IBM @server BladeCenter
And Citrix MetaFrame Presentation Server

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Introduction

Citrix MetaFrame in conjunction with Microsoft Windows Terminal Services permits users to run Windows-based applications from virtually any client on any computer using nearly any connection. This paper contains testing results and sizing recommendations for deploying Citrix MetaFrame on IBM @server BladeCenter systems. This testing was done in conjunction with Citrix in the IBM Solutions Enablement Performance Center in Research Triangle Park, North Carolina.

Citrix MetaFrame server software leverages existing IT investments while minimizing the cost of re-engineering. It provides a non-intrusive solution that allows the enterprise to regain control of applications and realize significant savings. This proven server-based computing solution reduces complexity, centralizes management and easily scales to accommodate corporate change, advancements in technology and expanding user needs.

In a server-based computing environment, application execution and data processing occur on centralized servers. These servers can be running either Windows 2000 Server or Windows Server 2003. Citrix MetaFrame software integrates and manages these server environments, creating a farm of resources presented to the user under one consistent interface, and providing a common framework to deploy applications to users.

For more information on products and features of Citrix MetaFrame, please visit http://www.citrix.com.

To successfully deploy applications, it is necessary to determine requirements for the systems that will be hosting the applications. This can be determined by answering simple questions:
- What hardware is needed to support *n* users?
- How many users will a specific piece of hardware support?

The results and analyses contained in this white paper address these issues although they should not be interpreted in isolation. There are many factors to consider in a complex, server-based computing model. Sizing and capacity planning need to apply to all parts of the model, from the MetaFrame servers to the users themselves.

Citrix MetaFrame Access Suite

Built on one of the most widely deployed presentation servers – Citrix® MetaFrame XP™ – the Citrix® MetaFrame® Access Suite is enterprise access infrastructure software that centralizes access to applications and information. MetaFrame Access Suite enables your IT staff to centrally provision, manage and support highly secure access to Windows, Web, and UNIX applications and information across the Internet, intranets, extranets, wide-area networks, local-area networks and wireless networks.

Citrix MetaFrame XP Presentation Server

The foundation of the Citrix MetaFrame® Access Suite, Citrix MetaFrame XP Presentation Server is one of the most widely deployed presentation servers for centrally managing Windows®, Web and legacy applications and delivering their functionality as a service to workers, wherever they may be.

MetaFrame XP Presentation Server is certified by Citrix to run on Windows 2000 and 2003 Servers, and supports virtually any custom or commercially packaged Windows application. MetaFrame XP Presentation Server provides an exceptional foundation to build a highly scalable, flexible, secure, manageable access solution that can help reduce computing costs and increase the utility of any information system.

Citrix MetaFrame XP Presentation Server for Windows offers three tailored solutions that address the needs of organizations of all sizes:

Version	Product Highlights	Typical Environments
Standard Edition	- Single Server Operation - Citrix Management Console - Centralized Printer Management - Centralized License Management - Active Directory Support - Advanced Shadowing - Client Time Zone Support - Web Interface	One server deploys applications for a small-to-medium sized company.
Advanced Edition	XPs features and: - Multiple Server Operation - Advanced Load Management	Large to enterprise server farms consisting of many servers.
Enterprise Edition	XPa features and: - Application Packaging & Delivery - Network Management - System Monitoring & Analysis	Large to enterprise server farms consisting of many servers. Additional tools are necessary to assist with management and application deployment.

IBM @server BladeCenter

The IBM @server BladeCenter is a 7U (12.25") modular chassis that is capable of housing up to 14 blade servers. The BladeCenter chassis allows individual blades to share resources such as power, switch, management and blower modules. The front view of the BladeCenter chassis is shown below:

From this, we can see the 14 slots; in this example, these have been populated by a single HS20 blade server and 13 processor blade fillers. These processor blade fillers are required if a slot is not populated by a blade server. The BladeCenter media tray is also shown; it is located at the top of the chassis above the blade slots.

The media tray is a hot-pluggable unit that contains an interface card, CD-ROM, and diskette drive. Mounted on the interface card is a USB 1.1 port and system information LEDs which provide status information for your IBM @server BladeCenter and BladeCenter server blades.

Overall, the key features of the IBM @server BladeCenter are the following:
- Rack-optimized, 7U modular design enclosure – Holds up to 14 hot-swap BladeCenter HS20 or JS20 blades or seven HS20 blades, with up to six enclosures in a 42U rack.
- Contains a high availability mid-plane supporting the hot-swap of individual blades.
- Two 1800-watt, hot-swap power modules and support for two optional 1800-watt power modules – provides redundancy and power for robust configurations.
- Two hot-swap 325 CFM blowers and thermal sensors throughout to monitor and alert of over-temperature conditions.
- Management module – lets you manage and control components in the enclosure.
- Optional hot-swap redundant Ethernet and Fibre Channel switch modules (supports up to four network switch modules).
- Control panel – contains USB port and status LEDs.

BladeCenter HS20

The IBM @server BladeCenter HS20 blades are high-throughput, two-way SMP-capable Xeon-based blade servers, highly scalable by adding memory and a second processor. Two Intel Xeon DP connectors are standard on the blade board to support installation of a second processor. High-speed, PC2100 DDR SDRAM is synchronized for 533MHz processor-to-memory subsystem performance with current processors. There are four memory DIMM connectors; due to two-way interleaving, installation of memory options in pairs is required. Current memory options are 256 MB, 512 MB, 1 GB, and 2GB size DIMM's, which support a minimum of 512 MB and a maximum of 8 GB of system memory.

The picture below shows the layout of the BladeCenter HS20:

The IBM @server BladeCenter HS20 features:
- A choice of up to 3.2 GHz Intel Xeon DP processors with a 533 MHz front-side bus (FSB) and full-speed 1 MB ECC L2 cache.
- Standard 512 MB or 1 GB system memory with Chipkill ECC support – Supports 8 GB maximum.
- Dual Broadcom 5703 Gigabit Ethernet controllers with teaming and failover support.
- Integrated service processor – monitors critical components on each blade for remote and local systems management.
- ATA-100 IDE controller – economical interface for up to two optional 40 GB IDE hard disk drives. ATA interface supports RAID-1 (mirroring) of the IDE drives.
- SCSI expansion connector – supports optional storage unit containing an Ultra320 RAID 1 SCSI controller and backplane support for two hot-swap hard disk drives.

BladeCenter HS40

Recently announced by IBM, the IBM @server BladeCenter HS40 an excellent complement to the HS20, providing four-way SMP-capable Xeon-based blade servers. A single Intel Xeon MP processor is standard on the blade board, with support of installation of up to four processors. High-speed, PC2100 DDR SDRAM is synchronized for 400MHz processor-to-memory subsystem performance with current processors. There are eight memory DIMM connectors; due to two-way interleaving, installation of memory options in pairs is required. Current memory options are 512 MB, 1 GB, and 2 GB size DIMM's, which support a minimum of 1 GB and a maximum of 16 GB of system memory.

The picture below shows an image of the BladeCenter HS40:

The IBM @server BladeCenter HS40 features:
- A choice of up to four 2.8 GHz Intel Xeon MP processors with a 400 MHz front-side bus (FSB) and full-speed 2 MB ECC L3 cache.
- Standard 2 GB system memory with Chipkill ECC support – Supports 16 GB maximum.
- Four Intel Gigabit Ethernet controllers with teaming and failover support.
- Integrated service processor – monitors critical components on each blade for remote and local systems management.
- SCSI expansion connector – supports optional storage unit containing an Ultra320 RAID 1 SCSI controller and backplane support for two hot-swap hard disk drives.

Test Results

The following describes the hardware and software used in our testing, as well as the results.

Test Hardware

Our test hardware and software configuration was as follows:

Component	Description
System Model	**IBM BladeCenter HS20**
Processor	**2 x Intel Xeon DP 2.4 GHz**
Hyper-Threading	**Enabled**
Memory	**4 GB (4 x 1 GB DIMM)**
Hard Disk Drive	**System #1 1 – 40 GB IDE HDD** **System #2 1 – 18 GB 15K RPM SCSI HDD**
Network	**2 x Broadcom Gigabit Ethernet**
Operating System	**Windows Server 2003 Enterprise Edition**
Version of MetaFrame	**Citrix MetaFrame XP 1.0 for Windows, Feature Release 3 / Service Pack 3**
Application Software	**Microsoft Office 2000**

All page files were on the local C: drive and all user profiles were stored locally on the system. Systems were installed in a workgroup environment. Windows Server 2003 was installed in application server mode with relaxed security, and Citrix MetaFrame XPe was used with all default settings. The Citrix MetaFrame data store was stored on a separate server using Windows 2000 Server and Microsoft SQL Server 2000.

Client Machines

The user environment was simulated using a variety of IBM @server xSeries 300 systems as clients. These systems were equipped with either an 800 MHz Intel Celeron processor or a 1 GHz Intel Pentium III processor. Each client had at least 256 MB of memory and was connected to the network at 100 Mbps.
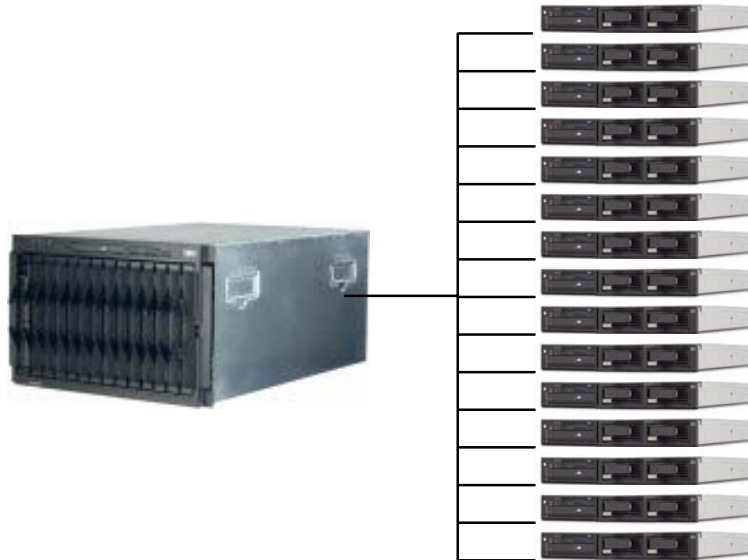
Results

The chart below summarizes the results of our testing.
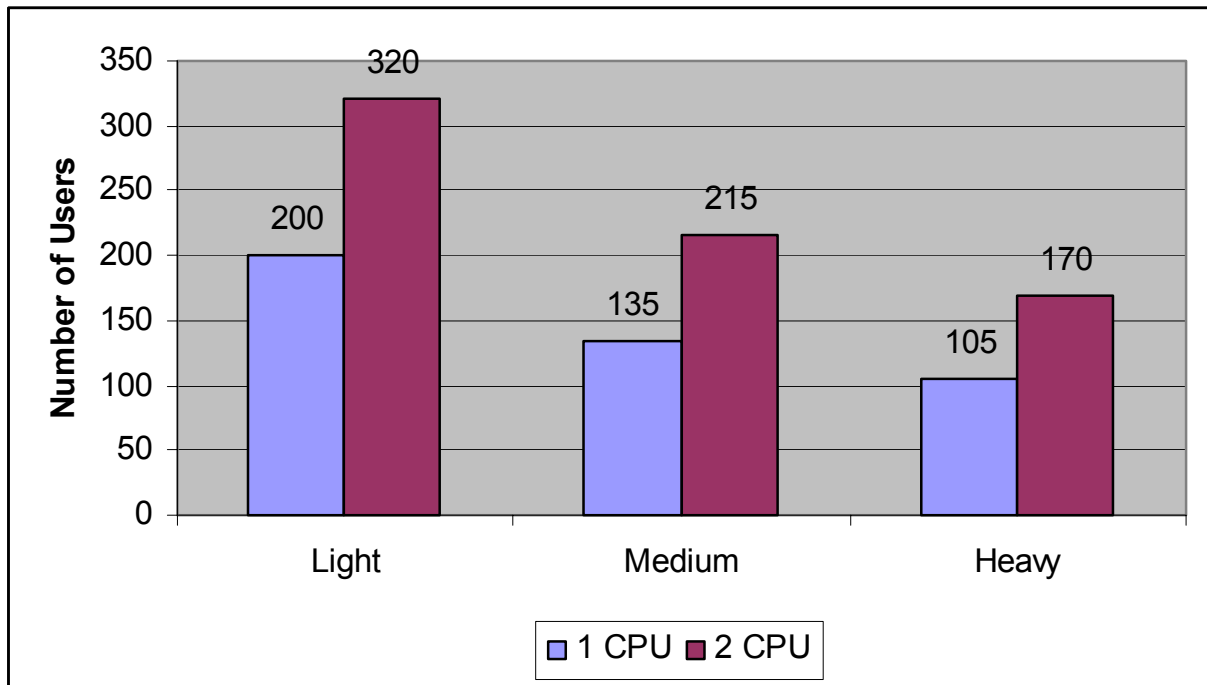
In general, we found excellent scaling between 1 and 2-way systems, up to the limitation of the memory installed in each system. In every case the advances made in Windows Server 2003 allowed us to scale well past the limitations that were in Windows 2000 Server due to Page Table Entries.

Determining CPU Requirements

While many people consider the speed (in megahertz) of the CPU to be the most important factor in determining the performance of a server, in many cases this is not true. In the case of Citrix, memory is the most critical component of the solution. However, the speed of the CPU does play a crucial role.

The chart below tells us much about the CPU scaling of a MetaFrame solution:
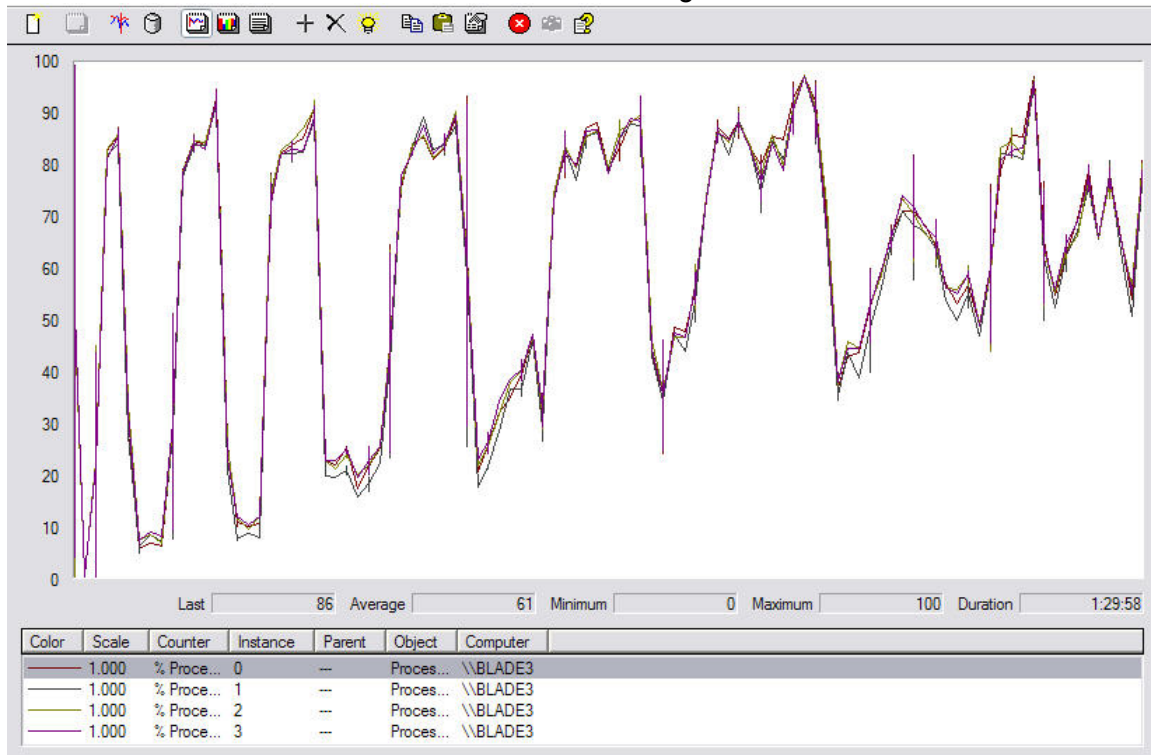
From this chart we can deduce two things. First is that we see four CPUs in our test system. This is due to Intel's hyper-threading technology, which is present in the Xeon DP processors used by the HS20. As we can see, with hyper-threading enabled we get even scaling with all four processors. There is no spiking or anything to show us that hyper-threading is hurting our solution. Therefore, we recommend that hyper-threading be enabled for your MetaFrame solution.

What we can also see from our chart are the two things that need to be considered when sizing your processors for your MetaFrame solution. And that is sustained CPU utilization (i.e. when users are doing work) versus peak CPU utilization (such as when users log in). In our chart above we can see the effects of log in, when CPU utilization increased to 90% of higher for a period of time, and then decreased to a lower utilization once the users are completely logged in. Therefore, our recommendation is that, if possible, you size for peak workload, with no more than 80% CPU utilization under sustained workload.

CPU utilization is also a direct effect of the amount of memory that you have in the system. If there is not enough memory in the system, portions of the working set will be

paged out to disk, causing additional CPU utilization both for the paging operation and for the fact that the CPU's may now be waiting for information to be paged to disk before any other instructions can be completed.

2-way versus 4-way

While our testing involved only the HS20 in a 1-way and 2-way configuration, there are many questions on whether it is worthwhile to deploy MetaFrame on a 4-way system. From our testing, while it is very possible to deploy MetaFrame on a 4-way system there is not enough value to justify the solution, given that the amount of memory required is the main concern, and not the availability of more processors or a larger processor cache. Therefore, we recommend only deploying MetaFrame on systems no larger than 2-way.

Front Side Bus

Due to the importance of memory in a MetaFrame solution, the most critical component of the solution is not the speed of the CPU, but the speed of the Front Side Bus (FSB). As the greatest concern is the speed to be able to access memory, the ability to have a faster FSB will greatly improve the experience for your users. Currently, the HS20 is available with a 533MHz FSB. If possible, we recommend the greatest FSB speed possible to be utilized in the MetaFrame solution.

Determining Memory Requirements

Determining the proper amount of memory required for a server-based computing solution is probably the most difficult aspect of the entire environment.

At the simplest level, it is possible to install a system, install the operating system and MetaFrame, and then install the application and connect to the application via a MetaFrame session. You can then measure how much memory an application has committed – which is the memory that the operating system has guaranteed that this application can access. The problem with this is, of course, that the application may not necessarily use all of the memory allocated to it, especially at any one point in time.

The portion of memory that an application is currently using (or has accessed recently) is called the working set of that application. As the operating system, by design, is permitted to page the memory outside of an applications working set, without any degradation of the running of the application, this can be considered a better measure of the amount of memory that is actually needed by an application, as opposed to looking at how much total memory that application requires.

The difficulty in sizing the proper working set of an application comes from the nature of the operating system. When physical memory is abundant, pages outside the working set are left in memory, even if they are not being used. As physical memory becomes scarce, those pages not being used now begin to be paged to the page file. Finally, when physical memory is exhausted, memory inside the working set is now paged out to disk. This is when what is called 'disk thrashing' occurs, as memory that is part of the working set is constantly paged in and out of memory.

So, how do we go about determining the proper memory requirements for a server? We begin by determining the memory required by the operating system and MetaFrame, which is 256 MB for the operating system (as recommended by Microsoft) and 64 MB for MetaFrame (as recommended by Citrix). From here we can begin to determine the amount of memory required for our applications and our users.

From our testing, we can see that a basic Office user (running an application such as Microsoft Excel or Word) utilizes around 4 MB of RAM per user. A user running more intensive applications, such as Internet Explorer, can utilize up to 20 MB to 30 MB. But, what does this tell us amount the amount of users we can support? Using basic numbers like these, and a recommendation that average memory utilization average around 70%, we can come up with a formula to determine the amount of memory required. That is:

> Maximum amount of users = (Maximum server memory in MB – 320 MB) x 0.7 / RAM required in MB per user.

So, for example, given a system with 2.5 GB of memory and an application set requiring 24 MB of memory per user, with 70% memory utilization we would have:

> Maximum amount of users = (2560 - 320) * 0.7 / 24 = 65.3 users that can be supported.

This assumes that all working set data will be kept in physical memory, and no paging to occur. While this is best for performance, it may not be the best from a cost perspective, as this assumes that everything is kept in memory.

But, how do we determine the amount of the working set that can safely be paged to disk? This can only be done by testing your user environment in a memory constrained system, such as one with a minimal (512 MB or so) amount of memory. Unfortunately, there is no good answer on when to stop, or when active portions of the working set are now being paged to disk. This can only be done by talking to your users, and learning when they "feel" the system has become too slow for acceptable performance.

Determining Disk Requirements

The IBM @server BladeCenter HS20 has three options for hard disk drive storage. These are:

- IDE – Either 1 or 2 40 GB 5400 RPM ATA-100 IDE hard disk drives
- SCSI – Either 1 or 2 SCSI Hard Disk Drives attached to the HS20 via the HS20 SCSI Storage Expansion Unit. This unit supports up to 2 - 146GB, 10,000 RPM hard disk drives up to 2 – 73GB, 15,000rpm hard disk drives.
- Fibre Channel – the HS20 supports attachment of a Fibre Channel daughter card directly to the HS20. Using this adapter and the BladeCenter 2-port Fibre Channel Switch Module a 2GB / second Fibre Channel connection can be made to either a 3rd party storage array or an IBM TotalStorage FAStT.

When determining the disk requirements for your MetaFrame solution, care needs to be taken relative to the speed of the hard disk drive that the data will be stored on. In normal operation, there should be little to no paging occurring to disk, as described in the "Determining Memory Requirements" section. Therefore, in this environment the rotational speed of the disk drive is not an issue.

Care does need to be taken, however, when memory is either not sufficient for the workload, or that additional burdens are not placed on the hard disk drives, such as storing user data or application data. When this occurs, a disk bottleneck is almost guaranteed.

For example, here is a system with only 1024 MB of RAM:
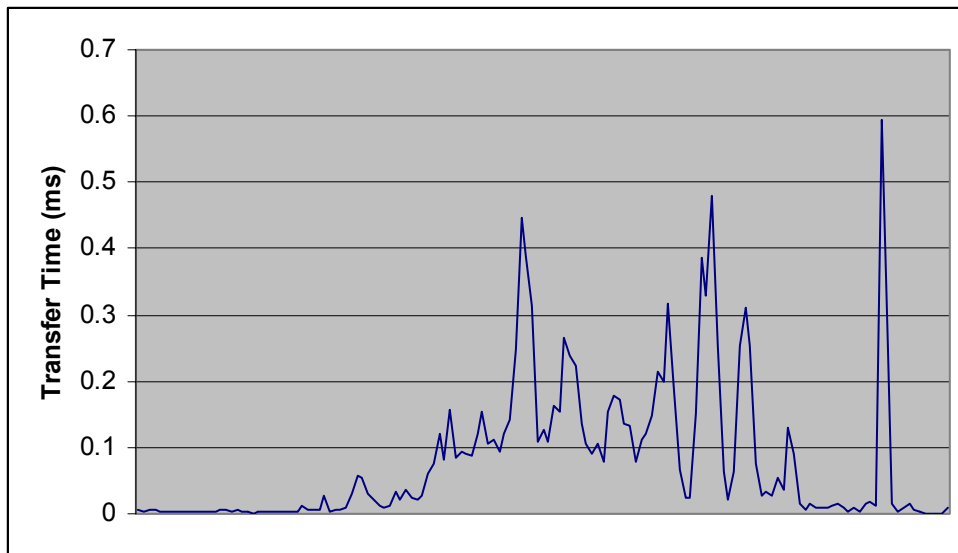
As you can see, once memory was exhausted as the workload was increased disk paging began to occur and the working set of each user was paged to disk. This paging increased as memory became more and more constrained until performance of the entire system was constrained by the performance of the disk. In our example, we were using a single 40 GB IDE disk. Utilizing a SCSI disk in this scenario would have made the "curve" more smooth, but still would not have eliminated the bottleneck in question.

In general, the size of the disk is not an issue, as disk sizes have increased such that there is no issue with containing all of the operating system and application software on a single hard file. What has increased is the need for recovery / backup and for performance.

Basic recommendations

Our testing showed that, when the system is configured with enough physical memory, the disk no longer becomes a significant factor in the sizing and performance of the system. Based upon this, in most situations we would recommend using the IDE hard disk drive option with the HS20 server blades. This gives you adequate performance with the maximum of space available. As well, with the recent introduction of the ability to utilize RAID 1 (Mirroring) with the internal IDE drives of the HS20 we now have a solution that gives both price/performance and redundancy is a small form-factor and at a very low cost.

However, the utilization of RAID 1 IDE drives does cost us the usage of the second drive connection to connection to other devices such as additional networking or Fibre Channel. Therefore, if you have an existing Fibre Channel storage infrastructure we recommend using a single IDE drive to house your operating system and applications, and through the use of the Fibre Channel daughter card utilize your existing storage infrastructure for all other data. This gives you the ability to local boot your system, but the availability and performance of Fibre Channel for your most important data.

Finally, the ability to use SCSI should be reserved for those environments where the ability to have hot-swap drives local to each system and the capacity of SCSI is paramount. Again, RAID 1 capabilities can be utilized here as in the IDE drive environment.

An important thing to remember is that adding the HS20 SCSI Storage Expansion Unit means that only seven HS20 server blades can be fit into a single chassis. While this is still a outstanding usage of space, a balance needs to be made in whether it is best to transition your blades to SCSI as opposed to IDE, or to instead have the capability to add additional HS20 server blades, or go to the usage of Fibre Channel.

Some other points to remember:
- If possible, place the Windows page file on a dedicated hard disk drive.
- If possible, do not partition physical drives into multiple logical drives.
- If there are requirements to have RAID capabilities, this can be accomplished with either IDE or SCSI hardware RAID, depending on model and disk subsystem chosen. At no time do we recommend using software RAID.

Determining Network Requirements

Typically, network utilization tends to be low in a server-based computing environment. This low utilization is realized by the efficiency of the Citrix ICA protocol, as well as the usage of data compression. ICA is an on-demand protocol. This means that when the screen is static and no key presses, mouse movements or clicks are occurring, no bandwidth is being consumed. This provides for a more efficient use of the network.

As the HS20 is configured with two Broadcom 5703 Gigabit Ethernet adapters, network bandwidth for each individual blade should not be an issue. However, to maximize the efficiency of the adapters it is strongly recommended that the latest Broadcom drivers be utilized in the solution. The latest drivers (7.0.5 at time of writing) can be found at http://www-3.ibm.com/pc/support/site.wss/document.do?lndocid=MIGR-43815.

As stated, network bandwidth of an individual HS20 blade is not a consideration. At 200 users running a basic Microsoft Office application, usage was around a mere 1200 Kbps/Second per user. As our test environment consisted of two 4-port Ethernet switches installed in the BladeCenter chassis, traffic was evenly divided between the two switches, as shown in the figure below:
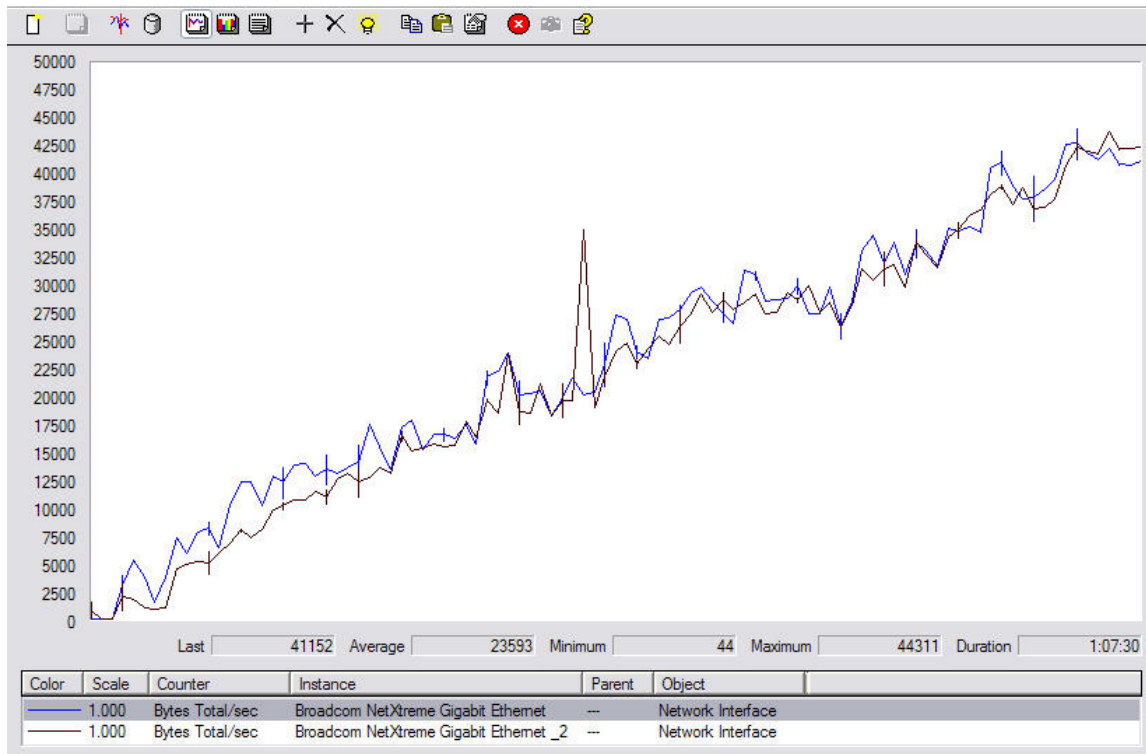

As shown, as users were increased network usage increased in a linear fashion. Note that for our test environment roaming profiles and network file shares were not used, therefore all requests were local to the system. In a typical server-based computing environment you can expect additional network traffic to occur.

Citrix recommends at least 20 Kbps for a typical production environment. However, even using 20 Kbps as our model we find that a single gigabit Ethernet connection will suffice.

One of the advantages of utilizing BladeCenter is its' ability to have network traffic either be directed through two different switches or network paths, as well as the ability to allow for trunking of network traffic. This is due to the design of the BladeCenter, as shown below:
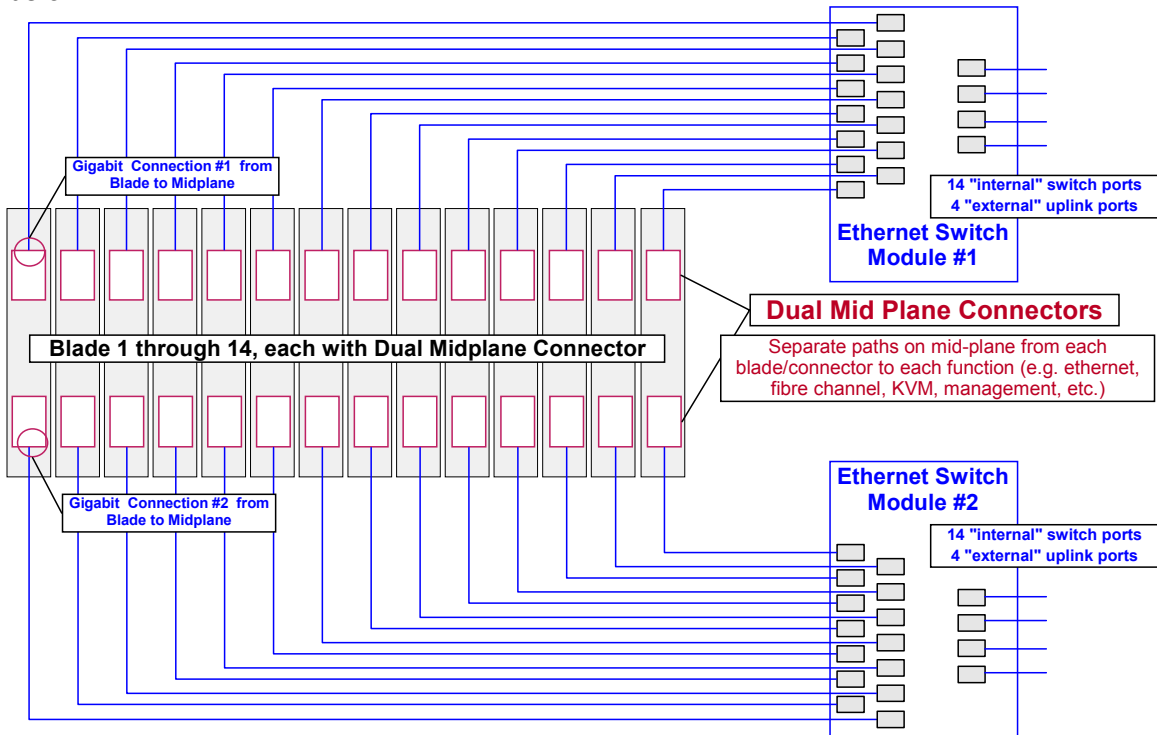
As you can see in the figure above, each HS20 blade has a single connection to Ethernet switch module #1, and one to Ethernet switch module #2. This allows for the ability for traffic to be managed between network segments, as well permitting the ability for the uplink ports to be trunked together, allowing for greater total throughput of the BladeCenter.

In most Citrix environments, a single Ethernet switch will be sufficient due to the ability to run at Gigabit speeds. However, a second switch can be used to provide for redundancy in case of a switch failure, a network cable failure or a chip failure on one of the blades itself.

Performing Additional Capacity Planning Tests

To test or not to test?

The purpose of this document is to give a good starting point from which to make decisions on a Citrix MetaFrame computing environment. It may be more effective to go straight into pilot mode, rather than spend large amounts of resources analyzing users' work habits and capturing these actions from a simulated script.

Once a server configuration is chosen as a starting point (based on this paper's findings), users can gradually be added to determine the maximum number that a system configuration can support. If more server resources are required, it is always possible to add another server to a MetaFrame farm.

As an aid to understanding the various factors involved when deploying application using MetaFrame, the following should also be taken into consideration.

Determining application suitability

Some applications, such as those that make very extensive use of graphics or multimedia capabilities, may not be suited to operating in a server-based computing environment.

If the application is suitable, next a determination needs to be made if it is more appropriate to run the application alone through the MetaFrame server rather than starting an entire desktop session. This can save significant amounts of resources on the MetaFrame server, potentially allowing more users to log in simultaneously.

Characterization of users

Usage patterns need to be considered as they can have a significant performance impact on the MetaFrame server. For example, if all users log in at the same time of day, this will have an impact on the overall system performance. Additional resources may need to be allocated in order to handle peak usage times.

Appendix A – About IBM @server xSeries and BladeCenter Servers

As the world's leading server manufacturer, IBM has the goal of providing the greatest capability possible in an industry-standard server at a price appropriate for your business. If you are using industry-standard technologies, IBM xSeries servers provide you with a reliable foundation for you networked businesses by delivering outstanding power, scalability, control, and service.

On demand computing - information anywhere, anytime - may provide information access to millions of new users and devices. These new capabilities will drive huge requirements onto the back-end systems that support them. Server infrastructures will require new capabilities for communicating and managing ever larger amounts of information in a more dynamic and cost-effective manner than ever before.

In addition, the adoption of e-business technologies for business-to-consumer, Business-to-business and intra-business applications are accelerating; and this is placing higher demands on technology platforms. More significantly, businesses are increasingly turning to industry-standard technologies such as Intel processors along with Microsoft Windows Server 2003 or Linux operating systems for the new e-business foundation.

By building robust capabilities into xSeries servers and working on new technologies to enhance industry-leading capabilities for the future, IBM xSeries X-Architecture addresses these requirements and helps prepare you for the next wave of e-business, on demand. The key to doing this successfully is experience - experience in software and hardware capabilities, experience in procedures and practices, and experience in supporting high-availability platforms. IBM has a long heritage of high-availability platform support, and xSeries is leveraging that experience throughout it's' product line.

For more information about xSeries, please visit http://www.ibm.com/eserver/xseries

Universal Servers

xSeries 205

The ultra-affordable x205 delivers outstanding value and availability to small and medium-sized businesses. Advanced capabilities make the server easy to manage, which can control IT expenses. With such features as Intel Pentium 4 processors with up to 533 MHz front-side bus speeds, optional hot-swap hard disk drives, and 2 GB of memory, the x205 offers incredible price / performance. And with Alert Standard Format (ASF) and IBM Remote Supervisor Adapter II support you have options to insure system availability and remote support 24/7.

For more information on the xSeries 205 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x205.html

xSeries 225

The 2-way x225 provides outstanding value to workgroups by combining scalable performance and new availability features at an affordable price. Designed to support

such environments as file-and-print sharing and workgroup applications, the x225 offers such features as hot-swap hard disk drives, Chipkill memory, and optional redundant power supplies to improve availability.

For more information on the xSeries 225 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x225.html

xSeries 235

This flexible 2-way server, maximized for high availability in distributed environments, supports extreme expandability of more than 1.3 TB of storage. Its industry-leading, high-availability features help deliver maximum uptime. The x235 delivers leading Ultra320 HDD performance with affordable data protection and server availability. The x235 also delivers integrated Ultra320 RAID-1 functionality, which provides the ability to mirror hard disk drives for data protection and even higher server availability. X-Architecture features like Chipkill memory, Active PCI-X technology and hot-swap cooling/power keep your server available when you need it. For flexibility to meet your custom space needs, the x235 offers a tower-to-rack conversion kit.

For more information on the xSeries 235 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x235.html

xSeries 255

This affordable, high-capacity 4-way Intel Xeon MP-based server is designed for businesses with multiple locations or data centers delivers economical high performance and combines high-availability features with tremendous internal storage. Equipped with the latest Intel Xeon MP processors and up to 24GB of Chipkill memory, the x255 supports numerous Enterprise X-Architecture features such as Active Memory, Active PCI-X, and redundant components such as fans and power supplies.

For more information on the xSeries 255 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x255.html

Rack Optimized Servers

xSeries 305

This highly affordable, ultra-dense one-way server, designed for edge-of-network and Web-based systems, is a value-packed, entry-level 1U server. With its' incredibly small 16.75 inch packaging, integrated dual Gigabit Ethernet, and support for the IBM Remote Supervisor Adapter II, the x305 offers both exceptional reliability and performance at a very attractive price point.

For more information on the xSeries 305 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x305.html

xSeries 335

This ultra-dense, 1U, 2-way SMP server helps you do more with less, while helping reduce costs and save space. The x335 packs the latest Intel Xeon DP processors and support for up to 8 GB of Chipkill memory into a sleek, cost efficient package. Support for the latest Ultra 320 hard disk drives and integrated RAID 1 capability give you added performance and redundancy at no additional cost or sacrifice of space. And IBM's

innovative C2T cabling technology can ease setup and eliminate over 120 cables from a full rack of servers.

For more information on the xSeries 335 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x335.html

xSeries 343

The x343 is a high performance, 2-way, fully NEBS compliant carrier grade server optimized for communications infrastructure. Designed for Linux, the xSeries 343 takes telecommunications servers and Next Generation Networks to new levels. Built especially for network equipment providers and service providers, this powerful server is rich in design and functionality. Two Intel Pentium III, 1.266 Ghz processors provide the engine for high compute environments. Featuring a sub-20" deep chassis ideal for space constrained communications environments, the xSeries 343 is also equipped with dual, redundant hot swap DC power supplies for high availability, six PCI slots for extreme expandability and an external alarm panel providing 24x7 surveillance of system outages. Complete with IBM Director systems management software, the x343 is the smart choice for IP-based Next Generation Networks.

For more information on the xSeries 343 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x343.html

xSeries 345

This highly available 2-way 2U server delivers mission-critical performance, expandability and availability for dense data environments. The x345 is packed with the latest Intel® Xeon™ processors supporting 533Mhz FSB, DDR memory, Dual Ultra320 SCSI controllers, support of Ultra320 HDDs, Integrated Dual Gigabit Ethernet and five PCI slots. The x345 is a feature-rich application serving platform for space constrained data centers and application service providers.

For more information on the xSeries 345 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x345.html

xSeries 365

With the xSeries 365, IBM introduces a rack-dense, high-performance 4-way server that combines exceptional price and performance with the datacenter readiness of Enterprise X-Architecture™, creating a powerful new solution for mission-critical enterprise applications.

- Second-generation Enterprise X-Architecture technology with the latest Intel® Xeon™ MP processors
- Exclusive "pay as you grow," remote I/O scalability using RXE-100 I/O expansion chassis
- Flexibility to be used for high performance, value performance or I/O-intensive server applications
- Powerful 4-way SMP in space-efficient, slender 3U form factor
- Large internal storage (up to 876 GB) with support for RAID 1 integrated into the system
- Interoperability with iSeries servers through native IXA-adapter support

For more information on the xSeries 365 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x365.html

xSeries 382

The x382 is a rack-dense, 2U, 2-way Intel Itanium 2 based server optimized for high-performance computing and cluster use. With support to up to 16 GB of RAM, integrated dual Gigabit Ethernet and support for two hot-swap hard disk drives and integrated RAID 1 capability the x382 is ideal for either your first entry into the 64-bit Intel environment or for your most demanding needs.

For more information on the xSeries 382 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x382.html

High-performance Scalable Servers

xSeries 445

IBM takes it to the next level with the xSeries high-performance flagship, the x445! This next-generation scalable enterprise server offers the increased XpandOnDemand™ scalability, industry-leading price/performance, and exceptional mission-critical availability required for today's on demand world. Optimized for server consolidation and high-end databases, the xSeries 445 combines scale-up or scale-out flexibility with the high performance of Intel Xeon MP processors.

Powered by second-generation Enterprise X-Architecture™, this 4U rack-optimized, industry-standard server supports "pay-as-you-grow" scalability up to 16-way by simple interconnection of two xSeries 445 chassis as a single 8U configuration with support for up to 32-way available in the near future. This innovative, modular server architecture delivers the ultimate enterprise solution: high-performance, high-availability, remote manageability, and investment protection.

For more information on the xSeries 445 please visit:
http://www.pc.ibm.com/us/eserver/xseries/x445.html

xSeries 455

The x455 is a leadership Itanium 2 solution that leverages the proven Enterprise X-Architecture chipset to deliver commercially viable 64-bit systems. The x455 builds on the XpandOnDemand building-block architecture. Purchase only the capacity and I/O you need, when you need it, without having to buy costly, underutilized up-front infrastructure.Built in 4U modules, the x455 supports expanability to up to 16-way with over 250GB of memory, offering tremendous power for your high computing applications or databases.

For more information on the xSeries 455, please visit:
http://www.pc.ibm.com/us/eserver/xseries/x455.html

IBM @server BladeCenter

The IBM@server BladeCenter is a 7U (12.25") modular chassis that is capable of housing up to 14 blade servers. The BladeCenter chassis allows individual blades to

share resources such as power, switch, management and blower modules. Key features of BladeCenter are the following:

- Rack-optimized, 7U modular design enclosure–-holds up to 14 hot-swap BladeCenter HS20 or JS20 blades or 7 HS20 blades with up to six enclosures in a 42U rack.
- Contains a high availability midplane supporting the hot-swap of individual blades.
- Two 1800-watt, hot-swap power modules and support for two optional 1800-watt power modules–-provides redundancy and power for robust configurations.
- Two hot-swap 325 CFM blowers and thermal sensors throughout to monitor and alert of over-temperature conditions.
- Management module–-lets you manage and control components in the enclosure.
- Optional hot-swap redundant Ethernet and Fibre Channel switch modules (supports up to four network switch modules).
- Control panel–-contains USB port and status LEDs.

For more information on BladeCenter and the BladeCenter chassis please visit: http://www-1.ibm.com/servers/eserver/bladecenter/chassis/more_info.html

IBM @server BladeCenter HS20

Designed to support the Intel Xeon DP processor, BladeCenter HS20 blades deliver density without sacrificing performance, allowing you to scale your computing needs only when you need it, without having to purchase costly systems or processors up front. Features of the HS20 include:

- A choice of up to 3.2 GHz Intel Xeon DP processors with a quad-pumped 533 MHz front-side bus (FSB) and a full-speed 512 KB or 1 MB ECC L2 cache.
- Standard 512 MB or 1 GB system memory with Chipkill ECC support–-supports 8 GB maximum.
- Dual Broadcom 5703 Gigabit Ethernet controllers with teaming and failover support.
- Integrated service processor–-monitors critical components on each blade for remote and local systems management.
- ATA-100 IDE controller–-economical interface for up to two optional 40GB IDE hard disk drives.
- SCSI expansion connector—supports optional storage unit containing an Ultra320 SCSI RAID 1 controller and backplane support for two hot-swap hard disk drives.

For more information on the BladeCenter HS20 please visit: http://www-1.ibm.com/servers/eserver/bladecenter/hs20/more_info.html

IBM @server BladeCenter HS40

Designed to support the Intel Xeon MP processor, BladeCenter HS40 blades deliver density without sacrificing performance, allowing you to scale your computing needs only when you need it, without having to purchase costly systems or processors up front. Features of the HS40 include:

- A choice of up to four 2.8 GHz Intel Xeon MP processors with a quad-pumped 400 MHz front-side bus (FSB) and a full-speed 2MB ECC L2 cache.

- Standard 2 GB system memory with Chipkill ECC support-–supports 16 GB maximum.
- Four Intel Gigabit Ethernet controllers with teaming and failover support.
- Integrated service processor-–monitors critical components on each blade for remote and local systems management.
- SCSI expansion connector—supports optional storage unit containing an Ultra320 SCSI RAID 1 controller and backplane support for two hot-swap hard disk drives.

For more information on the BladeCenter HS40 please visit: http://www-1.ibm.com/servers/eserver/bladecenter/hs40/more_info.html

IBM @server BladeCenter JS20

Featuring POWER technology and advanced SIMD capabilities, the BladeCenter JS20 is an ideal platform for high performance computing (HPC) environments. With support for two 1.6 GHz PowerPC 970 processors and up to 4GB of RAM, the JS20 can scale to meet your most demanding needs. Integrated dual Gigabit Ethernet and support for multiple IDE hard disk drives round out the package. As well, the JS20 leverages your existing BladeCenter or xSeries investment by using the same tools (IBM Director) that you use today to manage your Intel server, desktop, and laptop environment.

For more information on the BladeCenter JS20 please visit: http://www-1.ibm.com/servers/eserver/bladecenter/js20/more_info.html

Appendix B – Completing the solution with IBM Director and Remote Deployment Manager

As we have demonstrated in this white paper, the combination of IBM eServer BladeCenter and Citrix MetaFrame can be a powerful solution in solving your problems. However, the best systems in the world will not improve productivity if you do not have a way to manage and deploy them. IBM has the solution here with the powerful combination of IBM Director 4.1 and Remote Deployment Manager. Together, these two applications can deploy, monitor, and manage your MetaFrame deployment.

Remote Deployment Manager

IBM Remote Deployment Manager 4.11 is the latest installment in the IBM Systems Management Portfolio of deployment products and is the follow on to the standalone version of RDM 3.x. RDM 4.11 can be purchased as an optional add on to IBM Director. RDM 4.11 smoothly integrates into IBM Director 4.1 providing a consistent look and feel and a single point of control.

This beneficial tool simplifies and automates the deployment, redeployment, lower-level management and disposal of IBM xSeries servers, IBM IntelliStation workstations, IBM ThinkPad laptops, IBM ThinkCentre desktops and IBM Point-of-Sale computers. RDM uses imaging technology from industry leader PowerQuest to provide high performance cloning, recovery, and reprovisioning solutions. This provides back up of the initial image of the server and incremental images of the server.

Because Remote Deployment Manager gains control of a PC before it starts its local operating system, many of the lower-level tasks that previously required a visit to each computer can now be performed over the network. Using Remote Deployment Manager, a network administrator can remotely flash a selected system's BIOS, modify CMOS settings, and perform deployment of the following operating systems:

- Windows 2000 Server
- Windows 2000 Advanced Server
- Windows 2000 Professional
- Red Hat Linux 7.3
- Red Hat Linux 8.0
- Red Hat Enterprise Linux 2.1 Advanced Server (32-bit)
- Windows XP Professional
- Windows Server 2003 Standard Edition
- Windows Server 2003 Enterprise Edition (32-bit)
- Windows Server 2003 Web Edition

To help protect sensitive information when a system is redeployed or retired, Remote Deployment Manager can erase all data on the system's hard drives, making the data as non-recoverable as possible.

Remote Deployment Manager can save your IT staff time and money by enabling deployment, update, maintenance and retirement of systems remotely. It helps make systems management simpler and less time-consuming, thereby helping to lower the total cost of ownership of IBM systems.

For more information on Remote Deployment Manager please visit: http://www-1.ibm.com/servers/eserver/xseries/systems_management/sys_mig ration/rdm.html

IBM Director 4.1

IBM Director is a comprehensive systems-management solution. Based on industry standards, it can be used with most Intel-microprocessor-based systems. IBM Director has features designed expressly to work with the hardware in the following IBM systems and products:

- IBM xSeries servers
- IBM BladeCenter chassis
- IBM HS20 and JS20 blade servers
- IBM ThinkCentre desktop computers
- IBM IntelliStation workstations
- IBM ThinkPad mobile computers
- IBM TotalStorage Network Attached Storage (NAS) products
- IBM SurePOS ™ point-of-sale systems

A powerful suite of tools and utilities, IBM Director automates many of the processes required to manage systems proactively, including capacity planning, asset tracking, preventive maintenance, diagnostic monitoring, troubleshooting, and more. It has a graphical user interface that provides easy access to both local and remote systems.

IBM Director can be used in environments with multiple operating systems (heterogeneous environments) and integrated with robust workgroup and enterprise management software from IBM (such as Tivoli), Computer Associates, Hewlett-Packard, Microsoft, NetIQ, and BMC.

In addition to making available a new version of IBM Director, enhanced extensions to IBM Director will also be available for IBM customers who want advanced capabilities. IBM Director Server Plus Pack consists of five additional tools for advanced server managements to help optimize performance and maximize availability. These tools are tightly integrated with IBM Director for consistent management from a single console.

For more information on IBM Director please visit: http://www-1.ibm.com/servers/eserver/xseries/systems_management/directo r_4.html

Appendix C - Windows Server 2003 Tuning

For the most part, Windows Server 2003 comes very well tuned "out of the box". However, there are some additional tuning characteristics you may want to look at in your MetaFrame environment.

Page File

Windows Server 2003 will automatically size your page file based upon the amount of physical memory that is installed in the system. However, this can cause your page file to potentially become fragmented due to growth. Therefore, it is recommended that the initial and maximum size of the page file be set to the same value.

In addition, the page file should be located on a dedicated physical drive if possible. If this is not possible, then the page file should be located on the C: drive and **NOT** a separate partition on a physical drive. To do so will cause additional latency as the physical disk head has to perform additional seeks.

As far as the size of the page file, the recommendation is double the amount of physical memory in the system – up to 4096MB.

Registry

Our recommendation is to set the registry to 256MB to avoid growth and fragmentation during operation.

Services

All unnecessary services in Windows Server 2003 should be disabled. These may include:
- Automatic Update
- Error Reporting Service
- Help & Support
- Print Spooler
- Protected Storage
- Remote Registry
- Task Scheduler
- System Event Notification
- Windows Time
- Wireless Configuration
- Windows Management Interface

Other

While not specifically a tuning requirement, the following should also be taken into consideration in deploying your MetaFrame environment:
- Roaming Profiles – if possible, profiles should be stored on a dedicated Active Directory Domain Controller and not any of the MetaFrame servers.
- My Documents – you should redirect the user's My Documents folder to a network file share as opposed to being hosted locally on the MetaFrame server.