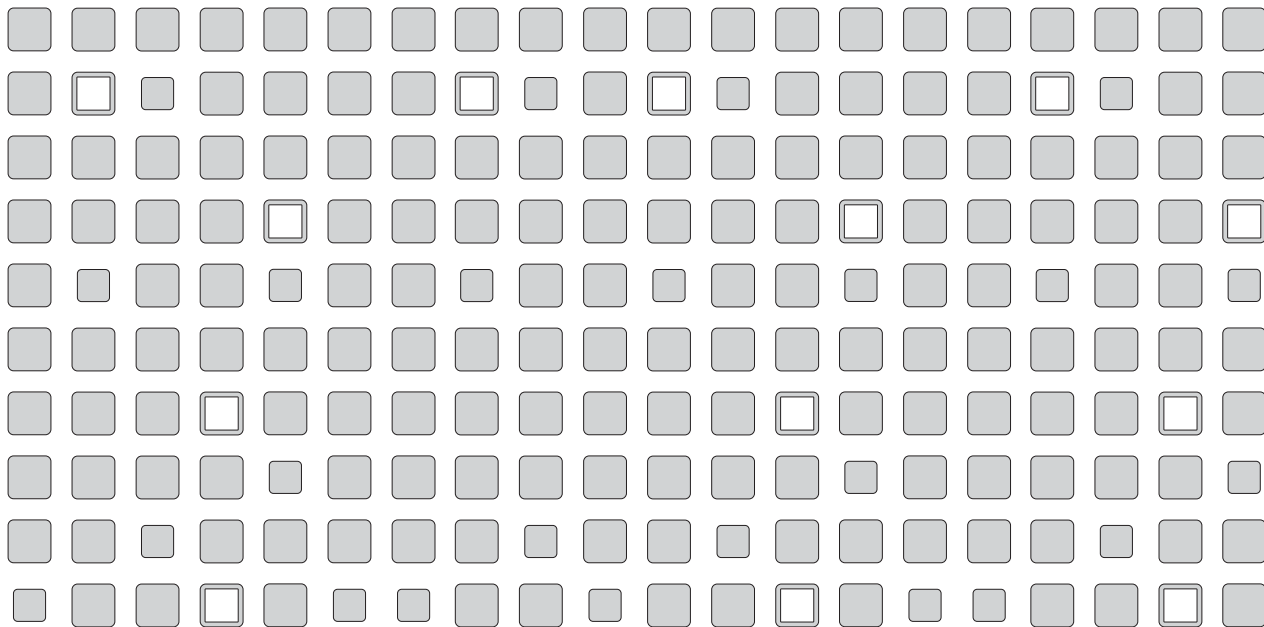


Reference and Capacity Planning with Citrix Presentation Server

ESX Server 2



VMware, Inc.

3145 Porter Drive
Palo Alto, CA 94304
www.vmware.com

Please note that you can always find the most up-to-date technical documentation on our Web site at <http://www.vmware.com/support/>.

The VMware Web site also provides the latest product updates.

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Introduction

The purpose of this reference guide is to recommend the best architecture designs for users implementing Citrix in a VMware environment. This guide outlines the advantages and recommendations for deploying Citrix® Metaframe® operating in virtual machines running on VMware ESX Server, and contains the following sections:

- [Features of Using ESX Server With Citrix on page 6](#)
- [Introduction to Citrix Systems on page 9](#)
- [Introduction to Virtual Infrastructure on page 12](#)
- [Planning on page 16](#)
- [Sizing on page 25](#)
- [Performance on page 26](#)
- [Manageability on page 29](#)
- [Availability on page 32](#)

Citrix Metaframe, like Windows® Terminal Services and other Windows Terminal Services-based products, provides access to Windows applications for multiple networked users. Application processing occurs on the Citrix server, while clients use the application remotely, even over low bandwidth connections. Citrix extends Windows Terminal Services to provide user, system and application management features on the server over almost any network to clients for a wide range of devices.

Features of Using ESX Server With Citrix

ESX Server offers many powerful features to Citrix administrators. Here is a glance at some of the most important features:

- Virtual machines may be administered centrally.
You can manage an individual virtual machine or group of virtual machines remotely.
- Virtual machines are isolated.
Each virtual machine operates independently of other virtual machines which run on the same physical hardware. Any communication between virtual machines must be established explicitly. Crashing one virtual machine does not crash other virtual machines. Isolation is particularly useful for testing, controlling viruses and managing applications that misbehave.
- Virtual machines can be configured to use hardware resources.
Virtual machines offer complete control of hardware resources. You can configure virtual machines running CPU-intensive applications to use one or two processors, and give virtual machines with memory-intensive applications greater amounts of memory. In this way, you manage the resources that applications use on a single physical machine to balance the load between virtual machines, and take advantage of all processing power and memory available.
- Virtual machines are easily copied and deployed.
Once a virtual machine is created and configured, you can use it as a master from which you can create copies in minutes. The copies have the same operating system, configuration and applications, but have unique system identities.
- Virtual machines can be moved between physical machines.
VMotion can transfer the entire system and memory state of a running virtual machine from one ESX Server machine to another. The transfer period is usually imperceptible to users. This feature is useful for testing, deploying software (including Citrix and operating systems) across a large organization, and maintaining hardware without interrupting service.
- Machines can be consolidated.
Existing machines, including their various operating systems, can be virtualized and consolidated onto fewer physical machines, maximizing resource usage and freeing up machines, physical space and power.

Scalability

Running Citrix in the ESX Server environment can avoid some operating system limitations and make more efficient use of multiprocessor systems, resulting in a nearly linear increase in the number of users served by larger machines. In a conventional Citrix installation, a one- or two-processor machine provides superior performance per processor. Additional processors do not support the same number of users per processor. Virtual machines running Citrix allow you to circumvent some of the factors that limit the number of users able to use a physical machine by increasing your ability to assign hardware resources and by circumventing the limitations of Windows 2000 kernel memory. While the conventional Citrix machine's per processor performance drops sharply in systems with more than two processors, the machine running Citrix in virtual machines continues to add users in a nearly linear fashion.



However, note the following with respect to running ESX on two-way servers:

- The overhead of a virtual machine depends heavily on the applications running in the Citrix client.
- To determine the performance of virtual machines, test them in the environment in which they are deployed.
- The performance of a single virtual machine can be lower than that of a single physical machine, due to virtual machine overhead.
- Using ESX Server is likely to better utilize resources and the corresponding number of sustainable user connections only on four-way and above server class machines.
- When you configure your servers to maximize the number of user connections per physical server, in most cases it is best to create multiple, uniprocessor virtual machines rather than a single, dual-processor virtual machine. Distribute the user count that would have been expected from a two-way machine across two uniprocessor virtual machines.

Isolation

Each virtual machine operates independently. Independent operation carries with it the advantages of separate hardware, including isolating any misbehaving applications, protecting users from monopolization of resources and enhancing security. If one virtual machine is powered off, the others continue to operate. If one virtual machine is infected with a virus, the others are not infected unless you explicitly set up a network between the virtual machines. If you set up a network between virtual machines, choose to enhance security between the virtual machines using firewalls and other measures that are similar to the characteristics between physical machines.

Aside from the inherent benefits, these features make virtual machines ideal for operating misbehaving applications. If the application crashes, the other machines and their users are unaffected. If an application attempts to monopolize a CPU, its access to CPU resources can be limited, leaving resources available to other applications and users.

Convenience

Citrix installations tend to expand. As more users are added, the need for additional servers increases. ESX Server can make growth easier to manage and afford. Virtual machines run on the heterogeneous hardware that already exists in the environment. Once you have created and installed an application on a virtual machine, you can copy that virtual machine, avoiding the time-consuming process of configuring the operating system and installing the application. ESX Server management tools allow you to manage farms of virtual machine servers from across the network. VMotion lets you move the virtual machines across the network while it is still in use.

Creating virtual machines is easy. Once you have designed one virtual machine, you can create copies. You can then tune each machine to meet specific processing and memory needs. The virtual machine is stored in a single container file, including its guest operating system and applications such as Citrix, which can then be moved between ESX Server machines. Rolling out a new system is as easy as copying a file across the network.

Once created, a virtual machine does not rely on a specific platform or device. Virtual machines are hardware-independent, interacting with an abstracted hardware interface. The file-encapsulating virtual machine contains all the information it needs to use the devices it encounters, without awkward driver installation. You can put your virtual machine on a CD-ROM, carry it to a trade show and run it, with all settings and applications intact.



You can use VMotion to move a virtual machine to any ESX Server machine, and the virtual machine will use the processors and devices present. With VMotion, virtual machines run continuously while you move them to a new ESX Server machine. You can also move virtual machines to other physical machines to perform hardware maintenance without interrupting service.

The VMware Remote Console and the VMware Management Interface or VirtualCenter allow you to manage an ESX Server machine and the virtual machines from anywhere on the network. Use these tools to start and stop applications, make changes to the operating system in virtual machine, and perform the tasks required of day-to-day administration.

ESX Server installs directly onto bare metal machines, providing an environment for creating, configuring and managing multiple virtual machines. Each virtual machine operates independently, with its own guest operating system, resources, applications and network IP address. The virtual machine's guest operating system may be any of a number of standard operating systems, including Windows 2000®, Windows 2003®, Windows NT®, Novell NetWare®, SuSE and Red Hat Linux™. Only Windows guests are applicable to Citrix installations.

Citrix on the ESX Server 2.x platform can provide nearly linear scaling of user load on bigger machines, and control of hardware resource allocation among virtual machines. ESX Server also brings rapid system deployment, security through virtual machine isolation and mirroring, powerful system administration tools, and cost reduction from hardware consolidation to Citrix.



Introduction to Citrix Systems

Citrix Systems provides an infrastructure access to resources. The Citrix family of access products offers connectivity to centralized applications through the Citrix MetaFrame Access Suite.

The Citrix MetaFrame Access Suite is infrastructure that:

- Gives workers access to enterprise applications and information from anywhere over any connection.
- Enables IT staffs to manage applications, deployments, monitoring and measurement.
- Ensures that users have access to resources to protect the information data.

This reference guide focuses on the Citrix Presentation Server, Enterprise Edition (Feature Release 2, Service Pack 4) from the Citrix MetaFrame Access Suite.

Citrix MetaFrame Access Suite

On-Demand Enterprise

With growth, companies are struggling to provide access to data. Citrix gives users access to data without having to use multiple access tactics, allowing organizations to be accessible from anywhere.

The Citrix infrastructure is packaged and sold as the Citrix MetaFrame Access Suite. Each component product— MetaFrame Presentation Server, MetaFrame Secure Access Manager, MetaFrame Password Manager and MetaFrame Conferencing Manager—solves a particular access challenge for an organization, while all of the components work together to power the on-demand enterprise. By deploying this access strategy on VMware technology, each remote user logs on to a Citrix server running on a virtual machine running on a VMware ESX Server machine that resides in the corporate data center.

The Citrix infrastructure implements an access strategy which offers secure, easy and instant access to information, improving business agility and driving growth.

Citrix MetaFrame Presentation Server

- **Citrix MetaFrame Presentation Server, Standard Edition**
Citrix MetaFrame Presentation Server, Standard Edition delivers the level of control that departments, workgroups and small organizations need to extend the reach of Microsoft® Windows® 2000 Server and Windows Server™ 2003 to any device. With MetaFrame Presentation Server, Standard Edition, smaller organizations can centralize IT management and control, and provide workers with secure access to applications anytime, anywhere, over any connection.
- **Citrix MetaFrame Presentation Server, Advanced Edition**
Citrix MetaFrame Presentation Server, Advanced Edition provides small to medium-sized organizations with additional scalability, manageability and application availability to meet growth requirements.
- **Citrix MetaFrame Presentation Server, Enterprise Edition**
Citrix MetaFrame Presentation Server, Enterprise Edition provides large organizations and multi-national corporations with the ability to scale, rapid application deployment, and comprehensive management and monitoring capabilities. This version of MetaFrame Presentation Server was tested in ESX Server virtual machines. The data in this paper comes from installations of Citrix Presentation Server, Enterprise Edition (Feature Release 2, Service Pack 4).



Licensing Software

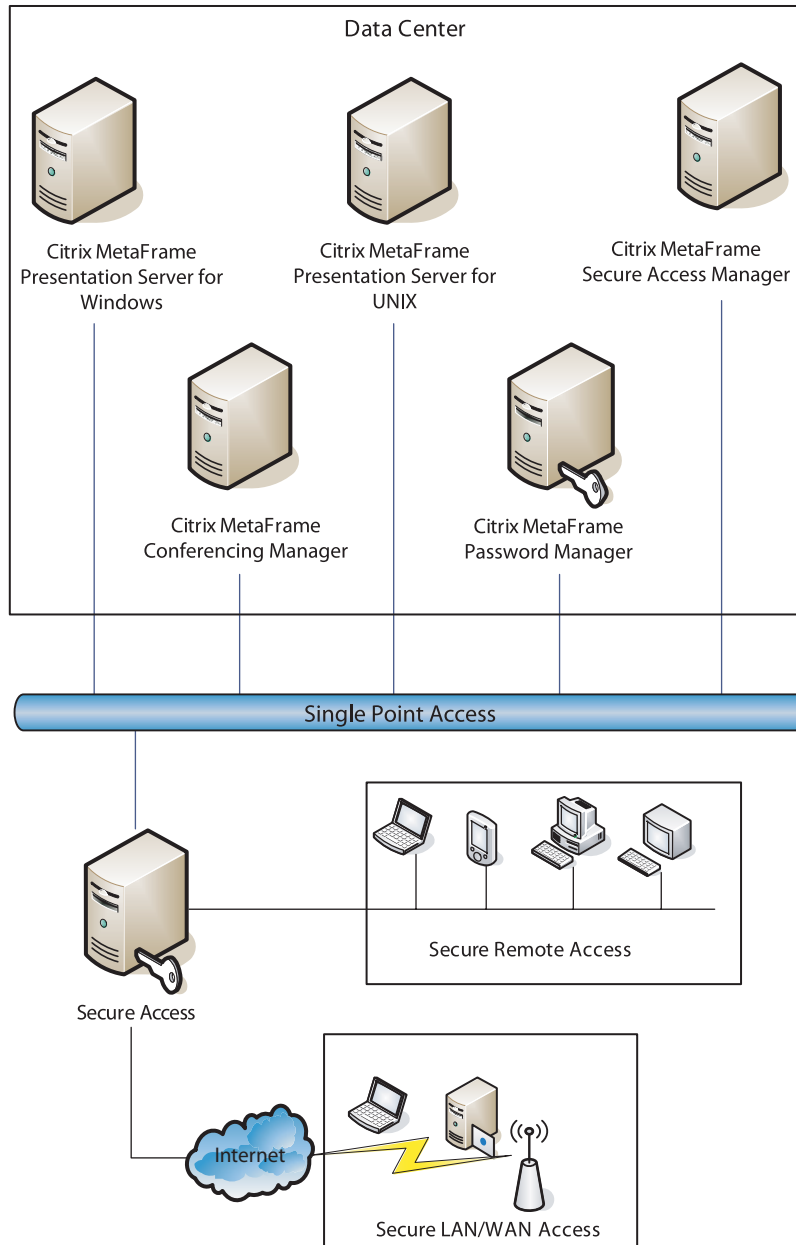
The Citrix pricing model is based on active users (the maximum number of simultaneous users on a server at any given time). At publication time, Citrix licensing is priced per CPU or based on the number of active users. Please discuss pricing for your deployment with a Citrix representative, since the Citrix model may change at any time.

Typical Access Suite Architecture

When deploying a Citrix Access Suite environment, an end-to-end deployment could look like the following figure. This figure outlines the components and technologies used when planning

a Citrix MetaFrame Access Suite deployment. The benefits of VMware server consolidation apply to the components of this architecture.

Citrix MetaFrame Access Suite



These components typically make up a Citrix end-to-end MetaFrame deployment.

Introduction to Virtual Infrastructure

VMware, Inc., is the global leader in virtual infrastructure software for industry-standard systems. VMware's comprehensive virtual infrastructure solutions for enterprise desktops, servers, and development and test groups solve the hard problems of efficiency, flexibility and security, and provide an easy transition to next generation computing models.

Virtual Infrastructure — Virtualization is the use of software to simulate hardware or a total computer environment which the software is actually running. This software is known as the ESX Server and the guest operating system runs in the virtual machine.

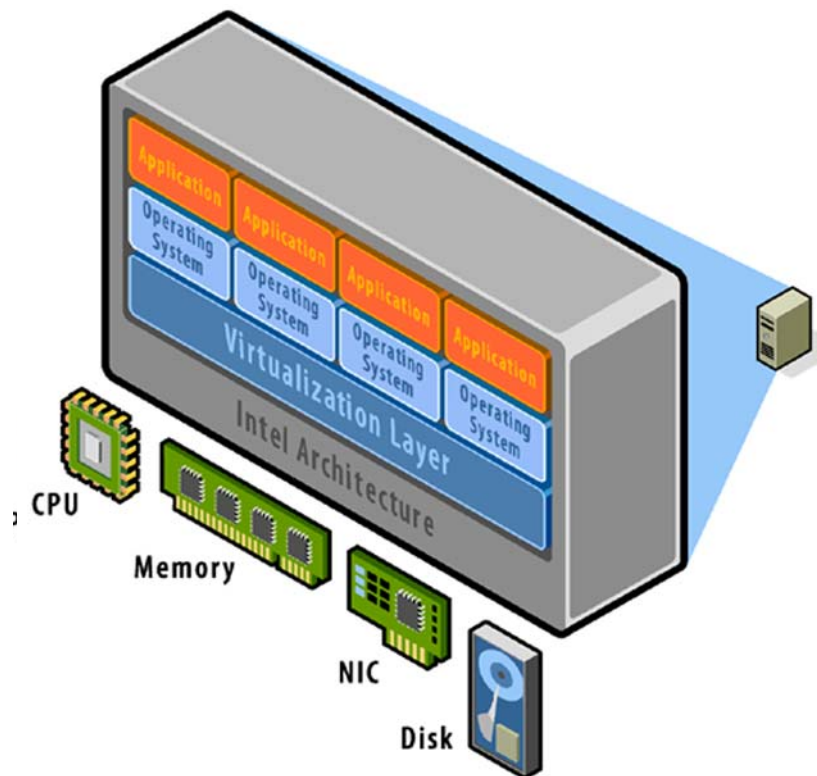


Figure 1 VMware ESX Server Virtualization Layer

As shown in [Figure 1 VMware ESX Server Virtualization Layer](#) the VMware ESX Server virtualization layer brings hardware virtualization to the standard x86 server platform. The virtualization layer is common among VMware desktop and server products, providing a consistent platform for development, testing, delivery and support of application workloads from the developer desktop to the workgroup and to the data center.

As with mainframe virtualization, the VMware virtual machine offers complete hardware virtualization. The guest operating system and applications (those operating inside a virtual machine) can never directly determine which specific underlying physical resources they are accessing—such as which CPU they are running on in a multiprocessor system, or to which physical memory their pages are mapped. The virtualization of the CPU incorporates direct execution: user-level code is typically executed by the hardware CPU without overhead introduced by virtualization.

The virtualization layer provides an idealized platform that is isolated from other virtual machines on the system. It provides the virtual devices that map to shares of specific physical



devices. These devices include virtual CPUs, memory, I/O buses, network interfaces, storage adapters and devices, human interface devices, BIOS and others.

Each virtual machine runs its own operating system and applications; virtual machines cannot talk to each other or leak data, other than via networking mechanisms similar to those used to connect separate physical machines. This isolation leads many users of VMware software to build internal firewalls or other network isolation environments, allowing some virtual machines to connect to the outside while others are connected only via virtual networks through other virtual machines.

Successful deployment of Citrix in a virtual environment depends on a clear understanding of the concepts and technologies of virtual infrastructure. This overview provides a basic understanding of the terminology used when planning a virtual Citrix implementation.

Introduction to VMware Terminology

VMware products are categorized into three areas:

- vPlatform,
- vTools
- vManage.

This guide focuses on the vPlatform (specifically ESX Server) and vManage categories.

Note: You can find more information on the entire VMware product suite can be found at <http://www.vmware.com/>.

vPlatform — computer virtualization that enables partitioning, resource management and hardware independence for optimal utilization and availability. vPlatform products (VMware ESX Server, Virtual SMP, GSX Server, Workstation and VMware ACE) virtualize x86-architecture computing in mainframe-class virtual machines. vPlatform products are the building blocks for the VMware virtual infrastructure:

- Most virtualized Citrix deployments are hosted in a virtual machine using ESX Server, which is virtualization software that enables the deployment of multiple, secure, independent virtual machines on a single physical server.
- ESX Server runs directly on the hardware, in contrast to VMware Workstation and GSX Server products, which use host operating systems to access hardware.
- Also, ESX Server supports dynamic management of memory, CPU, disk, and network traffic.
- ESX Server can host up to 80 virtual CPUs or 80 single-processor virtual machines (provided that the server hardware can sustain the load). ESX Server is also capable of running two-processor virtual machines (where the guest operating system sees two CPUs) when using the Virtual SMP add-on.

The size of your environment determines the correct physical-to-virtual consolidation ratio.

vManage — provides centralized management of the virtual infrastructure. VirtualCenter manages hundreds of servers from a central location, and allows instant provisioning to increase operational productivity. VMotion allows virtual machines to move without having an impact on users and, since computing resources can be reconfigured easily, helps IT departments manage change. With VirtualCenter and VMotion, server consolidation and workload management become continuous improvement processes to increase utilization and efficiency in the data center.

- VMware VirtualCenter is the primary tool for managing a virtual environment in which multiple installations of ESX Server exist.

- This tool gives complete, centralized control of the ESX Server machines' resources, and can also be used for deploying new virtual machines with guest operating systems on any ESX Server machines through the use of templates or images.
- The VMotion add-on allows you to migrate a running virtual machine from one ESX Server machine to another (that is attached to the same shared disk), for continuous operation if the physical server needs to be taken down for maintenance, or the load lightened on a heavily used ESX Server machine.

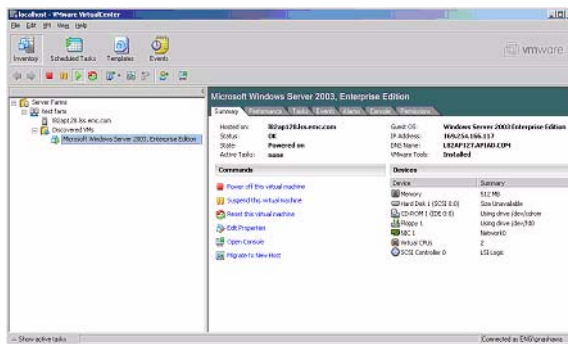


Figure 2 VMware VirtualCenter

- With VMotion, you can make dynamic changes without impacting users, thus providing rapid reconfiguration and optimization of resources across the virtual infrastructure. ESX Server Virtual Infrastructure Nodes (VINs), managed by VirtualCenter, allow you to respond to data center needs.

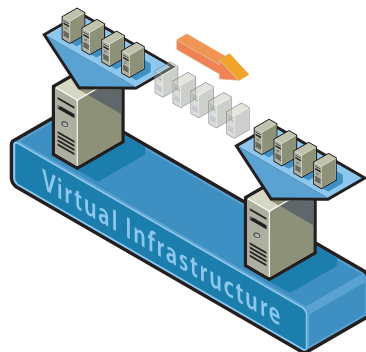


Figure 3 Server Consolidation with VMotion

VMware ESX Server

VMware ESX Server is virtual infrastructure software for partitioning, consolidating and managing systems in mission-critical environments. ESX Server and ESX Server-based VINs provide a highly scalable, virtual machine platform with advanced resource management capabilities that can be managed by VMware VirtualCenter. VIN encompasses ESX Server, Virtual SMP, VMotion and VirtualCenter agent.

VMware ESX Server Architectures

ESX Server transforms diverse physical systems into a pool of logical computing resources. Operating systems and applications are isolated in multiple virtual machines that reside on a single piece of hardware. System resources are dynamically allocated to any operating system based on need, providing datacenter-class capacity utilization and control of server resources.

ESX Server simplifies server infrastructure by partitioning and isolating server resources into secure and portable virtual machines. ESX Server allows you to remotely manage, automatically provision, and standardize server resources on a uniform platform. Advanced resource management controls allow IT administrators to guarantee service levels across the enterprise. ESX Server runs directly on the x86-based system hardware to provide a secure, uniform platform for deploying, managing, and remotely controlling multiple virtual machines. [Figure 4 ESX Server Infrastructure](#) shows a representation of the ESX Server infrastructure.

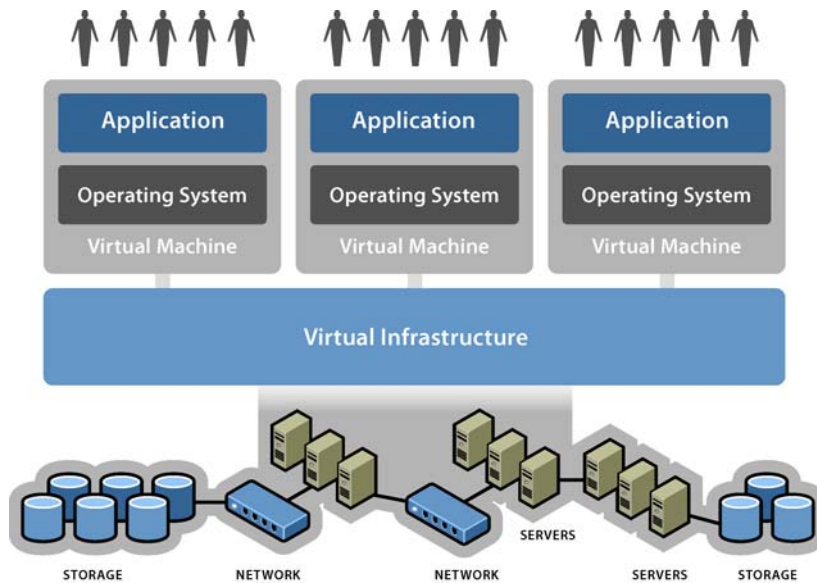


Figure 4 ESX Server Infrastructure

VMware ACE and Citrix Differences

VMware ACE is an enterprise solution for IT desktop managers who want to provision secure, standardized PC environments throughout the extended enterprise. VMware ACE and Citrix Metaframe server are complementary solutions that address different user needs. In many cases, VMware ACE and Citrix client deployments can be combined. VMware ACE installs easily and improves the manageability, security and cost-effectiveness of any industry-standard PC. VMware ACE enables IT desktop managers to apply enterprise IT policies to a virtual machine containing an operating system, enterprise applications and data, to create an isolated PC environment known as an assured computing environment. Through Virtual Rights Management technology, VMware ACE enables IT desktop managers to control the expiration of the assured computing environment, secure enterprise information on PCs, and ensure compliance with IT policies.



The table below lists the differences between ACE and the Citrix suite.

Task	VMware ACE	Citrix
Management	Distributed	Centralized
Data	Runs as a virtual machine on user desktop	Pulled from server typically in a data center
Connectivity	Online or offline	Online only
Shared Instance	No, dedicated to user	Yes, shared by number of connected users
Administration Policies	Virtual machine controls	Server controls
Security	Virtual machine security	Server connectivity security

Planning

Selecting the Correct Hardware

A Citrix deployment on an ESX Server machine requires specific hardware. Refer to the *VMware Systems Compatibility Guide* for the list of physical platforms qualified to run ESX Server. The following hardware configuration is required to deploy Citrix in a virtual environment.

Virtual Disk and Memory Requirements

The following requirements are for the virtual machine and not the ESX Server. In addition to the virtual machine's Windows operating system requirements, Citrix Presentation Server, Enterprise Edition requires the following:

- 85MB virtual disk space for standard Citrix Presentation Server, Enterprise Edition installation, including Citrix Management Console, without ICA Client software.
- 200MB virtual disk space for installing all ICA Client software.
- 20MB virtual disk space for MetaFrame Secure Access Manager services on the Citrix Presentation Server, Enterprise Edition installation.
- 64MB RAM allocated for the virtual machine running Citrix Presentation Server, Enterprise Edition services, including IMA.

MetaFrame supports multiple users in Microsoft Windows environments. A multi-user system requires more system resources than a single-user system. This section provides some guidelines that can help you decide on a hardware configuration that supports users with optimal performance. Most companies find that their users can be categorized as defined in [Identifying and Defining Types of Citrix Users on page 22](#).

Processor, Bus and Memory

The processor and bus architecture are fundamental to the performance of Citrix Presentation Server, Enterprise Edition. Properly laying out and configuring the ESX Server platform are building blocks for a successful deployment.

ESX Server supports SCSI drives and the higher-performance bus, PCI or PCI-X, for best performance. The ESX Server hardware bus supports the high, sustained, data transfer rates that are typical of a Citrix Presentation Server, Enterprise Edition server.

The memory (RAM) requirement for the virtual machine running Citrix Presentation Server, Enterprise Edition is 16MB plus 4MB for each typical user, or 8MB for each power user. This requirement does not change for a virtual machine. You also need to allocate enough memory



from the ESX Server machine to the each virtual machine. In many cases, adding RAM has a greater effect on performance than upgrading to a faster processor if the virtual machines are swapping.

In general, processor and RAM requirements for Citrix Presentation Server, Enterprise Edition scale almost linearly in virtual machines. You can almost double the number of users supported on a multiple, uniprocessor virtual machine by doubling the number of processors and doubling the amount of RAM allocated by the ESX Server machine. By configuring multiprocessor-capable ESX Server systems, you provide for convenient system scaling as the requirements grow when more virtual machines are added later.

Note: Not all multiprocessor configurations scale the same way, due to differences in buses, application loads and other limitations. Many times, you can increase performance by adding several, uniprocessor virtual machines rather than using the Virtual SMP for multiple-processor virtual machines. Multiple, uniprocessor virtual machines may provide additional connectivity than that provided by a single, multiprocessor physical or virtual machine on larger machines provided resources are available. The bus architecture on the ESX Server hardware in a multiprocessor system is crucial for multiprocessor performance as well.

Hard Disks

The hard disk subsystem in a server is an important factor in system throughput. The hard disk type supported by ESX Server is a Small Computer System Interface (SCSI) drive. SCSI disk drives and adapters, especially Fast Narrow SCSI (SCSI-2), Fast Wide SCSI, Wide Ultra SCSI and Wide Ultra2 SCSI devices, have significantly better throughput than other types of disk drives. VMFS file systems on SCSI drives provide the required throughput for performance and also the locking mechanisms necessary for data protection.

For the highest disk performance, consider using a SCSI-based Redundant Array of Independent Disks (RAID) controller. RAID controllers automatically place data on multiple disk drives, and can increase disk performance and improve data reliability.

Use NTFS for all disks in the virtual machine on which Citrix Presentation Server, Enterprise Edition servers reside. NTFS allows security configuration, better performance and more fault tolerance.

In many cases, the use of network storage with virtual infrastructure is beneficial. A Storage Area Network (SAN) and Network Attached Storage (NAS) offer two different levels of design and are alternatives to internal storage. SAN gives block access for application servers connected to the SAN. Applications use SAN-based block access-to-access disk storage over an optical storage network. NAS servers, meanwhile, allow you to access files over the network. NAS uses the CIFS, SMB and NFS protocols for access to storage shares over IP. This is similar to sharing a folder from a server. ESX Server virtual machine disks can reside only on SAN or direct attached storage; however, NAS can be used for archiving, storing virtual machine templates and storing miscellany.

Today, ESX Server supports local SCSI drives or SAN-attached drives to store the virtual machine files.

Network Interfaces

The Citrix Independent Computing Architecture (ICA) protocol is highly compressed and causes negligible loading on a network, but because the Citrix Presentation Server, Enterprise Edition server handles all network requests, a high performance network interface card (NIC) is recommended. If you install a multiport, asynchronous communications adapter for supporting



serial ICA connections, be sure to use an adapter to reduce interrupt overhead and increase throughput.

Understanding Storage in Virtual Machine with Citrix

With the dramatic growth in data volumes, SANs have the potential to scale the manageability of information in the user's enterprise environment. The improved use of existing storage capacity is designed to support future growth and peaks in demand. SANs also enable better structuring of data so that archiving and retrieving information is faster and less expensive.

Storage resources can also be managed from a central site. This greatly reduces the cost of storage management and the risk and cost associated with remote backups. Manageability is discussed later in this guide. Recommendations for storage implementation are also given later in this guide.

ESX Server

Selecting a virtualized environment depends upon several factors. When planning to virtualize the Citrix farm, you must understand the expected results.

Understanding Networking Requirements in Virtual Machines with Citrix

Understanding the terminology in a virtualized environment is key to successful network deployments of Citrix in a virtual machine.

Network Basics

VMware provides virtual networking components to create a wide range of configurations.

- **NIC Teaming** – NIC teaming allows users to group two or more physical NICs into a single, logical network device called a bond. Once a logical NIC is configured, the virtual machine is not aware of the underlying physical NICs. Packets sent to the logical NIC are dispatched to one of the physical NICs in the bond, and packets arriving at any of the physical NICs are automatically directed to the appropriate logical NIC.

If you select **Typical** for the setup path in the New Virtual Machine Wizard when creating a virtual machine, the wizard sets up bridged networking for the virtual machine. The wizard then connects the virtual machine to the appropriate virtual network.

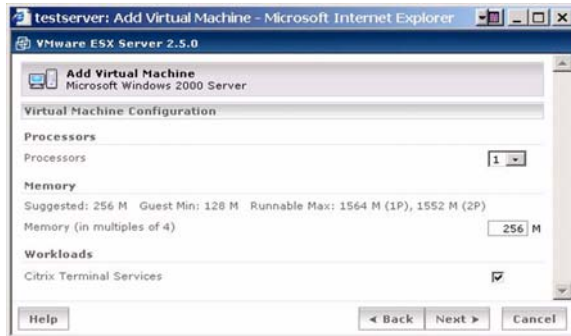
Citrix Client Terminal Services Features

In ESX Server 2, the VMware Management Interface contains a new option designed to optimize virtual machines to run a high number of processes (by allocating a larger cache for internal data structures). This feature is particularly useful in the Citrix environment, and so is named Citrix Terminal Services. For best Citrix performance, make sure this feature is selected.

When creating a new virtual machine for use with Citrix, select **Citrix Terminal Services** in the tuning selections. Use the VMware Management Interface to perform these tasks. On the Status Monitor tab, click the **Add Virtual Machine** button. The Add Virtual Machine window shows a



variety of virtual machine resources, including Citrix Terminal Services, found at the bottom of the window, under **Workloads**. Click the box to select **Citrix Terminal Services**.



Enabling Citrix Terminal Services improves performance for all terminal services applications (as well as other applications that must handle a high number of processes).

Always refer to the recommendations in the *ESX Server Installation Guide* and *Administration Guide* when enhancing virtual machine performance.

- Processors – Virtualization of the processors provides the best scaling performance from the server. The number of virtual CPUs created on the ESX Server machine may be less than or equal to the number of physical processors present.
- Network Driver – Virtual machines are independent of physical hardware and use virtual drivers to communicate with the actual hardware present. The default drivers for virtual machines are the drivers that are most likely to work in all cases. For best performance of Citrix Terminal Services, make sure the fastest network driver available is installed. By default, the vlnace driver is installed to interface with network interface cards. You should make sure the vmxnet network driver is installed instead. The vmxnet driver is part of VMware Tools that enhance the performance of the guest operating system. VMware recommends that you use the vmxnet driver whenever possible.
- Memory – Set the minimum and maximum memory addressable by the virtual machine's guest operating system using the VMware Management Interface. Some cases show it may be useful to create virtual machines with memory which cannot be swapped out. To do this, set the minimum memory for the guest operating system equal to the maximum memory.
- COM Ports – Disable ports COM1 and COM2 in each virtual machine running Citrix. The presence of these ports can cause random spikes in CPU utilization. To disable the ports, do the following:
 - a. Power on the virtual machine and log on as the Administrator user.
 - b. Right-click the **My Computer** icon and choose **Manage**. The Computer Management window appears.
 - c. Click **Device Manager** in the left pane.
 - d. In the right pane, click the plus (+) sign next to **Ports**.
 - e. Right-click **Communications Port (COM1)** and choose **Disable**.
 - f. Right-click **Communications Port (COM2)** and choose **Disable**.



g. Click **Yes** in the confirmation dialog box.

Note: In releases prior to ESX Server 2.1, the Workloads Citrix Terminal Services option in the Management Interface was not present. In these earlier releases, you can realize the same performance advantage by adding a single line to the configuration file of the virtual machine.

At the top of the Edit Configuration page, click **Use Text Editor**. Add this line:

```
workload="TerminalServices"
```

Click **Save Changes** to save the changes to the configuration file.

Efficient Processor Use

Some applications are not written to take advantage of a multiprocessor environment, with the result that the processing power of some of the server's processors may be used only partially or not at all. Rather than using a multiprocessor system to run such an application inefficiently, you can run multiple instances of the application divided between the available processors, fully using the available power. This, however, does not imply that multiple Citrix servers should be run inside a virtual machine.

In addition to the virtual SMP recommendations mentioned earlier, VMware also recommends configurations running N uniprocessor Citrix virtual machines for best performance, where N is the number of physical processors. In some cases, $N-1$ is best, particularly if you expect the Console Operating System to be used heavily (either by agents or by lots of remote consoles).

Virtual Machines, Guest Operating Systems and Applications

Physical and Virtual Server Sizing Guidelines

When selecting a server on which to install ESX Server, you should note the performance gain and expectations. For example, the number of connected users may not increase when you run two uniprocessor virtual machines rather than running a single, two-processor physical machine. The number of users depends on the application load running on the Citrix environment. This is not to say that virtualization is not useful. By adding virtualization, the user benefits from greater flexibility, ease of provisioning and dynamic resource allocation provided by VMware technologies such as VMotion.

In most cases, installations with ESX Server on four-CPU and eight-CPU machines may show performance gains over native deployments. The cut-off point depends on the application. Citrix performance may maximize at a two-processor load. When using larger server hardware, the user can reduce the number of physical servers by using ESX Server for the Citrix environment. This reduces the number of physical machines while increasing the functionality in the virtualization layer.

If the number of connected users decreases due to an application running in Citrix becoming kernel bound, VMware ESX Server offers a way to increase the number of connected users. By spreading the connected users across multiple virtual machines, dedicated kernel space is allocated to the virtual machine, thereby allowing the kernel-bound applications to have their own, independent kernel space. This allows multiple, dedicated kernel spaces (via the independent virtual machines) and increases the number of users connected to the physical machine. An application is said to be kernel bound when it reaches kernel data structure limitations and not just running a lot in the kernel.

Guest Operating Systems Resource Requirements

Citrix Presentation Server, Enterprise Edition can be configured to run on the guest operating systems listed below. Specific requirements are outlined for each guest-operating environment.



When installing Citrix on an ESX Server machine, you should configure each virtual machine to satisfy the requirements of the guest operating system that runs inside it.

- **Windows NT Server 4.0, Terminal Server Edition** – This requires Windows NT Server 4.0, Terminal Server Edition with Service Pack 5 or later, 32MB of virtual RAM and a virtual hard disk with at least 128MB of free space in the guest operating environment.
- **Windows 2000 Server and Advanced Server** – We recommend a 900MHz or faster processor on the ESX Server machine, 256MB of virtual RAM and a 2GB virtual hard disk with at least 1GB of free space in the guest operating environment.
- **Windows Server 2003, Standard Edition, Enterprise Edition** – We recommend a 900MHz processor for the ESX Server machine, 256MB of virtual RAM and a 2GB virtual hard disk with at least 1GB of free space in the guest-operating environment.

Note: Windows 2000 Terminal Services must be installed before Citrix Presentation Server, Enterprise Edition can be installed. Terminal services are not installed in Windows 2000 by default; installation is performed using the Add/Remove programs in the Control Panel. Install terminal services in Application Server mode.

Avoiding Windows Kernel and User Memory Limitations

The server-based computing world has long been hampered by what is referred to as the Windows 2000 Paged Address Pool (PAP) and System Page Table Entry (SPTE) limitations, or registry size limit. The Windows 2000 operating system is able to address up to 4GB of memory. VMware can help with this issue by dedicating virtual machines with independent memory space on hardware while potentially increasing the number of connections.

The connection is split by default between kernel (SPTE) and user processes (PAP). Windows 2000 machines used for terminal services tend to run more applications and support many more users than the traditional, single-user PC. The number of users and applications can challenge the memory limits of Windows 2000, Windows 2003 and Windows NT 4.0, filling kernel memory. In the past, administrators have avoided this problem by limiting the number of users on machines dedicated to terminal services.

The conventional Citrix multiprocessor system must assign the same 4GB pool of kernel memory to the activities of all processors present. Without kernel memory, much and sometimes most processor power languishes, unused. When you use virtual machines, each instance of Citrix has its own virtual machine, using one or two CPUs; each CPU has its own 4GB of memory. A single, physical machine with four processors and four single-CPU virtual machines offers the kernel, user, and applications a 16GB limit, whereas the conventional system has only 4GB.

Server and Citrix MetaFrame Server Farm Names

It is important to understand the differences between a virtual infrastructure farm and a Citrix MetaFrame farm. The Citrix farm is a collection of servers within the Citrix architecture. The name of the server farm can contain 32 or fewer characters. To operate in mixed mode (for interoperability with a MetaFrame 1.8 farm), the name must exactly match the name of the MetaFrame 1.8 server farm. Server farm names are case-sensitive.

Multiple Citrix Presentation Servers, Enterprise Edition servers in the same farm (or multiple Citrix Presentation Server, Enterprise Edition and MetaFrame 1.8 farms operating together in mixed mode) cannot have the same server name. Change the name of the server before installing Citrix Presentation Server, Enterprise Edition. Support includes servers whose names include extended characters only if the network's DNS server supports extended characters in server names.



A virtual infrastructure farm is a collection of virtual machines that are associated within a virtual environment. These machines can be managed by Virtual Center, and the virtual machines have the ability to move seamlessly from one ESX Server machine to another.

Understanding the Deployment Environment

Citrix deployment may vary on configurations. Testing specific deployments in virtualized environments is recommended prior to deployment in production. See [Methodology on page 27](#) for proper considerations and performance characteristics. For example, high performance Citrix farms may give negative results when using VMware. A proof of concept in the customer's environment prior to deploying in a production scenario would provide best results. Without proper sizing and understanding, the deployment may not show the desired results.

Identifying and Defining Types of Citrix Users

An important part of using this guideline for sizing a MetaFrame server is categorizing the users who will access the server and identifying the types of applications the users will require. Citrix identifies two types of users: typical users and power users.

- **Typical user** – Generally uses one or two applications, and uses only one at a time. Little program data is transferred between the client and server, and the user rarely uses Object Linking and Embedding (OLE). The amount of memory required by all users' applications is between 4 and 8MB. A user who accesses a single instance of MS Word falls into this category, as long as that user does not use OLE or access other applications.
- **Power user** – Uses three or more applications, often with several active at the same time. This more sophisticated user often cuts and pastes data between local and remote applications, and uses OLE heavily. More data is being moved between the client and server. Power users consume more resources than typical users. A good rule of thumb is that one power user is equivalent to two typical users in processor utilization and RAM requirements. The amount of memory required by all the users' applications is between 8 and 16MB.

Server vendors have also defined two additional types of users to consider when you size servers: the light user and the advanced power user.

- **Light user** – Accesses an application only infrequently, and the application uses less than 4 MB of memory. Depending on the applications and the way the user works, the number of users per CPU can be much higher than the typical user. The number of users per CPU is highly dependent on the application accessed.
- **Advanced power user** – Accesses applications that require more than 32 MB of memory for all user applications. To accommodate this type of user, you may require a proof of concept in order to better understand resource utilization on the server.

Types of Applications

A typical user's configuration consists of running a single application, such as the following:

- Microsoft® Word
- Microsoft® Excel
- Microsoft® Outlook 2000
- Microsoft® Internet Explorer (IE)
- Adobe® Acrobat® Reader



A power user has a heavier application load. This user has multiple applications or a suite of applications running at once. The applications used include the following:

- Microsoft® Office
- Microsoft Word
- Microsoft Excel
- Microsoft® Outlook 2000
- Microsoft Internet Explorer
- Adobe Acrobat Reader

Configuring Windows 2000 Guest Operating System

VMware recommends that, when running Windows 2000 in a virtual machine as a MetaFrame server, you should use FR1, FR2 or FR3. Then, make the following modifications:

- After disabling the COM port, apply Citrix hotfix XE102W014 when using FR2 and earlier. For a download link and instructions on applying the hotfix, go to the Citrix Web site (www.citrix.com), navigate to the support section and search for XE102W014.
- Check the appropriate box in the management interface, or manually add a line to the virtual machine's configuration file as discussed in [Citrix Client Terminal Services Features on page 18](#). Save appropriate changes to save the configuration file.

Citrix Compatibility

Confirm that an application is compatible with Citrix before trying it with Citrix and ESX Server. Use the Windows performance tools `perfmon` or Task Manager to measure the resources demanded by the application. If the application is compatible with Citrix but has unusual CPU or memory requirements, you can configure the size of the virtual machines to fit the needs of the application.

ESX Server and SAN Environments

There are many terms used to describe disks and disks arrays. The device can be the LUN or the disk itself. Physical disks presented to an ESX Server machine can reside on local storage or on a disk array usually attached to a SAN. A Logical Unit Number (LUN) is a three-bit identifier used on a SCSI bus to distinguish between up to eight devices (logical units) with the same SCSI ID. A raw disk is an exact bit-for-bit copy of an entire hard disk

When presenting physical disks (or LUNs) to an ESX Server machine, the user has the option of creating a VMFS device or presenting the entire disk (or LUN) to the virtual machine as a raw disk. ESX Server 2.5 introduces the concept of SAN transparency (formerly called raw disk mapping, or RDM).

A raw disk (LUN) is a hard disk in a virtual machine that is mapped to a physical disk drive in the host machine. A virtual machine's disk can be stored as a file on the host file system or on a raw disk device. When a virtual machine is configured to use a raw disk, ESX Server directly accesses the local disk or partition as a raw device (not as a file on a file system).

ESX Server 2.5 improves support for raw LUNs as virtual disks using SAN transparency and pass-through RDMs. ESX Server version 2.5 includes new features for using raw disks, such as allowing raw disks to be managed as easily as virtual disk files, allowing VMotion of virtual machines that use raw disks, and improving VirtualCenter support of clustered virtual machines.

SCSI pass-through RDMs enable SAN replication software to run inside of virtual machines. In addition, pass-through RDMs enable backup offloading solutions so that ESX Server machines



can be backed up faster without any load placed on the virtual machines or on the Service Console. ESX Server 2.5 also allows REDO logs to be added to raw disks.

When you use array-based functionality from the virtual machine, a raw device must be presented to the virtual machine. Raw devices provide the ability to pass SCSI commands directly from the virtual machine to the array. Applications that need direct access to the array must use raw devices.

VMFS (VMware ESX Server File System) is a simple, high-performance file system on physical SCSI disks and partitions, used for storing large files such as the virtual disk images for ESX Server virtual machines and, by default, the memory images of suspended virtual machines. The VMFS also stores the redo-log files for virtual machines in non-persistent, undoable or append disk modes.

To create a virtual machine on a VMFS, you must create a special file on the disk. The `.vmdk` file, or image file, is the actual virtual drive containing the operating system, data and applications. Each virtual disk file is assigned to an accompanying configuration file, the `.vmx` file, which VMware ESX Server uses to access disk image files and set up the virtual hardware. The `.vmx` configuration file can be associated with over 16 virtual disk files. When the first virtual machine is created, the `.vmx` file contains the location of the virtual disk, the memory size, and some basic hardware setup information (such as CD-ROM, floppy and network connections).

A virtual machine's `.vmdk` file always has to reside on a VMFS. This VMFS volume may be on the SAN or on local disk. Raw disk mappings are typically used on SAN LUNs. In this case, raw disk mappings work when the fiber channel HBA used is dedicated to the virtual machine. In the case of a raw disk mapping, the `vmkfstools -i` (for import) and `-e` (for export) command options are available for mobility

ESX Server Storage Recommendations for Citrix MetaFrame

When planning storage requirements with ESX Server and Citrix MetaFrame, you need to remember that application storage and user storage vary depending on the deployment, type of applications and user requirements. The following are best practices when allocating storage to virtual machines running Citrix MetaFrame:

- All virtual disks (`.vmdk` or `.disk`) should be Microsoft Windows File System (NTFS) in the virtual machine to allow for security configuration, better performance and fault tolerance for Citrix deployments.
- Configure the ESX Server with large amounts of memory; remember that page files need sufficient space.
- When using single-CPU physical servers, you should allocate 40MB for the registry to accommodate user profiles and application settings.
- The storage subsystem is an important factor in system throughput. SCSI drives are supported with ESX Server. For best performance, consider using a SCSI-based Redundant Array of Independent Disk (RAID) controller or hosting the virtual environment on a SAN.
- VMware recommends that you allocate users' home directories in the guest operating system on separate storage (like SAN), depending on the size of the deployment.

Sizing

Citrix MetaFrame Sizing in a Virtual Machine

Consider the following sizing guidelines when implementing Citrix in a virtual environment. In some cases, deploying Citrix in an ESX Server environment provides great benefit; in other cases, multiple two-processor servers are a better solution. The following list outlines where physical server benefits meet the customers expectations and needs.

- Potentially increased flexibility with single-CPU virtual machines using ESX Server – When upgrading applications on the servers or administering the servers, you can remove a small percentage of overall system capacity without impacting overall system performance and functionality. Physical machines, especially monolithic, eight-way boxes, do not provide the same advantage.
- Redundancy improvements with VMware ESX Server implementations – When you encounter problems on hardware, a smaller percentage of users is impacted and can be off-loaded to other virtual machines. Problems are isolated to physically distinct hardware on the ESX Server machine.
- Ability to segment high load processes with dual-processor implementations – Two-processor systems distribute processing to physically separate systems. If a power user engages in activity that drives CPU, memory, or I/O utilization up, the impact is isolated to that single system. If you expect peak loads from a community of power users, you may want to look at four-processor systems and limiting their user load to the same level as other two-processor systems. Unfortunately, this decreases the price/performance ratio.
- VirtualCenter reduces administration costs – The decision to use Virtual Center and use large, multiprocessor systems rather than two-processor systems revolves around the additional costs associated with administering more virtual servers. Using VMware VirtualCenter to manage the environment, administrators can use Citrix management tools and then publish applications to new virtual servers from a single console. The proposed architecture is necessary to the success of the implementation.
- Companies that standardized on a two-way scale out, many smaller servers versus single larger servers will see better performance on Citrix on physical servers for high performance Citrix farms

Workload and User Application Expectations

Understanding the customer's difficulties can help you determine the customer's expectations of the deployment. Addressing problems that do not need to be addressed makes for an unsuccessful deployment. One way to identify the requirements of the site is to monitor a test site. By using monitoring tools, you are better able to identify problems and to tune the configuration for the deployment environment. This helps identify the level of functionality and performance, and identify the final size criteria for the deployment.

General Sizing Guidelines

Determining if the customer's Citrix environment will benefit from using virtualization requires you to understand and size the environment. The deployment is based as much on the applications as on the number of users to be supported. Therefore, knowing the number of users to be supported is only the first step in properly choosing and configuring the server to be used for the deployment.



When determining whether or not to consolidate to a VMware environment, you must take specific steps to ensure a successful deployment. You need to understand the user loads, types of applications and so on to help you decide on the architecture to recommend. For example, using two, uniprocessor virtual machines rather than a single, dual-processor virtual machine increases the number of connected users.

Performance

This section describes the techniques and tools that you can use to tune and measure virtual machines for best performance with an application. Application performance varies depending upon the environment as well as upon workload demands. The best gauge for determining how applications perform in an environment is to exercise a test suite prior to implementing Citrix in a production deployment. This section describes the methods to use, and a specific example.

Configuring a Microsoft Windows Guest Operating System for Performance

When you configure a Windows 2000, Windows XP or Windows Server 2003 guest operating system for better performance inside a VMware ESX Server virtual machine, consider the following procedure.

Note: Optimization pertains to the guest operating system that is running inside a VMware ESX Server virtual machine.

Select the guest operating system: Make certain the correct guest operating system is selected in the Virtual Machine Settings editor. Choose **VM > VM Settings > Options**.

Install VMware Tools: Make certain VMware Tools is installed. VMware Tools provides an optimized SVGA driver and sets up the VMware Tools service to run automatically when the system starts. Among other things, the VMware Tools service allows you to synchronize the virtual machine's clock, which can improve performance for some functions. You can also install the vmxnet virtual NIC driver as part of the VMware Tools configuration. Install VMware Tools by choosing **VM > Install VMware Tools**.

Disable visual effects: The fade effects that Windows 2000, Windows XP and Windows Server 2003 use when displaying menus can be somewhat slow and make the virtual machine seem less responsive. To disable the fade effects, right-click the guest operating system desktop, then choose **Properties > Appearance > Effects** (on Windows XP or Windows Server 2003) or **Properties > Effects** (on Windows 2000) and clear the **Use transition effects for menus and tool tips** check box.

Disconnect the CD-ROM: It is also recommended that the CD-ROM be disconnected from the Windows operating system. The operating system checks the drive periodically, using CPU cycles. You can disconnect the CD-ROM, if you do not need to use it, by choosing from the **Devices** menu.

Windows Disk Performance on Multiprocessor Systems: By following these recommendations the user can avoid potential problems in a VMware ESX Server environment. The I/O issue is especially noticeable when the virtual machine is booting.

Note: Performance in Windows guest operating systems may also be affected by disk fragmentation.

If you notice slow disk performance in the virtual machine, check if the virtual disk files are badly fragmented. If they are fragmented, you can improve performance by running a defragmentation utility to reduce fragmentation on the affected disk.

Using Performance Monitoring Tools

The best way to determine if VMware ESX Server and Citrix are right for an environment is to test a sample set of the proposed applications. Citrix performance varies, depending on what is run on the Citrix client. VMware ESX Server performance also varies, depending on the application. It is important for customers to test their applications prior to deploying full production environments. In addition, VirtualCenter along with VMK usage and ESXtop may be used for performance monitoring.

It is important to note that the numbers used in the example that follows are benchmark numbers only, and are not meant to be representative of a real workload. They were obtained from test run in-house by VMware and represent the peak load obtained with this benchmark; typical customer configurations do not run servers at peak loads in a production environments.

This section describes how to benchmark Citrix in customer environments and provides an example, not an accurate count of a number of users.

VMware provides the following suggestions for customers planning on deploying this test case in a test environment. Note the following:

- The Citrix Server Test Kit (CSTK) toolkit is available from the Citrix Developer's network at www.citrix.com/cdn.
- The users in our test were the power user type in CSTK. Power users run more than one application at a time. For these tests, we chose the applications Excel and Access, and each user ran a predefined script of operations for those applications.

Citrix recommends that you use performance monitoring tools to get accurate accounts of system performance and the effects of configuration changes on system throughput. The most important measurements for performance monitoring are the percentage of total processor time, memory pages per second, percentage of network utilization, and hard disk I/O rates.

A good way to estimate how many users a server can support is to measure system performance when there are two to five users on the system, and then scale the results. This method has been found to yield reliable results.

Once you have confirmed that the application is compatible with Citrix, try running it in a virtual machine with Citrix running under ESX Server. ESX Server tools such as `vmkusage` and `esxtop` can be used to monitor resource utilization in this environment to see how the application runs and to confirm that the virtual machines are configured to use resources appropriately for best performance.

Methodology

This section contains performance tests that suggest methods you can use to measure the performance of applications under Citrix and ESX Server 2. Tests provide data on the number of users supported by virtual machines using one or two virtual CPUs under particular loads. Using these techniques and the client applications, the user should be able to gauge the user load and performance that applications will provide in the Citrix and ESX Server environments.

The tests were conducted using the Citrix performance tool Citrix Server Test Kit 2.1. Each automated user used Microsoft Excel and Microsoft Access heavily. User activity was scripted so that each user followed the same series of tasks, providing a measurable iteration of user activity.



Users were added in small groups, with pauses between additions, to let all users fully complete their logons before going on to the next group of users. After each group of users was added, the time required for a single iteration of task activity for a single user was measured, providing an indication of system load. When the number of script failures following the introduction of a new group of users equaled the number of users added, the test ended. The graphs in this section show the increase in time required for each iteration as a function of the number of users.

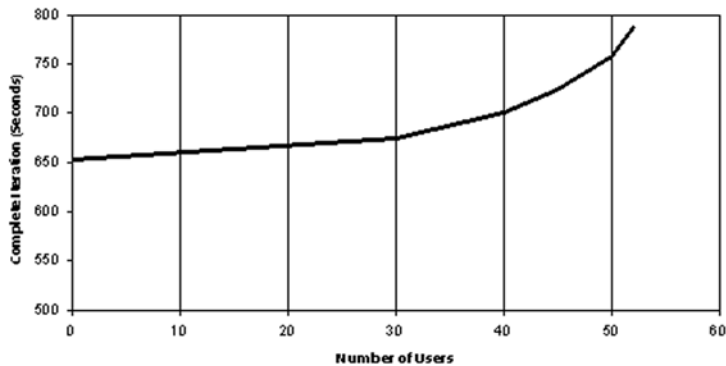
These tests followed best practices as described in this section, including recommended workarounds and settings. The hardware included:

- 4 CPU Servers with 2 GHz x86 processors (512 KB cache)
- Virtual machines were configured to use 3.6GB RAM and one or two virtual CPUs, as specified

The results show the number of users and the corresponding time (in seconds) required to complete one iteration of the test suite. The data show that iteration time increased until the test was stopped. If the test scripts failed, the time required does drop, providing the appearance of abruptly improved performance.

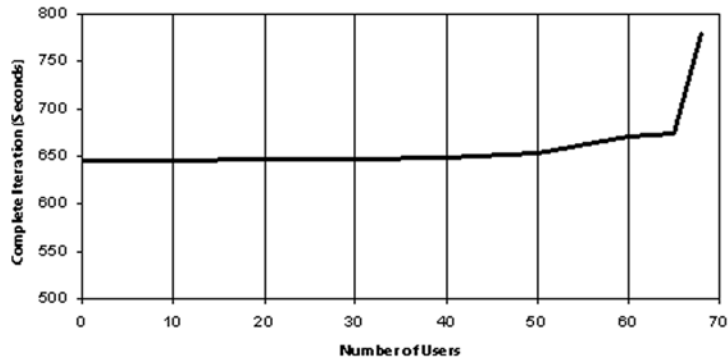
This is an example of methodology tested and the customer results may vary based on specific customer environmental characteristics.

The virtual machine configured to use one virtual CPU supported up to 53 productive Citrix users.





The second example used the Virtual SMP license with the virtual machine configured to use two virtual CPUs. It supported up to 66 users. Again, results may vary based on specific environments.



Note: In this test, the dual-CPU virtual machine does not support as many users as does two, single-CPU virtual machines. While this is often the case, it will not always be true—depending upon the application.

Tuning and Configuring

This section contains references regarding tuning, configuration, and bug fixes available for ESX Server 2.x. Please refer to the VMware white paper titled *Best Practices for VMware ESX Server 2*, and the ESX Server manuals, *ESX Server Installation Guide* and *ESX Server Administration Guide*.

For specific performance and tuning tips for Citrix FR1 and FR2 with Windows 2000 in a virtual machine, or for information on configuring virtual machine memory for Citrix performance in ESX Server, refer to [Configuring a Microsoft Windows Guest Operating System for Performance on page 26](#).

Network Throughput

You must consider the type of network adapter (or NIC) in order to prevent a performance bottleneck on the network configuration on the virtual server. Network performance varies based on the networking infrastructure, physical hardware and other factors. Proper tools can be used to monitor the network performance.

- The protocol used to access MetaFrame server is highly compressed and causes negligent loading on a network, so we recommend using a high performance network NIC with failover capabilities to improve the reliability of the server.
- Installing only one protocol on the server frees system resources and helps reduce network traffic.
- Running multiple, uniprocessor virtual machines with a similar number of connected Citrix users improves network performance than connecting to dual CPU server configurations.

Manageability

Manageability is a critical part of a successful deployment. Managing a Citrix environment in a virtual environment is no different. Managing a Citrix environment occurs on several levels. Managing system resources, backing up and recovering, and understanding the details of the software installed in a datacenter all have an impact on the operation of the environment.

Management Tools

VirtualCenter is a tool that can be used to manage the Citrix environment. Using technologies such as VMware ESX Server Virtual Infrastructure Nodes (VIN) enables intelligent workload management. VMotion technology allows dynamic changes without impacting users, thus providing rapid reconfiguration and optimization of resources across the virtual infrastructure. ESX Server VINs, managed by VirtualCenter, provide a means to respond to data center needs.

Another option for managing Citrix in a virtual machine is to use Microsoft Operations Manager (MOM) 2005. Citrix is part of the Windows Management Alliance supporting Microsoft's Dynamic Systems Initiative (DSI). This is an infrastructure targeted to reduce the complexity of IT challenges by improving software manageability. Microsoft Operations Manager (MOM) 2005 is part of this initiative.

The Microsoft licensing model has changed from the previous version, MOM 2000. There is now one type of monitored server license, called the OML, delivered for a set price. This pricing model is regardless of operating environment, version, applications being monitored, or number of processors. Licenses are based on physical servers. A single license is required for an ESX Server machine — and all virtual machines running on that machine can have a MOM agent installed, and are covered by the single OML license for the physical box.

MOM 2005 provides operations management to improve the IT operations. It manages events, monitors and alerting, reports trend analysis, and provides system- and application-specific knowledge. The software also contains built-in authentication agents and servers, designed to help protect organizations from misuse of the management system.

Backup and Recovery

There are two parts of an ESX Server machine to back up regularly — the ESX Server service console and the server's virtual machines. There is only one approach to backing up the service console, but there are two approaches to backing up the virtual machines.

Backing Up the Service Console

VMware recommends backing up the service console first. The service console, a customized version of Linux, provides the interface between the user and the ESX Server machine. It provides the ESX Server management tools, services the remote console and provides a command prompt for more direct management of ESX Server. It also keeps track of all the virtual machines on the server and their configurations.

The service console should not have any major changes during its long lifetime in the data center, other than periodic upgrades. Although you can recover the state of the service console without much trouble, having it safely backed up can save time and worry if you need to restore the system. In other words, having a clean backup of the service console is important, but it is not necessary to back it up as frequently as you back up the virtual machines and their associated data.

One factor that might influence the decision to back up the service console is if it would be faster to rebuild the ESX Server machine with the installation media. If you decide to back up the service console, then you need to identify what to back up. For example, it may be best to back up the `.vmx` files for the virtual machines and specific settings, but backing up the entire console operating system may not be the correct procedure.

Back Up Virtual Machines as Physical Machines

Virtual machines provide complete guest operating systems on virtual hardware. You can back up these operating system installations in the same way you do their physical counterparts.



Attach backup hardware to the ESX Server and assign to the virtual machines. The backup servers can be installed on them. Then install backup agents, and back up the data over the network to other backup servers. data to another machine manually, or using a script.

Backing up a virtual machine either by script or manually looks and feels exactly the same as backing up a regular physical machine. If virtual machines are installed on raw disks (rather than using the ESX Server VMFS file system), manual or scripting is the preferred approach to backing up virtual machines. If the virtual machines raw disks are on a SAN, then you should use array-based technology for backup and recovery.

For a complete reference on backup and recovery methods and products, refer to www.vmware.com/pdf/esx_backup_guide.pdf.

Availability

When discussing availability, you must also understand the customer's expectations. For example, one expectation of proper design is that there is no single point of failure in the architecture. Components must provide redundancy or functional specialization to contain faults.

Citrix in a virtual environment can offer similar types of availability, depending on the deployment strategy. This section outlines how to increase availability when deploying Citrix in a virtual infrastructure.

Citrix has worked with VMware to deliver a highly reliable, interoperable and manageable server and client consolidation solution that helps remote offices and clients simplify their IT environments and reduce desktop administration tasks by centralizing application delivery. The solution encompasses Citrix MetaFrame XP application serving and management software, and VMware ESX Server virtual machine software operating on X86-processor based systems.

VMware ESX Server gives customers a way to approach 24x7 availability and server consolidation for their Citrix MetaFrame deployments—creating a more manageable environment.

Increasing Virtual Machine Availability Using a SAN

- Availability is one of the key design criteria for a SAN. By abstracting storage away from specific virtual and application servers, you can maintain the service in a more robust manner through storage-specific functionality. In a well-designed SAN, a host has multiple paths to the storage subsystem. Such a design should be mandatory for applications such as Citrix MetaFrame to increase the availability of the applications.
- Availability can be improved by using software that works with networked storage systems to intelligently manage I/O paths. The ESX Server machine that manages multiple paths to a storage array controls VMware multipathing. Multipathing ensures that applications on the host have highly available access to storage, and that optimal performance is provided at all times.
- Features of VMware multipathing that result in increased availability and performance include:
 - **Support for multiple paths:** VMware multipathing automatically detects path failures and redirects I/O to other available paths for several kinds of path management policies that can be set by the user. It supports multiple paths between a logical device and a host, thereby enabling the host to access a logical device even if a specific path is unavailable. Also, multiple paths can share the I/O workload to a given logical device.
 - **Automatic path failover:** VMware multipathing automatically redirects I/O from a failed path to an alternate path, which eliminates loss of data and application downtime. Failovers are transparent and non-disruptive to applications.
 - **Proactive path testing and automatic path recovery:** When the original path is set to persistent, VMware multipathing periodically tests failed paths to determine if they have been fixed. When a failed path passes the test, it is restored automatically for reuse. During path restoration, the storage system, host and application remain available. VMware multipathing also periodically tests live paths that are idle, which allows VMware multipathing to report path problems quickly and avoid delays that would otherwise result from trying to use a defective path when I/O is directed to a logical device.

- **High-availability cluster support:** VMware multipathing is particularly beneficial in clustered environments because it can prevent operational interruptions and costly downtime, assuming other availability technology is not in place. VMware multipathing path failover capability avoids node failover, thereby maintaining uninterrupted application support on the active node in the event of a path disconnect as long as another path is available.

High Availability in Citrix Secure Gateway Services

Citrix provides a way to seamlessly integrate high availability with MetaFrame XP Presentation Server. Using the MetaFrame Secure Access Manager is a way to integrate with other members of the MetaFrame Access Suite, bridging Windows and the Web to provide simple, secure access. The suite has a central management console, making it easy for users to manage their work and their environments. Deploying this suite in a virtual machine provides the ability to scale the infrastructure without the cost of physical servers.

Previous versions of Citrix offered a product called NFuse. NFuse Elite became MetaFrame Secure Access Manager in new releases. The NFuse Elite name is no longer used, and is replaced by MetaFrame Secure Access Manager, version 2.0. Customers are no longer able to order or purchase the product named NFuse Elite.

The name NFuse Classic product referred to the Web interface that allowed users to access applications enabled by MetaFrame via a browser. Because this is a feature of MetaFrame, it is now called Web interface for Citrix MetaFrame Server, and is no longer known as a separate entity.

It is important to understand the products and how they are referred to in the Citrix product suite.

When you are planning for highly available Citrix deployments in a virtual machine, one technology that can be used to meet the requirements is Citrix Secure Gateway. The Citrix Secure Gateway can be configured to provide redundancy to increase system availability by deploying multiple NFuse servers or newer Citrix MetaFrame Secure Access Manager, Secure Gateway servers and STA servers. Multiple Citrix MetaFrame Secure Access Manager servers can provide a redundant path in the event of a failure.

In order to deploy more than one MetaFrame Secure Access Manager Server, a load balancer is required. The function of the load balancer is to distribute client sessions to one of a number of servers offering a service. This is normally done by implementing a virtual address on the load balancer for a particular service, and by maintaining a list of servers offering the service.

Load balancing can be achieved using virtual machines. Providing an application algorithm can be as simple as a round robin, in which each client connection request is assigned to the next server in a circular list of servers, or in a more elaborate algorithm based on machine load and response times.

One option for load balancing uses the Microsoft Network Load Balance server (NLBS). Load balancing is used for various network services and applications such as Citrix. The main objective of network load balancing is to maintain resiliency in case of a failure and to maintain performance levels during peak periods for the most important network services, including firewalls, routers and switches.

There are implementation differences between the versions of NLBS that ship with Microsoft Windows 2000 Advanced Server and Microsoft Application Center Server. Microsoft provides network load balancing that comes with the Windows Server operating system and can run seamlessly in a virtual machine. The Application Center Server version of network load balancing



forces the use of NetBIOS over TCP/IP, typically on the perimeter interfaces of the Application Center Server cluster. This is not recommended for externally available interfaces because of security concerns.

A load-balancing solution that manages an array of Secure Gateway servers can provide key benefits, such as scalability and high availability. Load balancing provides high availability by automatically detecting the failure of a secure gateway server and redistributing client traffic among the remaining servers.