IBM

Implementing Microsoft Exchange 2000 Server on IBM @server xSeries Servers

Maximize the performance of Exchange 2000 Server

Executive Summary

Microsoft® Exchange 2000 Server and Exchange 2000 Enterprise Server are excellent platforms for providing enterprise messaging and collaboration solutions for companies of all sizes. If you have already standardized on Exchange 2000 Server, the next step is to decide what server to run it on. Of course you want blistering speed—and many servers can meet that requirement—but speed alone isn't enough. To truly get your money's worth you need much more.

You need high availability: if your server is frequently offline, it's not doing the job you bought it for. You need manageability: if the server requires a lot of manual administration and is difficult to setup and manage, your administrators will be unproductive. You need scalability so that your server can grow along with your business needs. You need the flexibility to use your server as your needs dictate rather than being stuck in the pigeonhole that a server vendor designates for that server. And you need world-class services and support from your server vendor.

IBM @server xSeries servers offer all that and more. Drawing on the decades of experience and expertise that helped build our midrange and mainframe systems, IBM has developed a blueprint for bringing the reliability, availability and scalability of our "big iron" enterprise servers to the xSeries product line. This blueprint is IBM X-architecture[1], designed to provide the advances in technologies needed to implement business-critical, core business, e-business and deep computing applications.

This paper provides guidelines for the initial phases of sizing and configuring Exchange 2000 Server on xSeries servers. Proper sizing is important to a successful Exchange Server 2000 implementation. This paper also describes the various hardware and software technologies—many of them unique to IBM—and service and support offerings that xSeries servers use to help meet your Exchange 2000 Server requirements for availability, manageability, scalability and flexibility.

Note: If you have already decided to run Exchange on xSeries servers, you can go right to the sizing information in Section I. If you are still undecided about whether IBM offers the best products for your environment, you should begin with Section II, to understand more about the xSeries product line and the IBM/Microsoft relationship.

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[1] See the white paper entitled "IBM X-architecture" at http://**ibm.com**/eserver/xseries for more information. From the xSeries home page, select **Library** and you will see links to the different types of documentation available.

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I. Basic Sizing Guidelines

The following guidelines divide the sizing process into several parts to simplify the process of determining the correct server to use and configuring it with the correct number of processors, the right amount of memory and disk storage, and addressing other factors that affect the performance of the finished Exchange 2000 Server system.

IBM software engineers have performed extensive analyses with Exchange Server using Microsoft LoadSim 2000 to generate testing benchmarks. Although LoadSim 2000 results alone can't be viewed as a realistic prediction of actual user loads, these benchmarks serve to provide a relative scaling of an Exchange Server environment. The results were used in concert with the recommendations of IBM Global Services consultants, who had extensive implementation experience with Exchange 2000 Server, in order to determine the best server "fit."

Recently, the IBM @server x330 was run through the Microsoft Exchange 2000 MAPI Messaging Benchmark (MMB2). During the four-hour steady state test, the x330 provided a weighted 95th percentile response time of **225ms** for **5,000** MMB2, with average send queue size of **52** and average CPU utilization of **89** percent[2]. The same benchmark was run on the xSeries 220. During the test, the IBM @server x220 provided a weighted 95th percentile response time of **155ms** for **2000** MMB2, with average send queue size of **11.2** and average CPU utilization of **75** percent.

Note: This data can provide a benchmark for comparing hardware and/or software products, *but cannot be used as a deployment guide for production environments*. For deployment specific information contact a Microsoft or IBM representative. This sizing guide is not intended to be a substitute for a professional evaluation of all possible factors that can influence an Exchange 2000 Server configuration. A somewhat more precise sizing can be performed online at the IBM Web site[3]. However, it is highly recommended that you consult with an experienced IBM representative or consultant to determine which server will best meet all your requirements for a high-performance Exchange 2000 Server system.

The sizing process begins by gathering information about your needs:

Gather Information

In order to correctly determine the size and configuration of your Exchange server, you will need to collect usage and other information about your organization. Because Exchange 2000 Server can be implemented on a stand-alone server, as part of a cluster of servers at one location, or as part of a multisite system, the type of implementation you will be using has a great effect on the sizing and performance of an Exchange configuration. For a detailed sizing, an experienced consultant or IBM representative will need to know the following:

- Total number of users
- Peak usage requirements (messages per hour)
- Peak number of e-mail messages sent per hour or day
- Average size of e-mail and attachments
- Type of clients used (Outlook, Web browsers, etc.)
- Distance the users are from the server (number of "hops," etc.)

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[2] The **x330** server was configured with dual **1GHz** Intel® Pentium® III processors and **4GB** of memory. The **x220** was configured with one **933MHz** Pentium III processor and **2GB** of memory. The default Microsoft Loadsim MMB2 profile was used, which represented the tasks typically performed by a corporate e-mail user. Results were based on four hours of steady state running. This test measures the messaging throughput of a single server, single site topology. Its purpose is to measure the maximum throughput of a Microsoft Exchange Server on this hardware configuration.

[3] Go to http://www.developer.ibm.com/welcome/myvc.pl?mvcid=overview&packageid=999mes2k&language=en.

- Type of configuration (stand-alone, multiserver cluster or multisite)
- Your network topology (Gigabit Ethernet, 10/100Mbps Ethernet, token ring, etc.)
- Type of hardware connectors used (RJ-11, RJ-45, BNC, etc.)
- Expected user growth rate

After collecting this information, there are other determinations that you will need to make—first to establish the best server model to use, then to configure the correct amount of memory and disk storage, what type of RAID (redundant array of independent drives) configuration to use, and your backup and recovery requirements.

These steps may require an iterative process to determine the appropriate configuration for your needs. As you delve further into your fact gathering you may find that some of your estimates will change, resulting in different answers to other questions. (For example, if your expected growth rate is high enough you may decide to change your answer to the network topology question from 10/100 Mbps Ethernet to Gigabit Ethernet.) During the course of testing with sample data, and then with a small test group of users before a widespread deployment, you may discover that your sizing assumptions were incorrect. In some cases it may be advisable to work with an experienced IBM representative or IBM Partner to develop a pilot system.

Estimate Server Size by Number of Users

Although all of the information listed above is needed to perform a detailed sizing, you can make a rough approximation of the workload your Exchange 2000 Server system will have to support using the number of expected concurrent users. This can be used to estimate the size and type of xSeries server you will need. (*Table 1* illustrates how many users can be supported by the various xSeries servers.)

xSeries Server Model	Max. Number of Processors	*Maximum* Concurrent Users				
		Up to 2,000	Up to 4,000	Up to 5,000	Up to 7,000	Up to 8,000
x200	1 Pentium III	Yes				
x220	2 Pentium III		Yes			
x230	2 Pentium III			Yes		
x240	2 Pentium III			Yes		
x250	4 Pentium III Xeon™				Yes	
x300	1 Pentium III	Yes				
x330	2 Pentium III			Yes		
x340	2 Pentium III			Yes		
x350	4 Pentium III Xeon				Yes	
x370	8 Pentium III Xeon[4]					Yes

Table 1. *Determining which server is the best fit for your needs*

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[4] Using four processors. Although the x370 supports eight processors, and other applications—such as IBM DB2—can take full advantage of all eight, Exchange 2000 Server does not benefit significantly from more than four processors in a server.

Determine Number of Processors Needed

Using *Table 1* you should be able to determine which server will best meet your requirements. If in doubt, overestimate rather than underestimate so you don't get caught short by unexpected growth. If your expected maximum is 6,000 users, an x240 server would fit the bill (with ten percent capacity to spare), but an x250 system provides for more growth potential. Keep in mind the maximum number of processors supported by a server. If you start with two processors in a system that supports up to four processors (rather than buying a 2-way server), you can add additional processors later as needed. (Once CPU utilization reaches 80 percent, it's time to add another processor.)

You might also consider using more than one server to share the workload in a cluster configuration[5]. For example, even if one 4-way x250 server can handle 7,000 users, two clustered 2-way x230 systems can support up to 8,000 users between them by sharing the workload.

Although limited processor "horsepower" can be a bottleneck, it is far more likely that performance problems will be caused by insufficient memory or disk storage capacity (if you haven't exceeded the processor limits outlined in *Table 1*). Generally, adding processors without also increasing your memory and/or disk storage will not have a significant effect on Exchange 2000 Server performance. You should look for memory and disk shortages first, before adding processors.

Note: In the case of servers that offer a choice of processor speeds, you should always choose the fastest available option, even if it appears to be "overkill" at first. Experience shows that user demands generally increase faster than expected. You are likely to need an increase in processor resources sooner than you think, and having capacity to spare from the start will enable you to delay having to purchase the first processor upgrade . It will also give you more total capacity when the system is fully upgraded, delaying the need to add another server to the system.

Determine Server Memory Requirements

Having sufficient memory is important to the performance of Exchange 2000 Server. The more memory Exchange has available to it the more space is available for data caching. This enables Exchange to retrieve frequently accessed information from memory rather than having to read it from the hard disk drive, thus improving performance considerably.

A useful rule of thumb for determining the memory you will need for Exchange is to multiply the number of users by 300**KB**, then add an additional 256**MB** for Microsoft Windows™ 2000 itself. For example, a 5,000-user Exchange configuration would require *at least* 1.75GB of memory. Because this is just an estimate, and because of other factors that might affect the memory required, it's a good idea to *overestimate.* Some sample memory sizes are shown in *Table 2*. (These numbers are merely a starting point. Having 2GB to 2.5GB instead of 1.75GB in the previous example might provide better performance in a real-world environment.) When selecting a server, be sure to consider user growth rates and the maximum server memory supported.

Number of Users	*Minimum* Memory Required
100	310MB
500	448MB
1,000	576MB
2,000	896MB
3,000	1.25GB
4,000	1.5GB

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[5] For a white paper on implementing a clustering solution with Exchange 2000 and IBM @server xSeries servers go to http://www.developer.ibm.com/welcome/myvc.pl?mvcid=download&packageid=990&docid=DFB6C5F4E788504D862569 D500136D79&filename=BM+and+MSExchange+2000+Cluster+SCSI.pdf&language=en.

5,000	1.75GB
7,000	2.5GB
9,000	3.0GB

Table 2. *Exchange 2000 Server memory requirements*

Note: Although some xSeries servers support more than 4GB of RAM, a maximum of 4GB is recommended for Exchange 2000 Server and Windows 2000.

Determine Server Disk Storage Requirements

The capacity, speed and number of hard disk drives, as well as the type of RAID used, greatly affect the overall performance of Exchange 2000 Server.

The number of drives in the array has the most significant impact on performance. SCSI disk controller technology allows multiple drives to read and write simultaneously. The more drives you have the more data can be transferred at once. When hundreds or thousands of users are accessing files concurrently, the more read/write heads Exchange has available to it the faster the response time will be.

Exchange allows an administrator to assign a maximum amount of disk storage to each user's mailbox. To approximate the disk space required for the server, multiply the total number of expected users by the storage space allowed per user. For example, if the per-user limit is 40MB[6] and there are 3,000 users, the mail database disk requirement would be approximately 120GB (40MB * 3000). This number accounts only for the *Private* Information Store for users' mailboxes. If you also utilize the *Public* Information Store (newsgroups), you will need to allow additional space for this as well. In a multiserver site, Microsoft recommends dedicating a single server for this task, using other servers for user mailboxes.

Determining the *number* of drives to use depends on the size of the drives and on the RAID level that you prefer. Given the previous example, and a server with 18.2GB drives and RAID 5, you would need the following (always rounding up to the next whole drive):

120GB / **18.2** = 6.6, or **7** disk drives + **1** drive for RAID 5 parity + **1** drive as a hot spare = **9 drives total**

If performance is your highest concern, this would be the optimum solution. However if cost is a strong concern, using a smaller number of higher-capacity (but more expensive) drives *may* reduce the cost, but at a loss of performance (due to the decreased number of read/write heads available). For example, by using 36.4GB drives instead of 18.2GB drives you can reduce the number needed by three (leaving room to add three more dives later):

120GB / **36.4** = 3.3, or **4** disk drives + **1** drive for RAID 5 parity + **1** drive as a hot spare = **6 drives total**

One advantage of using higher-capacity drives, of course, is that it allows you to have a larger total capacity without having to replace any existing drives or resort to external storage. As with memory, it is a good idea to estimate your storage needs on the high side. Disk space is relatively inexpensive and a lack of it can greatly impact Exchange 2000 Server performance.

Another aspect of hard disk drives to consider is rotational speed. This too can have a significant impact on performance gain. (The faster the disk spins the faster the read/write heads can get to the data—this is called rotational latency—and the higher the data transfer rate of the drive.) As a result, one of the easiest ways to improve the overall performance of a computer system is to install a higher speed hard disk drive. The majority of server drives operate at either 7200rpm or 10,000rpm. The fastest drives run at 15,000rpm. When available, it is strongly recommended that

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[6] MB equals one million bytes and GB equals one billion bytes when referring to hard disk drive storage capacity; accessible capacity may be less depending on user environments.

10,000rpm drives be utilized at a minimum—15,000rpm if your budget allows, especially for the Information Store (or database) server.

The final consideration for disk storage involves RAID. When configuring disk drives for Exchange Server, it is essential to use some form of RAID technology to ensure fault tolerance and continuous availability. Although Windows 2000 includes *software* RAID capability (meaning that it uses the system microprocessor to process the RAID commands), IBM recommends using *hardware* RAID, such as IBM ServeRAID™ Ultra160 SCSI adapters or IBM FAStT (Fiber Array Storage Technology) Fibre Channel adapters. A hardware implementation (with its own onboard processor) offers dramatically increased performance, improved reliability and the ability to recover an array (and your data) without using Windows 2000. ServeRAID adapters also provide enhanced RAID capabilities, with new technologies such as RAID 1E and 5E, and optimize the disk subsystem utilizing write-back technology.

The optimum configuration for Exchange Server requires a minimum of three physical disk arrays: one for the system, one for Exchange Server log files and one for Exchange Server databases. The system array contains the Windows operating system files, the Exchange Server program files and perhaps the Page file. The log file array contains the log files that Exchange Server creates, and the Exchange Server database array contains both the private and public store databases used by Exchange (PUB.EDB and PRIV.EDB).

For the best performance, it is recommended that the system array be configured as RAID 1 (striping). (If you are using an IBM ServeRAID adapter, use RAID 1E—RAID 1 Enhanced.) Configure the log file array as either RAID 1 (or 1E) or RAID 0 (mirroring), depending on the desired level of fault tolerance. The Exchange Server database array should be configured as either RAID 1/1E or RAID 5 (RAID 5E—RAID 5 Enhanced—if using a ServeRAID adapter), depending on the size of the database, the number of disks in the disk array, the response time required and the size of your server budget. Configuring the Exchange Server database array as RAID 5/5E (striping with parity) provides a higher degree of safety than RAID 1 does. However, a RAID 5 configuration is slower than a RAID 1 array due to the processing time for the parity data.

On the other hand, RAID 5 can be more cost-effective than RAID 1. For example, utilizing RAID 1 across ten drives would require using five of those drives to mirror the other five, for safety. RAID 5 uses the equivalent of only one disk drive of those ten for parity information, resulting in three additional disk drives available for I/O operations (after one is reserved for a hot spare). The additional storage provides significantly more disk space for the Exchange Server database files. (For a description of how RAID 1E and 5E are superior to RAID 1 and 5, respectively, see the section below that discusses ServeRAID technology.)

Note: We do *not* recommend using RAID 5/5E for the drive storing the Exchange Server *log* files. The log files are written sequentially by Exchange Server and have no read access during normal Exchange Server operation. RAID 5/5E is less efficient for handling this type of disk activity.

Performance-tuning Exchange 2000 Server

The following information will help you get the best performance from Exchange:

Performance and Capacity Monitoring

Once Microsoft Exchange 2000 Server is configured and running, there are various ways to determine if there are any bottlenecks or other performance problems. One such method is to use IBM Director, which is included with each xSeries server. IBM Director provides a suite of powerful tools to help manage and monitor all servers on the network.

Capacity Manager is one of the tools included with IBM Director. The latest Capacity Manager has been enhanced with artificial intelligence, including powerful forecasting algorithms that project

resource requirements for CPU, memory and disk. Capacity Manager also identifies existing and potential bottlenecks and recommendations to resolve the bottlenecks. Visit http://**ibm.com**/us/server/capmgr/index.html for more information on Capacity Manager.

In addition, Exchange 2000 Server provides a number of Windows 2000 performance monitor charts that can be used to spot-check the performance of the server. Although these are useful in detecting if a problem exists, the performance monitor provides more definitive information for specific problem areas. There are also a number of third-party tools designed to monitor various Exchange Server environments. The tool you select depends on the nature of your environment.

II. Why Use IBM @server xSeries Servers?

xSeries servers offer the tools and capabilities that allow your organization to obtain a competitive advantage from your IT investment, while helping you control your business computing environment more precisely and with less effort. IBM @server xSeries servers extend today's industry-standard hardware and software platforms to include advances in the technologies needed to implement business-critical core applications.

There are many aspects to a server and all are important: performance, availability, scalability, manageability, flexibility, and the service and support infrastructure to not only keep your business up and running, but operating at the highest possible level of effectiveness. The following topics describe how xSeries servers address these requirements.

The IBM / Microsoft Partnership

IBM and Microsoft have had a long-standing working relationship. Various partnerships and collaborations have existed over the last 20-plus years and continue to exist today. IBM works closely with Microsoft to implement industry standards; to ensure that IBM products will be fully compatible with, and take advantage of, the latest Microsoft operating systems; and to cooperate on the development of future technologies.

Some of the current cooperative projects include:

- **IBM Center for Microsoft Technologies** — Open since 1993, the ICMT consists of well over 100 software engineers, test and quality specialists and enterprise solutions support staff, whose mission is to adapt Microsoft software products to IBM products and to optimize IBM hardware for Microsoft products. The center played an important role in the development and testing of Windows NT and Windows 2000, achieved through early involvement in the design cycles of products from both companies. The Performance Lab constantly compares the performance of Microsoft software running on IBM hardware to that of competitive hardware, and helps the development teams to design IBM servers to be the best possible platforms for Microsoft operating systems.

- **IBM Executive Briefing Center (Kirkland, Washington)** — Located near both the ICMT and Microsoft headquarters, this state-of-the-art facility highlights the synergy between the products of the two companies, in briefings and demonstrations for customers and IBM Partners.

- **Microsoft Gold Certified Partner for Support Services** — In order to help customers meet the demands of an increasingly competitive market, IBM Global Services has joined with Microsoft to become a Microsoft Gold Certified Partner for Support Services (formerly known as Microsoft Certified Support Center). This partnership benefits users of both IBM and Microsoft products by improving product compatibility. Microsoft Gold Certified Partners have the expertise necessary to design, develop and implement support services tailored to the critical business needs of users of Microsoft products.

- **IBM Enterprise Services for Microsoft Technologies** — A consulting practice of IBM Global Services, the ESMT offers comprehensive project analysis, design, planning, development and deployment services as well as customized training to help IT organizations that have standardized on Microsoft technologies. The ESMT has a staff of over 2500 Microsoft Certified Professionals located worldwide, with years of practical experience with these technologies. Services range from basic implementation and deployment of Windows operating systems with Microsoft Office® and Microsoft BackOffice® to more complex solutions involving Exchange 2000 Server, Windows 2000 Datacenter Server and application development. These include solutions for business transformation, e-business, customer relationship management, business intelligence and supply chain management.

Performance Leadership

Our focus on designing xSeries systems for enterprise-class reliability, availability and serviceability has led to significant achievements in performance as well. Benchmark records have come to be expected for IBM Intel architecture servers. In 1998, Netfinity® systems achieved an impressive 23 benchmark records for Intel processor-based servers. These benchmarks came from all application areas, including database, Internet, e-mail and ERP applications. In 1999, Netfinity systems achieved 42 number-one benchmark records. In 2000, Netfinity and xSeries servers added 33 more records to the tally.

IBM @server xSeries servers are continuing this impressive streak with additional benchmark wins in 2001. In March 2001 a cluster of IBM xSeries 370 servers with X-architecture set a new **TPC-C** (TPC Benchmark C) record[7], shattering the previous record for *any hardware, operating system and database configuration*. The x370 cluster's TPC-C performance was **56** percent better than the world record achieved by an IBM Netfinity 8500R cluster just eight months earlier (in July 2000). If that wasn't enough, the IBM @server x350 *also* set a record, in the 4-way enterprise server class, beating the previous record for the **TPC-H** (TPC Benchmark H) benchmark of Business Intelligence[8] by a striking **46** percent.

Award-Winning Products

IBM @server xSeries servers and IBM Netfinity (the predecessor to xSeries) systems have received outstanding recognition from customers, IBM partners and the industry for innovations and leadership in bringing enterprise levels of performance, scalability and reliability to this rapidly growing market. In January 2001, **five** IBM @server xSeries models won international design awards. The *Industrie Forum* awarded the xSeries 220, x260, x330, x340 and x350 with its seal for outstanding quality of design. In May, the IBM x330 was awarded the *Network Computing* Editors' Choice award. The x330 was recognized for its innovative features like Cable Chaining Technology (C2T), Light Path Diagnostics™ and the Advanced System Management processor. In addition, the x240 was recognized for its performance by making *Smart Business* magazine's A-List four consecutive months this year. *Table 3* lists a sampling of the many recent awards our vision and products have won (through May 2001):

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[7] As of 3/19/01. The 8-way IBM **x370** cluster (running Microsoft Windows 2000 Datacenter Server and Microsoft SQL Server 2000 Enterprise Edition) achieved a record TPC-C score of **688,220.90** transactions per minute C (tpmC) at **$28.89** per tpmC. Configurations available as of 5/31/01. Go to *http://www.tpc.org* for details of the TPC-C benchmark.

[8] As of 3/23/01. The 4-way IBM **x350** achieved a top TPC-H score of **1169 Queries/hour** @100GB at a cost of **$166/QphH@100GB**. Configurations available as of 5/31/01. Go to *http://www.tpc.org/* for details of the TPC-H benchmark.

Publication	Award	Server	Award Date
Smart Business magazine	Enterprise Server A-List	Netfinity 5600	May - December 2000
PC Expert International) magazine	'Must' 2-Way Server	Netfinity 5600	July 2000
PC Quest International) magazine	Users Choice Award	Netfinity family	August 2000
PC Magazine	Editor's Choice	Netfinity 5100	November 2000
InfoExame (International) magazine	Best Server	Netfinity 7100	November 2000
Windows 2000 (Australia) magazine	Editor's Award — 2-way Server of the Year	@server x330	December 2000
Windows 2000 (Australia) magazine	Editor's Award — 4-way Server of the Year	Netfinity 8500R	December 2000
PC Magazine	Best Products of 2000 - Small Business Solutions	Netfinity family	January 2001
Industrie Forum	Design Award	@server x220, x260, x330, x340, x350	January 2001
Smart Business magazine	Enterprise Server A-List	@server x240	January through April 2001
Network Computing magazine	Editor's Choice — 1U server	@server x330	May 2001

Table 3. *Recent awards won by xSeries and Netfinity server*s

These awards confirm that IBM is demonstrating a clear difference between xSeries servers and other Intel processor-based servers in the market. They are an important part of how we measure the success of our product directions and the IBM X-architecture strategy. Yet even more important is the faith our customers are placing in the xSeries products. IBM Intel processor-based server sales have grown dramatically since we introduced IBM X-architecture. Such growth demonstrates that customers see the value xSeries servers deliver to businesses of all sizes.

Designed for Reliability, Availability and Serviceability

There are many facets to high availability. Hardware and software shouldn't crash and bring the server down; ideally if hardware fails you should be able to replace it without taking the server offline, or if you must, the component should be identified rapidly, removed and replaced easily, and the system should be brought back up quickly. If software fails often it requires taking the system down to restart the operating system. Avoiding that step alone could save you a lot of money in terms of lost business and employee productivity. Also, recognizing that hardware does fail occasionally, software does sometimes lockup, and disasters happen to the best of us, it is imperative to have plans and processes in place for dealing with these occurrences in a timely and efficient manner. The following topics describe many of the hardware, software and services that IBM offers to keep your xSeries servers up and running.

Historically, Intel processor-based servers have had to be shut down for repairs and upgrades. Taking servers down to repair or reconfigure them reduces availability and impacts productivity. For this reason xSeries servers include technologies to prevent hardware and software outages and minimize downtime. Anticipating the rare occasions when components fail, IBM has developed numerous technologies that allow you to identify, diagnose, repair and upgrade your xSeries servers with little or no downtime.

IBM @server xSeries servers are designed from the ground up for high Reliability and Availability, along with ease of Serviceability (RAS). Features such as gold-plated connectors, rubber mounts on hard drive carriers (for reduced vibration), Chipkill™ memory, hot-add/hot-swap drive bays and PCI card slots, redundant fans and power supplies, Software Rejuvenation, and widespread use of Predictive Failure Analysis® all combine to promote maximum server reliability and availability. Leading-edge diagnostic and serviceability aids, including IBM Light Path Diagnostics and hot-swap components, allow you to replace failing parts without powering down the server, thus helping to keep your business up and running.

Today, you can buy select xSeries servers that allow you to hot swap not only components such as fans, hard disk drives and power supplies, but many PCI adapters, including LAN, RAID and SCSI, as well. These same technologies can be used to reconfigure or scale up your xSeries servers by adding components—without disruption—to increase system performance or capacity while maintaining server availability.

The following technologies provide some of the advantages provided by IBM X-architecture[9], which is based on decades of IBM experience and leadership in mainframe servers.

- **IBM Active PCI** — Active PCI allows you to hot add (an industry first) and hot swap PCI components—including LAN, RAID (Redundant Array of Independent Disks), SCSI and other adapters—in select xSeries systems without powering down the system.

- **IBM Advanced System Management** — A dedicated processor, either integrated or on an optional adapter, provides complete remote management of an xSeries server—even if the server is offline. Other capabilities include the monitoring of system conditions such as temperature, voltage and other parameters. Out-of-operating-range conditions trigger automatic PFA alerts (see below).

- **IBM Automatic Server Restart (ASR)** — A combination of hardware and software that allows an xSeries server to restart itself unaided in the event of an operating system crash or a transitory hardware event (such as a power flicker).

- **IBM Chipkill memory** — This enhanced ECC memory technology provides storage that is many times more effective than standard ECC DIMMs at correcting multibit (and even multi*chip*) memory errors and reducing downtime and potential lost data from system crashes.

- **IBM Light Path Diagnostics**— Working in conjunction with PFA and environmental self-monitoring features, built-in LED indicators attached to individual components—as well as an external service panel—alert you to problems and help you quickly locate and replace failed or soon-to-be-failing components.

- **IBM Predictive Failure Analysis™ (PFA)** — With PFA, an xSeries server can monitor system components—such as memory, processors, hard disk drives (HDDs), voltage regulator modules, fans, power supplies and even software—that are exhibiting signs of impending failure, and notify you *before* server problems occur. Many types of gradual failures can be predicted with a high degree of accuracy. Statistical analyses of similar devices that have failed in the past reveal patterns, which have been used to develop failure detection methodologies for various devices and even software (see Software Rejuvenation, following).

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[9] See the white paper entitled "IBM X-architecture" referenced on page 1 for more information about these and other technologies.

Simple to Manage

Availability is only part of the story. To be effective a server must also be easy to manage. IT managers routinely identify storage management as one of their primary challenges. In fact, it is estimated that the cost of manually managing direct-attached LAN storage can double every three years. IBM system management software adds intelligence and combines leading-edge, proven capabilities that integrate into the enterprise to help provide world-class server and storage management across your IT solution. All this is accomplished through a centralized infrastructure that can help businesses realize a reduction in management resource costs.

As we introduce more sophisticated features in xSeries servers, we know the importance of making complex technology easy to use. That's why our goal is to Make IT Easy™. Being able to deploy a new server in less than an hour, or to accurately plan upgrades, is no simple task—unless you are using xSeries servers.

xSeries servers currently come with many management tools that Make IT Easy, including IBM Director, Capacity Manager, System Installation Tool Kit, Update Connector Manager and Tivoli® Storage Manager.

IBM Cable Chaining Technology (C2T)

Look at the back of a typical rack of servers and you will see a rat's nest of cables connecting everything together. Instead of requiring up to three long, entangling cables per server, this new IBM technology uses only one short (12") connector. Not only does this reduce an incredible amount of clutter, but simplifying the cabling topology also reduces setup time, speeds problem diagnosis and lowers the cost of rack-mounted system cabling. For an illustration of the dramatic difference IBM Cable Chaining Technology (currently available only in the x330) can make, look at the following examples: *Figure 2* shows a competitor's rack using conventional cabling technology, while *Figure 3* shows the vast improvement IBM C2T cabling can make to the configurability and serviceability of your racks:
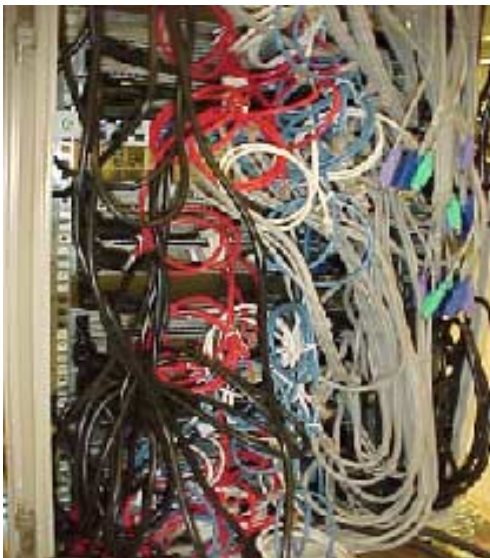
Figure 2. *Traditional rack cabling*

Figure 3. *IBM Cable Chaining Technology*

IBM Cable Chaining Technology[10] makes initial rack setup a snap, greatly simplifies the replacement of failed servers or cables, reduces the cost of cabling and eliminates many possible points of failure.

[10] See the white paper entitled "IBM OnForever Initiative" at http://**ibm.com**/eserver/xseries for more information about

IBM Director with Universal Manageability Services

IBM Director with UM Services™ is a combination of server and client manageability software with a simple graphical user GUI interface (GUI). It provides the application logic and data store of management information in an SQL database, and it includes a GUI that allows simple hardware management via single-click or drag-and-drop actions. UM Services tools include system hardware and OS inventory capability; resource utilization features; an Alert on LAN® switch that allows an administrator to monitor connections, restart failed systems and restore CMOS or failed drives; power management and monitoring; and a Security Manager to restrict user access to systems from a remote connection.

With IBM Director, xSeries servers provide you with the most sophisticated and easy-to-use local and remote systems management tools available. Optional UM Server Extensions extend the manageability of hardware and software. By letting IT administrators view the hardware configuration of remote systems in detail and monitor the usage and performance of critical components, such as processors, disks and memory, IBM Director can help you manage your server with ease and efficiency. More importantly, it can help you control many of the hidden costs of operation. The UM Server Extensions are often referred to as Life Cycle Tools. These utilities, downloadable from the Web, extend the manageability of your xSeries hardware throughout its life cycle. Life Cycle Tools include Advanced System Management, Capacity Manager, Cluster Manager, Fibre Channel RAID Manager, Power Redundancy Monitoring, Rack Manager, RAID Manager, Software Rejuvenation, System Availability and Update Connector™ Manager. The most important of these are Capacity Manager and Software Rejuvenation. (For descriptions of the other features—and a more detailed explanation of Software Rejuvenation—see the "IBM X-architecture" white paper referenced on page 1.)

- **Capacity Manager** — Capacity Manager monitors critical server resources such as processor utilization, disk capacity, memory usage and network traffic. Using advanced artificial intelligence, it identifies bottlenecks for an individual system or a cluster and recommends upgrades to prevent diminished performance or downtime. Capacity Manager can even identify latent bottlenecks and make recommendations for preventive action. For example, Capacity Manager can predict hard disk drive space and memory shortages that might cause problems for your systems. Because Capacity Manager features can help you predict problems *before* they occur, the administrator can perform proactive planning and—if necessary—schedule service and upgrades before potential problems degrade performance.

- **Software Rejuvenation** — In networked servers software often exhibits an increasing failure rate over time, typically because programming errors generate increasing and unbounded resource consumption. Other causes can include data corruption and numerical error accumulation, such as round-off errors. These errors can spawn threads or processes that are never terminated, or result in memory leaks or file systems that fill up over time. These effects constitute a phenomenon known as "software aging," and may be caused by errors in application, middleware or operating system software. As a system's resources gradually approach a critical level, the server becomes more likely to experience the dreaded "blue screen of death" or the "red screen of death," depending on your operating system.

  Advanced IBM analytical techniques allow IBM Director software rejuvenation to be self-educating, basing responses on the experience of system outages on a given server. Predictions of this sort allow Predictive Failure Analysis (PFA) capabilities for software—just as IBM critical hardware components offer—allowing the opportunity for an administrator to schedule servicing (rejuvenation) at a convenient time in advance of an actual failure, avoiding costly downtime.

Cable Chaining Technology. From the xSeries home page, select **Library** and you will see links to the different types of documentation available.

To help you avoid downtime, IBM Director software rejuvenation can be scheduled to reset all or part of the software system with no need for operator intervention. A reset might include just the application that is responsible for the aging—further reducing any impact on system operation—or it could include the entire operating system.

When software rejuvenation reinitializes a server, the server's failure rate falls back to its initial lower level, because resources have been freed up and the effects of numerical errors have been removed. This has a dramatic effect on the overall system availability of your xSeries server.

When software rejuvenation is invoked within a clustered environment, cluster management failover services (such as Microsoft Cluster Services and Microsoft Datacenter Server) may be used to gracefully stop the offending subsystem and restart it on the same or another node in the cluster in a controlled manner. In a clustered environment, xSeries servers can be set to failover to another server, then be reset by IBM Director without downtime. IBM is the first to offer software PFA (via Software Rejuvenation), and as any experienced administrator knows, software crashes are far more common than hardware problems.

The combination of IBM Director software rejuvenation operating in concert with the various X-architecture hardware technologies reduce server downtime, making xSeries servers capable of handling the most critical business applications.

IBM System Installation Tool Kit

This includes three powerful system deployment and migration software tools that can facilitate and expedite the deployment of Microsoft Windows operating systems to any network-connected and compliant computers in your enterprise. The package consists of:

- **IBM LAN Client Control Manager™ (LCCM)** — LCCM is an automated, remote software management and distribution tool. LCCM takes advantage of features implemented and integrated into supported PCs to allow administrators to remotely perform many tasks that previously required their presence at the desktop system PC. It simplifies the deployment of client systems by allowing an administrator to preconfigure operating systems and application software and install them via the LAN.

- **IBM Software Delivery Assistant (SDA)** — SDA helps eliminate delays caused by waiting for the IT staff to find time to update each user's system. It eliminates the cost of user downtime caused by the absence of necessary software on their systems. It also aids in reducing disk storage costs, because the company needs to maintain only a single server image of all its applications. SDA accomplishes this by installing all applications required by a user's job description, including core applications (such as personal productivity tools) and others (including enterprise resource planning, customer care, financials, human resources, programming languages, etc.). SDA recognizes the user's profile and therefore knows who that user is, what his or her job is, and what software is needed for that person to accomplish the job.

- **IBM System Migration Assistant (SMA)** — SMA enables custom settings, e-mail and data to be migrated from a user's former PC to the new PC accurately, efficiently and effectively. When older computers are refreshed or new computers are distributed, moving user data and system settings to the new system can be expensive and time-consuming. Users who can't find the spreadsheet their boss sent them or who lose the valuable bookmarks they have been saving in their browser over the years are not only frustrated, they are unproductive. SMA can help resolve these issues.

Tivoli Storage Manager

Tivoli Storage Manager utilizes high-performance patented technologies to protect and manage your mission-critical business information in an enterprise-wide Storage Area Network (SAN) and

traditional network environment. Combined with Tivoli Storage Manager's host of optional products, Tivoli offers an end-to-end scalable solution spanning palmtops to mainframes on over 35 platforms.

Scalability and Flexibility

Speed and standard features are part of the equation, but it is equally important to plan for the future. Can the server you are interested in be expanded to the number of processors and internal hard disk drives that you will need in the future? If you need more disk storage than it can hold internally, can you attach external drives? How many and what kinds and capacities? What about tape backup and Storage Area Networks? How about rack options? These are all important questions to ask. The following topics describe the current IBM offerings in these areas.

IBM ServeRAID Technology

As your storage capacity grows, your need for data integrity increases as well. Beyond a point, disk array technology becomes a necessity, providing both security against data loss and the prevention of costly downtime due to a disk crash. RAID technology can also produce a performance boost in some configurations. For these reasons, IBM offers an industry-leading SCSI RAID solution called IBM ServeRAID.

ServeRAID technology helps you build a reliable foundation for business-critical computing. ServeRAID is a combination of hardware, software and firmware for creating an array of disks using Ultra160 SCSI devices. Through hardware and software functionality, multiple physical disks can be treated as one logical disk array. Data is stored redundantly in various ways, offering *nine* levels of RAID to enhance integrity and availability of your data. (Soon IBM will begin delivering Ultra320 SCSI solutions.) The IBM ServeRAID solution consists of:

- **ServeRAID adapters** — Currently, the flagship of xSeries SCSI controller offerings is the ServeRAID-4 family of adapters. These 64-bit, Active PCI controllers are managed by ServeRAID Manager, which allows you to administer all your ServeRAID subsystems across an entire enterprise from a single session. ServeRAID controllers offer additional capabilities that are exclusive to ServeRAID or previously were found only in high-end sophisticated storage subsystems, including FlashCopy™, RAID 1E and RAID 5E and adapter and cluster failover. Data is stored redundantly in various ways, offering *nine* levels of RAID to increase performance and enhance the availability of your data.

- **RAID 1-Enhanced (RAID 1E)** — Typical RAID 1 controllers allow the mirroring of data to two drives concurrently, requiring that drives be added in pairs—an odd drive would go unused. IBM ServeRAID adapters, by contrast, support an enhanced mode of RAID 1 called RAID 1E. RAID 1E allows the mirroring of data to either an even number of drives or an odd number, allowing you to increase drives one by one, if desired, rather than always in pairs.

- **RAID 5-Enhanced (RAID 5E)** — Standard RAID 5 technology spreads data across all the drives in the system except one, which is used as a "hot spare," in case one of the other drives fails. (If a drive fails, the hot spare immediately and automatically replaces it.) This means that one drive is always unused pending a failure, resulting in an inefficient use of available drive space. By contrast, IBM Enhanced RAID 5, or RAID 5E, spreads all data, parity and hot-spare space across all of the drives, permitting 100% utilization of available drive space. This offers not only more efficient use of drive space but also faster throughput (because there are more drives operating) than traditional RAID 5 arrays.

- **Other RAID levels** — In addition to industry-standard RAID **0**, RAID **1** and RAID **5**, ServeRAID adapters also support RAID **00** (striping across multiple arrays), RAID **10** (1+0, which combines RAID 1 mirroring and RAID 0 striping), RAID **1E0** (1E+0, striping across multiple 1E arrays) and RAID **50** (5+0, striping across multiple RAID 5 arrays).

- **FlashCopy** — FlashCopy is high-availability software included with ServeRAID that provides an almost instantaneous copy of a logical volume. By supporting fast duplication FlashCopy minimizes application downtime associated with performing backups and restores. In addition, FlashCopy can improve system performance by offloading host resources. This tool takes a snapshot of the source drive and places it on the target drive, which can then be extracted and used in another server or placed on tape.

ServeRAID 1E and 5E adapter technologies can significantly improve data transfer rates and at the same time be used as the cost-effective foundation of a business-critical storage strategy. The advanced fault tolerance of enhanced RAID technology lets you effectively implement networked business systems with large amounts of storage space that must be available for your business to continue operating. IBM ServeRAID provides an outstanding solution for implementing RAID technology in xSeries servers.

External Hard Disk Drive Expansion

If the built-in disk capacity of your xSeries server is insufficient for your long-term needs, look to the IBM EXP300 SCSI RAID expansion units for more "closet space" in which to store your "stuff." Or, if your need is for both large capacity and high-speed offsite storage for disaster recovery planning, then IBM Fibre Array Storage Technology (FAStT) is just what you're looking for.

IBM EXP300. The EXP300 storage expansion unit offers an expansive **509GB** of disk storage (14 x 36.4GB)—more even than most xSeries servers. It fits in a 3U package, allowing up to 14 expansion units to be used in a standard 42U rack (meaning that a full rack of EXP300 units can hold an amazing **7.1TB**). (As described earlier, a ServeRAID adapter offers either one, two or four channels. Each channel can support up to 14 devices in one EXP300 unit.) The EXP300 provides PFA advanced warning of impending hard disk and fan failure, and the hot-swap capability allows you to service those components without having to take the unit offline. The EXP300 also uses dual redundant hot-swap power supplies for a greater level of security. (To use an EXP300 unit for a RAID array you will need a ServeRAID adapter or other RAID card.)

The EXP300 is optimized for Ultra160 SCSI—with a sustained data transfer rate of **160MBps**—but it supports both Ultra2 and Ultra160 SCSI drives simultaneously to facilitate phasing in the faster Ultra160 drives with your existing Ultra2 drives.

IBM Fibre Array Storage Technology (FAStT). The IBM FAStT family of storage solutions is designed for the high-availability, high-capacity requirements of your business. The long distance capabilities, high data transfer rates and wide range of storage configurations offer the power and reliability you need to protect your valuable data assets and to keep your business-critical applications and information available. Because IBM FAStT Fibre Channel solutions can support transfers over distances up to **10km (6.2 miles)** at rates of **100MBps**, companies can more easily configure offsite xSeries servers and storage systems to keep critical data available around the clock—even in the event of a catastrophe.

IBM FAStT hot-swappable and redundant RAID controllers support the uninterrupted flow of your business, thus helping to keep your systems available. Using a **single** IBM FAStT Host Bus Adapter connected to an IBM FAStT 500 Storage Server, you can configure a Storage Area Network (SAN) to support your massive data requirements, with up to **220** hard disk drives in **22** FAStT EXP500 Storage Expansion Units using a dual-loop configuration. If that isn't enough, just add more FAStT adapters. (The IBM FAStT 200 Storage Server is available for more modest SAN needs, supporting up to **30** drives using two FAStT EXP500 units.) The EXP500 expansion unit includes hot-swap redundant power supplies and dual-cooling fans, along with IBM Light Path Diagnostics to warn of faults, excessive temperature and other environmental concerns. Each FAStT EXP500 expansion unit can support up to **734GB**, using **ten 73.4GB** drives (or **182GB**, using **ten 18.2GB 15,000**rpm drives). Up to **14 3U** EXP500 units can be installed in a standard 42U rack for ease of configuration and servicing, totaling as much as **10.2TB** per rack.

If you have clustering requirements, configure your IBM FAStT storage solution for the highest availability with redundant IBM FAStT adapters, hubs and RAID controllers. Add long-wave cabling between your IBM FAStT hubs to build disaster recovery into your enterprise storage system. In the event of a catastrophic failure or natural disaster, your work can be transferred to your failover location immediately, without interruption or loss of data. Hot-swappable, redundant fans and power supplies help increase system uptime and ease of installation, while battery backup RAID circuitry helps protect against loss of data in the event of a power failure. All of this provides still another level of availability for your business-critical applications and data, moving you closer to continuous access and availability.

Tape Backup Options

Once you have stored gigabytes or terabytes of valuable data in these internal and external disk drives you will need fast, reliable and equally voluminous tape backup to protect that data and access it as needed. And if you require long-term archival storage, tape is still the most cost-effective solution available. IBM offers several choices of technologies for different needs and budgets: Digital Linear Tape (DLT), Super DLT (SDLT) and Linear Tape-Open (LTO).

Digital Linear Tape. DLT drives provide an entry-level tape storage solution that delivers high performance and reliability. The *IBM DLTVS* half-high tape drive is designed to operate at sustained data rates of up to **4MB** per second—**14.4GB** per hour—(with maximum compression). The DLTVS drive supports both DLT8000 (up to **80GB** compressed) and DLT4000 (up to **40GB** compressed) cartridges. The *IBM DLT8000* drive is a full-high drive that offers the same maximum capacity as the DLT1 with a data rate of up to **6MBps (21.6GB per hour)**. In addition to the DLT8000 and DLT4000 cartridges, it also reads DLT7000 (**70GB**) cartridges. Both the DLTVS and DLT8000 drives use an Ultra2 Low Voltage Differential (LVD) SCSI interface. For more modest tape backup needs, the half-high *IBM DLT4000* drive has a SCSI-2 Fast interface and a maximum capacity of **40GB** (compressed) and a sustained data rate of 3MBps **(10.8GB per hour)**. All use industry-standard DLTtape IV cartridges.

Super Digital Linear Tape. SDLT drives offer the maximum in data compression available today, with up to **220GB** per cartridge (compressed). *IBM 110/220 Internal SDLT Tape Drive* uses an Ultra2 LVD SCSI interface and offers a data transfer rate of up to **80GB** per hour (with compression). The SDLT drive is fully compatible with existing DLT tapes, and may be rack-mounted.

Linear Tape-Open. The LTO specification was jointly developed by three of the world's leading storage producers: IBM, Hewlett-Packard, and Seagate. The *IBM LTO Internal Tape Drive* comes in two models—half-high and full-high—and have a capacity of up to **200GB** with compression. The full-high model has a sustained data transfer rate of up to **108GB per hour** (compressed) for the ultimate in tape performance. The lower-cost half-high version has half the transfer rate of its full-high sibling. Both LTO drives use an Ultra2 SCSI LVD interface and can optionally be rack-mounted. (The full-high drive can be installed in a stand-alone external enclosure as well.)

xSeries Tape Automation. For high-volume/high-capacity environments, IBM offers several choices of automated tape library:

- The *R220 Stackable Tape Library* is a 5U rack-mounted LTO tape unit that includes one tape drive with ten tape cartridge slots, and has room for an optional second drive (with ten more slots). If that isn't enough, up to two *Library Expansion Units* (also 5U) can be attached (with two optional tape drives apiece), resulting in a maximum of **six tape drives** and **60 cartridge slots**. The *220 Tape Library* is a 5U tower version of the R220, with no support for Library Expansion Units (LXUs). Both the R220 and the 220 (and the LXUs) offer a maximum storage capacity of **4TB** compressed (20 x 200GB)—**12TB** for the R220 with two LXUs attached—and a maximum throughput of **54GB** per hour per drive.

- If reduced tape handling is more important to you than capacity and throughput, the *IBM 109 Autoloader* offers one drive and nine cartridge slots in a 6U tower package (optionally rackable). The Autoloader provides a total capacity of **1.8TB** (**54GB** per hour throughput), and a tape exchange speed of as little as **35** seconds.

As SCSI-attached tape solutions, the IBM tape drives connect to Fibre Channel server adapters through selected IBM Storage Area Network data gateway products. With their higher capacity and performance, the IBM LTO and SDLT drives are excellent alternatives to DLT, 1/4", 4mm, or 8mm tape drives.

Rack Solutions for xSeries

To enable you to rack-mount your xSeries rack-optimized and universal servers, IBM offers a number of rack cabinets to suit your specific needs[11]:

NetBAY™42 Enterprise Rack. Built like a tank and large enough to meet your most demanding needs, yet small enough to pass through a standard (3.02m/80") height door, the NetBAY42 features 42U of fan-free rack space designed for enhanced airflow. At merely 202cm (79.5") high by 64cm (25.5") wide, this EIA 310-D-Type A lockable cabinet with universal hole spacing holds up to 42U of servers and other devices. In addition, it has four 1U sidewall compartments for 1U devices designed for "zero space" use. The heavy-duty casters allow up to 667kg (1470 lbs) of internal load capacity (928kg/2045 lbs total) to be moved easily (leveling pads are included), while the perforated door provides unimpeded airflow. The NetBAY42 is sturdy enough to ship fully preconfigured from an IBM facility, and deep enough (96cm/38") to securely support extra-deep devices, such as the x370 server or tape automation. Using **14** 3U EXP300 SCSI storage expansion units (described earlier), each with **14** 36.4GB hard disk drives (**509GB** total), you can configure a rack with a whopping **7.1TB** of high-speed disk storage. (The EXP200 can be used to provide an additional **ten** drives/**364GB**, if preferred.) Using **14** FAStT EXP500 Fibre Channel expansion units each containing **14 73.4GB** hard disk drives gives you **10.2TB** of storage per rack should you need it.

NetBAY42 Standard Rack. The NetBAY42 Standard Rack is a lower-cost 42U rack than the NetBAY42 Enterprise Rack. It is slightly taller (207cm/81.5") than the Enterprise Rack (so it won't go through a door assembled and configured), and not quite as sturdy (internal load capacity up to 374kg/824 lbs using casters; 646kg/1424 lbs with leveling pads; 499kg/1100 lbs; 771kg/1700 lbs total, respectively). Thus it is best suited for configurations that are expected to be moved only within the business location. Like the Enterprise Rack, the Standard Rack is an EIA 310-D-Type A lockable cabinet with universal hole spacing and four 1U sidewall compartments. It can be ordered with a choice of glass or perforated door, both of which support a fan-free environment when used with xSeries ServerProven®[12] products. There is an optional 203mm (8") extension to securely support deep devices. Side panels are standard with the perforated door and optional with the glass door.

NetBAY22 Rack. The NetBAY22 is similar to the NetBAY42 Enterprise Rack except that it supports more modest needs for cabinet space, offering up to 22U of space (with two 1U sidewall compartments) in a 118cm (46.5") x 60cm (23.5") unit. It supports up to 338kg (746 lbs) of internal load weight (421kg/928 lbs total), and the glass cabinet door and sidewalls are lockable. (Like the NetBAY42 Standard there is an optional 203mm (8") extension to support deep devices.) Using **seven** IBM EXP300 storage expansion units, loaded with 36.4GB hard disk drives, you can create a rack with **3.55TB** of high-speed disk storage.

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[11] Go to http://www5.pc.**ibm.com**/us/me.nsf/US-webdocs/Spec+Sheet:+IBM+Rack+Solutions for a spec sheet containing more information about IBM rack solutions.

[12] IBM makes no representations or warranties regarding non-IBM products and services that are ServerProven, including but not limited to the implied warranties of merchantability and fitness for particular purpose. These products are offered and warranted by third parties.

NetBAY3/3E Rack. If you are looking for a modular approach that allows you to start small with a rack solution and grow as needed, consider the NetBAY3. It is a 3U cabinet (with lockable door) that fits neatly under a tower server like the x250. Up to three NetBAY3 units can be stacked under the server, giving you 9U (3 x 3U) of rack space. The NetBAY3 enclosure comes in two depths, to match the footprint of the server. The NetBAY3 fits servers that are 609.6mm (24") deep, including the x250. If you also have servers that are 711.2mm (28") deep (such as the x370) the NetBAY3E is the appropriate choice. Each NetBAY3 is just large enough to hold an EXP300 expansion unit with 509GB of disk space (12 x 36.4GB). An optional caster set allows you to easily move your "stack" of NetBAY3 enclosures without removing the server on top.

IBM @server **xSeries and Netfinity Rack Configurator.** Configuring a full rack of servers and ensuring that you have all the cables, power distribution units, KVM (keyboard, video and mouse) switch boxes and other components you need, as well as the proper airflow clearances, electrical circuits and other environmental conditions, is not the easiest task in the world. To simplify this chore, IBM offers no-charge rack configurator software for xSeries and Netfinity servers. The IBM @server xSeries and Netfinity Rack Configurator[13] program helps you check, correct and report the following:

- Components by product number and position
- Width and depth; front, rear and side clearances; total weight and top clearance
- Infrastructure specifications, including weight, power, volt-amps (VA), heat (BTU/hr), bays, EIA, outlets and console ports
- Cables and connectors by component position

Introducing the IBM @server **xSeries Servers**

The following thumbnails briefly describe the xSeries server models[14] that are supported with Exchange 2000 Server. (Note that all servers include a CD-ROM drive and a 1.44MB floppy drive. All but the x370 include at least one integrated 10/100 Ethernet controller.)

Universal Servers	
	The **x200** is a value-packed **4U uniprocessor** tower server (adaptable to rack use—as are the other xSeries universal servers) at an entry-level price. It offers a choice of Intel **Celeron**™ or **Pentium III** processor, up to **1.5GB** of ECC RAM, **145.6GB** of Ultra160 **SCSI** hard disk storage in **four** bays (out of **seven** bays total), and **five** PCI slots. Predictive Failure Analysis (PFA) support is included for hard disk drives. Some models include an IDE tape drive.
	The **x220** provides a value-priced **2-way** Intel Pentium III server in a **4U** package. It offers up to **4GB** of ECC SDRAM, **five** PCI slots, and **seven** drive bays, for a maximum of **145.6GB** of internal Ultra160 SCSI hard disk storage. (Some models include hot-swap hard disk drive s). The x220 provides PFA support for hard disk drives.

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[13] Go to http://**ibm.com**/pc/qtechinfo/BBOD-3MDQFF.html to download the most current version of the Rack Configurator.

[14] For more specifics about these and other xSeries models, see the individual spec sheets.

The **x230** offers a scalable high-performance platform with **2-way** Pentium III power, **4GB** of ECC memory, **six** hard disk drive bays supporting **218.4GB** of internal Ultra160 SCSI disk storage. An open full-high bay supports either a tape backup option or **two** additional hard disk drives (for a total of **291.2GB**) and **five** PCI slots in a **5U** tower package (easily convertible to industry-standard rack use). PFA support is included for hard disk drives, processors, memory, Voltage Regulator Modules (VRMs) and fans.

The **x240** is a higher-availability version of the x230—using Ultra2 SCSI hard disk drives, adding a **third** hot-swap/redundant cooling fan and a **second** hot-swap/redundant power supply, and replacing **three** of the five PCI slots with hot-add/hot-swap **Active PCI** slots.

The **x250** is a **4-way** Pentium III **Xeon** server built for environments running business-critical applications that are subject to rapid growth. The **5U** x250 provides high performance for IT departments using deskside deployments and can be converted easily for use in an industry-standard rack. It includes PFA support for hard disk drives, processors, memory, VRMs, fans and power supplies. With support for up to **16GB** of ultrareliable **Chipkill** memory, **four Active PCI** slots (plus **two** standard PCI slots) **364GB** of internal hot-add/hot-swap Ultra160 SCSI hard disk capacity in ten hard disk drives—plus multiple tape offerings—the x250 offers high-availability features that can't be beat.

Rack-Optimized Servers

The **x300**, at just **1U** high, is a value-packed server at an entry-level price. It offers a choice of **one** Intel **Celeron** or **Pentium III** processor, up to **1.5GB** of ECC RAM, **80GB** of **IDE** hard disk storage (or up to **72.8GB** of Ultra160 **SCSI** storage using an optional SCSI adapter) in two drive bays (a third bay is available for other devices), **two** PCI slots (**one** available in SCSI models), and integrated **dual** 10/100 Ethernet controllers. Up to **42** x330 servers can be installed in a standard 42U rack, providing 42 processors and up to **3.06TB** of SCSI or **3.36TB** of IDE storage per rack.

The **x330** provides leadership features in a rack-dense **1U** package, including **Cable Chaining Technology** (C2T), Light Path Diagnostics an integrated Advanced System Management processor, and integrated **dual** 10/100 Ethernet adapters. It supports up to **two** Pentium III processors, **4GB** of ECC memory, **two** PCI slots, and **72.8GB** of Ultra160 SCSI disk space in **two hot swap** drive bays (leaving **one** non-hot-swap bay available for other devices). PFA support is included for hard disk drives, processors, memory, VRMs and fans. Like the x300, up to **42** x330 servers can be installed in an industry-standard rack, supporting up to **84** processors and **3.06TB** of disk storage per rack.

The **x340** is a sleek **3U** rack-mounted **2-way** Pentium III workhorse. It has room for **three** hard disk drives and **109.2GB** of Ultra160 SCSI hard disk space (up to **six** drives and **218.4GB** with an optional internal expansion kit), **4GB** of ECC memory, and **five** PCI slots. The x340 includes PFA support for hard disk drives, processors, memory, VRMs and fans . Up to **14** x340 servers can fit in a standard rack .

	The **x350** is a high-speed **4-way** Pentium III **Xeon** enterprise server in a **4U** rack-optimized package. The x350 supports up to **16GB** of **Chipkill** memory, **six Active PCI** slots, and **three** disk drive bays containing **109.2GB** of internal SCSI hard disk drive storage (up to **218.4GB** with an optional expansion kit). PFA support is provided for hard disk drives, processors, memory, VRMs, fans and power supplies.
	The **x370** is a high-performance **8-way** Pentium III **Xeon** enterprise server built to tame even the most demanding applications. With **12 Active PCI** slots, support for up to **32GB** of ECC memory and **two** Ultra2 SCSI hard disk drives totaling **72.8GB** of internal storage, the server easily handles data-intensive processing tasks. It includes PFA support for hard disk drives, processors, memory, VRMs, fans and power supplies. The Storage Area Network (SAN)-optimized design supports both SCSI and Fibre Channel solutions, for **terabytes** of *external* disk storage. This makes the **8U** x370 ideal for mission-critical business solutions. (The rack design can be converted to tower use, if needed.)

IBM Service and Support

IBM, with over 40 years of service and support expertise, provides unrivaled service and enterprise-class support for all customers of xSeries servers. Now more than ever, time is money. When you need answers, you need them quickly. IBM is committed to giving you a fast response for all your information and service needs on xSeries systems. The key to advanced service and support is enabling xSeries servers with features—such as Advanced System Management processors, Predictive Failure Analysis (PFA) and IBM Director software—that allow for enhanced service and support.

The IBM three-year onsite limited warranty[15] for most xSeries models provides hardware problem-determination onsite and remotely, with the latest IBM technology and tools. Labor and IBM parts are covered for the full duration of the warranty period, including parts identified during PFA and the installation of required engineering changes. This limited warranty offers far more than the typical industry-standard warranty. International warranty service is also available. And the IBM warranty supports you 24 hours a day, seven days a week.[16] Going far beyond merely providing a warranty and technical support, IBM offers an unparalleled breadth of testing, consulting services and other service and support offerings. These include:

Electronic Service Agent. This innovative "call home" feature allows xSeries servers to immediately and automatically place a service call to IBM support, which can dispatch onsite service if necessary. The Electronic Service Agent (ESA) provides proactive electronic support and problem management capabilities through a secure electronic dialogue between your systems and IBM. ESA monitors your networked servers for hardware errors and has an integrated performance monitor function that automatically collects system utilization information. ESA can also perform hardware and software inventories and reports inventory changes to IBM. All information sent to IBM is stored in a secure database and used for improved problem determination.

IBM HelpCenter®**.** More than 1,800 support specialists comprise the award-winning IBM HelpCenter. These specialists can answer your questions about IBM servers, network equipment, storage options and other IBM products—in 22 languages. The IBM HelpCenter also handles

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[15] For terms and conditions or copies of the IBM Statement of Limited Warranty, call 1 800 772-2227 in the U.S. In Canada call 1 800 426-2255. Telephone support may be subject to additional charges. With respect to onsite service, IBM sends a technician after attempting to resolve the problem remotely.

[16] Response time varies. May exclude some holidays.

OEM operating systems and applications supported on IBM systems. You can reach IBM experts by phone, fax and the Internet, including interactive Web-based forums monitored by IBM specialists. The HelpCenter is available 24 hours a day, seven days a week, 365 days a year, and spans 12 facilities around the world[17] that provide backup and overflow support for one another as needed. A single, centralized database helps IBM technicians share customer information and solutions worldwide to provide fast, accurate responses to customers. We're there when you need us.

IBM ServerProven® program. The IBM ServerProven[12] software solutions program focuses on validating application solutions and hardware options in collaboration with vendors. This validation reduces integration risks, helps ensure smoother installation and reduces the need for post-implementation support. To date, more than 2,500 business applications from more than 600 worldwide vendors—including e-business, Web commerce, Web collaboration and messaging, ERP, CRM, accounting, financial management, healthcare, distribution, manufacturing, retail, telephony, construction and property management solutions—have earned the IBM ServerProven emblem, indicating that the software has been validated for specific, real-world configurations.

The ServerProven program[18] supports leading network operating systems, including Microsoft Windows NT® and Windows 2000. The ServerProven program also includes an extensive selection of compatibility-tested options for xSeries servers that are easy to install and use.

IBM ClusterProven™ program. The IBM ClusterProven program[19] defines technical and functional requirements for high-availability clustering solutions, allowing solution developers to validate complete configurations for IBM cluster servers. This includes IBM @server xSeries hardware, operating systems, clustering middleware and application software. These solutions can take advantage of clustering to enable additional capabilities in that environment.

The IBM ClusterProven program[20] is part of an ongoing, strategic effort to achieve continuous system application availability. This cross-platform initiative demonstrates the commitment IBM and other leading solution developers have made to high availability and support of clustered servers.

Cluster registration. When IBM Business Partners install a cluster solution at your location, they register that solution with the IBM HelpCenter. IBM is committed to offering faster service by placing trained cluster technicians near your location, helping ensure minimal network downtime in the event your system fails. It also lets us notify you of important information relevant to your environment and proactively prevent outages.

IBM @server Certification[21] (via the TechConnect® Program). More than 10,000 IBM and Business Partner specialists have been rigorously trained in the IBM @server Certification program for xSeries servers.

Worldwide IBM service. If you should ever need assistance from trained technicians, more than 132,000 IBM service professionals are available to perform service in 164 countries.

Maintenance parts. When you need replacement parts you can't afford to wait, so IBM makes sure that parts are available from 471 stocking locations worldwide, helping you get your servers back up and running quickly.

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[17] HelpCenter response times vary and support hours may vary by geography.

[18] Go to http://**ibm.com**/pc/compat/serverproven/index.htm for more information about the ServerProven program, including a list of compatible products.

[19] IBM makes no warranties, express or implied, regarding non-IBM products and services that are ServerProven or ClusterProven, including but not limited to the implied warranties of merchantability and fitness for particular purpose. These products are offered and warranted solely by third parties.

[20] Refer to http://**ibm.com**/servers/clusters for more on the ClusterProven program.
[21] For more on TechConnect support deliverables go to http://**ibm.com**/pc/techconnect/overview/index.html.

IBM Global Services. IBM Global Services has a commitment to providing open, vendor-neutral solutions that fit a company's technology profile and address short- and long-term business objectives. From early consulting, planning and design through integration and testing, IBM Global Services can offer custom-contract services for configuration, installation, tuning, remote maintenance operations and monitoring for your clustered systems to maximize the benefits of information sharing across the enterprise. Service offerings include:

- **IBM Global Services consultants.** IGS is the largest IT consulting services operation in the world. IBM Global Services[22] business and technology consultants understand the key role that an IT infrastructure must play to enable business-critical applications such as e-business, customer relationship management, supply chain reengineering and business intelligence**.** They can help you plan a transition from Windows NT to Windows 2000, set up and optimize a clustering solution, design an entire network or even run your IT organization. And they can offer business recovery services in case of a disaster. Recent billion dollar-plus outsourcing contracts signed by IGS include AT&T, the Bank of Scotland, Boeing, Dell (yes, Dell) and Nissan North America.

- **IBM ServicePac** — IBM ServicePac is a family of prepackaged technology services provided by IGS that are easy to purchase, affordable and available in convenient configurations. Each service offering comes complete with a well-designed scope of service, service agreement terms and conditions and easy instructions. ServicePac packages are available for warranty upgrades to 9/5 (nine hours a day, five days a week) and 24/7 with onsite response times of two and four hours, respectively. Installation services are also available to help you get up and running quickly. ServicePac services for xSeries servers address the need to provide end-to-end suites of services that improve your ability to conduct business. These services range from planning, installation, integration and migration to high availability, LAN management, asset management, performance management and capacity planning. Backup and recovery services can also be provided as part of IBM service and support for xSeries servers. These services are customized to meet your needs. For details, see the High Availability Services topic.

- **Solution Assurance** — Solution Assurance is an IBM process that includes technical examination of a proposed xSeries server solution by IT subject-matter experts to help ensure that the proposed solution will meet your business requirements, will meet performance objectives, is technically viable and that all the solution components are compatible: hardware, software and services. Solution Assurance includes an in-depth analysis of the proposed solution and its adoption into your environment and a review of other business-critical needs, including skills assessment, backup/recovery procedures and disaster recovery planning, security planning, and many others. The Solution Assurance team assesses the overall risks of the specific implementation and creates action plans for reducing risk factors.

IBM High Availability Services

The optional IBM Global Services High Availability Services[23] offering is an extension of the xSeries hardware and software features designed to help you achieve your business-critical availability objectives.

For decades IBM has built a business of providing mission-critical, high-availability solutions. IBM has made a commitment to provide these solutions across all @server hardware platforms and the services organization. IBM recently introduced a number of cross-server initiatives and

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[22] See http://**ibm.com**/services for more on IGS consulting services.
[23] The High Availability Services for Business Critical Systems offering is an optional service in the U.S and selected other countries. On the @server xSeries platform, it is offered only for eligible xSeries environments at this time. IBM reserves the right to change the terms and conditions of the offering at any time without notice. Refer to http://**ibm.com**/services/its/us/highavail2.html for more details.

programs designed to further enhance server and application reliability, and has also introduced new services that address high availability end-to-end.

Underscoring the importance of services in achieving maximum availability, IBM Global Services offers an unmatched suite of high-availability services across all @server platforms. With a comprehensive High Availability Services portfolio, IBM can perform readiness workshops and availability assessments and deliver recommendations that clearly identify inhibitors to achieving your business-critical availability objectives. IBM can then offer a tailored packaged solution to address those availability inhibitors. IBM High Availability Services provides a strategy for implementing a tailored solution for each individual customer's business availability goals. IBM recently announced the third stage in a series of five planned announcements that address customers' demand for customized high-availability services.

IBM delivers High Availability Services in a phased approach with an Availability Readiness Workshop, the Availability Assessment—a tailored packaged solution mapped to the assessment recommendations—and now, if a customer's business requires, a service level agreement for availability guarantees[24] on eligible @server platforms. When a High Availability Solution is proposed, consideration must be given to the cost of downtime and your business-critical availability goals, balanced with the affordability of the solution. Achieving true high availability is an individual customer's business decision and should be part of the overall IT business strategy.

The High Availability Solutions package consists of a tailored selection of services and capabilities designed to help you improve the availability of your business-critical systems and environment. The services and capabilities proposed fall into three broad categories:

- **Prevention** — Preventing problems by planning and designing the IT environment for high availability. This includes proactive identification of potential problems with system configurations and data flow design that is focused on eliminating single points of failure.

- **Best practices management** — Ensuring that tested management procedures and disciplines are in place to manage the environment and the day-to-day operational processes and resources.

- **Resolution** — Ensuring that rapid resolution capability, skills and tested processes exist for any potential failure that threatens availability.

Conclusion

If you are in the market for a server for Microsoft Exchange 2000 Server with industry-leading high-availability features, ease of manageability, the scalability to grow along with your business and the flexibility to be used in multiple configurations @server xSeries systems are right for you.

Reliability and serviceability technologies like Active PCI, Advanced System Management, Chipkill memory, hot-add/hot-swap components, Light Path Diagnostics, Predictive Failure Analysis and Software Rejuvenation help keep your xSeries servers up and running and minimize outages.

Manageability features such as Capacity Manager, Cluster Manager, RAID Manager, Rack Manager, ServerGuide, System Installation Tool Kit and Update Connector Manager—to name a few—help simplify the setup, administration and fine-tuning of xSeries servers and the deployment of clients.

Scalability features, including multiple processors, additional power supplies and fans, lots of memory and internal disk storage, terabytes of external storage in SCSI or Fibre Channel

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[24] The High Availability Services for Business Critical Systems now offers a *service level agreement for an availability guarantee* on eligible @server xSeries environments. IBM reserves the right to change the terms and conditions of the offering at any time without notice.

expansion units and several choices of high-speed, high-capacity tape drives mean that as your Exchange 2000 Server requirements grow, so can your xSeries servers.

Finally, xSeries servers give you the flexibility to start out with a single deskside tower unit and grow to a multiunit rack implementation as your needs increase.

All this, plus the optional IBM High Availability Services and other service and support options give xSeries systems the competitive edge over other Intel architecture servers. When you require a server, you need one that will not let you down. With all these advantages, you can't go wrong with IBM @server xSeries servers.

Additional Information

Visit our Web site at http://**ibm.com**/eserver/xseries for more information on IBM @server xSeries servers directions, products and services. From the xSeries home page, select **Library** and you will see links to the different types of documentation available.

Go to *http://microsoft.com/exchange* for information about Microsoft Exchange 2000 Server.