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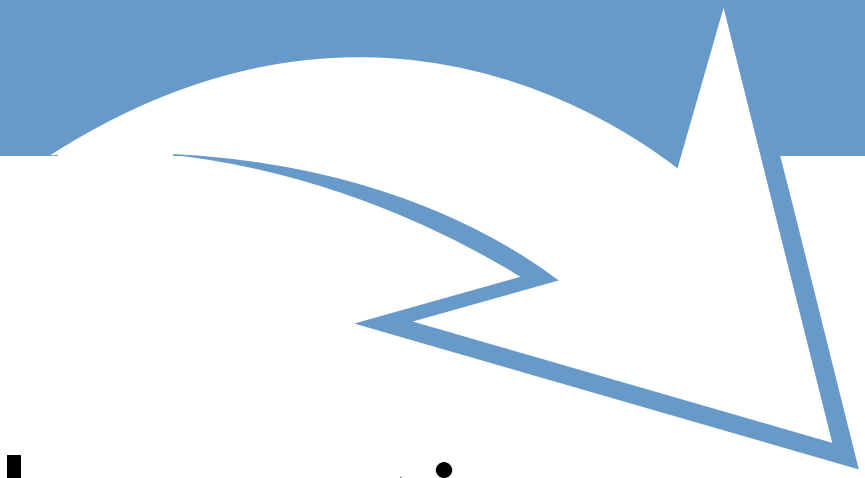

Implementing Virtualization in the Small Environment

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Greg Shields

Introduction to Realtime Publishers

by Don Jones, Series Editor

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Chapter 1: What Is the Technology Behind Virtualization?

Virtualization. Even if you're not technology savvy, you've likely heard of its concepts and perhaps even a few of its products. Virtualization's technology is a big and obvious play in enterprise environments. Its promise of shrinking your data center footprint, reducing power and cooling costs, and enhancing the workflow of your business make it a perfect fit for environments of size.

But small businesses and small environments needn't necessarily be left out in the cold. These oft-overlooked places—where no- or low-cost technologies are a necessity and administrators must take broad responsibility rather than specialize—stand to gain as well. Yet with so much information in the market today, much of which is focused on the needs of large environments, small businesses and their computing needs have a hard time understanding virtualization's technology, let alone justifying a move to it.

Thus the reason for this guide. This goal of this guide is to illuminate the technologies, the cost savings, and the workflow improvements that small businesses and environments will see with virtualization. By asking and answering a series of four important questions, this guide will pull you through the four most critical hurdles that you must understand to be successful in your virtualization implementation.

As the individual in charge of your company's technology decisions, you have probably asked yourself these same four questions:

- **What is the technology behind virtualization?** With the media's level of hype surrounding virtualization, an uninformed person could think it would solve every IT problem. Obviously this isn't true, but what exactly is virtualization and what can it do? Chapter 1 of this guide will discuss those technologies and what virtualization is really all about.
- **What business benefits will I recognize from implementing virtualization?** Understanding this technology is great, but the technology must provide a direct benefit to the small business to be of value. Chapter 2 of this guide will discuss the hard and soft benefits that small businesses and environments can immediately see by virtualizing servers.

- **What do I need to get started with virtualization?** Following an understanding of virtualization's benefits, small businesses next want to know how to get started. Virtualization comes in many no-cost and for-cost flavors, and can be implemented in innumerable configurations. Chapter 3 will discuss common first steps for small environments as well as the trigger points for investing in its no-cost solutions.
- **What are the best practices in implementing small environment virtualization?** Virtualization is no longer a nascent technology. Having been available for many years, a common set of best practices for its implementation have been developed. Following these best practices will ensure that your implementation provides the greatest value to your business.

A Product-Neutral Approach

There are many virtualization products available on the market today, each with its set of benefits and detractors, features and gotchas. With this reality in mind, this guide will take a product-neutral approach to presenting the technologies associated with virtualization.

The goal with this guide is to empower you with the information you need to make smart decisions about how to improve your computing efficiency with virtualization technology.

What Is Virtualization?

Circling around today's IT conversations, the question is really no longer "Should I virtualize my servers?" but "When can I do it?" Although systems virtualization has technically been around since 1967 with its start in IBM mainframes, its incorporation into Intel x86 systems started in the late 1990s. Since that time, virtualization has matured quickly over a few short years to become a major component both in the server room as well as on individual desktops.

As such, virtualization is not new technology. Although some vendors have recently introduced new products that fit under virtualization's banner, this technology has been around for a long time. Because of this long history, virtualization and its products today are mature solutions that are trusted by enterprises worldwide. That trust extends to even the most critical of server workloads.

Layers of Abstraction

At its most basic, virtualization is involved with the abstraction of computer resources. This abstraction is put into place because it enables a logical separation between a resource and how that resource is used. Consider the address book on your telephone. This address book provides an excellent example of how a layer of abstraction works. When you enter a name into that address book, you assign it a telephone number. You do so because it is operationally easier to work with a person's name than their individual phone number. Abstracting that person's number beneath their name makes it easier and more efficient to work with the telephone system.

Another benefit of abstraction is the ability to relocate an underlying resource without affecting how you access it at the top level. With your telephone address book, it is possible to change a person's underlying phone number without changing their name. As a result, a change to that person's phone number doesn't have to change your process for calling them.

With virtualization, this abstraction exists between two "layers" of a computer system. There are many virtualization architectures available today, with the differences in each having to do with where that layer is positioned. This guide will discuss the kind of virtualization commonly called *hardware virtualization* or *systems virtualization*. In this type of virtualization, everything that makes up a computer's operating system (OS), installed applications, and data are abstracted away from its physical hardware to create a "virtual" server. Figure 1.1 shows an example of how this setup looks in comparison to the earlier phone number example.

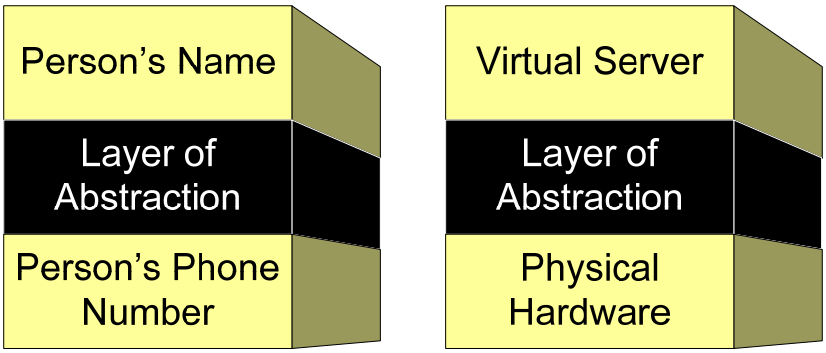

Figure 1.1: Virtualization involves adding layers of abstractions to resources.

The Hypervisor

For virtualized computers, that layer of abstraction is handled through the use of a hypervisor. This hypervisor is a thin layer of code that is installed directly on top of a server's physical hardware. "Below" itself, the hypervisor's code interfaces with the hardware devices that make up the physical server. At the same time, the hypervisor presents a uniform interface "above" itself, upon which virtual machines can be installed. The job of the hypervisor is to intercept hardware resource requests from residing virtual machines and translate those requests into something understandable by the physical hardware. The reverse holds true as well: Requests from physical hardware that are destined for a virtual machine are translated by the hypervisor to an emulated device driver the virtual machine can understand.

As you can see in Figure 1.2, no matter what hardware composition is present on the physical machine, each residing virtual server sees the same set of emulated hardware because they are exposed "on top" of the hypervisor.

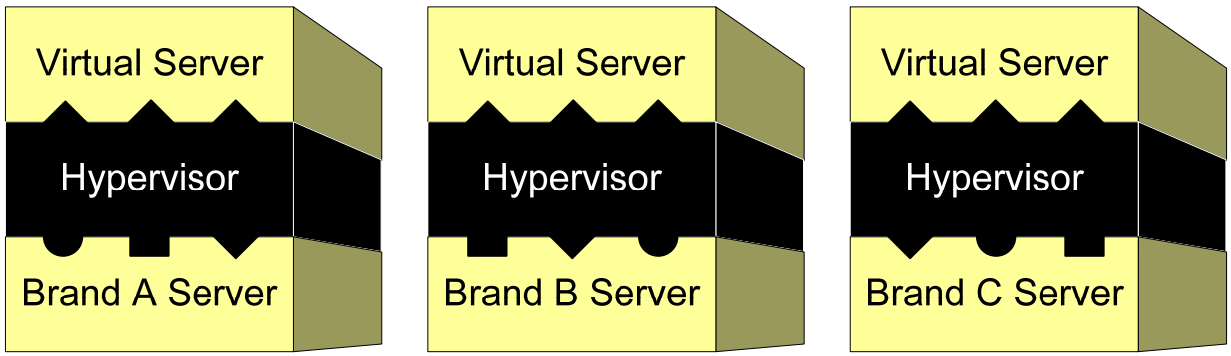

Figure 1.2: The hypervisor abstracts each server's unique hardware to create a uniform platform for virtual servers.

The benefit of this abstraction is that the computer's OS and applications no longer directly rely on a specific set of physical hardware. A virtual machine can be run atop essentially any physical hardware, effectively decoupling hardware from software. If a piece of physical hardware experiences a problem, the processing of that server instance can be manually or automatically relocated to different hardware. If Brand A of a server is no longer available for purchase or parts, it is now trivial to relocate the virtual machine to Brand B. In every case, this movement requires no configuration change to the virtual machine itself.

Hardware Independence with Virtual Servers

This introduction of hypervisors into the traditional data center enables levels of systems commonality never before seen by IT. Whereas physical servers are often quite different from each other in terms of device and hardware composition, virtual servers operate with functionally the same hardware. When every server in your environment runs with the same hardware, you have fewer drivers to deal with, fewer conflicts to plan for, and a much more predictable environment to administer.

A result of this commonality is greater flexibility with the positioning of server instances. Consider the situation in which a critical server experiences a problem. In the worst of cases, it can be necessary to relocate that server's OS and applications to a new piece of hardware. You might want to do so because the service that server is running is highly critical to your business, and its extended downtime costs you money.

If that server is a physical server, this task is exceptionally complex and is generally possible when the two servers have the exact same hardware. This requirement presents a problem because many environments use servers from multiple vendors or product generations, and keeping exact spares on-hand to support this need is expensive and wasteful. As a result, a server's hardware problem can directly impact the functionality of your critical business services.

With virtual servers, a hardware problem isn't really a problem at all. Because virtual servers are decoupled from their physical hosts, they tend to see a greater level of inherent resiliency. Should a virtual server's host experience a problem, moving the virtual server to a new host involves little more than a file copy. This process can be invoked by an administrator when the problem occurs, or in some cases, can occur automatically when virtual monitoring software recognizes the problem. In either case, the hypervisor ensures that a uniform platform exists for virtual machines no matter what kind of server to which it is installed.

Virtualization Reduces Your Hardware Footprint

Virtual machines are also superior to physical machines because more than one virtual machine can run atop a single host. Because virtualization eliminates the direct connection between server instance and physical hardware, the hypervisor can support the running of multiple virtual machines atop a single host. This ability to consolidate multiple physical machines onto a single virtual host provides substantial cost savings while increasing the efficient use of existing hardware. In essence, with virtualization, you'll actually use *more* of your purchased server hardware.

Why is this true? As an average, many Windows server computers rarely use more than 5 to 7% of their available processor resources. They are often overloaded with RAM memory, sometimes containing 4×, 8×, or greater memory than is actually needed to process their assigned mission. This massive over-engineering of computer hardware has been common in IT as the rate of server hardware performance—and subsequent reductions in cost—has outpaced the needs of software. It also happens due to the standardized hardware configurations that are available to be purchased through the major server vendors. As a result, many non-virtualized servers today spend much of their time idly flipping ones and zeroes as they wait for their next instruction.

Yet with your small business, you likely want to get the most out of those costly server purchases. With virtualization, another major job of the hypervisor is to schedule hardware resource requests between virtual machines on the same host. Thus, a large number of underutilized physical computers can be easily consolidated onto a single virtual host and run concurrently.

The result is that the number of physical servers you need to run your business goes down significantly. This reduction in your total number of physical servers means less equipment to manage, to power, and to keep cool, all of which directly reduces your overall costs. Figure 1.3 shows a representative example of how this reduction might change the look of your server racks.

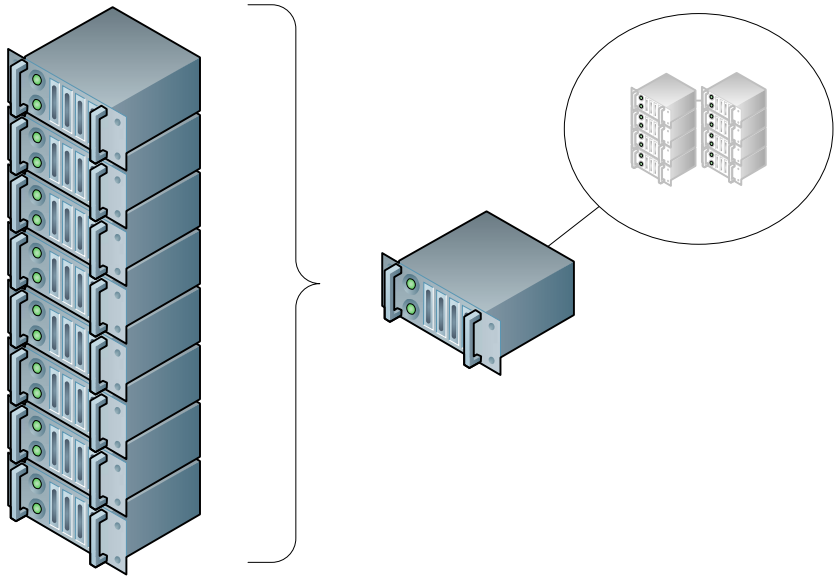

Figure 1.3: Virtualization consolidates many underutilized physical machines onto a single virtual host.

Virtual Consolidation Requires Performance Management

Obviously, with the consolidation of many server instances onto fewer physical servers, there is the potential to simply go too far. When too many virtual machines are collocated on the same host, each finds itself fighting for needed resources. The result is that the performance of every virtual machine goes down.

One critical skill that gains priority in virtualized environments is the monitoring and management of host and virtual server performance. Your virtual platform software should include the necessary tools to allow you to watch for and correct performance-related problems. This guide will talk more about best practices for performance management in Chapter 4.

Virtual Disks Enjoy Special Benefits

One mechanism that enables this flexibility with virtual servers is in the way their hard disks are presented. Inside a traditional physical server's hard disk are stored the thousands of files and folders required for that server instance. Those thousands of files and folders are responsible for the OS, any installed applications, and even the data that the server works with in fulfilling its mission.

The OS that makes up a virtual server still requires each of those files to be available, and from the perspective of the virtual server itself, those files are individually accessible. However, from the perspective of the virtual host, all the files and folders on that server's disk drive are encapsulated into a single file. This single file—typically one per disk volume—bestows unique capabilities on the virtual server:

- **File relocation.** Since the entire composition of a virtual machine is encapsulated into a single disk file, relocating a server from one host to another requires little more than moving that file to a new host. Virtual platforms often have a small handful of additional files that store configuration information about the virtual machine itself. Yet every file and folder that makes up that server is effectively encapsulated into that single disk file per mounted volume.
- **File copy replication.** Making the previous feature even more useful is the ability to copy that single file to create a new one. Completing this process creates an exact replica of the original server that can be hosted elsewhere in the environment. This capability makes it easy for administrators to create additional servers as necessary. Entire server template libraries can be created for commonly needed servers, drastically reducing the amount of time required to build new servers when needed.
- **File snapshots.** Today's modern file systems and virtualization platforms include the ability to "snapshot" the server's disk file as well. This snapshotting process effectively creates a second disk file that is connected to the first. When this process is initiated, all changes to the original disk file are instead written to the second disk file. The virtualization platform combines both the original and "delta" disk files to create and process the virtual server. The benefit here is that a snapshot of that virtual server's state can be created at any point. Changes made to that virtual server after the snapshot are stored in the delta file. If those changes are later no longer desired, the administrator simply "rolls back" the server to its pre-snapshot state, eliminating the deltas. This feature enables administrators to protect a server's state from the installation of a poorly developed patch or application. It allows administrators the flexibility to work with a server knowing that any changes can be immediately rolled back if mistakes are made or can be merged with the server's "main" disk file if successful.

- **Single-file backup and guaranteed restore.** Traditional backups with physical servers have historically been an area of concern with IT administrators. With thousands of files that make up a typical Windows server, the loss of only a single file in a regular backup can prevent the successful emergency restore of that server. Making this problem worse, backup software can sometimes miss files because they are locked or in use. The combination of these two problems makes the successful restore of a failed server a less-than-guaranteed situation. With virtual servers, however, backing up the entire server requires backing up only its single disk file. This encapsulation of a server's state onto a single disk file goes far towards ensuring its successful restore.
- **Inexpensive disaster recovery.** Lastly, small environment disaster recovery has historically been impossible due to the operational costs and complexities of managing a secondary off-site data center containing duplicate servers and other hardware. Virtual servers and their disk files bring inexpensive and operationally feasible disaster recovery to even the smallest of businesses. Necessary is the off-site replication of backed up virtual server disk files. Also needed at that backup site are a set of servers that can later power on those virtual servers after a disaster. Because of the impact of the hypervisor, those servers needn't be the exact same hardware as what is installed at your primary site.

Virtualization Enables Cost-Effective Role Isolation

A common architectural decision in many of the smallest environments is to operate numerous server roles atop a single server. These services can be infrastructure services such as DNS, DHCP, or Active Directory (AD) domain services, or in some cases, can be user services such as SQL, application services, or email servers like Microsoft Exchange.

This assignment of multiple roles per server is actually in conflict with the best practices for Windows server architecture design. Best practices suggest that each server role or application should be installed to its own individual server. The reasons for this role isolation are many:

- Isolated roles are less likely to conflict with each other
- The loss of one server will not negatively impact the processing of other services
- Patching, update, and administrative requirements grow less complex when roles are isolated
- Lowered complexity means a reduction in the chance for an outage

The problem is that small businesses and environments are often forced into multiple roles per server because of limited funding. Many small businesses simply cannot afford the costs associated with purchasing individual servers for each needed service. This situation is especially problematic when considering the low resource-utilization nature of many infrastructure services. Although role isolation is a good idea, most infrastructure services use very little of a server's processing power, making their consolidation appear to make more sense for the small environment.

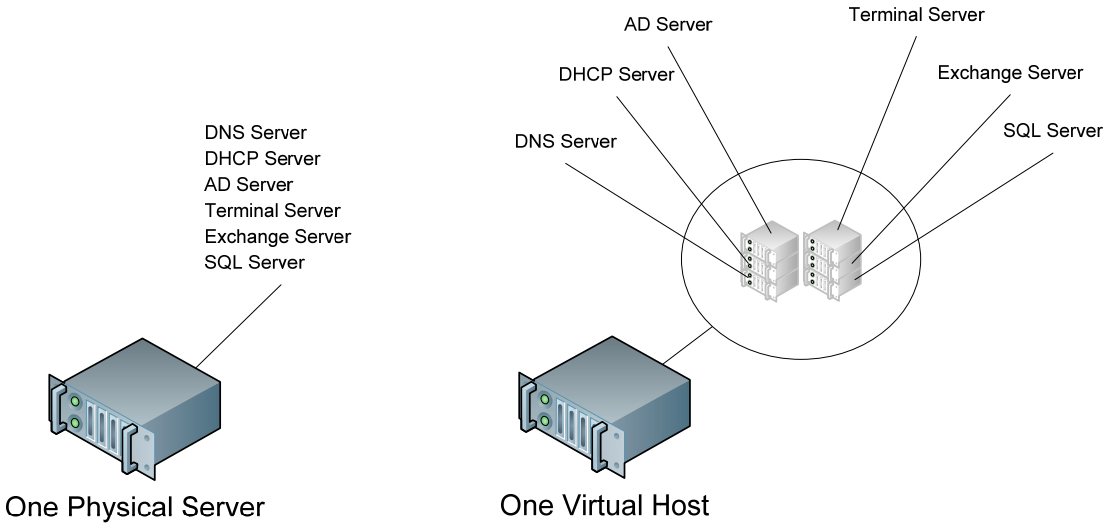

Figure 1.4: On the left is a physical server with consolidated roles. The right shows the same server as a virtual host supporting role isolation.

Figure 1.4 shows how the addition of virtualization often changes the outcome of this decision. Incorporating virtualization into the small environment offers an opportunity to address this conundrum, due to two major factors:

- **Low-use infrastructure services tend to be excellent candidates for virtualization.** Infrastructure services such as those discussed earlier tend to require very few resources in order to accomplish their stated missions. For example, in very small domains, AD domain services requires very little processor power and can be operated atop a server configured with as little as one gigabyte of RAM. This level of service consumes only a slight percentage of a server's total available resources. As such, virtualizing multiple critical but low-needs services such as these provides a way to efficiently isolate each into its own virtual server.

- **Special virtualization licensing from Microsoft extends the value of each physical license.** With the release of Windows Server 2003 R2 in 2005, Microsoft updated the terms of its licensing agreements. These new terms added licensing benefits for certain editions of its server OS. Specifically, a company is entitled to install and license an additional four virtual instances for every purchased license of Windows Server 2003 R2 Enterprise Edition. For Windows Server 2003 R2 Datacenter Edition, an unlimited number of additional virtual instances can be installed and licensed. This count of additional licenses is related to concurrently running instances, giving a business the option to install—but not run—an unlimited number of non-running instances. With the release of Windows Server 2008, Microsoft changed the terms again to allow one additional virtual instance when purchasing Windows Server 2008 Standard Edition.

The combination of a virtualization's consolidation capabilities with Microsoft's licensing benefits now enables even small businesses to build the right level of role isolation into their networks. By building role isolation per best practices, small businesses and environments can further enhance the resiliency of their servers and services.

P2V Converts Physical Servers to Virtual Servers

All of this discussion about moving to virtualization is incomplete without a nod to the tools that enable the direct conversion of physical servers to virtual ones. Moving your environment from physical to virtual needn't require the wholesale reinstallation and rebuild of every server in your environment. Rather, all virtualization platform software typically includes a set of tools that convert physical servers to virtual servers. These tools are generically referred to as *P2V Tools*.

This P2V process is very similar to the processes used to image and rapidly deploy desktops and laptops. Where it differs is in the end result. Instead of rapidly deploying an image to a new piece of physical hardware, the result of a P2V conversion is the creation of a virtual server's disk file. The P2V process is also different in that its processes automatically inject the proper device driver software into the imaged virtual server. This injection is required so that the server can correctly interoperate with the virtual platform and its hypervisor. These tools are particularly useful in that they can convert physical servers without requiring them to be powered down. Most P2V software available today can complete a full conversion while the source machine remains online and operational.

In the past, early P2V software was quite different in the types of capabilities and feature sets available. However, today's P2V software has become a relative commodity between vendors. As such, the capabilities between the P2V software of one virtualization platform vendor and another are fairly similar. This being said, there remain two areas in which differences remain. The first has to do with the administrative activities that wrap around the P2V process. These relate to scheduling of the P2V process, P2V agent distribution, the automatic mounting of converted servers into the virtualization environment, and scripting exposure for custom actions.

Motioning Automates Load Balancing & Failover

Earlier, this chapter discussed how small businesses and environments—just like large enterprises—cannot function if their services are not up and operational. Lacking those services, even the small business stands to lose money, as they cannot meet the needs of their customers. To that end, it was also discussed how virtualization enables a virtual server to be relocated from one host to another in the case of a host problem.

The generic industry term for the automated move of virtual machines from one host to another is *motioning*. There are three common ways in which motioning can occur with a virtual machine:

- This process can be invoked by an administrator to relocate virtual servers off a potentially failing host.
- It can be invoked to move running virtual machines off of a host prior to an upgrade that involves downtime on that host.
- It can automatically relocate and restart all virtual machines onto new hosts after a complete host failure.
- It can be used as a performance management tool to load-balance virtual servers across available physical hosts to ensure the best possible performance.

Different virtualization platforms enable motioning through different mechanisms, and each requires its own set of technologies for this automated relocation to take place. Essentially, all virtual platforms can relocate a virtual server through a traditional file copy when that server is powered off. However, some provide the ability to relocate that virtual server while it remains powered on. This process is often generically referred to as *live migration*, and it requires a bit more additional technology involvement than what is required for a traditional file copy. Let's take a look at the components that are commonly required in order to enable this added reliability for your virtual servers:

- **Supporting virtual platform.** First and foremost, your virtual platform must support the live migration capability. Important to note here is that the features necessary for accomplishing a live migration often require an add-on cost to the base cost of the virtual platform.
- **Flexible networking.** Your networking infrastructure must support the correct configuration and features necessary to recognize a server has been moved from one network port to another and to quickly re-converge. The networking protocols necessary to enable this automated reconfiguration work with the virtual platform to handle the change and are often a feature available only in business-class networking devices.

- **Shared storage.** Lastly, some form of shared storage is usually required for the storage of virtual machines. This requirement is commonly fulfilled through the use of shared storage such as iSCSI, fibre-channel, NFS, and others, all of which have the necessary capabilities to support multiple, simultaneous host access. Although the relocation of a virtual server while it is powered off usually involves moving its disk files as well, most live migration technologies only relocate the processing of the virtual machine. The virtual machine's disk files do not actually move during the relocation. Figure 1.5 shows a graphical example of how this process works. You'll see in this figure how the processing of the virtual machine changes hosts but the virtual machine's disk files do not.

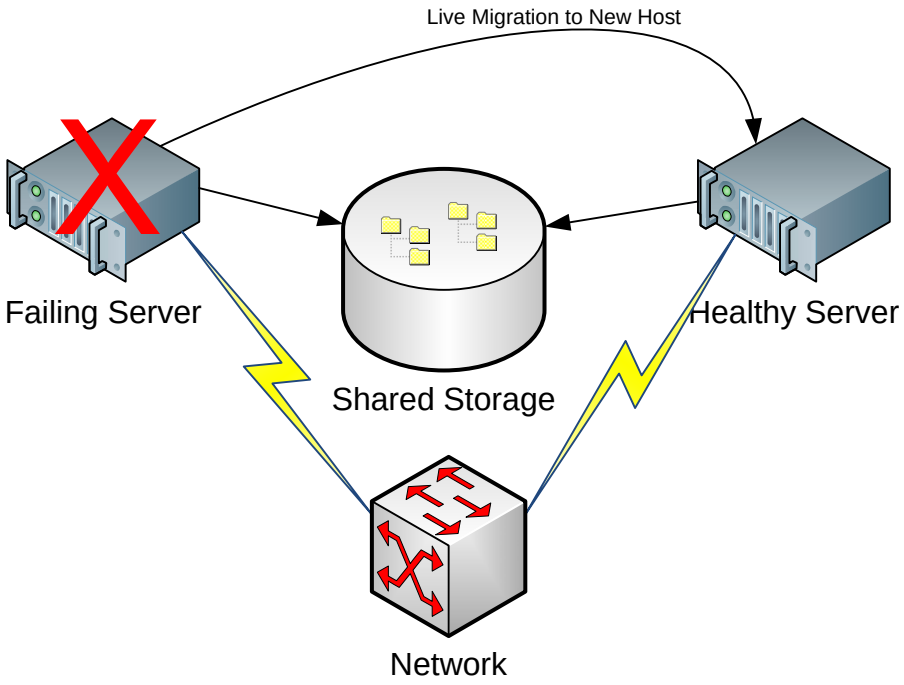

Figure 1.5: With live migration, when a host is failing or load needs rebalancing, virtual machine processing can be automatically relocated to a new host without server downtime.

Live Migration with Storage Relocation

Although most live migration technologies do not relocate server disk files during a migration, some virtualization platforms are beginning to include this as a feature. This dual migration of server processing and disk file relocation can be a boon for environments that want to maintain the uptime of their servers while moving their disk files to new locations.

High-end motioning technologies all involve add-on costs to virtualization environments, yet they enable the highest levels of resiliency and load balancing for your virtual servers. Thus, using them in your environment will involve a tradeoff of cost versus capabilities.

When considering a virtualization solution, factor in your business' tolerance for downtime. Due to the nature of their business, some small environments can tolerate the loss of even a critical server for a few hours up to a day or more. Others cannot tolerate downtime for even a few minutes.

> Chapter 2 will go into greater detail about this tradeoff and the differences in capabilities between no-cost and for-cost virtualization platforms.

What Will This Technology Cost?

It can cost as much as…nothing. Virtualization platforms exist today with prices that range from freeware to very expensive. The key differences between platforms are in the type and scalability of features that layer on top of the basic capabilities outlined in this chapter.

The basic ability to install a hypervisor to a virtual host and begin running virtual machines is today considered a commodity technology from the perspective of price. Essentially, every virtualization software vendor today provides the basic capability to run virtual servers atop a hypervisor for no cost. Other no-cost features include:

- The ability to remotely access the virtual server's console over the network
- The ability to enact machine-level changes to that machine, such as power on, power off, reboot, and others
- The ability to perform basic snapshotting
- The ability to perform basic virtual server backup and restore of entire virtual servers at once

These capabilities enable small businesses and environments with light needs to quickly move to virtualization with very little or no initial capital investment. For the needs of many small businesses and environments, these capabilities available with virtualization's free software options will suffice. What are missing from these free tools, however, are the additional management functionality and high-end features that may be a necessity down the road.

> Chapter 3 will discuss this decision in more detail with a description of common features available in each class of virtualization software.

It's More Than Just Software

It is important to note that with the more robust classes of virtualization software, there are more costs to the organization than just the software itself. When an organization decides that it needs more advanced capabilities, additional hardware such as servers, storage, networking, and cabling will likely be necessary as well. This additional hardware can substantially increase the cost associated with making the jump to high-end virtualization. That being said, substantial additional benefits are gained with those additional costs.

Will My Existing Servers Be Supported?

In all likelihood, yes. It is true that many virtualization platforms require the use of recent hardware features on servers that support virtualization extensions directly on the hardware itself. However, not all virtualization platforms have these requirements. Many no-cost virtualization solutions can be run atop essentially any server available today.

It is, however, important to temper the previous statement with a caution. Virtualization is all about performance. As such, the specified hardware requirements that are necessitated by many high-end virtualization solutions are in place to ensure the highest level of performance. From a technical perspective, virtualization solutions of the type focused on in this guide can be broken down into two major classes:

- **Type-1.** Type-1 virtualization solutions as a whole are the most equivalent to what has been discussed in this chapter so far. These solutions leverage a hypervisor that itself is installed directly atop physical hardware. Type-1 virtualization solutions can and often do require specialized hardware, yet they enjoy the highest levels of performance. This is due to the hypervisor's extremely "thin" code as well as its positioning directly between virtual servers and hardware.
- **Type-2.** Type-2 virtualization solutions actually install as applications on top of an existing OS. These solutions leverage the existing OS and its integrations into hardware resources. The hypervisor for these types of virtualization solutions is functionally equivalent to what has been discussed in this chapter thus far. However, because of the added OS "layer" beneath the hypervisor, these solutions suffer from lowered levels of performance.

Your existing servers—even those that are beyond their operational life cycle—are very likely to support Type-2 virtualization and its products. Your more recently purchased servers are likely to support both classes. Obviously, with Type-1 virtualization's dramatic performance enhancements, it is a likely goal for use in your small environment today.

Telling Them Apart

In every case, a Type-1 virtualization solution will involve the direct installation of a hypervisor to a host system. That host system can include an OS for management purposes or can be devoid of a full OS entirely. In every case, a Type-2 virtualization solution will arrive as an application that is installed on top of an existing OS instance.

Virtualization Makes Sense for Even the Smallest of Environments

Virtualization makes sense for large enterprises. In an all-physical world, their massive environments are so wasteful of processor cycles as well as power and cooling energy that any consolidation of servers to virtual servers makes sense.

But virtualization makes sense for the small environment too. Small environments stand to gain reliability advantages from virtualization's enhanced systems commonality. The ability to relocate virtual servers when hardware failures occur is a boon to availability for small environments. The accident protections gained through snapshots reduce downtime that is related to administrator mistakes. Tying all of these together are the cost savings gained through consolidating many servers onto few.

It is the goal of this guide to assist you with understanding the nuances of how virtualization can work in your small business or environment. To continue this discussion, the next three chapters will expand the conversation to include the benefits, implementation suggestions, and best practices you can employ today to incorporate virtualization into your business and technology plans.

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