Virtualization

From the Desktop to the Enterprise

CHRIS WOLF AND ERICK M. HALTER

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Virtualization: From the Desktop to the Enterprise

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This book is dedicated to my wonderful wife, Melissa, and son, Andrew.
True success is not measured by professional accomplishments
but rather by the love and respect of one's family.
As George Moore says, "A man travels the world over
in search of what he needs and returns home to find it."
—Chris Wolf

This book is dedicated to my family: Holly, Zack, Ella, and Gates,
and to the teachers who taught me to write and think...and Elvis too!
—Erick M. Halter

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—Chris Wolf

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—Erick M. Halter

Introduction

Virtualization is a concept that has evolved from what many first recognized as a niche technology to one that's driving many mainstream networks. Evidence of virtualization exists in nearly all aspects of information technology today. You can see virtualization in sales, education, testing, and demonstration labs, and you can see it even driving network servers.

What's virtualization? Well, to keep it simple, consider *virtualization* to be the act of abstracting the physical boundaries of a technology. Physical abstraction is now occurring in several ways, with many of these methods illustrated in Figure 1. For example, workstations and servers no longer need dedicated physical hardware such as a CPU or motherboard in order to run as independent entities. Instead, they can run inside a virtual machine (VM). In running as a virtual machine, a computer's hardware is emulated and presented to an operating system as if the hardware truly existed. With this technology, you have the ability to remove the traditional dependence that all operating systems had with hardware. In being able to emulate hardware, a virtual machine can essentially run on any x86-class host system, regardless of hardware makeup. Furthermore, you can run multiple VMs running different operating systems on the same system at the same time!

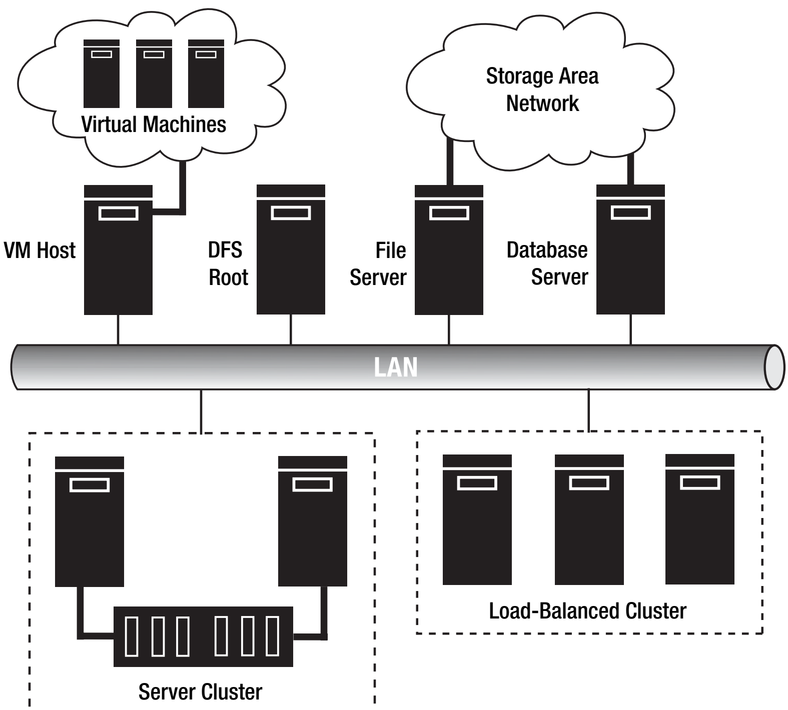

Figure 1. *A virtualized information system*

Virtualization extends beyond the virtual machine to other virtualization technologies such as clustering. *Clustering* allows several physical machines to collectively host one or more virtual servers. Clusters generally provide two distinct roles, which are to provide for continuous data access, even if a failure with a system or network device occurs, and to load balance a high volume of clients across several physical hosts. With clustering, clients won't connect to a physical computer but instead connect to a logical virtual server running on top of one or more physical computers. Clustering differs from virtual machine applications in that it allows for automated failover between physical hosts participating in the cluster. You could view failover as the movement of a virtual server from one physical host to another.

Aside from virtual machines and clustering, you'll also see the reach of virtualization extend to network file systems and storage. In reaching network file systems, technologies such as Distributed File System (DFS) allow users to access network resources without knowing their exact physical location. With storage virtualization, administrations can perform restores of backed-up data without having to know the location of the physical media where the backup resides.

Now, if your head is already spinning, don't worry, because you're probably not alone. With such as vast array of virtualization technologies available, it can be difficult to first tell one from another and also come to an understanding as to which technologies are right for you. That's why we decided to piece together a reference that explains each available virtualization technology, whether you're interested in running virtual machines on your desktop or are planning to add virtualization layers to an enterprise network environment. In this book, we'll guide you through all aspects of virtualization and also discuss how to fit any and all of these complex technologies into your IT life. Let's start by looking at the format of each chapter in this book.

Chapter 1: Examining the Anatomy of a Virtual Machine

Two major software vendors, EMC (Legato) and Microsoft, are leading the virtual machine software charge. In spite of their products' architectural differences, the terminology and the theory that drives them are similar.

In Chapter 1, we'll start by explaining the buzzwords and the theory associated with virtual machines. We'll address such topics as virtual networks, virtual hard disks, and CPU emulation. We'll also give you an overview of the major virtual machine products, outlining the differences between EMC's VMware Workstation, GSX Server, and ESX Server products, as well as Microsoft's Virtual PC and Virtual Server 2005.

Chapter 2: Preparing a Virtual Machine Host

With an understanding of the ins and outs of virtual machines, the next logical step in VM deployment is to prepare a host system. Several factors determine a host's preparedness to run a VM application, including the following:

- Physical RAM
- CPU
- Hard disk space
- Networking

When selecting a host, you'll need to ensure that the host meets the VM application's minimum hardware requirements and also that enough resources are available for the number of VMs you plan to run simultaneously on the host. Properly preparing a host prior to running virtual machines on it will almost certainly result in better stability, scalability, and long-term performance for your virtual machines. After finishing Chapter 2, you will not only be fully aware of the techniques for preparing a host system for virtual machines but will also be aware of the many gotchas and common pitfalls that often go unrecognized until it's unfortunately too late.

Chapter 3: Installing VM Applications on Desktops

When deciding to run virtual machines on workstations, you have two choices of workstation application: VMware Workstation (shown in Figure 2) and Virtual PC (shown in Figure 3). VMware Workstation is supported on Windows NT 4.0 (with SP6a) or higher Windows operating systems and can also run on Linux (Red Hat, Mandrake, or SuSE). Microsoft Virtual PC is supported on Windows 2000 Professional, Windows XP Professional, and Windows XP Tablet PC Edition.

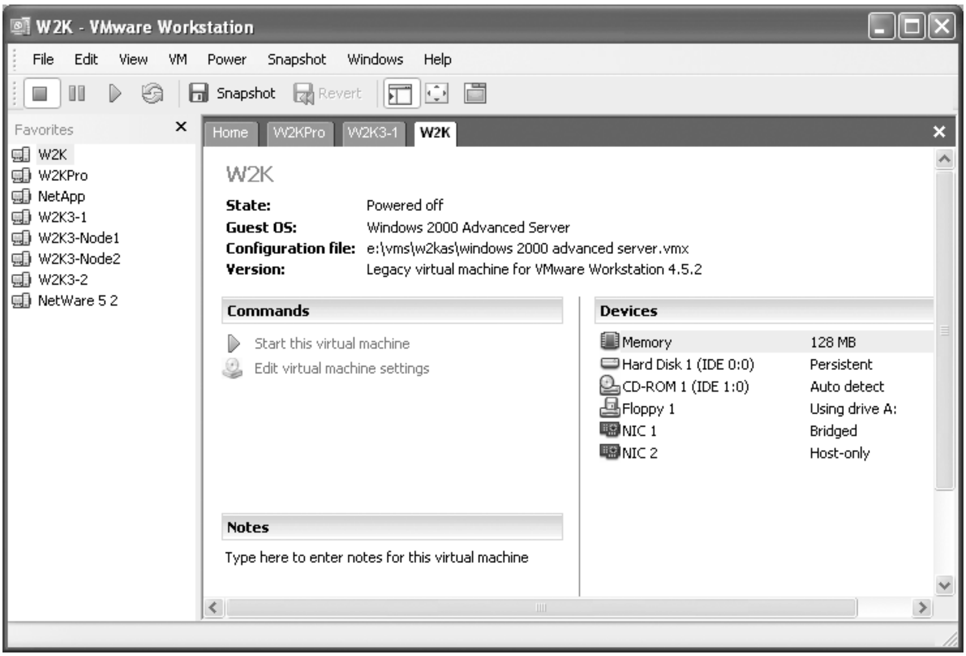

Figure 2. *VMware Workstation UI*

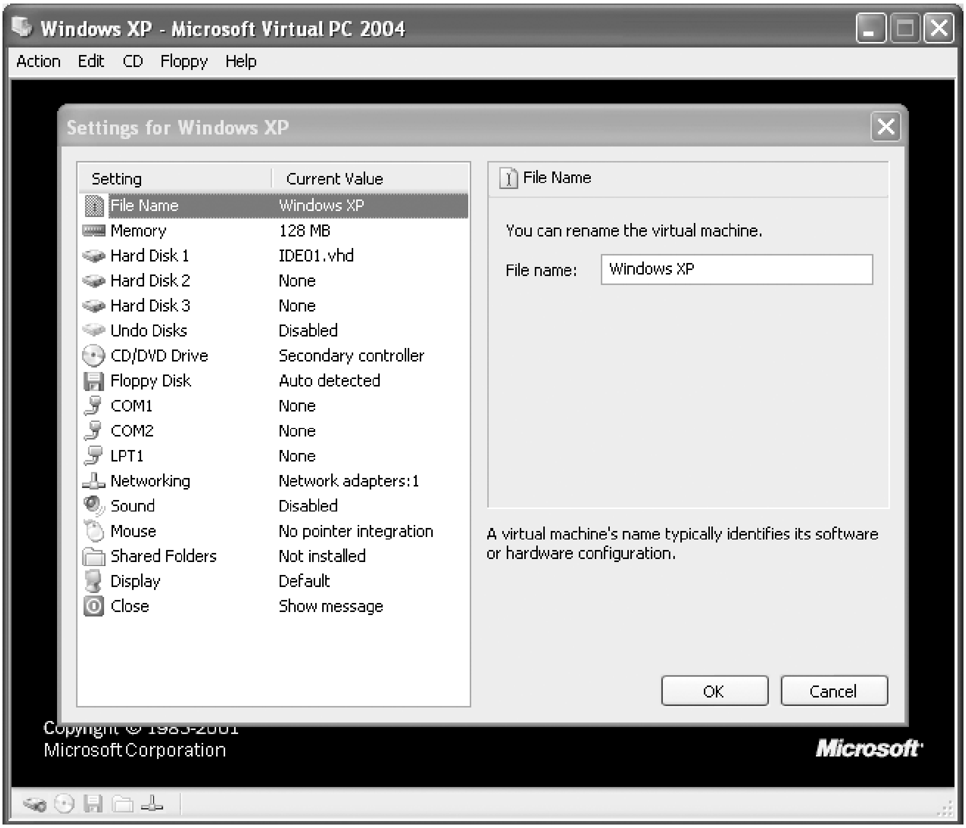

Figure 3. *Virtual PC UI*

As you can see, your current operating system may decide the VM application you choose. Chapter 1 will also help with the VM application decision, as it will outline all of the differences between each program. Once you've decided on a VM application, you'll be able to use this chapter to get you through any final preparations and the installation of VMware Workstation and Virtual PC.

Chapter 4: Deploying and Managing VMs on the Desktop

Chapter 4 provides guidance on deploying specific VM operating systems on your workstation system, including examples of both Windows and Linux VM deployments. Once your VM is up and running, you can perform many tasks to optimize and monitor their performance and to also ease future VM deployments. Topics in this chapter include the following:

- Monitoring the performance of VMs
- Staging and deploying preconfigured VMs

- Running VMs as services
- Configuring VMs to not save any information
- Administering through the command line and scripts

As you can see, this chapter is loaded with information on VM management. This is the result of years of experience, so you'll find the tips and techniques presented in this chapter to be as valuable as a microwave oven. Although they may not heat your food any faster, they definitely will save you plenty of time managing your virtualized network.

Simply installing and running virtual machines is really just the tip of the iceberg. Once your VMs are configured, you can perform many tasks to make them run better and run in ways you never thought possible. In Chapter 4, you'll see all of this and more.

Chapter 5: Installing and Deploying VMs on Enterprise Servers

Chapters 5 and 6 are similar in format to Chapters 3 and 4. In Chapter 5, we'll walk you through the installation and deployment process of VM applications on server systems, with the focus on using the VMs in a production role.

As with Chapter 3, in this chapter we devote time to both VMware GSX Server deployments on Linux and Windows operating systems and Microsoft Virtual Server 2005 deployments on Windows operating systems. With the decision to run VMs in production comes a new list of responsibilities. Whether you're looking to run domain controllers, file servers, or even database servers as VMs, you must consider several performance factors for each scenario before setting up the VMs. Many of us have learned the sizing game the hard way, and we don't want you to have to suffer as well. An undersized server can sometimes be the kiss of death for an administrator, as it may be difficult to get additional funds to "upgrade" a server that's less than two months old, for example. Sizing a server right the first time will not only make VM deployment easier but it may also help to win over a few of the virtualization naysayers in your organization. When deploying cutting-edge technology, you'll always have pressure to get it to run right the first time, so pay close attention to the advice offered in this chapter. We've made plenty of the common deployment mistakes already, so you shouldn't have to do the same!

Chapter 6: Deploying and Managing Production VMs on Enterprise Servers

Running VMs in production may involve managing fewer physical resources, but the fact that multiple OSs may depend on a common set of physical hardware can cause other problems. For example, rebooting a VM host server may affect four servers (a host plus three VMs) instead of one. Problems such as this put more pressure on you as an administrator to consider how an action on one server can impact several other servers.

With VMs in production, keeping the host system happy will likely result in well-running virtual machines. Again, with many systems depending on the hardware of one system, a hung CPU, for example, could have devastating consequences. This is why monitoring and maintenance is still crucial after deployment. To help ease your mind, in this chapter we'll give you guidance on all the most common VM server administrative tasks, including the following:

- Automating the startup and shutdown of virtual machines
- Monitoring VM and host performance and alerting when performance thresholds are passed
- Using Perl and Visual Basic scripts for management, monitoring, and alerting
- Spotting host system bottlenecks and taking the necessary corrective action

As with its predecessors, you'll find Chapter 6 to have valuable information for managing production virtual machines.

Chapter 7: Backing Up and Recovering Virtual Machines

Now that you have your VMs up and running, you can't forget about protecting them. In this chapter, we'll cover all the methods for backing up and recovering virtual machines. We'll discuss the following:

- Backing up VMs with backup agent software
- Backing up VMs as "flat files"
- Backing up the VM host
- Using the available scripted backup solutions

As you can see, you'll have plenty of alternatives when deciding on how to best protect your virtual machines. In this chapter, we'll not only show you each VM protection methodology but we'll also outline the common pitfalls that exist with certain choices.

Chapter 8: Using Virtual File Systems

While the first half of the book is devoted to the design, deployment, and management of virtual machine solutions, the second half deals with the remaining virtualization technologies currently available. Chapter 8 leads off by explaining virtual file systems. With virtual file systems, you can manage files and file shares transparent to their physical location. For users, this means they won't need to know where a file is physically located in order to access it. For administrators, this means that if a file server needs to be brought down for maintenance, you can move its data temporarily to another server so that it remains available to users, without the users ever noticing a difference. Also, it's possible to configure replication with your virtual file system solution, which can allow for both load balancing and fault tolerance of file server data.

To tell the complete virtual file system story, we'll explain the most widely employed solutions available today, including both DFS and Andrew File System (AFS).

Chapter 9: Implementing Failover Clusters

The general concept of clustering is to allow multiple physical computers to act as one or more logical computers. With server or failover clusters, two or more physical servers will host one or more virtual servers (logical computers), with a primary purpose of preventing a single point of failure from interrupting data access. A single point of failure can be any hardware device or even software whose failure would prevent access to critical data or services. With the server cluster, a virtual server will be hosted by a single node in the cluster at a time. If anything on the host node fails, then the virtual server will be moved by the cluster service to another host node. This allows the virtual server running on the cluster to be resilient to failures on either its host system or on the network. Figure 4 shows a typical server cluster.

One aspect of the server or failover cluster that's unique is that all physical computers, or nodes, can share one or more common storage devices. With two nodes, this may be in the form of an external Small Computer System Interface (SCSI) storage array. For clusters larger than two nodes, the shared external storage can connect to the cluster nodes via either a Fibre Channel bus or an iSCSI bus.

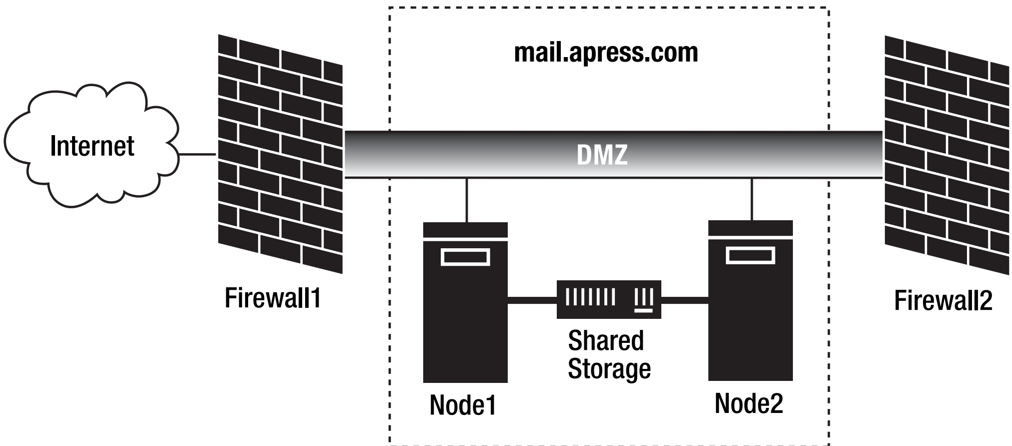

Figure 4. *Two-node mail server cluster*

In Chapter 9, we'll fully explain server clustering, outlining its deployment options and common management issues. To tell the complete clustering story, we'll cover the deployment and management of both Windows and Linux clustering solutions.

Chapter 10: Creating Load-Balanced Clusters

Load-balanced clusters give you the ability to relieve some of the load on an overtaxed server. With load balancing on Microsoft servers, you can configure up to 32 servers to share requests from clients. On Linux, you can even go beyond the 32-node limit imposed by Microsoft server operating systems.

In short, load balancing allows you to configure multiple servers to act as a single logical server for the purpose of sharing a high load of activity imposed by network clients. In a load-balanced cluster, two or more physical computers will act as a single logical computer, as shown in Figure 5. Client requests are evenly distributed to each node in the cluster. Since all clients attempt to access a single logical (or virtual) server, they aren't aware of the physical aspects of the network server they're accessing. This means a client won't be aware of which physical node it's in communication with. Configuring load-balanced clusters will give you a great deal of flexibility in a network environment that requires a high level of performance and reliability. Because of its natural transparency to clients, you can scale the cluster as its load increases, starting with two nodes and adding nodes to the cluster as the demand requires.

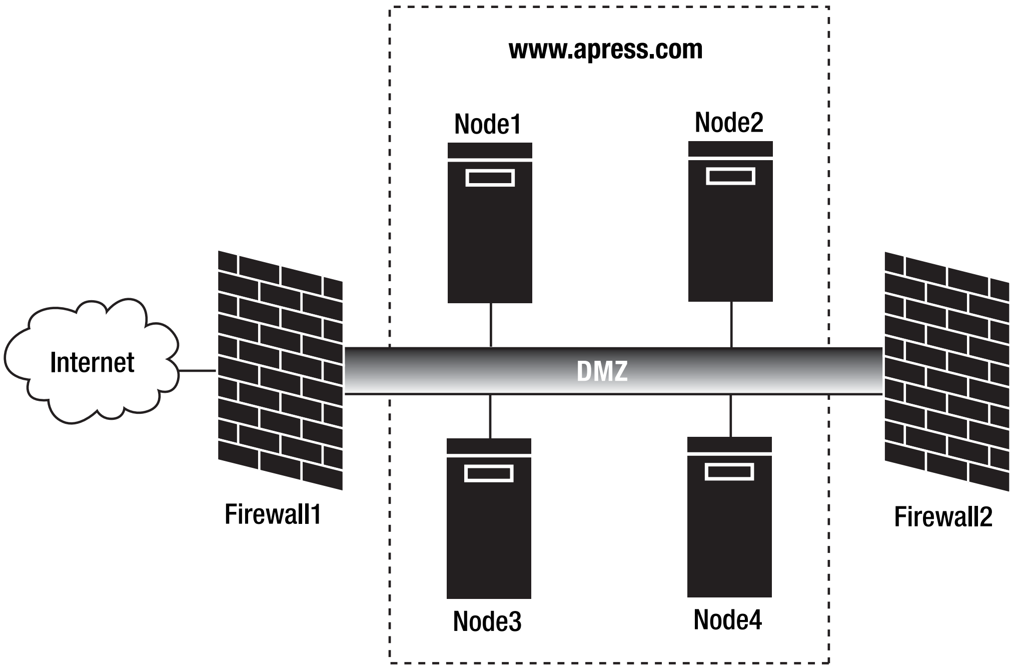

Figure 5. *Four-node load-balanced Web server cluster*

Since load-balanced clusters don't share a common data source (as with server or failover clusters), they're typically used in situations that require fault tolerance and load balancing of read-only data. Without shared storage, writing updates to a load-balanced cluster would be difficult to manage, since each node in the cluster maintains its own local copy of storage. This means it's up to you to make sure the data on each cluster node is completely synchronized. Because of this limitation, load-balanced clusters are most commonly a means to provide better access to Web and FTP services.

In Chapter 10, we'll take you through the complete design and implementation process for load-balanced clusters. We'll show you examples of when to use them and also detail how to deploy load-balanced clusters on both Windows and Linux operating systems.

Chapter 11: Building Virtual Machine Clusters

Although many organizations have or plan to run clusters in production, few have resources to test cluster configurations. That's where building virtual machine clusters can help. With virtual machine clusters, you can build and test working cluster configurations on a single system. Having this ability gives you several advantages, including the following:

- The ability to have others train on nonproduction equipment
- The ability to perform practice restores of production clusters to virtual machines
- The ability to perform live demonstrations of cluster configurations using a single system

Before virtual machines, most administrators had to learn clustering on production systems, if at all. Few organizations had the resources to run clusters in lab environments. When it comes time to test disaster recovery procedures, many organizations can't practice recovery for clusters, again because of limited resources. By being able to run a working cluster inside of virtual machines, organizations now have a means to test their backups of server clusters and in turn prepare recovery procedures for the production cluster. Applications and resources that run on server clusters are often the most critical to an organization. Oftentimes, when a disaster occurs, it's the clusters that must be restored first. Without having the ability to test recovery of the cluster and thus practice for such an event, recovering a cluster in the midst of a crisis can be all the more nerve-racking.

After reading Chapter 11, you'll understand the methodologies needed to configure nearly any cluster configuration using virtual machine technology.

Chapter 12: Introducing Storage Networking

The development of storage virtualization has been fueled by the rapid growth of storage networking. In short, storage networking allows you to network storage resources together for the purpose of sharing them, similar to a TCP/IP network of workstations and servers.

To understand the methodologies and benefits of virtualized storage resources, you must first be comfortable with storage networking technologies. This chapter lays the technical foundation for Chapter 13 by fully dissecting storage networking. Topics covered in Chapter 12 include storage area networks (SANs), network-attached storage (NAS), and direct-attached storage (DAS). Several modern storage networking protocols will be discussed, including the following:

- Fibre Channel Protocol (FCP)
- Internet Fibre Channel Protocol (iFCP)
- Fibre Channel over Internet Protocol (FCIP)
- Internet SCSI (iSCSI)

In addition to covering all the relevant storage networking protocols, we'll also dive into the hardware devices that drive storage networks. The following are some of the most common storage networking hardware devices that will be examined in this chapter:

- Fibre Channel switches
- Fibre Channel bridges and routers
- Fibre Channel host bus adapters (HBAs)
- Gigabit interface converters (GBICs)

Many in IT don't find storage to be the most thrilling topic, but nearly all realize its importance. Because of the inherently dry nature of storage, you may find that this chapter serves dual purposes: it lays the foundation for understanding storage virtualization, and it may substitute as an excellent bedtime story for your children, guaranteed to have them sleeping within minutes!

Chapter 13: Virtualizing Storage

Storage virtualization stays within the general context of virtualization by giving you the ability to view and manage storage resources logically. Logical management of storage is a significant leap from traditional storage management. For many backup administrators, having to restore a file often meant knowing the day the file was backed up and also knowing the exact piece of backup media on which the file was located. With storage virtualization, many backup products now abstract the physical storage resources from the administrator. This allows you as an administrator to simply tell the tool what you want, and it will find the file for you.

With data continuing to grow at a near exponential rate, it can be easy to become overwhelmed by the task of managing and recovering data on a network. As your data grows, so do the number of storage resources you're required to track. Having the right tools to give you a logical view of physical storage is key to surviving storage growth without having to seek mental counseling. Okay, maybe that's a stretch, but you'll certainly see how much easier your life as an administrator can become after you finish reading this chapter.

Chapter 14: Putting It All Together: The Virtualized Information System

Following a theme common to most technical references, Chapters 1–13 cover virtualization technologies one at a time, making it easy for you to find specific information on a particular topic. However, although it's nice to understand and appreciate each technology, it's also crucial to understand their interrelationships. In this chapter, you'll see examples of networks running several combinations of virtualization technologies simultaneously.

Many find relating virtualization technologies to their organization's networks to be challenging. Some common questions we run into quite frequently include the following:

- How can I justify an investment in virtualization to upper management?
- What are the best uses for server-class virtual machine products?

- What are the best uses for workstation-class virtual machine products?
- How can I optimize data backup and recovery between VMs and my production storage area network?
- What situations are best suited for clustering solutions?
- What questions should I ask when sizing up suitable hardware and software vendors?
- What precautions must be observed when integrating different virtualization technologies?

In addition to answering the most common questions surrounding running virtualization technologies in production and test environments, we'll also provide examples of the methods other organizations are using to make best use of their virtualization investments. This chapter wraps up with a detailed look at a process for maintaining standby virtual machines that can be automatically brought online if a production VM fails.

Appendix

Although virtualization product vendors such as EMC and Microsoft will go far to aiding you with support utilities, several other vendors also offer products to add virtualization layers to your existing network and to also aid in managing virtualized network resources.

In this appendix, we'll shower you with examples of some of the latest and greatest virtualization products on the market today. Several of these vendors have allowed us to include evaluation versions of their products on the book's companion CD. With so many virtualization software and hardware vendors contributing to the virtualized information system, you'll probably find managing your virtual resources to be much simpler than you ever imagined.

Summary

Virtualization is no longer an umbrella for disconnected niche technologies but is rather what's seen by many as a necessity for increasingly complex information systems. Virtual machine technology has broad appeal to many different levels of IT professionals. Sales associates can run software demonstrations on virtual machines. Instructors now have a tremendous amount of flexibility when teaching technical classes. They can now demonstrate several operating systems in real time, and their students no longer have to team up with a partner in order to run client-server networking labs. Now students can run client and server operating systems on a single computer in the classroom.

VM technology today has reached several other IT professionals as well. Network architects and administrators can now test software deployments and design solutions on virtual machines, prior to introducing new technologies to a production environment. For our own testing, we've found that our wives are much happier since we no longer each need half a dozen computers in the home office. Now a single computer with several virtual machines works just fine. However, both of us no longer receive a Christmas card from the electric company thanking us for our high level of business each year.

Although the savings on electricity might be a bit of a stretch, the expanded roles of virtualization certainly aren't. When approaching this book, start with Chapter 1 if your first interest is virtual machines. This will set a solid foundation for Chapters 2–7. Following Chapter 7, you'll find that the remaining chapters serve as independent references on the various technologies that drive virtualization. Since Chapter 14 focuses on making all virtualization technologies seamlessly operate together in the same information system, you'll want to read it after Chapters 1–13.

To safely integrate virtualization technologies into your IT life, you first need to have a good understanding of what's available, when to use each technology, and also how to use them. That being said, let's not waste any more time discussing how great virtualization technology is. Instead, turn to Chapter 1 to get started with the anatomy of a virtual machine.

CHAPTER 1

Examining the Anatomy of a Virtual Machine

In the preface, you learned how to quickly slice and dice this book to get good, quick results. Now you'll look at what's going on under the hood of virtual machines (VMs). At the component level of VMs and physical hardware, you'll revisit some fairly basic concepts, which you might take for granted, that contribute to the successful virtualization of a physical computer. By taking a fresh look at your knowledge base, you can quickly tie the concept of virtualized hardware to physical hardware.

Wrapping your mind around the term *virtual machine* can be daunting and is often confusing. This stems from the varying definitions of the term *virtual machine*. Even the term *virtual* brings unpredictability to your understanding if you don't understand *virtual* to mean "essence of" or "properties of." In short, if a list of specifications is equal to a machine (think: personal computer), and if software can create the same properties of a machine, you have a VM. If you further reduce a computer to its vital component, electricity, it's easier to understand a VM: the entirety of a computer deals with "flipping" electricity on or off and storing an electrical charge. If software exists such that it can provide the same functionality, a hardware emulator, then a VM exists.

Hardware virtualization offers several benefits, including consolidation of the infrastructure, ease of replication and relocation, normalization of systems, and isolation of resources. In short, VMs give you the ability to run multiple virtual computers on the same physical computer at the same time and store them on almost any media type. VMs are just another computer file offering the same ease of use and portability you've grown accustomed to in a drag-and-drop environment.

Virtualization software protects and partitions the host's resources, central processing units (CPUs), memory, disks, and peripherals by creating a virtualization layer within the host's operating system (OS) or directly on the hardware. "Running on the metal" refers to virtualization software that runs directly on the hardware: no host operating system is required to run the software. Every virtual machine can run its own set of applications on its own operating system. The partitioning process prevents data leaks and keeps virtual machines isolated from each other. Like physical computers, virtual machines require a physical network, a virtual network, or a combination of both network types to communicate.