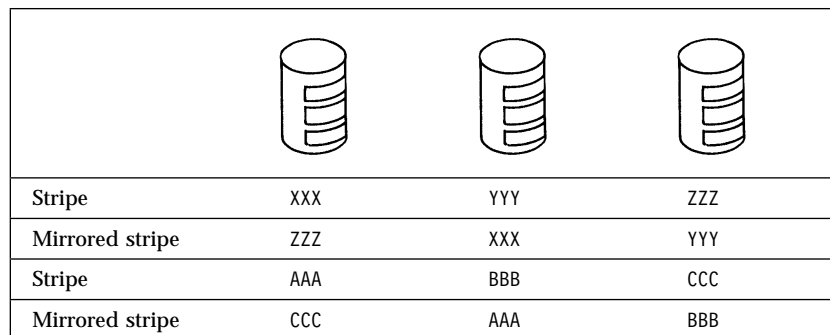
In the event of a drive failure in an array that contains a logical drive assigned RAID level 0, the RAID adapter will not activate a hot-spare drive.

RAID Level 1

RAID level 1 provides an enhanced feature for disk *mirroring* that stripes data and copies of the data across all the drives in the array. The first stripe is the data stripe; the second stripe is the *mirror* (copy) of the first data stripe, but written on another drive. Because the data is mirrored, the capacity of the logical drive when assigned level 1 is 50% of the physical capacity of the grouping of hard disk drives in the array.

RAID level 1 uses two drives. If more than two drives are in the array, the RAID adapter automatically switches the RAID level to the Enhanced RAID level 1.

The following illustration shows data arranged in a disk array with three hard disk drives. The logical drive is assigned RAID level 1. Notice that the mirror of the first data stripe (XXX YYY ZZZ) is shifted one drive. The other data stripes in level 1 follow the same pattern.



If you have only two drives available, the second drive is a mirror copy of the first drive.

RAID Level 5

RAID level 5 stripes data and parity across all drives in the array. When a disk array is assigned level 5, the capacity of the logical drive is reduced by one drive (for data parity storage).

Level 5 is generally the most desirable choice, because it offers both data protection and increased throughput. Level 5 gives you higher capacity than level 1, but level 1 offers better performance. If after using level 5 you are dissatisfied with the performance and can tolerate lower capacity, you can backup the data stored in the array, and then redefine the level to level 1; or, you can use a logical drive that you have assigned level 1.

Note: Before you reconfigure or redefine an existing array, be sure to back up your data. When you redefine an existing array, all data in that array is lost.

If you want to have a hot-spare drive and also assign level 5, you must have at least four hard disk drives, with no logical drives assigned level 0.

RAID Adapter Features

The IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A supports:

- A 32-bit Micro Channel data bus (automatically configurable)
- Streaming-data transfers
- A 4MB adapter cache, which significantly improves server performance by keeping frequently used SCSI-device data available for immediate transfer
- SCSI-2 Tagged Command Queuing
- *Hot-spare drives*, which enable the disk-array subsystem to perform data recovery and data reconstruction automatically, in the event of a single disk failure in a level-1 or level-5 array
- Two internal 16-bit connectors and one external 16-bit connector that can support four arrays

You can connect SCSI devices to both of the internal connectors, or to one internal connector and to the external connector. You cannot use all three connectors at the same time.

Overlapped Input/Output Operation

The RAID adapter provides multiple data paths to and from arrayed drives. This enables your server to respond to requests from several users simultaneously. If one user requests data that resides on the first drive in the array and a second user requests data that resides on the second drive, the RAID adapter can deliver the requested data to both users simultaneously.

Interleave Depth/Stripe Unit

The granularity at which data from one file is stored on one drive in the array before subsequent data is stored on the next drive in the array is called the *interleave depth*. For optimum system performance, you can set the interleave depth to a unit size of from 8KB to 64KB of data. The collection of these units in logical order, from the first drive in the array to the last drive in the array, is called a *stripe*.

Queue Depth

Commands are queued in the RAID adapter with a queue depth of 61. To obtain better performance, the commands in the queue will be *reordered* and *coalesced* on a hard disk drive basis. That is, the adapter organizes the commands according to which drive will be responding, and then orders and combines two or more commands, when possible, before sending them to the drives.

Cache

The RAID adapter has 4MB of memory, of which more than 3MB is used as cache memory. You can configure this cache memory to operate in write-through or write-back mode on a logical-drive basis. Cache memory has parity to detect memory errors and retry algorithms to recover from errors that appear sporadically. For more information, see “Cache Memory” on page 30.

Hot-Spare Drive Replacement

A hot-spare drive is any hard disk drive defined for automatic use in the event of a drive failure. The hot-spare drive must be of equal capacity to or greater capacity than the drives in the array it is intended to replace. You can define multiple drives as hot-spare drives.

If a hard disk drive fails in a RAID level-1 or RAID level-5 array, the RAID adapter automatically re-creates the data from the failed drive on the hot-spare drive. When you replace the failed drive and run the operating-system-specific utility program, the RAID adapter will automatically define the replacement drive as your new hot spare.

Data Protection

The RAID adapter provides the server with a data redundancy technique that distributes data across all the drives in the array. In the event of a single drive failure in a RAID level-1 or RAID level-5 array, the remaining drives in the array service read and write requests, without loss of data. The failed hard disk drive *appears* to be operating correctly, although at reduced performance.

When you replace the failed drive, the data in logical drives assigned RAID levels 1 and 5 is rebuilt on the new hard disk drive, using the parity information stored on the other hard disk drives in the array. You must replace and rebuild the failed drive in a timely manner to avoid multiple-drive failures and reduced performance. Once the RAID adapter rebuilds the drive contents, full performance and fault-tolerance functions are restored.

Hard Disk Drive Mapping

In the following tables, the drive locations shown on your RAID Configuration utility screen (described by channel and bay number) are mapped to the physical locations in your server. The SCSI ID for each device is also shown in reference to the channel and bay to which it is attached. The first table shows the server configuration as it is shipped. If you install another IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A in your server, you can use the same

combinations shown in the following tables, depending upon your space availability.

Displayed Channel Number	Displayed Bay Number	Bank and Bay Physical Location	SCSI ID
1	1	C1	0
1	2	C2	1
1	3	C3	2
1	4	C4	3
1	5	C5	4
1	6	C6	5
1	7	A1 (CD-ROM)	6

Table 1. One-Channel Mapping

In the following table, both internal channels of the RAID adapter are used. The first channel is connected to the standard backplane behind bank C, and the second channel is connected to the optional backplane behind bank D.

Displayed Channel Number	Displayed Bay Number	Bank and Bay Physical Location	SCSI ID
1	1	C1	0
1	2	C2	1
1	3	C3	2
1	4	C4	3
1	5	C5	4
1	6	C6	5
1	7	A1 (CD ROM)	6
2	1	D1	0
2	2	D2	1
2	3	D3	2
2	4	D4	3
2	5	D5	4
2	6	D6	5
2	7	Not Used	6

Table 2. Two-Internal-Channels Mapping

In the following table, one internal channel and the external channel on the RAID adapter are used. The first channel is connected to bank C, and the second channel (the external connector of the RAID adapter) is attached to an external DASD storage enclosure. (Refer

to the documentation that comes with the storage enclosure for physical locations.)

Displayed Channel Number	Displayed Bay Number	Bank and Bay Physical Location	SCSI ID
1	1	C1	0
1	2	C2	1
1	3	C3	2
1	4	C4	3
1	5	C5	4
1	6	C6	5
1	7	A1 (CD-ROM)	6
2	1	External	0
2	2	External	1
2	3	External	2
2	4	External	3
2	5	External	4
2	6	External	5
2	7	External	6

Table 3. One Internal Channel and One External Channel Mapping

Configuring is the process of identifying the software and devices that are installed in or attached to your server, then deciding how the software and devices will use or share the available server resources.

One of the most appealing design features of your server is that it eliminates the use of jumpers and switches on the system board and on adapters. You no longer need to disassemble the server, locate the adapter publications, and manually set jumpers and switches to assign server resources.

The IBM PC Server 720 uses programmable configuration features, configuration programs, and configuration files to assign interrupt levels, input/output addresses, memory addresses, arbitration levels, and other server resources.

Programmable Configuration

The programmable configuration hardware consists of:

- Nonvolatile RAM on the system board
- Hardware used to store the device ID
- Registers on the system board, processor board, bridge cards, and adapters

Instead of jumpers and switches that you set manually, the system board and adapters have registers that act as electronic switches. These read and write registers are set by the POST routine each time you turn on the server. The registers are volatile storage areas, and retain the configuration information only while the server is turned on. When you turn off the server, the configuration information is cleared from these registers.

A current copy of the configuration information is stored in a battery-backed memory area known as nonvolatile RAM. The same battery that supports the nonvolatile RAM module supports the real-time clock module, which provides a time-of-day clock, a 100-year calendar, and 64 bytes of nonvolatile RAM that the server uses to store some setup information, such as the power-on password.

Each processor board, PCI adapter, and Micro Channel adapter has a unique device ID. The POST routine and the configuration programs use the device ID to identify the type and location of each board or adapter in the server. The configuration programs also use the device ID during the configuration process to locate the appropriate configuration files for the system board and Micro Channel adapters.

The programmable configuration hardware, together with the configuration programs and configuration files, simplifies the process of configuring the server hardware by:

- Eliminating the need for setting jumpers and switches on the system board, processor boards, and adapters
- Enabling you to configure the server automatically or manually using menu-driven programs
- Identifying the type and location of each device in the server
- Resolving server resource conflicts

Configuration Programs

IBM provides the configuration programs in two places:

- On the Reference Diskette.
- On the hard disk. Models that come with one or more hard disk drives have the configuration programs preinstalled in a partition (called the System Partition) on one of the hard disk drives.

The Reference Diskette and Diagnostic Diskette that come with your system contain the utility, configuration, and test programs for your server. Collectively these programs are called the *system programs*. These menu-driven programs guide you through the hardware configuration process. After you start these diskettes, you can press the F1 key to get helpful online information about each program.

Disk Array Configuration Programs

Additional configuration programs for disk-array models are located on the IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A Option Diskette, which comes with your server.

You can use the IBM RAID configuration programs to configure your hard disk drives into disk arrays and logical drives that best serve your needs. The RAID adapter option diskette also contains device drivers and administration utility programs for the IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A. Refer to the "Configuring the Disk Array" section of your *User's Handbook* and the README file on the RAID adapter Option Diskette for information about installing these device drivers and using the utility programs.

Using the System Programs

You must use the configuration programs on the Reference Diskette when you install a new device, when you remove or change the position of an existing device, or when you have the battery that supports nonvolatile RAM replaced.

Most people use the Automatic Configuration program, which allocates the server resources for optimum performance. However, if you are experienced and want to change the default values, or if you have a device that requires special considerations, you can use the Change Configuration program on the Reference Diskette to customize the configuration.

The configuration programs on the Reference Diskette are as follows:

- **Set configuration** lets you view, change, back up, or restore the configuration information. It also runs the Automatic Configuration program.

During the configuration process, the Set Configuration program reads the device ID of each device in the server to determine its type and location. Then it uses the information in the configuration files to assign the appropriate server resources.

- **View configuration** lets you view the current configuration information stored in nonvolatile RAM.
- **Change configuration** lets you customize the configuration or resolve a configuration conflict.

When a configuration conflict exists, an asterisk (*) appears next to the conflicting item on the Change Configuration or View Configuration screen. If the conflict is with a server resource that cannot be shared, the asterisk appears to the left of the slot number that contains the conflicting device. If other choices are available for the conflicting device, the asterisk appears to the right of the slot number.

- **Backup configuration** lets you back up the configuration information to the hard disk or to a diskette.

Run this program each time you change the configuration. That way, if the battery fails and the system configuration information is lost, you can use the Restore Configuration program to recover the server configuration information.

- **Restore configuration** lets you restore, from the hard disk or a diskette to nonvolatile RAM, the configuration information that was copied by the Backup Configuration program.
- **Run automatic configuration** configures the system board and adapters automatically. This is the simplest way to configure the server hardware, because you do not have to make any decisions about resource assignments.

This program sets the configuration assignments, such as the memory address of an adapter, to the default values for the device. If you have a custom configuration or you are using an operating system or application that requires specific server resources, use the Change Configuration program.

- **Set and view SCSI device configuration** lets you assign, view, or change the configuration of the SCSI devices in non-disk-array models. For disk-array models, you must use the RAID configuration utility programs to set and view the SCSI drive configuration.

The SCSI device configuration program also allows you to enable or disable the Presence Error Reporting feature and the Accept SCSI Configuration feature.

The Presence Error Reporting feature allows you to keep the configuration information for a SCSI device in nonvolatile RAM, even after you remove the device from the server. When the POST routine checks for the presence of a SCSI device and finds the Presence Error Reporting feature disabled, the POST routine does not report a configuration error. This feature is very useful if, for example, you share a single tape-backup drive among several servers.

The Accept SCSI Configuration feature allows you to add and remove SCSI devices without reconfiguring the server. When this feature is enabled, the SCSI configuration is not checked during POST. This feature is very useful if you frequently add and remove SCSI devices.

- **Display memory map** lets you view the Micro Channel adapter memory assignments. This program also shows the memory addresses available for additional hardware and software, such as an adapter or an expanded memory specification (EMS) driver.
- **Use the PCI Configuration program** lets you see which PCI devices are installed and where they are located in the server. The PCI Device Configuration screen lists the current settings, such as the interrupt level, ROM address, and I/O address for the installed PCI devices. Your server automatically configures PCI devices. However, if a conflict exists between two PCI devices or between a PCI device and a Micro Channel device, an asterisk appears next to the conflicting setting on the PCI Device Configuration screen. Instructions for viewing and changing the PCI device settings are in your *User's Handbook*.

Configuration Files

The Set Configuration program on the Reference Diskette uses configuration files to assign interrupt levels, I/O addresses, memory addresses, arbitration levels, and other server resources.

All the files needed to configure the standard features of the server are preinstalled in the System Partition or are on the Reference Diskette.

When you install an optional device, such as a network adapter, you might need to copy configuration files from the Option Diskette that comes with the device to the System Partition or to the Reference Diskette.

The Set Configuration program uses two types of files to configure the server: adapter description files and adapter description programs. Some devices require only an adapter description file, but more complex devices sometimes require an adapter description program. Configuration files for optional devices usually are provided on an Option Diskette supplied with the device.

The following table shows the types of files used to configure the server. You can identify each file by the first digit in the file name and by its file-name extension. The *xxxx* in the file name represents the ID for the device.

File Name	Description
@xxxx.ADF	Adapter description file
Cxxxx.ADF	Adapter description program
Dxxxx.ADF	Adapter description file (system board)
Pxxxx.ADF	Adapter description file (built-in features)
Sxxxx.ADF	Adapter description program (system board)

Table 4. Identifying Configuration Files

Adapter Description Files

The Set Configuration program uses the information in an adapter description file to identify the device and to allocate server resources.

Adapter description files include:

- The device ID and several choices for interrupt levels
- I/O, RAM, and ROM addresses
- Arbitration levels
- Other server resources that the device can use

Usually, these files also contain the informational text messages and interactive prompts that you use when you configure the server.

During the configuration process, the Set Configuration program locates and reads the adapter description file for each device. If the program cannot find the adapter description file, the server prompts you to insert the Option Diskette for the device. If you insert the diskette, and the Set Configuration program still cannot find the adapter description file, the program disables the device.

The adapter description file for a device specifies the type of memory (system or nonsystem) that the device requires. System memory is controlled by the primary operating system, and only masters, such as bus masters, can use it (see “Bus Master Implementation” on page 36 for more information). Nonsystem memory is not controlled by the operating system. When nonsystem memory is physically located on an adapter, it is known as memory-mapped I/O.

Adapter Description Programs

Some devices have a memory-address space that is not accessible before the operating system starts. These devices need an adapter description program to configure them during the configuration process.

A device that needs an adapter description program has an entry in its adapter description file that tells the Set Configuration program to run the adapter description program. During configuration, the Set Configuration program reads the adapter description file for each device. When it finds an entry for an adapter description program, it locates and runs it.

If the Set Configuration program cannot find the adapter description program, the server prompts you to insert the Option Diskette for the device. If you insert the diskette, and the Set Configuration program still cannot find the appropriate adapter description program, the program disables the device.

Option Configuration Files

The configuration files for an optional device normally are provided on an Option Diskette that comes with the device. This diskette contains files that the system uses to assign settings that define how the device will operate.

Whenever you install a device that comes with an Option Diskette, be sure to read the instructions that come with the device. You might need to copy configuration files from the Option Diskette to the System Partition or to the backup copy of the Reference Diskette. Use the instructions provided with the device to install the configuration files. If no instructions are provided, use the Copy an Option Diskette program to install the configuration files.

Before copying the configuration files, the Copy an Option Diskette program checks the Option Diskette for valid configuration files. If the program does not find valid configuration files, a message appears. If the program finds valid configuration files, it checks the System Partition or the Reference Diskette for duplicate file names. If it finds duplicate file names, it checks the dates of the files; then it copies only the files from the Option Diskette that have later dates than the existing files. When option-configuration files are copied to the System Partition or the Reference Diskette, they become an integrated part of the system programs.

Some devices require custom software, known as *device drivers*, to function properly. Device drivers are programs that the operating system loads after the hardware is configured. Some Option Diskettes contain device drivers and an automatic device-driver installation utility program. Keep the original Option Diskette in a safe place in case you need to rebuild the system programs or reinstall a device driver.

If your server has a System Partition, make a backup copy of the System Partition after you install the configuration files. In the event of a hard-disk failure, you can recover the configuration information.

Configuration Conflicts

The configuration programs usually assign server resources so that conflicts are avoided. But when a hardware device or a software program requires a resource that already has been assigned to another device or program, a conflict might occur.

Hardware Conflicts

The basic design of your server avoids conflicts among interrupt levels, arbitration levels, and DMA assignments. Conflicts among these resources are rare and usually occur when you install multiple adapters that require the same resources.

Most adapters are very flexible, and their adapter description files list many choices of interrupt levels, addresses, arbitration levels, and DMA channels that they can use. However, some adapters may have adapter description files that list only one choice. These adapters are most likely to cause hardware configuration conflicts.

You can find hardware conflicts by using the Change Configuration or View Configuration program. If a hardware conflict exists, an asterisk (*) appears next to the conflicting item on the Change Configuration or View Configuration screen. If the conflict is with a server resource that cannot be shared, the asterisk appears to the left of the slot number that contains the conflicting device. If other choices are available for the conflicting device, the asterisk appears to the right of the slot number.

The configuration programs assign server resources, starting with the adapter in the lowest-numbered expansion slot. If you have a hardware conflict that you cannot resolve using the Change Configuration program, you can install the more flexible adapters in higher-numbered slots, and the less flexible adapters (those whose adapter description files list few choices or fixed resources) in the lower-numbered slots. If you need to determine how flexible an adapter is, use a text editor to view its adapter description file.

Hardware and Software Conflicts

Some operating systems and application programs have special requirements for memory-address space that are not detected by the hardware configuration programs. Occasionally, these requirements are for memory-address space that already is assigned to a device.

When a memory-address conflict exists, one or more of the following might occur:

- The server cannot load the operating system.
- The server does not function.
- An application program does not operate or returns an error.
- Screen messages indicate a conflict exists.

You can resolve this type of conflict by changing either the software configuration or the hardware configuration.

The best way to resolve a memory-address conflict is to change the software configuration. This allows you to continue using the Automatic Configuration program to configure the server hardware.

Some programs do not allow you to modify the software configuration. In this case, change the hardware configuration so that it conforms with the requirements of the software program.

To change the hardware configuration, use the Display Memory Map program on the Reference Diskette to view the addresses that are available; then use the Change Configuration program to assign a new memory address to the conflicting adapter. This is a less desirable way to resolve a memory-address conflict, because by using the Change Configuration program, you have created a custom configuration and can no longer use the Automatic Configuration program. Automatic Configuration will set the configuration assignments back to the default values. If you use the Change Configuration program to resolve a conflict, the conflict will recur if you run the Automatic Configuration program.

Chapter 9. Input/Output Ports and Connectors

The input/output (I/O) connectors are for attaching external devices, such as printers, keyboards, and displays, to your server. The I/O connectors include:

- Two serial-port connectors
- One parallel-port connector
- One video-port connector
- One keyboard-port connector
- One auxiliary-device-port connector
- SCSI-port connectors (vary by model)

Serial Ports

Your server comes with two serial ports. These ports are used to communicate with printers, plotters, external modems, scanners, and auxiliary terminals. These ports also enable you to transfer data between computers.

Serial ports transfer data one bit at a time, using direct memory access (DMA). DMA is a method of transferring data between I/O devices and system memory without intervention by the system microprocessor. (See “Direct Memory Access” on page 27 for more information.)

Serial ports can transfer data *asynchronously*, which means that they can transmit any number of characters at any time, with no restriction on the duration of the pauses between characters.

The serial ports can transmit and receive data and commands at rates of from 300 bits per second up to 345 600 bits per second. (To use a serial port at 345 600 bits per second, you need a special shielded cable. For information about this cable, contact your IBM authorized reseller or marketing representative.)

Each serial port has a 9-pin, male D-shell connector on the back of the server. The pin-number assignments of this connector conform to the RS-232C industry standard. The following table shows the pin-number assignments for the serial-port connectors.

Pin	Signal	Pin	Signal
1	Data carrier detect	6	Data set ready
2	Receive data	7	Request to send
3	Transmit data	8	Clear to send
4	Data terminal ready	9	Ring indicator
5	Signal ground		

Table 5. Serial Port Pin-Number Assignments

When you turn on your server, the POST routine assigns the serial ports to specific communication port addresses. You can install adapters to increase the number of serial ports in your server. Your server can support a maximum of 16 serial ports.

Some application programs use only certain ports, and some modems are designed for use only at certain communication port addresses. You might need to change communication port address assignments to resolve conflicts by using the Change Configuration program.

Parallel Port

The parallel port usually is used to communicate with printers, and transfers data one byte at a time using DMA. The parallel port has a 25-pin, female D-shell connector on the back of your server.

The following table shows the pin-number assignments for the parallel-port connector.

Pin	Signal	Pin	Signal
1	STROBE	14	-AUTO FD XT
2	Data 0	15	-ERROR
3	Data 1	16	-INIT
4	Data 2	17	-SLCT IN
5	Data 3	18	Ground
6	Data 4	19	Ground
7	Data 5	20	Ground
8	Data 6	21	Ground
9	Data 7	22	Ground
10	-ACK	23	Ground
11	BUSY	24	Ground
12	PE	25	Ground
13	SLCT		

Table 6. Parallel Port Pin-Number Assignments

When you turn on your server, the POST routine assigns the parallel port a specific port address. The IBM PC Server 720 can support a maximum of four parallel ports. You can add additional parallel ports by installing special adapters. You can change the parallel-port assignments by using the Change Configuration program.

Video Port

The system board in your server has one SVGA video port. This port is used to attach a video display. The video port has a 15-pin analog connector on the back of the server.

The following table shows the pin-number assignments for the video connector.

Pin	Signal
1	Red
2	Green or monochrome
3	Blue
4	Monitor ID 2 (not connected)
5	Ground
6	Red ground
7	Green ground or monochrome ground
8	Blue ground
9	Reserved
10	Ground
11	Monitor ID 0 (not connected)
12	Monitor ID 1 (not connected)
13	Horizontal synchronization (Hsync)
14	Vertical synchronization (Vsync)
15	Monitor ID 3 (not connected)

Table 7. Video Port Pin-Number Assignments

Keyboard and Auxiliary-Device Ports

The IBM PC Server 720 system board has one keyboard port and one auxiliary-device port that supports a mouse or other pointing device.

The following table shows the pin-number assignments for the connectors used by the keyboard and auxiliary-device ports.

Pin	Signal
1	Data
2	Not connected
3	Ground
4	+5 V dc
5	Clock
6	Not connected

Table 8. Keyboard and Auxiliary-Device Port Pin-Number Assignments

SCSI-2 Port

The IBM PC Server 720 comes with a SCSI-2 adapter preinstalled. The SCSI-2 adapters support both internal and external small computer system interface (SCSI) devices.

The IBM SCSI-2 Fast/Wide Streaming-RAID Adapter/A, which ships in the disk-array models, has one dedicated internal 68-pin connector for attaching SCSI devices. A second internal 68-pin connector is common with the external 68-pin connector. When the external connector is used, the second internal connector cannot be used.

The IBM PC Server SCSI-2 Fast/Wide PCI Adapter, which ships in the non-disk-array models, has one internal 68-pin connector, one internal 50-pin connector, and one external 68-pin connector. When the external connector is used, the second internal connector cannot be used.

You can attach a total of 15 SCSI devices to these connectors. These SCSI connectors allow you to expand the capabilities of your server by attaching different types of SCSI devices, such as drives or printers.

The following table shows the pin-number assignments for the internal and external 68-pin SCSI connectors.

Pin	Signal	Pin	Signal
1	Ground	35	Data 12
2	Ground	36	Data 13
3	Ground	37	Data 14
4	Ground	38	Data 15
5	Ground	39	Data P1
6	Ground	40	Data 0
7	Ground	41	Data 1
8	Ground	42	Data 2
9	Ground	43	Data 3
10	Ground	44	Data 4
11	Ground	45	Data 5
12	Ground	46	Data 6
13	Ground	47	Data 7
14	Ground	48	Data P0
15	Ground	49	Ground
16	Ground	50	Ground
17	+Term power	51	+Term power
18	+Term power	52	+Term power
19	Reserved	53	Reserved
20	Ground	54	Ground
21	Ground	55	-Attention
22	Ground	56	Ground
23	Ground	57	-Busy
24	Ground	58	-Acknowledge
25	Ground	59	-Reset
26	Ground	60	-Message
27	Ground	61	-Select
28	Ground	62	-Control/Data
29	Ground	63	-Request
30	Ground	64	-Input/Output
31	Ground	65	Data 8
32	Ground	66	Data 9
33	Ground	67	Data 10
34	Ground	68	Data 11

Table 9. 68-Pin SCSI Port Pin-Number Assignments

The following table shows the pin-number assignments for the internal 50-pin SCSI connector on the IBM PC Server SCSI-2 Fast/Wide PCI Adapter.

Pin	Signal	Pin	Signal
1	Ground	2	Data 0
3	Ground	4	Data 1
5	Ground	6	Data 2
7	Ground	8	Data 3
9	Ground	10	Data 4
11	Ground	12	Data 5
13	Ground	14	Data 6
15	Ground	16	Data 7
17	Ground	18	Data P
19	Ground	20	Ground
21	Ground	22	Ground
23	Reserved	24	Reserved
25	Not connected	26	Terminator power
27	Reserved	28	Reserved
29	Ground	30	Ground
31	Ground	32	-Attention
33	Ground	34	Ground
35	Ground	36	-Busy
37	Ground	38	-Acknowledge
39	Ground	40	-Reset
41	Ground	42	-Message
43	Ground	44	-Select
45	Ground	46	-Control/data
47	Ground	48	-Request
49	Ground	50	-Input/output

Table 10. 50-Pin SCSI Port Pin-Number Assignments

Chapter 10. Video Subsystem

The IBM PC Server 720 is equipped with a super video graphics array (SVGA) controller that uses a 15-pin, analog video connector. (For information about the video connector, see “Video Port” on page 82.)

This video controller supports high resolution graphics and fast refresh rates that exceed the specifications of the ISO 9241 Part 3, Visual Display Requirements. It also provides reduced-flicker operation when used with noninterlaced displays that meet ISO standards. For more information, see “How Displays Operate” on page 88.

The SVGA controller includes a video display buffer with 512KB of video dynamic random access memory (VDRAM). The amount of VDRAM in your server determines the resolution and the number of colors supported. Additional features of the SVGA controller include:

- Integrated VGA emulation
- Support for the 132-column text mode
- Screen resolution of 1024 x 768 pels with up to 256 colors (noninterlaced memory), 640 x 480 pels with up to 16.8 million colors (noninterlaced memory), or 1280 x 1024 pels with up to 256 colors (interlaced memory)

Operating system drivers are required for 1280 x 1024 pels with up to 256 colors. Refer to the documentation that comes with your operating system for more information.

How Displays Operate

The most common distinguishing characteristics of displays are resolution, dot pitch, vertical-refresh rate, screen size, and color.

Resolution and Dot Pitch

If you look closely at the screen, you can see that the entire image is made up of many tiny dots, called *pels*. Resolution is measured by the number of pels needed to fill the screen (horizontal-by-vertical).

Dot pitch is more difficult to visualize. The inside of the display screen is coated with light-emitting materials called *phosphors*. Color displays use three phosphors: red, green, and blue. The phosphor coating is made up of dots arranged in a red-green-blue pattern. The distance from the center of one phosphor dot to the center of the next phosphor dot of the same color is called the *dot pitch*. Dot pitch is measured in millimeters, such as 0.28, 0.31, and 0.41.

In general, the display with the highest resolution and finest dot pitch produces the sharpest image. A display with a fine dot pitch, such as 0.28, produces sharper, better defined characters than a similar display that uses a coarser dot pitch, such as 0.41.

These characteristics can be very important. A system used extensively for detailed graphics might need a display that shows more colors, at a higher resolution and finer dot pitch, than one used exclusively for word processing. For some applications, a black-and-white (monochrome) display might do as well as a color display.

Vertical-Refresh Rate

The phosphors on the inside of the display screen hold their brightness and color for a very short time. Therefore, the image has to be redrawn many times each second to refresh the phosphors. The vertical-refresh rate is the speed at which the image on the screen is redrawn.

The image is redrawn from top to bottom. By the time the bottom rows are drawn, the top rows are starting to fade. The two ways of redrawing the image are *interlaced* and *noninterlaced*. The interlaced

method draws every other row from top to bottom, then starts at the top to fill in the rows that were skipped on the first pass. The noninterlaced method draws the complete image on each pass.

The vertical-refresh rate affects the stability of the image on the screen. Displays that have a fast, noninterlaced refresh rate provide a very stable image with little or no flicker detectable. Displays with slower refresh rates tend to have more flicker, which is particularly noticeable with white and other light-colored backgrounds. You can minimize the flicker by changing the colors you work with. Many programs allow you to select colors.

Sensitivity to flicker varies from person to person, with young people being the most sensitive. Noninterlaced flicker occurs when the screen is redrawn at a rate that is slow enough to be detected by the human eye. Interlaced flicker occurs when the pattern of pels in adjoining lines is very different, or when an object on the screen is made up of alternating bright and dim lines.

Some application programs cannot reproduce all colors, and use a technique called *dithering* to combine two colors. For example, light red might be produced by alternating lines of white and red. As the image is continually refreshed using the interlaced method, the red lines are drawn on one pass and the white lines on the next pass. As a result, the light-red object might appear to flicker while the rest of the image on the screen remains stable.

Selecting a Display

Displays come in many sizes and types. The video controller in your server supports a wide range of monochrome and color displays with various capabilities.

To take full advantage of the video capabilities provided by your server, use a display with a fast noninterlaced refresh rate. IBM provides many displays that you can use with your system. The following is a partial list of displays and their characteristics.

Type	Dot Pitch	Resolution (pels)	Maximum Vertical Refresh Rate
6324	0.28	1024 x 768	72 Hz noninterlaced
		800 x 600	72 Hz noninterlaced
		640 x 480	72 Hz noninterlaced
6325	0.28	1024 x 768	72 Hz noninterlaced
		800 x 600	72 Hz interlaced
		640 x 480	72 Hz noninterlaced
9524	0.28	1024 x 768	72 Hz noninterlaced
		800 x 600	72 Hz noninterlaced
		640 x 480	72 Hz noninterlaced
9525	0.28	1024 x 768	72 Hz noninterlaced
		800 x 600	72 Hz noninterlaced
		640 x 480	72 Hz noninterlaced

Table 11. Display Types and Characteristics

For more details, refer to the information supplied with your display. See your IBM authorized reseller or marketing representative for the latest list of displays.

Using Your Display

The following information will help you use your display comfortably and correctly.

Brightness and Contrast Controls

Use the brightness and contrast controls to adjust the image on the screen for maximum viewing comfort. On a new display, set the controls near their center position. Setting these controls to their maximum position can decrease the useful life of the display.

As the display gets older, the image tends to become dimmer. Adjust the brightness and contrast controls to compensate for this condition.

Screen-Saver Programs

Leaving the display turned on for prolonged periods without changing what appears on the screen can have an adverse affect on the display. The image might burn into the phosphor coating, leaving a permanent image, or cause darkening of some areas of the screen.

You can avoid this problem by using a screen-saver program. This turns off the video signal when the keyboard has not been used for a defined period. When you are ready to work with the system again, pressing a predefined key restores the image to the screen. Several companies produce screen-saver programs. Contact your IBM authorized reseller for details.

Avoiding Fatigue

Performing any visually demanding task for a prolonged period of time (for example, knitting, reading, or viewing a display screen), can cause eye fatigue. The American Academy of Ophthalmology considers displays safe for normal use and has declared they present no hazard to vision and do no damage to the eye. To minimize eye fatigue, reduce any annoying glare and make sure your vision is properly corrected. If eye discomfort persists, consult your eye-care professional or physician.

Similarly, sore muscles or joints can result from any job or activity during which you stay in a fixed position or repeat the same movement over a long period. This is not unique to viewing a display screen. Eye fatigue and sore muscles and joints can be reduced by modifying work practices. Take breaks, rotate tasks, and adjust the display, lighting, and chair height.

Additional information is available by ordering the following publications through your nearest IBM branch office.

- *Comfort and You* (G360-2050)
- *The VDT Workstation and Vision* (SV04-0309)
- *Working with Displays* (G325-0620)

Chapter 11. Security Features

Security features deter unauthorized use of your server and data. If you use your server in a public environment, such as an office, you might want to protect it and the data stored on it by using one or more security features.

Begin by evaluating your security needs. Where will the system be located? Does it need to be secured to permanent furniture or fixtures? Should use of the system be limited? When you have identified your security needs, you can activate or implement the appropriate security features.

LogicLock

LogicLock features, the advanced security features that come with your server, include tamper-evident switches. This active security system uses microswitches on the covers to indicate if someone has tried to open the front cover. Keylocks and a system of passwords help prevent unauthorized access.

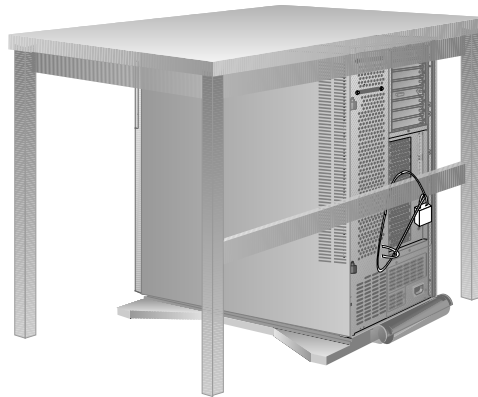
Other LogicLock features are operating-system dependent. To use them, you must install an operating system that supports them. To find out if your operating system supports a particular security feature, see the documentation that comes with your operating system.

Securing Hardware

One method of deterring theft is to fasten the server to a stationary object, such as a table, a desk, or a wall. Another approach is to locate critical resources, such as servers, in a limited-access area behind locked doors. Your server has a U-bolt facility, which allows you to secure the system to a stationary object with a cable or chain. The PC Server 720 also has a keyed lock on the door that covers the drives.

U-Bolt Facility

If your server is in an area accessible to the public, you might need a method of securing it to a stationary object. Two holes at the rear of the server accommodate a U-bolt. After the U-bolt is installed, you can use a cable or chain to lock the server in place. (This capability is referred to as a *cabl*e-down or a *bol*t-down feature.) Step-by-step instructions for installing the U-bolt are in the “Installing Options” section of your *User's Handbook*.



Door Lock and Keys

A door lock mechanically deters access to the drives. It controls access to the small door that covers the removable media drives as well as the entire front cover. If the covers are forced open without unlocking the lock, a microswitch detects the intrusion. The next

time you start the system, the power-on self-test displays a message informing you that the covers have been tampered with.

Two keys are provided with your server. Always store these in a safe place. Anyone who has the key serial number and manufacturer's address can order duplicate keys, so also store the tag in a safe place.

Cable-Cover Option

At the rear of your server are several connectors that can be used to send and receive data. Anyone with the correct equipment and knowledge can use these connectors to gain access to the data stored on your hard disks and other storage devices. Your server accommodates an optional cable cover that helps guard against someone using the connectors in this way.

The cable-cover option prevents the cables from being removed from the rear of the server, and prohibits other computers or devices from being attached to the unused connectors.

Note: The cable cover does not protect against unauthorized access through devices attached outside of the system, such as expansion enclosures.

The cable-cover option is available from your IBM authorized reseller or marketing representative.

Unauthorized-Access Monitor

The unauthorized-access monitor works with the administrator (or privileged-access) password when you are using DOS. If you set an administrator password and the unauthorized-access monitor feature is enabled, your server will alert you if an attempt has been made to tamper with the locked covers. If it detects any tampering, the system will stop all operations or display an error message. If the system stops, any data in memory waiting to be stored might be lost. (The response to tampering varies with the operating system you are using.)

When you set an administrator password, the unauthorized-access monitor is automatically enabled. If you do not want the system to

stop operations if the covers are tampered with, disable the unauthorized-access monitor using the Change Configuration program.

Securing Data

It is very difficult to secure shared information from theft, but an effective method is to limit user access. Only users who need the software or data should be able to access it. This level of access control is provided as a standard feature of most network programs. Another common feature of network programs to help secure data from theft is password protection. Passwords are easy to use and very effective. They help prevent unauthorized users from accessing sensitive files.

Some advanced network management programs can actually audit usage based on names, adapter addresses, date, time, and unsuccessful attempts to access a file. This information can help you identify users who are attempting to access restricted data.

To secure extremely sensitive data, you can use a commercially available data-encryption tool. These tools encode the data files so that they are unintelligible, and thus useless if stolen. You can encrypt data by using a program or using an encryption device. The software programs are usually less expensive than the hardware devices, but they are slower.

Power-On Password

The power-on password locks the keyboard and mouse (if attached to the mouse port) to help prevent unauthorized use of your server. If you are using a mouse that is connected to the serial port, the mouse remains active.

You do not need to use a power-on password to use your server, but a password helps protect the data you store on your server. Keep a record of your password in a secure place.

Unattended-Start Mode

After you set a power-on password, you can enable the unattended-start mode. This locks the keyboard and mouse, but allows the system to start the operating system and carry out the instructions in the CONFIG.SYS and AUTOEXEC.BAT files. The keyboard and mouse remain locked until you enter the correct password.

This mode is ideal for systems that operate unattended. If a power failure occurs, the system automatically restarts when power returns, and resumes normal operation without operator intervention.

When using an IBM mouse in the unattended-start mode, the keyboard and mouse ports are disabled (locked). (A serial mouse is not affected.) Because of this, the system cannot detect that a mouse is attached, and an error occurs. Refer to your *User's Handbook* for instructions.

Administrator Password

Warning: If an administrator password is set, then forgotten, it cannot be overridden or removed.

Using this security feature requires some planning and ongoing administration. It allows you to control who has access to the system programs. If an administrator password is set, you must enter it to use the system programs. Your server comes with the administrator password feature set to *disabled*.

After an administrator password is set, only those who know the password can perform tasks such as:

- Altering computer settings or features controlled by the system programs.
- Running diagnostic tests.
- Resetting the system after a forced entry. If the server is forced open, a POST error occurs. To clear the error, you must enter the administrator password.

Use the administrator password when highly classified information must be protected. Although it can be used with your power-on password, it provides a much higher level of security when used with an operating system that controls access through the use of passwords. This type of operating system is called a *secured* or *trusted computing base*.

To set an administrator password, first set your selectable drive-startup sequence. You can select the default drive-startup sequence, which currently includes the CD-ROM and diskette drives. To have a totally secure system, you can remove the CD-ROM and diskette drives from the drive-startup sequence.

Keyboard Password

A keyboard password allows you to lock the keyboard while the system is turned on. This is useful if you leave your system on and unattended. With the keyboard locked, no one can use your system.

The way you set the keyboard password depends on the operating system you are using. The OS/2 operating system provides keyboard-password protection as a standard feature.

If you forget your keyboard password, turn off the server for at least 5 seconds; then turn it on. The keyboard password is erased from memory when you turn off the server.

Selectable Drive-Startup

Warning: If you change your startup sequence, be extremely careful when doing *write* operations (such as copying, saving, or formatting). You can accidentally overwrite data or programs if you select the wrong drive.

Selectable drive-startup allows you to control the startup sequence of the drives in your server. Each time you turn on the server, it checks the drives as it looks for the operating system. The order in which the system checks the drives is the *drive-startup sequence*.

In most cases, you do not need to change the default drive-startup sequence. However, if you set an administrator password, or are

working with multiple hard disk drives, multiple operating systems, or different sizes of diskette drives, you might want to change the default drive-startup sequence.

The default drive-startup sequence checks the primary diskette drive for a self-starting diskette. If one is present, the operating system or program is loaded from the diskette. If not, the system checks the primary hard disk for an operating system. If one is present, it is loaded from that hard disk.

If you start the system from a diskette, the drive containing the diskette becomes drive A, regardless of the defined sequence, and the first hard disk selected in the startup sequence becomes drive C. You can choose a startup sequence of up to four drives.

You can *customize* the startup sequence by changing the order in which the system checks the drives. You decide which four drives are the first to be checked, *and* the order in which the system checks them.

Removable Media

If you are using your server in an environment where a diskette is left in the drive while the server is unattended, an electronic-eject diskette drive can provide the security you need to protect the diskette from theft or damage. This separately purchasable diskette drive allows you to lock a diskette in the drive or prohibit someone from inserting a diskette in the drive while the drive is not in use. Not all operating systems support this feature. Contact your IBM authorized reseller or marketing representative for details.

Protecting Data from Loss

You can use several methods to prevent the loss of data. Consider these methods carefully, because some of them affect the performance, reliability, and hardware requirements of the server.

The three primary ways to protect your data from loss are:

- Wait until the data accumulates on the server, and then make backup copies of all the hard disks.

- Configure a RAID level 1 disk array (disk mirroring) to duplicate the data as it is entered.
- Configure a RAID level 5 disk array and store the parity information about the data on the array as the data is being entered.

Backup Copies

A good method for preventing the loss of data is to make copies of the data. That way, in the event of a hardware failure, you can always recover the information.

Backing up the entire contents of a hard disk to diskettes can be very time-consuming and, in the case of a network server that has multiple hard disks, might require hundreds of diskettes. A faster and more efficient way to back up the data is to use a tape-backup drive. Using a tape-backup drive, you can copy several billion bytes of data from the hard disks to a single tape.

There are two problems with making backup copies. First, someone has to remember to do it. And second, you usually need to disconnect the server from the network to make the backup copies.

Redundant Copies

A convenient way to copy the contents of a hard disk is to duplicate all data as it is being entered (such as with a RAID level-1 disk array). This duplicate copy is then stored on another hard disk. If one hard disk fails, you still have access to the data on the other. This method is more expensive than backing up to diskettes or tapes, because it doubles the amount of disk space needed. (See “RAID Level 1” on page 63 for more information.)

Parity Information

Storing parity information about the data as the data is being entered (such as with a RAID level-5 disk array) is an efficient, cost effective, and reliable method commonly used to guard against the loss of data. In the event of a hard disk failure, the parity information and the data on the remaining functional disks are used

to reconstruct the data that was stored on the failed drive. (See “RAID Level 5” on page 64 for more information.)

Viruses

Computer viruses are a problem that exists within the personal computer community. A virus is a program (or instruction hidden within a program) that *infects* other programs by modifying them without your knowledge. Like any other program, the virus can do anything it is programmed to do. Some viruses are practical jokes, causing unusual or erratic screen behavior. Others are destructive, erasing or damaging files or overloading memory and communication networks.

Viruses are difficult to detect. Many stay inactive until triggered by a specified event such as a date or command. Others are activated when an infected program is started a specified number of times. When the symptoms of the virus appear, it might be difficult to determine if the problem is a hardware failure, a problem in the software, or a virus.

Several programs are available to detect viruses. They typically examine files and look for patterns associated with these viruses, or look for unexplained changes in the size of files. These programs are best used as a preventive measure to detect a virus before it becomes widespread or causes damage. Many computer users check for viruses on a regular basis.

When a virus is found, it must be removed. This might be as simple as replacing a file, or it might require the assistance of a trained technician.

Viruses are generally spread unknowingly from computer to computer when programs are exchanged or shared. If you don't know where a program came from, be careful. Most reputable program distributors and bulletin-board owners scan their files to guard against viruses and maintain records to identify program owners.

These tips will help you guard against computer viruses:

- Write-protect original program diskettes before using them. This ensures the diskettes will not be infected if a virus is already present in your system.
- Avoid using programs and diskettes from unknown sources.
- If you use programs provided from public-domain software distributors or bulletin-board services, find out what precautions they take to guard against viruses.
- Back up all critical data and programs regularly.
- Watch out for unexpected changes in file size.
- Use password protection to limit access to your system or network.

Erased Files

Erasing a file from a diskette or hard disk does not destroy the file. With the right software, all or part of an erased file can be reclaimed. This can be a security risk if you sell or give someone a system that once contained classified or confidential information.

To help ensure that no readable information is left on a hard disk, you can do a low-level format. An operating-system format operation does not remove all information from a hard disk.

The operating-system format operation works a little differently with diskettes. It writes a repeated pattern over the entire surface. Any information that was on the diskette becomes unreadable.

Depending on the type of information stored, your company might require additional safeguards.

Backup Power Supply

To prevent the loss of data caused by a power fluctuation, you can install a backup power supply. The two basic types of commercially available backup power supplies are *uninterruptible* and *standby*.

Uninterruptible Power Supply

This type of power supply works as an interface between the main power source and the server. It automatically takes over when the main power source is lost.

An uninterruptible power supply connects directly to the main power source (electrical outlet). The server then connects to the power supply. The power supply transfers the power from the main power source to its internal battery, which then provides the power to the server.

Uninterruptible power supplies require no switching time (because they are always on), and they protect the server from power surges. However, they usually cost more than standby power supplies.

A 9-pin, serial-port cable is shipped with your server. You can use this cable to attach an American Power Conversion (APC) uninterruptible power supply (UPS) to your server.

Standby Power Supply

This type of power supply waits until it detects a drop in voltage, then switches on and provides power to the server until its battery power is depleted. A standby power supply is usually less expensive than an uninterruptible power supply. A disadvantage of a standby power supply is the amount of time that it needs to switch itself on; the more time it takes, the greater the chance of losing data.

Appendix A. Product Warranties and Notices

Warranties

International Business Machines Corporation

Armonk, New York, 10504

Statement of Limited Warranty

The warranties provided by IBM in this Statement of Limited Warranty apply only to Machines you originally purchase for your use, and not for resale, from IBM or an IBM authorized reseller. The term "Machine" means an IBM machine, its features, conversions, upgrades, elements, or accessories, or any combination of them. Machines are subject to these terms only if purchased in the United States or Puerto Rico, or Canada, and located in the country of purchase. If you have any questions, contact IBM or your reseller.

Machine: IBM PC Server 720

Warranty Period*: Three Years

**Elements and accessories are warranted for three months. Contact your place of purchase for warranty service information.*

Production Status

Each Machine is manufactured from new parts, or new and serviceable used parts (which perform like new parts). In some cases, the Machine may not be new and may have been previously installed. Regardless of the Machine's production status, IBM's warranty terms apply.

The IBM Warranty

IBM warrants that each Machine 1) is free from defects in materials and workmanship and 2) conforms to IBM's Official Published Specifications. IBM calculates the expiration of the warranty period from the Machine's Date of Installation. The date on your receipt is the Date of Installation, unless IBM or your reseller informs you otherwise.

During the warranty period, IBM or your reseller will provide warranty service under the type of service designated for the Machine and will manage and install engineering changes that apply to the Machine. IBM or your reseller will specify the type of service.

For a feature, conversion, or upgrade, IBM or your reseller may require that the Machine on which it is installed be 1) the designated, serial-numbered Machine and 2) at an engineering-change level compatible with the feature, conversion, or upgrade. Some of these transactions (called "Net-Priced" transactions) may include additional parts and associated replacement parts that are provided on an exchange basis. All removed parts become the property of IBM and must be returned to IBM.

Replacement parts assume the remaining warranty of the parts they replace.

If a Machine does not function as warranted during the warranty period, IBM or your reseller will repair or replace it (with a Machine that is at least functionally

equivalent) without charge. If IBM or your reseller is unable to do so, you may return it to your place of purchase and your money will be refunded.

If you transfer a Machine to another user, warranty service is available to that user for the remainder of the warranty period. You should give your proof of purchase and this Statement to that user.

Warranty Service

To obtain warranty service for the Machine, you should contact your reseller or call IBM. In the United States, call IBM at **1-800-772-2227**. In Canada, call IBM at **1-800-565-3344**. You may be required to present proof of purchase.

Depending on the Machine, the service may be 1) a "Repair" service at your location (called "On-site") or at one of IBM's or a reseller's service locations (called "Carry-in") or 2) an "Exchange" service, either On-site or Carry-in.

When a type of service involves the exchange of a Machine or part, the item IBM or your reseller replaces becomes its property and the replacement becomes yours. The replacement may not be new, but will be in good working order and at least functionally equivalent to the item replaced.

It is your responsibility to:

1. obtain authorization from the owner (for example, your lessor) to have IBM or your reseller service a Machine that you do not own;
2. where applicable, before service is provided —
 - a. follow the problem determination, problem analysis, and service request procedures that IBM or your reseller provide,
 - b. secure all programs, data, and funds contained in a Machine,
 - c. inform IBM or your reseller of changes in a Machine's location, and
 - d. for a Machine with exchange service, remove all features, parts, options, alterations, and attachments not under warranty service. Also, the Machine must be free of any legal obligations or restrictions that prevent its exchange; and
3. be responsible for loss of, or damage to, a Machine in transit when you are responsible for the transportation charges.

Extent of Warranty

IBM does not warrant uninterrupted or error-free operation of a Machine.

Unless IBM specifies otherwise, IBM provides non-IBM machines on an "AS IS" basis. However, non-IBM manufacturers may provide their own warranties to you.

Misuse, accident, modification, unsuitable physical or operating environment, improper maintenance by you, removal of product or parts identification labels, or failure caused by a product for which IBM is not responsible may void the warranties.

THESE WARRANTIES REPLACE ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A

PARTICULAR PURPOSE. HOWEVER, SOME LAWS DO NOT ALLOW THE EXCLUSION OF IMPLIED WARRANTIES. IF THESE LAWS APPLY, THEN ALL EXPRESS AND IMPLIED WARRANTIES ARE LIMITED IN DURATION TO THE WARRANTY PERIOD. NO WARRANTIES APPLY AFTER THAT PERIOD.

In Canada, warranties include both warranties and conditions.

Some jurisdictions do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.

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Circumstances may arise where, because of a default on IBM's part (including fundamental breach) or other liability (including negligence and misrepresentation), you are entitled to recover damages from IBM. In each such instance, regardless of the basis on which you are entitled to claim damages, IBM is liable only for:

1. bodily injury (including death), and damage to real property and tangible personal property; and
2. the amount of any other actual loss or damage, up to the greater of \$100,000 or the charge for the Machine that is the subject of the claim.

Under no circumstances is IBM liable for any of the following:

1. third-party claims against you for losses or damages (other than those under the first item listed above);
2. loss of, or damage to, your records or data; or
3. economic consequential damages (including lost profits or savings) or incidental damages, even if IBM is informed of their possibility.

Some jurisdictions do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights and you may also have other rights which vary from jurisdiction to jurisdiction.

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References in this publication to IBM products, programs, or services do not imply that IBM intends to make these available in all countries in which IBM operates. Any reference to an IBM product, program or service is not intended to state or imply that only IBM's product, program, or service may be used. Any functionally equivalent product, program, or service that does not infringe any of IBM's intellectual property rights or other legally protectable rights may be used instead of the IBM product, program, or service. Evaluation and verification of operation in conjunction with other products, programs, or services, except those expressly designated by IBM, are the user's responsibility.

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IBM	Micro Channel
OS/2	Operating System/2
PS/2	Personal System/2
NetFinity	ServerGuide

The following terms are trademarks of other companies:

APC	American Power Conversion
Intel	Intel Corporation
Kodak	Eastman Kodak Company
Microsoft	Microsoft Corporation
NT	Microsoft Corporation
Pentium	Intel Corporation
SCO	The Santa Cruz Operation, Inc.

C-bus is a trademark of Corollary, Inc.

UNIX is a registered trademark in the United States and other countries licensed exclusively through X/Open Company Limited.

Windows is a trademark of Microsoft Corporation.

Other company, product, and service names, which may be denoted by a double asterisk (**), may be trademarks or service marks of others.

Electronic Emission Notices

Industry Canada Class A Emission Compliance Statement

This Class A digital apparatus meets the requirements of the Canadian Interference-Causing Equipment Regulations.

Avis de conformité à la réglementation d'Industrie Canada

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Federal Communications Commission (FCC) Statement

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

Properly shielded and grounded cables and connectors must be used in order to meet FCC emission limits. IBM is not responsible for any radio or television interference caused by using other than recommended cables and connectors or by unauthorized changes or modifications to this equipment. Unauthorized changes or modifications could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Power Cords

For your safety, IBM provides a power cord with a grounded attachment plug to use with this IBM product. To avoid electrical shock, always use the power cord and plug with a properly grounded outlet.

IBM power cords used in the United States and Canada are listed by Underwriter's Laboratories (UL) and certified by the Canadian Standards Association (CSA).

For units intended to be operated at 115 volts: Use a UL-listed and CSA-certified cord set consisting of a minimum 18 AWG, Type SVT or SJT, three-conductor cord, a maximum of 15 feet in length and a parallel blade, grounding-type attachment plug rated 15 amperes, 125 volts.

For units intended to be operated at 230 volts (U.S. use): Use a UL-listed and CSA-certified cord set consisting of a minimum 18 AWG, Type SVT or SJT, three-conductor cord, a maximum of 15 feet in length and a tandem blade, grounding-type attachment plug rated 15 amperes, 250 volts.

For units intended to be operated at 230 volts (outside the U.S.): Use a cord set with a grounding-type attachment plug. The cord set should have the appropriate safety approvals for the country in which the equipment will be installed.

IBM power cords for a specific country are usually available only in that country:

IBM Power Cord Part Number	Used in These Countries
13F9940	Argentina, Australia, China (PRC), New Zealand, Papua New Guinea, Paraguay, Uruguay, Western Samoa
13F9979	Afghanistan, Algeria, Andorra, Angola, Austria, Belgium, Benin, Bulgaria, Burkina Faso, Burundi, Cameroon, Central African Rep., Chad, Czech Republic, Egypt, Finland, France, French Guiana, Germany, Greece, Guinea, Hungary, Iceland, Indonesia, Iran, Ivory Coast, Jordan, Lebanon, Luxembourg, Macau, Malagasy, Mali, Martinique, Mauritania, Mauritius, Monaco, Morocco, Mozambique, Netherlands, New Caledonia, Niger, Norway, Poland, Portugal, Romania, Senegal, Slovakia, Spain, Sudan, Sweden, Syria, Togo, Tunisia, Turkey, former USSR, Vietnam, former Yugoslavia, Zaire, Zimbabwe
13F9997	Denmark
14F0015	Bangladesh, Burma, Pakistan, South Africa, Sri Lanka
14F0033	Antigua, Bahrain, Brunei, Channel Islands, Cyprus, Dubai, Fiji, Ghana, Hong Kong, India, Iraq, Ireland, Kenya, Kuwait, Malawi, Malaysia, Malta, Nepal, Nigeria, Polynesia, Qatar, Sierra Leone, Singapore, Tanzania, Uganda, United Kingdom, Yemen, Zambia
14F0051	Liechtenstein, Switzerland
14F0069	Chile, Ethiopia, Italy, Libya, Somalia
14F0087	Israel
1838574	Thailand
62X1045	Bahamas, Barbados, Bermuda, Bolivia, Brazil, Canada, Cayman Islands, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Japan, Korea (South), Liberia, Mexico, Netherlands Antilles, Nicaragua, Panama, Peru, Philippines, Saudi Arabia, Suriname, Taiwan, Trinidad (West Indies), United States of America, Venezuela

This glossary includes terms and definitions from the following publications.

The *American National Dictionary for Information Systems*, ANSI X3.172-1990, copyright 1990 by the American National Standards Institute (ANSI). Copies may be purchased from the American National Standards Institute, 11 West 42 Street, New York, NY 10036. Definitions are identified by the symbol (A).

The ANSI/EIA Standard 440-A: *Fiber Optic Terminology*. Copies may be purchased from the Electronic Industries Association, 2001 Pennsylvania Avenue, N.W., Washington DC 20006. Definitions are identified by the symbol (E).

The *Information Technology Vocabulary*, developed by Subcommittee 1, Joint Technical Committee 1, of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC JTC1/SC1). These definitions are identified by the symbol (I). Definitions from draft international standards, committee drafts, and working papers being developed by ISO/IEC JTC1/SC1 are identified by the symbol (T), indicating that final agreement has not yet been reached among the participating National Bodies of SC1.

A

access time. The time interval between the instant at which a call for data is initiated and the instant at which the delivery of data is completed.

adapter. A printed circuit board that modifies the system unit to allow it to operate in a particular way.

address. (1) A value that identifies a register or a particular part of storage. The value is represented by one or more characters. (2) The location in the storage of a computer where data is stored. (3) To refer to a specific storage location by specifying the value that identifies the location.

address bus. The path used for the transmission of address information in a computer.

ANSI. American National Standards Institute. An organization consisting of producers, consumers, and general interest groups, that establishes the procedures by which accredited organizations create and maintain voluntary industry standards in the United States.

application. The use to which an information processing system is put; for example, a payroll application, an airline reservation application, a network application.

application program. (1) A program that is specific to the solution of an application problem. Synonymous with application software. (T) (2) A program written for or by a user that applies to the user's work, such as a program that does inventory control or payroll. (3) A program used to connect and communicate with stations on a network, enabling users to perform application-oriented activities.

arbitration. A process that determines which device or subsystem gains control of a bus when two or more devices or subsystems simultaneously compete for control.

B

backplane. In personal computers, a printed circuit board that sets the SCSI ID and termination for hot-swap hard disk drives.

bit. Either of the digits 0 or 1 when used in the binary numeration system. Synonymous with binary digit. (T)

bus bridge. A functional unit that interconnects two busses, such as a multiprocessor bus and a PCI bus.

buffer. (1) A routine or storage used to compensate for a difference in rate of flow of data, or time of occurrence of events, when transferring data from one device to another. (A) (2) A portion of storage used to hold input or output data temporarily.

bus. One or more conductors used for transmitting signals, data, or power. See also address bus and data bus.

bus master. A device or subsystem that controls data transfers between itself and a slave.

byte. A string that consists of a number of bits, usually 8, that are treated as a unit and represent a character.

C

cache. A buffer storage that contains frequently accessed instructions and data; it is used to reduce access time.

CD-ROM. Compact disc read only memory.

clock. A device that generates periodic, accurately spaced signals used for purposes such as timing, regulation of the operations of a processor, or generation of interrupts. (T)

configuration. The manner in which the hardware and software of an information processing system are organized and interconnected. (T)

configure. To set up a computer for operation by describing to the system the devices, optional features, and programs installed in the computer.

controller. A device that coordinates and controls the operation of one or more input/output devices, such as workstations, and synchronizes the operation of such devices with the operation of the system as a whole.

cycle. (1) An interval of space or time in which one set of events or phenomena is completed. (A) (2) A complete vibration, electric oscillation, or alternation of current.

D

DASD. Direct access storage device.

data bus. A bus used to communicate data internally and externally to and from a processing unit, storage, and peripheral devices. (A)

direct access storage device (DASD). A nonvolatile-storage device, such as a diskette drive, hard disk drive, or CD-ROM drive, in which access time is effectively independent of the location of the data on the storage medium.

direct memory access (DMA). The transfer of data between memory and input/output devices without microprocessor intervention.

disk array. Two or more hard disks interconnected to increase security, performance, or reliability.

disk duplexing. A method of storing data whereby the data from one hard disk is duplicated on another, with each hard disk drive using its own hard-disk controller. Contrast with disk mirroring.

disk mirroring. A method of storing data whereby the data from one hard disk is duplicated on another, with both hard disk drives sharing a single hard-disk controller. Contrast with disk duplexing.

DMA. Direct memory access.

E

EEPROM. Electrically erasable programmable read-only memory.

electrically erasable programmable read-only memory (EEPROM). EPROM that can be reprogrammed while it is in the computer.

EPROM. Erasable programmable read-only memory.

erasable programmable read-only memory (EPROM). A PROM that can be erased by a special process and reused. (T)

execution unit. In microprocessors, a logical unit that performs the arithmetic and logical operations specified by the microprocessor instruction set.

F

floating-point unit (FPU). In microprocessors, an execution unit that executes floating-point arithmetic instructions.

FPU. floating-point unit.

G

GB. Gigabyte.

gigabyte. (1) For processor storage and real and virtual memory, 2^{30} or 1 073 741 824 bytes. (2) For disk storage capacity, 1 000 000KB. (3) For transmission rates, 1 000 000 000 bytes.

H

hard disk. A rigid magnetic disk such as the internal disks used in the system units of personal-computer systems and in external hard disk drives.

hard disk drive. A disk drive that reads and writes data on rigid disks and can be installed in or connected to a computer.

hertz (Hz). A unit of frequency equal to one cycle per second.

I

input/output device. A device in a data processing system by means of which data can be entered into the system, received from the system, or both. (I) (A)

instruction. A statement that specifies an operation to be performed by a microprocessor, and that identifies data involved in the operation.

integer unit. In microprocessors, an execution unit that executes logical and integer arithmetic instructions.

I/O. Input/output.

ISO. International Organization for Standardization. An organization of national standards bodies from various countries established to promote development of standards to facilitate international exchange of goods and services, and develop cooperation in intellectual, scientific, technological, and economic activity.

K

KB. Kilobyte.

KBps. Kilobytes per second.

kilobyte. 2^{10} or 1024 bytes.

L

LAN. Local area network.

local area network (LAN). (1) A computer network located on a user's premises within a limited geographical area. Communication within a local area network is not subject to external regulations; however, communication across the LAN boundary may be subject to some form of regulation. (T) (2) A network in which a set of devices are connected to one another for communication and that can be connected to a larger network.

logical. (1) Pertaining to content or meaning as opposed to location or actual implementation. (A) (2) Pertaining to a view or description of data that does not depend on the characteristics of the computer system or the physical storage. (A) (3) Contrast with physical. (A)

LUN. Logical unit number

M

math coprocessor. A microprocessor that supplements the operations of the system microprocessor, enabling the computer to perform complex mathematical operations in parallel with other operations.

MB. Megabyte.

Mbps. One million bits per second.

MBps. Megabytes per second.

megabyte. (1) For processor storage and real and virtual memory, 2^{20} or 1 048 576 bytes. (2) For disk storage capacity and transmission rates, 1 000 000 bytes.

megahertz (MHz). A unit of measure of frequency equal to 1 000 000 cycles per second.

memory. Addressable storage space in the computer that is used for temporary storage of instructions and data while a program is running, or for permanent storage of microcode. Contrast with auxiliary storage.

microprocessor. A processor whose elements have been miniaturized into one or a few integrated circuits. (T)

millimeter (mm). One thousandth of a meter.

millisecond (ms). One thousandth of a second.

multitasking. In operating systems, the running of two or more programs simultaneously.

N

nanosecond (ns). One thousand millionth (10^{-9}) of a second.

network. (1) An arrangement of nodes and connecting branches. (T) (2) A configuration of data

processing devices and software connected for information interchange.

nonvolatile. (1) Pertaining to a storage device whose contents are not lost when power is cut off. (T) (2) Contrast with volatile.

ns. nanosecond.

O

operating system. Software that controls the execution of programs and that may provide services such as resource allocation, scheduling, input/output control, and data management. Although operating systems are predominantly software, partial hardware implementations are possible. (T)

P

parity bit. A check bit appended to an array of binary digits to make the sum of all the binary digits, including the check bit, always odd or always even. (A)

PCI. Peripheral component interconnect.

physical. (1) Pertaining to actual implementation or location as opposed to conceptual content or meaning. (A) (2) Contrast with logical. (A)

pipeline. In microprocessors, a technique used to shorten the

critical path of an instruction execution by performing multiple execution stages simultaneously.

programmable read-only memory (PROM). A storage device that, after being written to once, becomes read-only memory. (T) (A)

PROM. Programmable read-only memory.

PUN. Physical unit number.

R

RAID. Redundant array of independent disks.

random access memory (RAM). (1) A storage device in which data can be written and read. (2) A storage device into which data is written and from which data is read in a nonsequential manner.

RAS. Reliability, availability, and serviceability.

read-only memory (ROM). Memory in which stored data cannot be modified by the user except under special conditions. See also EEPROM, EPROM, and PROM.

register. (1) An integrated circuit that contains 8, 16, or 32 storage locations, each of which can store 1 bit of binary data. See also binary. (2) An area that stores binary data while it is being processed by the computer.

S

SCSI. Small computer system interface.

seek time. The time required for the access arm of a direct access storage device to be positioned on the appropriate track.

sequential. Pertaining to a process in which all events occur one after the other, without any time lapse between them.

sequential access. The capability to enter data into a storage device or a data medium in the same sequence as the data is ordered, or to obtain data in the same order as it has been entered.

server. (1) A functional unit that provides shared services to workstations over a network. (2) In a network, a data station that provides facilities to other stations.

SMP. symmetric multiprocessing.

small computer system interface (SCSI). A standard input/output interface used by personal computers.

startup sequence. In personal computers, the order that the computer uses to search the direct access storage devices for an operating system.

superscalar. In microprocessors, a technique in which multiple,

independent instructions are issued per clock cycle.

swap space. In virtual memory systems, external storage allocated to program and memory images.

symmetric multiprocessing. In personal computers, a multiprocessing design that enables two or more microprocessors to run concurrently and work independently, with each microprocessor capable of performing any task.

system board. In a system unit, the main circuit board that supports a variety of basic system devices, such as a keyboard or a mouse, and provides other basic system functions.

T

TB. Terabyte.

terabyte. (1) For processor storage and real and virtual memory, 2^{40} or 1 099 511 627 776 bytes. (2) For disk storage capacity, 1 000 000 000 KB. (3) For transmission rates, 1 000 000 000 000 bytes.

V

virtual. Pertaining to a functional unit that appears to be real, but whose functions are accomplished by other means.

volatile. (1) Pertaining to a storage device whose contents are lost when

power is cut off. (2) Contrast with nonvolatile.

W

wait state. A period during which a microprocessor suspends processing while waiting for a response to a request for an unavailable resource.

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