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Complex systems virtualization in the current's economical context

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Abstract. How can we dramatically improve the efficiency and availability of resources and applications in our organization? Today, the answer is very simple: virtualization. Reducing your capital and IT operational costs by virtualizing your IT infrastructure in a „virtual infrastructure" while increasing the efficiency, utilization and flexibility of your existing assets.

Go beyond server consolidation and deploy a standard virtualization platform to automate your entire IT infrastructure. Virtualization IT infrastructure delivers resources, applications and even servers when and where they are needed. Use the power of virtualization to better manage IT capacity, provide better service levels, and streamline IT processes.

Respond to market dynamics faster and more efficiently than ever before with an automated virtualization platform.

Keywords: system, complexity, complex systems, virtual, virtualization, virtual infrastructure, virtual machine, platform virtualization, application virtualization.

1 Introduction

"The systems paradigm is a way of thinking about the strategic environment, and how to develop processes în organizations that achieve strategic goals. The systems paradigm should be viewed as a tool that leaders can use to design their organization's capability to: (1) analyze tactical and strategic environments; (2) develop and enact strategies în response to environmental demands; and, (3) sustain an adaptive and productive organizational culture. These three types of organizational processes are important în determining whether an organization can achieve strategic objectives în competitive environments."A Leader's Strategic Analysis of the Environment

"Data center virtualization projects have a ripple effect throughout an organization's infrastructure and operations. Collapsing multiple physical devices into software affects the people and processes supporting the data center. Before embarking on data center virtualization deployments, enterprises should account for how business processes, administrative rights, capacity planning, performance monitoring tools and security strategies will need to change." AT&T, How to Virtualize..

2 Virtual

The term virtual is a concept applied in many fields with somewhat differing connotations, and also, differing denotations.

The term has been defined in philosophy as "that which is not real" but may display the salient qualities of the real.[citation needed] Colloquially, 'virtual' is used to mean almost, particularly when used in the adverbial form e.g., "That's virtually [almost] impossible".

Numerous philosophers have advanced conceptions of the virtual. Most prominent of these in contemporary philosophy has been Gilles Deleuze, who uses the term virtual to refer to an aspect of reality that is not material, but which is nonetheless real.

Deleuze's concept of the virtual has two aspects: first, we could say that the virtual is a kind of surface effect produced by the actual causal interactions which occur at the material level.

"Virtual" is not opposed to "real" but opposed to "actual," whereas "real" is opposed to "possible." This definition, which is almost indistinguishable from potential, originates in medieval Scholastics and the pseudo-Latin "virtualis".

Recently this conception of the virtual has been challenged and another core meaning has been elicited by (Denis Berthier, "Meditations on the real and the virtual" — in French), based on uses in science (virtual image), technology (virtual world), and etymology (derivation from virtue — Latin virtus). At the same ontological level as "possible," "real," or "potential," "virtual" is defined as that which is not real, but displays the full qualities of the real — in a plainly actual (i.e., not potential) — way.

The word virtual has been applied to computing and information technology with various meanings. It is used of software systems that act as if they were hardware systems[citation needed](virtual machine, virtual memory, virtual disk), of computer-generated simulations of reality (virtual reality), and of internet gaming environments wherein entire worlds are created (virtual world) or the real world is supplemented with virtual images (augmented reality). Other applications of the word are being found constantly in this fast expanding field, such as virtual community, virtual library, and virtual class.

Early motivations for applying 'virtual' to computers (i.e., virtualization) were sharing of actual devices by many users and coordination of multiple processes, as seen with the successful use of the virtual machine approach.

Internet and communication technology fostered de-coupling of space where events happen, and storage technologies facilitate de-coupling of time between a message being sent and received. These technologies build the environment for virtual work in teams, with members who may never meet each other in person. Communicating by telephone and e-mail, with work products shared electronically, virtual teams produce results without being co-located.

Similarly, a virtual world is a type of habitation founded upon web technology that allows interactions for pursuits, such as economy and real estate.

2.1 Virtualization

Virtualization is a term that refers to the abstraction of computer resources:

- Virtual machine (VM), a software implementation of a machine (computer) that executes programs like a real machine
- Platform virtualization, which separates an operating system from the underlying platform resources
- Full virtualization, sensitive instructions replaced by binary translation or trapped by hardware - all software can run in the VM, e.g. IBM's CP/CMS, VirtualBox, VMware Workstation
- Hardware-assisted virtualization, CPU traps sensitive instructions - runs unmodified guest OS; used e.g. by VMware Workstation, Xen, KVM
- Partial virtualization, for specific applications rather than the operating system

- Paravirtualization, a virtualization technique that presents a software interface to virtual machines that is similar, but not identical, to that of the underlying hardware, thereby requiring guest operating systems to be adapted
- Operating system-level virtualization, a method where the operating system allows for multiple user-space instances (virtual hosting, chroot jail + resource management)
- Application virtualization, the hosting of individual applications on alien hardware/software
- Portable application, a computer software program that runs from a removable storage device as a USB flash drive
- Cross-platform virtualization, allows software compiled for a specific CPU and operating system to run unmodified on different CPUs and/or operating systems
- Virtual appliance, a virtual machine image designed to run on a virtualization platform
- Emulation or simulation
- Virtual memory, which allows uniform, contiguous addressing of physically separate and non-contiguous memory and disk areas
- Storage virtualization, the process of completely abstracting logical storage from physical storage
- Network virtualization, creation of a virtualized network addressing space within or across network subnets
- Virtual private network (VPN), a computer network in which some of the links between nodes are carried by open connections or virtual circuits in some larger network(s), such as the Internet
- Memory virtualization, aggregates RAM resources from networked systems into virtualized memory pool
- Desktop virtualization, the remote manipulation of a computer desktop
- Database virtualization, the decoupling of the database layer, which lies between the storage and application layers within the application stack
- Timeline of virtualization development, further work in this area

Virtualization projects are under consideration or already in progress at many organizations looking to decrease their capital and real estate expenses and to launch energy-conservation initiatives. Through the use of special virtualization products and services, data center managers can apportion computing hardware resources to operating systems and applications on a time-sharing basis. In doing so, they can significantly boost the utilization and efficiency of servers, network equipment and storage devices. Such projects reduce the overall number of physical devices needed, the floor and rack space needed to house them and physical equipment management requirements.

Virtualization, then, holds a number of potential capital and operational cost-saving benefits. But it raises a few questions, too. For example, a mature virtual infrastructure will cross many traditionally separate internal groups of employees, such as those responsible for servers, networks, storage and security. So a virtualization project is likely to have an impact on organizational structure and responsibilities. Therefore, getting executive commitment and support, particularly from chief financial executives able to see the big-picture savings potential of going virtual, is critical to organization-wide buy-in and cooperation.

There are basic technical and logistical questions to consider when considering a virtualization plan:

- How do you calculate the appropriate ratio to use when consolidating physical servers and other devices into software-based virtual machines (VMs)?
- What is the impact of VMs on current disaster recovery and high-availability plans?
- Do security requirements shift in a virtual environment?
- How might software licensing/pricing models, power requirements and patch management processes need to change?

What is Server Virtualization?

Out of all three of the different types of virtualization discussed in this article, I believe that server virtualization is the type of virtualization you are most familiar with. When people say "virtualization", they are usually referring to server virtualization. However, they should really clarify what type of virtualization they are talking about because there are multiple types.

The Wikipedia defines virtualization as "a broad term that refers to the abstraction of computer resources". Another definition, also from Wikipedia is "a technique for hiding the physical characteristics of computing resources from the way in which other systems, applications, or end users interact with those resources".

With those definitions as our background, what is server virtualization? Simply put, server virtualization software allows you to run multiple guest computers on a single host computer with those guest computers believing they are running on their own hardware. By doing this, you gain all the benefits of any type of virtualization: portability of guest virtual machines, reduced operating costs, reduced administrative overhead, server consolidation, testing & training, disaster recovery benefits, and more.

Examples of server virtualization products are:

- VMware Server, Workstation, Player, and ESX Server
- Microsoft Virtual PC and Virtual Server
- Xen
- Virtual Iron
- And more

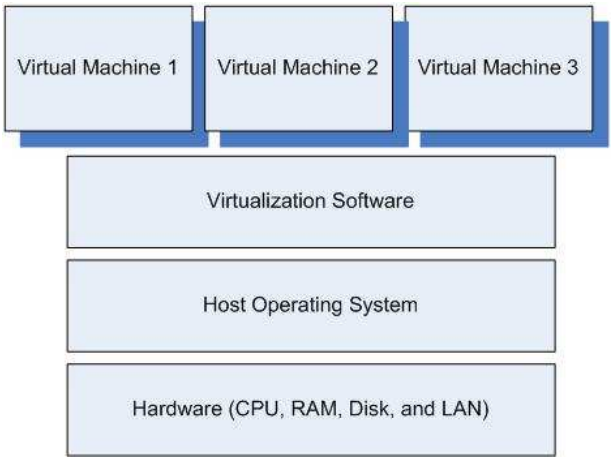
That said, different products provide different levels of virtualization. There are:

- full virtualization - guest OS is unmodified and believes it is running on the same hardware as the host OS
- para virtualization - guest OS is modified, as with Xen
- emulation - guest OS is unmodified but it is running on a software emulated CPU

There is no doubt that server virtualization is the wave of the future. Consider these facts:

- A 2007 Forrester Research study found that 40% of businesses are using server virtualization. Of those 40%, 50% of those are using VMware products and 9% are using Microsoft.
- Microsoft will be including Server Virtualization as part of the next release of the Windows Server operating system, codename Viridian.
- Cisco has announced a strategic investment in VMware and Cisco has stated that they believe that virtualization (across the board) is the future of computing. Cisco has made virtualization part of their Data Center 3.0 strategy.
- Microsoft will make the Windows Server 2008 virtualization software "Xen-Friendly"

Here is what Server Virtualization looks like:



What is Network Virtualization?

When I first heard of network virtualization, I thought of VLANs. I thought, "don't we already have network virtualization when we use VLANs?" I mean, a VLAN is a "virtual LAN", which sounds like a virtual network to me. While this logic makes sense, there is much more to network virtualization than just VLANs.

Like these other forms of virtualization, network virtualization is not that new. Sun and HP have been talking about network virtualization for years. Now, Cisco has picked up the network virtualization ball and run with it. They are touting NV as the next big thing and as an integral part of their Data Center 3.0 strategy.

What does network virtualization do? The theory behind network virtualization is to take many of the of the traditional client/server based services and put them "on the network". To Cisco, this means making routing and switches perform more services. Cisco says that the 3 parts of network virtualization are: access-control, path isolation, and service edge. This can be ambiguous when you first read about it but Cisco has a nice diagram that lays it all out to better visualize what it can do for you. As you can see from the diagram, inside Cisco's routers and switches you would find services like security, storage, VoIP, mobility, and application delivery. To Cisco, it is their strategy to continue generating revenue from their strong network infrastructure offerings. To me, this just helps to increase the value of your network devices and leverage the network infrastructure that is already required.

Another network vendor actually has, in my opinion, a stronger network virtualization initiative than Cisco. That company is 3Com. While 3Com is the equivalent of "David" to Cisco as "Goliath", 3Com actually has a working card that is inserted into a router. On that card is a fully-functioning Linux server that has a connection to the backbone of the router. On that Linux server, you can install applications like packet sniffers, VoIP, Security applications, and many more. In the future, it is planned to be able to run VMware on that Linux card so that you could, conceivably, run Windows Servers. 3Com's open-source network virtualization initiative is called 3Com ON, or open-network.

Network virtualization is still in its early stages and it is too soon to really say what it will or won't do for IT Pros like you and I.

What is Storage Virtualization?

Recently, I attended a conference on storage virtualization. The main presenter was Datacore. They have some fascinating products but they aren't the only storage virtualization products available. However, they may be one of the more reasonably priced.

So what is Storage Virtualization (SV)? Again, like network virtualization, when I first heard about storage virtualization, I thought that if I had a SAN, I was already doing it. However, like network

virtualization, there is more to it than that. Wikipedia defines storage virtualization is "the abstraction at any layer in the storage software and hardware stack.". This is what a SAN can do, in general, but there are many more features that SV can bring you.

Why would I want virtualization?

The industry buzz around virtualization is just short of deafening. This gotta-have-it capability has fast become gonna-get-it technology, as new vendors enter the market, and enterprise software providers weave it into the latest versions of their product lines. The reason: Virtualization continues to demonstrate additional tangible benefits the more it's used, broadening its value to the enterprise at each step.

Server consolidation is definitely the sweet spot in this market. Virtualization has become the cornerstone of every enterprise's favorite money-saving initiative. Industry analysts report that between 60 percent and 80 percent of IT departments are pursuing server consolidation projects. It's easy to see why: By reducing the numbers and types of servers that support their business applications, companies are looking at significant cost savings.

Less power consumption, both from the servers themselves and the facilities' cooling systems, and fuller use of existing, underutilized computing resources translate into a longer life for the data center and a fatter bottom line. And a smaller server footprint is simpler to manage.

However, industry watchers report that most companies begin their exploration of virtualization through application testing and development. Virtualization has quickly evolved from a neat trick for running extra operating systems into a mainstream tool for software developers. Rarely are applications created today for a single operating system; virtualization allows developers working on a single workstation to write code that runs in many different environments, and perhaps more importantly, to test that code. This is a noncritical environment, generally speaking, and so it's an ideal place to kick the tires.

Once application development is happy, and the server farm is turned into a seamless pool of computing resources, storage and network consolidation start to move up the to-do list. Other virtualization-enabled features and capabilities worth considering: high availability, disaster recovery and workload balancing.

What kinds of challenges does virtualization present?

This technology changes the way a data center is managed, administered and operated. For example, before server virtualization, you could walk into any data center, ask the admin to name the organization's top five applications, and he would be able to show you the machines those apps were running on. However, the traditional coupling of hardware and software is broken by virtualization.

This decoupling creates the potential for performance conflicts. For example, some applications have cyclical performance profiles. A West Coast stock-trading application and a SIMEX app running on the same machine are going to overlap at peak market hours, slowing performance. Consequently, administrators have to think through how the virtualized data center will operate. The major virtualization vendors typically provide extensive technical resources and at least some training to explain how their solutions work. But each data center operates differently, and it's up to the administrators to know their systems.

Determining Consolidation Ratios

A primary benefit of virtualization is optimizing the use of physical equipment, such as servers, rather than letting them run underutilized much of the time and wasting money. However, it’s best to avoid extremely high consolidation ratios that push physical hosts to near 100% utilization. Rather, data center managers should leave some wiggle room for moving VMs around in the event that there is a planned or unplanned outage. About 65% to 75% utilization is generally a good average to shoot for to make virtualization worthwhile but safe.

Something to consider when calculating maximum consolidation ratios is moving off of small-form-factor blade servers and onto larger chassis, the enclosures for the server blades, to allow for greater consolidation density. An approximate maximum consolidation ratio of a 1U blade server is 6:1, for example, where a maximum consolidation ratio of a 4U chassis is 30:1. So consolidation ratios might be bigger, and savings greater, with larger chassis.

Note, too, that the deployment of emerging applications, such as real-time presence and video streaming services, might require greater network capacity for shuttling communications quickly among VMs.

These applications might also lower the consolidation ratio that can be achieved compared to an existing data center environment without these applications in operation.

High-Availability_Implications_of_VMs

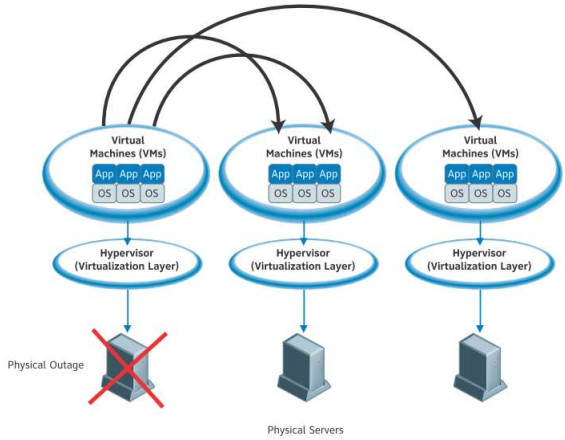
The wiggle room afforded by retaining a spare 25% to 35% capacity helps address failover and disaster recovery when determining the appropriate number of VMs to consolidate onto a single physical host. Fortunately, the failure of a given VM on a physical host will not affect the operation of another VM on that host, because each VM has its

own isolated set of compute, memory and power resources. So a VM could fail over to another VM on the same physical host or, in the case below, to a VM on a separate physical server.

Physical_Redundancy

Virtualization, again, reduces the number of physical hosts in operation by consolidating multiple VMs onto a single physical machine. The greater the consolidation ratio, then, the greater the impact will be if a single physical machine should go offline. For example, if a single server in the past hosted a single application and served a handful of users, only that one application and those users would be affected if the server went offline. If you put 10 applications and support for hundreds of users on a single physical device, however, and the host becomes unavailable, the failure affects many more applications and users, and has greater impact throughout the organization.

One-to-Many Failover in a Virtual Environment



You need to have a disaster recovery plan in place to address that issue. For example, a given physical host might be configured to fail over to one or more other physical hosts. Traditional high-availability configurations often require a 1:1 ratio of primary device to backup device. A virtualized environment, however, could be configured such

that a physical server can fail over to one of a set of backup servers, determined, in part, by the load balancing equipment that front ends the physical servers. This allows, then, for a many-to-one backup-to-primary configuration ratio, which increases service availability.

Security in a Virtual Environment

Moving to a virtualized data center means moving to two-tier security.

The physical hosts must be secured, as always, and, now, so do the VMs. In unvirtualized data centers, most security is provided by special-purpose physical appliances that protect static resources, such as servers with unchanging IP addresses. In a virtual environment, however, enterprise security teams

will need to deploy security tools that account for devices that might change addresses frequently in response to changing workloads.

Impact on Physical Infrastructure

As implied in the introduction, virtualization will carry performance implications for CPU, memory, networks and storage. In order to calculate them, the maturity of enterprise performance management and monitoring systems must develop in step with the virtual infrastructure.

2.2 Resources_and_Capacity

If a given enterprise traditionally has been operating its physical servers and other devices at very low utilization, monitoring their performance and resource consumption may not have been a priority or even necessary up until now. With virtualization's higher utilization rates, however, tools are required for capacity planning assessments and ongoing capacity monitoring and management that account for seasonal spikes and other peak processing periods. So as the enterprise assesses its server environment to determine what capacity and resources the virtual environment will require, it should also review the capacity planning and monitoring tools it has and whether they will be up to the task in the virtual world..

2.3 Power

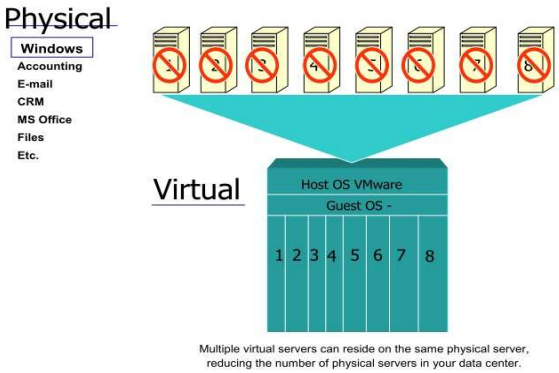
Migrating physical servers into a virtual environment will reduce overall power and cooling requirements. Note, though, that power requirements will be denser; more power will be required to support multiple VMs on a given physical server. In the interim, while enterprises build their virtual infrastructures, they will need to keep the physical infrastructure in place. During the migration period, enterprises will require enough power, cooling and rack space for both environments.

2.4 Time_Services

Clients and servers must agree on time of day so that files can be properly synchronized. Timing services are also important to system security. For example, computers connected to the Internet must keep accurate time for evidence gathering in the case of a system break-in. Encryption and authentication protocols also require accurate time on both server and clients. For auditing and accounting, many corporate governance mandates require a log of who changed what file at what time.

3 Planning a virtual infrastructure

Until recently, virtualization was utilized primarily in server consolidation projects at the enterprise level. But times are changing and, increasingly, virtualization is being recognized as a technology that can offer significant benefits to organizations of all sizes.



Virtualization is being widely embraced by the IT industry and smaller organizations are now looking to make use of the technology. This is resulting in an increased number of affordable product offerings as vendors compete to capture a share of the emerging small to midsize business (SMB) market. This significantly reduces a major obstacle to deploying virtualization at the SMB level: Cost.

SMB's are now perfectly positioned to reap the maximum benefits from virtualization. In enterprise-level organizations, a complex infrastructure can challenge even the most resourceful IT manager looking to employ virtualization. A successful implementation that migrates some servers from physical to virtual can make management of a data center a less onerous task.

SMB's, with smaller and less complicated infrastructures, are much less likely to encounter impediments to migrating a much greater proportion — or even all — of their physical infrastructure to a virtual environment.

But what is virtualization and what are the benefits of migrating to a virtual infrastructure?

Virtualization technology enables a single physical computer to appear to function as multiple virtual computers. With virtualization, you can run multiple, concurrent operating systems on a single physical server; each of the operating systems runs as a self-contained computer. You can easily create a virtual machine and have it ready and waiting for recovery in the case of unexpected downtime.

Separating the hardware from the software using virtualization provides numerous benefits. For example:

- As shown in the graphic above, many physical servers can be consolidated into fewer physical servers. In this example, each physical box has VMware running as the host operating system, while each virtual server can be a different guest operating system, such as Microsoft Windows Server®, Microsoft Vista® or one of the many Linux® distributions. These are called guest operating systems. Fewer physical servers result in a reduction in hardware costs, a reduction in server sprawl and, accordingly, a reduction in the amount of bought or leased floor space required to accommodate servers. While VMware is the host in this example, it easily could be Microsoft Virtual Server®, XenSource®, Parallels® or some other operating system.

- Fewer servers result in simplified management — backup and disaster recovery plans become easier to create, manage and maintain.

- Consolidation results in reduced electricity consumption and, accordingly, reduced utility bills leading to a reduction in the total cost of ownership (TCO) of each server.

- Each virtual machine environment — the guest operating system and everything that runs on that virtual machine — is stored as a single file on the virtual machine. This virtual machine can be moved easily and quickly to a different physical server, enabling zero-downtime for upgrades and maintenance.

- Virtual machines run in complete isolation from both the host machine and other virtual machines, resulting in complete fault and error containment.

- The production environment can be duplicated easily and quickly in order to create a test environment in which patches and updates can be validated prior to deployment on production servers.

This list is far from exhaustive and many organizations will find that virtualization offers numerous other benefits that will help to increase agility, reduce costs, and reduce management complexity of the data contained within their computer systems. It does, however, demonstrate just how cost-effective and efficient a virtual environment can be in an SMB.

In order for any virtualization project to be successful and deliver the best possible return on investment (ROI), extensive pre-migration planning is essential. An understanding of both virtualization concepts and the potential pitfalls is also critical to success. Thorough research should be undertaken prior to the commencement of the project.

3.1 Establishing goals and objectives

Creating a clearly defined set of goals and objectives helps ensure that the virtualization implementation fully meets an organization's requirements and delivers the maximum possible ROI. Establishing goals and objectives must, therefore, be the first step in any virtualization project. Goals and objectives need to document, as clearly as possible, the expected results of virtualization and should provide an answer to questions such as:

- What are the reasons for virtualization and/or server consolidation?
- How many physical servers potentially could be consolidated?
- Which virtualization approaches could be leveraged and which is the preferred solution?
- How will virtualization impact users?
- What are the security implications of migrating to a virtual infrastructure versus maintaining the status quo?
- How much downtime would a migration require?
- What are the risks and how could those risks be mitigated?
- What is the estimated cost of the project?
- What is the estimated ROI?

Goals and objectives are not set in stone and, invariably, will be modified and refined during the later stages of the planning process as the plan is executed.

The objectives associated with each goal should be underpinned with measurable and specific metrics which will make clear both the reason for the goal and its expected results. For example:

Goal	Objective
Maximize hardware utilization	• Achieve a X:Y consolidation ratio for servers • Achieve Z% hardware utilization for servers
Reduce server spraw	• X% utilization for application servers will result in a Y% reduction in the purchasing rate for new servers • Review procedures for purchasing and deploying servers

A common mistake many organizations make when planning virtualization is to focus almost exclusively on hardware consolidation and, in doing so, miss out on the opportunity to rationalize and consolidate other aspects of the business. For example, combining a number of systems into a single virtual infrastructure provides not only an opportunity to consolidate the hardware, it also provides an opportunity to consolidate and rationalize the job functions of support staff. Similarly, business processes, such as purchasing and deployment decisions, need to be reviewed. In order to derive the maximum benefit from virtualization and to obtain the best possible ROI, an organization should consider not only what hardware can be combined, but also what people and processes can be combined.

Creating a set of clearly defined goals and objectives will steer the virtualization project in the right direction and help ensure the deployment of a solution which is flexible, secure, cost-efficient, and fully meets both the present and future needs of the organization.

3.2 Analyzing the current infrastructure and identifying consolidation candidates

In an enterprise-level organization, the process of identifying all the servers in the infrastructure can prove challenging. In SMBs, quantifying inventory is a much less daunting job. However, once the

infrastructure has been mapped, it's still necessary to determine which servers are candidates for virtualization, and this is no easy task.

Not everything that can be virtualized should be virtualized. Running high-volume or high-performance applications in a virtual environment can result in I/O contention among virtual machines, causing bottlenecks and non-optimal performance. Similarly, a server running an application with highly variable performance might not make a good

candidate for consolidation. In some instances, non-optimal performance might be considered a worthwhile tradeoff in order to be able to consolidate but, in other instances, any performance loss would be unacceptable. The effects of consolidating each server must be considered individually. And remember, the servers you consolidate today should be reevaluated on a regular basis to ensure that you're getting the most performance from your infrastructure.

Remember that consolidation is not a one-way task. Servers that you consolidate today can be migrated back to physical servers later should the demands on the virtual machines change. Preparing for the future and recognizing that virtual-to-physical migrations are possible, and perhaps necessary, is an important aspect of capacity planning.

Fortunately, there are a number of products available that can help make the process of identifying candidates for virtualization a significantly more straightforward process.

VMware Capacity Planner, which is a combination of a local application and a hosted service, is probably one of the most complete applications for identifying candidates for virtualization. In fact, it delivers far more information than many organizations would actually need, but its pricing could put it out of reach of many SMBs.

Products from other vendors, while less fully featured than VMware Capacity Planner®, are nonetheless able to provide an organization with all the information it needs to plan a virtual infrastructure and, given their more modest pricing structures, are likely to be the preferred option for many SMBs.

These products can be used to gather detailed information, including utilization statistics, about all servers in the network, whether in a single location or multiple, geographically dispersed locations. That information can then be used to make informed choices about which servers potentially could be consolidated. Some products take things a stage further and provide the ability to automatically generate consolidation plans based on the optimal combination of workloads. Other products feature scenario-based modeling capabilities that enable different consolidation scenarios to be compared and contrasted based on consolidation ratio, power and space requirements and total cost of ownership (TCO).

Leveraging one of these applications can make inventory and identifying consolidation candidates a much speedier process. But this class of product only helps when you want to identify applications and then migrate to a virtual environment.

Products such as those from Acronis® Inc. allow you to migrate your operating system, applications, configuration files, network settings, and all other data on your system to and from virtual machines. While some tools, particularly those from virtualization operating systems vendors, aid you in going from the physical world to a virtual machine, there are few tools, such as Acronis True Image EchoTM, that assist you in going from one virtual hardware platform to another or from a virtual server to a physical server.

3.3 Analyzing applications

Because virtualization has only recently moved into the mainstream, many vendors have not yet extended support to applications run in a virtual environment. Prior to deciding to migrate an application into a virtual environment, an organization needs to ensure that the application will still be

supported by its manufacturer in the virtual environment. If it isn't, that too must be included in your analysis of whether to move to virtualization.

An organization is well served by considering products that enable both physical-to-virtual (P2V) and virtual-to-physical (V2P) migration, such as Acronis True Image Echo, as a workaround to the problem. Such applications can move a problematic server quickly and easily to and from a physical server. This results in the problem being reproduced in a physical environment and enables the IT manager to obtain support for the troubled application from the user's vendor.

Consideration should also be given to whether an application:

- Duplicates functionality already present in other applications
- Has become obsolete
- Has only a small number of users
- Is unstable
- Is approaching the end of its supported life cycle

Organizations also need to consider whether or not there is merit in devoting resources to migrating and consolidating an application that fits any of these criteria. In many cases, it might be decided that the most economical option is to decommission and replace the application.

In cases where new, high-end hardware will be obtained for use, as the host server for the virtual machines, you might want to consider repurposing one or more of the older systems to run these orphaned or soon-to-be-obsolete applications.

3.4 Why planning the virtual infrastructure ?

Once the physical infrastructure and applications have been inventoried and analyzed, an organization can begin to plan the virtual infrastructure in greater detail.

Consideration should be given to:

- Virtualization hosts: Is scaling-up or scaling-out the preferred option or can existing servers be utilized as hosts?
- Network: What changes need to be made in order to ensure that the connectivity needs of all virtual machines are met?
- Performance: What enhancements need to be made to the storage and network subsystems?
- Backup and recovery: How will virtualization affect backup and disaster recovery processes? What changes should be made?
- SAN and NAS storage: What reconfiguration will be necessary?

3.5 Evaluating potential solutions

There are an increasing number of server virtualization products on the market from such companies as VMware, Microsoft, XenSource (now part of Citrix) and Parallels.

When evaluating potential solutions, an organization must conduct extensive research and base its decision on factors including cost, management and migration capabilities.

Organizations might consider the history of the vendor. Given that deploying virtualization is a large-scale change, many organizations might wish to entrust their infrastructures to a company that has an established track record in the field of server virtualization.

3.6 Calculating ROI

While virtualization technologies have certainly become far more affordable, migrating to a virtualized infrastructure is, nonetheless, an expensive process. In order to establish whether virtualization provides a realistic and cost-effective solution, organizations must calculate the ROI. In enterprise level-organizations, ROI calculation probably will be outsourced to a specialized

consultancy firm, but this is an option that most SMBs would be likely to find cost-prohibitive. Rather, it's likely to be a do-it-yourself proposition.

ROI = [(Payback - Investment)/Investment)]*100

To calculate payback, an organization must establish the cost of maintaining the existing infrastructure and deduct from that the estimated cost of maintaining the virtual infrastructure. Establishing the cost of maintaining the current infrastructure is clear-cut — estimating the cost of maintaining a virtual infrastructure is not so straightforward.

Consideration should be given to the potential savings that would result from the following:

- A reduced purchasing rate for new servers
- Reduced electricity consumption (including cooling costs)
- Reduced maintenance and management costs
- The termination of hardware leases
- Reduced (planned and unplanned) downtime
- A reduction in the number of operating system licenses required
- The resale of retired equipment
- A reduction in the amount of (bought or leased) space needed to accommodate servers

Once the payback has been calculated, determining the ROI is a straightforward process.

3.7 Moving into industry

Virtualization has moved into the enterprise mainstream. Until recently, virtualization solutions tended only to be used to consolidate data center servers. However, that has changed and, today, virtualization is recognized as a technology that can provide substantial benefits to businesses of all sizes in all sectors of industry.

What is virtualization? In simple terms, it is a technology that allows a single computer to act as multiple computers. In a virtualized environment, multiple virtual machines, each with its own set of virtual hardware, can run heterogeneous operating systems in complete isolation from each other on the same physical computer.

This enables a business to do more with less. The workloads from underutilized servers can be consolidated to a fewer number of servers that results in increased utilization ratios and decreased total cost of ownership (TCO). Additionally, the removal of physical servers from the infrastructure results in decreased management, rack space, energy and heating, ventilation and air conditioning (HVAC) costs.

The savings can be considerable. VMware's TCO Calculator is an online too that provides a report contrasting the TCO of your current environment with the predicted TCO of your virtualized environment. Try it. You'll probably be surprised by the extent of the savings which could result from virtualization.

Virtualization can provide a business with real and substantial benefits, but it is not without costs. While many of the costs are obvious, such as the purchase price of the necessary hardware and software, others are not so obvious. In order for a virtualization project to deliver both the expected results and the expected return on investment (ROI), a business must understand not only the technical challenges, but also have a thorough understanding of the costs involved and the factors that can result in those costs rapidly increasing.

3.8 What's driving virtualization into the enterprise mainstream

Much of today's interest in virtualization is driven by the desire to consolidate servers to reduce sprawl, but many businesses are also looking to virtualization to provide a range of other benefits, including:

- Simplified management
- Reduced downtime
- Enhanced security
- Reduced networking and cabling costs
- Reduced server TCO
- Legacy environment re-hosting
- Reduced energy costs and a reduced carbon footprint

Virtualization can enable a business to meet each of these objectives, and some others too. But, as already stated, it is not without its financial impact; to derive maximum business value from a virtualization initiative, a business must ensure that each of those potential costs are established, assessed and factored into the ROI calculations.

Many IT organizations run applications on unique servers to ensure availability despite variable peak loads. Such provisioning, however, can lead to underutilization of overall server capacity and excessive hardware and operating costs.

To avoid those costs, companies look to virtualize servers. Virtual machine software creates one or more abstracted operating environments on a physical server, allowing the utilization of spare capacity. The software divides the physical operating system environment into several virtual machines, each with its own set of virtual hardware upon which different operating systems and applications can run.

Most of Fortune 1,000 companies use virtual machine software to virtualize servers, and another 30 percent plan to do so in the future.

As they should with all investments, companies should carefully consider the costs and benefits of server virtualization before implementation.

Core benefits of server virtualization include the following:

- Efficiency: Allows organizations to consolidate servers and utilize spare capacity
- Adaptability: Enables the use of all server resources for a variety of activities, including server consolidation and grid computing
- Cost savings: Has the potential to reduce hardware, labor, and operational/maintenance costs by reversing or preventing physical server sprawl

Industry experts claim that server virtualization can entail problems in the following areas:

- Patch management
- Security
- Support
- Licensing
- Virtual-server sprawl.

Based on adoption rates, however, companies tend to find that the potential benefits of server virtualization outweigh the potential drawbacks.

Virtual servers give IT organizations the power to align the capacity of any kind and number of servers

with load continuously and precisely, thus enabling efficient use of server capacity .

Analysts predict virtualization technology will continue to improve across the coming years, making virtual machine software increasingly easy to use and driving growth in the market. Notably, Microsoft plans to incorporate virtual-machine capabilities into the Windows operating system .

Virtualization Can Involve the Entire Data Center, a Single Server, or a Desktop Computer

In short, virtualization creates an abstracted operating environment, substituting physical computing elements with virtual machines (VMs) that replicate the original hardware or software they replace .

Virtualization was first developed in the 1960s to allow timesharing of large mainframe hardware. Today, virtualization can involve the entire data center, a single server, or a desktop computer.

3.9 Scientists boot one million Linux kernels as virtual machines

Computer scientists at Sandia National Laboratories in Livermore, Calif., have for the first time successfully demonstrated the ability to run more than a million Linux kernels as virtual machines.

The achievement will allow cyber security researchers to more effectively observe behavior found in malicious botnets, or networks of infected machines that can operate on the scale of a million nodes. Botnets, said Sandia's Ron Minnich, are often difficult to analyze since they are geographically spread all over the world.

Sandia scientists used virtual machine (VM) technology and the power of its Thunderbird supercomputing cluster for the demonstration.

Running a high volume of VMs on one supercomputer — at a similar scale as a botnet — would allow cyber researchers to watch how botnets work and explore ways to stop them in their tracks. "We can get control at a level we never had before," said Minnich.

Previously, Minnich said, researchers had only been able to run up to 20,000 kernels concurrently (a "kernel" is the central component of most computer operating systems). The more kernels that can be run at once, he said, the more effective cyber security professionals can be in combating the global botnet problem. "Eventually, we would like to be able to emulate the computer network of a small nation, or even one as large as the United States, in order to 'virtualize' and monitor a cyber attack," he said.

A related use for millions to tens of millions of operating systems, Sandia's researchers suggest, is to construct high-fidelity models of parts of the Internet.

"The sheer size of the Internet makes it very difficult to understand in even a limited way," said Minnich. "Many phenomena occurring on the Internet are poorly understood, because we lack the ability to model it adequately. By running actual operating system instances to represent nodes on the Internet, we will be able not just to simulate the functioning of the Internet at the network level, but to emulate Internet functionality."

A virtual machine, originally defined by researchers Gerald J. Popek and Robert P. Goldberg as "an efficient, isolated duplicate of a real machine," is essentially a set of software programs running on one computer that, collectively, acts like a separate, complete unit. "You fire it up and it looks like a full computer," said Sandia's Don Rudish. Within the virtual machine, one can then start up an operating system kernel, so "at some point you have this little world inside the virtual machine that looks just like a full machine, running a full operating system, browsers and other software, but it's all contained within the real machine."

The Sandia research, two years in the making, was funded by the Department of Energy's Office of Science, the National Nuclear Security Administration's (NNSA) Advanced Simulation and Computing (ASC) program and by internal Sandia funding.

To complete the project, Sandia utilized its Albuquerque-based 4,480-node Dell high-performance computer cluster, known as Thunderbird. To arrive at the one million Linux kernel figure, Sandia's researchers ran one kernel in each of 250 VMs and coupled those with the 4,480 physical machines on Thunderbird. Dell and IBM both made key technical contributions to the experiments, as did a team at Sandia's Albuquerque site that maintains Thunderbird and prepared it for the project.

The capability to run a high number of operating system instances inside of virtual machines on a high performance computing (HPC) cluster can also be used to model even larger HPC machines with

millions to tens of millions of nodes that will be developed in the future, said Minnich. The successful Sandia demonstration, he asserts, means that development of operating systems, configuration and management tools, and even software for scientific computation can begin now before the hardware technology to build such machines is mature.

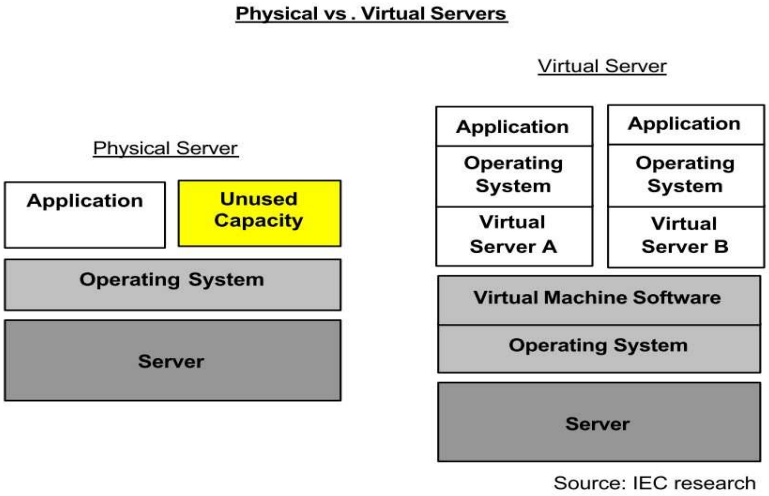
"Development of this software will take years, and the scientific community cannot afford to wait to begin the process until the hardware is ready," said Minnich. "Urgent problems such as modeling climate change, developing new medicines, and research into more efficient production of energy demand ever-increasing computational resources. Furthermore, virtualization will play an increasingly important role in the deployment of large-scale systems, enabling multiple operating systems on a single platform and application-specific operating systems."

Sandia's researchers plan to take their newfound capability to the next level.

"It has been estimated that we will need 100 million CPUs (central processing units) by 2018 in order to build a computer that will run at the speeds we want," said Minnich. "This approach we've demonstrated is a good way to get us started on finding ways to program a machine with that many CPUs." Continued research, he said, will help computer scientists to come up with ways to manage and control such vast quantities, "so that when we have a computer with 100 million CPUs we can actually use it."

3.10 Server Virtualization Enables the Partitioning of Servers and the Sharing of Resources

Virtual machine software utilizes spare capacity of servers by creating one or more abstracted operating environments in that space. The software divides the physical operating system environment into several VMs, each with its own set of virtual hardware upon which different operating systems and applications can run. In addition to running several applications on a single server, virtual machine software can also allow administrators to run one large application on multiple servers . Analysts predict that technology advancements in CPU virtualization will enable virtual machine software to manage the total resources of the server even more efficiently . The following diagram illustrates the differences between physical and virtual servers:



Source: IEC research

3.11 Virtual Machine Software Products Use Hypervisors to Communicate with Server Hardware

An essential component of virtual machine software is the hypervisor, also known as the virtual machine monitor. The hypervisor intercepts forbidden messages to the host OS and divides virtual environments. It is also responsible for sharing the computer's physical resources among the many VMs that could be running and for redirecting virtual devices to physical devices.

3.12 Server Virtualization can Increase Efficiency of Resource Use

Many IT organizations run applications on unique servers to ensure availability despite variable peak loads. Such provisioning, however, can lead to the common underutilization of server capacity mentioned above. In turn, this underutilization can entail a variety of management issues, including the following:

- Strain on facility space
- Low administrator-to-server ratios
- Excessive hardware costs
- Excessive maintenance and operational costs (power, cooling, etc.)

Server virtualization, however, allows IT organizations to pool excess capacity from physical servers while maintaining partitioned applications, thereby reducing the number of physical servers needed and lowering the associated management, operations, and maintenance costs.

3.13 Highly Adaptable, Virtual Servers Offer a Variety of Possible Uses

Aside from server consolidation, server virtualization can also be used to perform the following:

- Achieve grid computing: By partitioning servers, virtualization enables administrators to leverage spare capacity from multiple servers to run one large application .
- Reflect appropriate infrastructure for disaster recovery planning: Virtualization allows administrators to write server clusters appropriate to enterprise needs, as opposed to having exact clones of hardware sitting idle in a disaster-recovery site .
- Set up test environments quickly using minimal hardware: Virtual servers can duplicate the hardware found on production systems to set up test environments . Additionally, administrators can easily "sanitize" them for subsequent rounds of testing .
- Detect viruses before they infect the entire system: If a virus takes over a VM, the physical server should be able to detect it, thereby arresting its infiltration of the entire enterprise system.
- Roll back servers to pre-application-installation state: Virtual servers provide "snapshot" capabilities that enable administrators to roll back VM instances should the uninstall of patches or applications encounter difficulties.
- Manage servers remotely: Many virtual machine software products include remote workstations that allow administrators to manage virtual servers remotely, often through Web interfaces.

3.14 Server Virtualization can Lead to Significant Cost Savings

Because server virtualization enables the efficient use of server capacity, IT organizations that run virtual servers are able to reduce or stop the growth of their physical-server inventories. As such, server virtualization can reduce costs in the following areas :

- Hardware: Virtual servers can reduce server sprawl, thus reducing hardware procurement costs.
- Labor: Monthly labor costs for a single physical server can reach $3,000. By reducing the number of physical servers needed and enabling central management, server virtualization can lower the staff hours needed to administrate each server and thus lower labor costs.
- Operations and Maintenance: The total cost of ownership for physical servers also includes costs for ordinary operations and maintenance, including the following:
  - Data center space
  - Power
  - Cooling
  - Network connectivity
  - Backup and recovery.

Because it can reduce the number of physical servers, virtualization can lower spending on the necessary operational and maintenance costs for physical servers listed above.

3.15 Potential Drawbacks of Virtualization Could Temper Cost Savings

Although server virtua lization tends to increase efficiency, flexibility, and cost savings, industry experts note that virtualization can entail difficulties in several areas, including the following:

- Patch management: If an administrator reboots a host operating system after applying a patch, all the VMs running on that host OS will be taken down as well. This could lead to inconvenient and costly downtime for the business .
- Security: Evidence suggests that attackers have already developed tools to exploit virtual environments, whether by searching for VM tools and drivers or by installing a mini-application that detects the presence of VM environments (known as “The Red Pill” in reference to the popular Matrix films) prior to an attack. If an attacker breaches a physical server known to be running VM environments, damage could occur to all of the applications running on the one physical server .
- Support: Major vendors are generally loath to provide support for their products if they determine they are running in VM environments. For example, Symantec’s Web site claims that the vendor does not provide support for many of its products running in a VMware environment or in any other Windows-emulation environment . Microsoft will not provide support for any of its products running on non-Microsoft virtualization software .
- Licensing: Virtualization severs the ties that have historically bound software to hardware. Consequently, the traditional software licensing model of charging per CPU, which vendors still widely use, may force customers to pay full price for software that is not fully exploiting the machine because it is in a shared virtual environment. Companies that do not press their vendors for policy changes could see software costs increase when they virtualize, as vendors might charge per CPU available to the software (which can be numerous in a virtual environment) .
- Virtual-server sprawl: Although virtualization can keep physical server sprawl, the proliferation of multiple machines, in check, virtual machines can mult iply just as quickly. For example, many IT organizations find that 10 physical servers can quickly become 100 virtual machines. Without proper

management, such proliferation can cause operational problems, namely the disruption of applications running on all a physical server's VMs if the physical server is taken down .

3.16 Cost-Benefit Analysis and Risk Evaluation Should Figure Into Any Virtualization Decision

As they should with any strategic initiative, IT leaders should thoroughly examine the costs, benefits, and risks associated with server virtualization before implementation. The followin g is a list of questions that can aid IT organizations in the decision-making process:

Questions to Ask Before Implementing Server Virtualization

- Is the average CPU utilization rate at or below 30%?
- Is the majority of our applications portfolio custom-developed?
- Can our risk profile tolerate running applications on virtual servers, given that a problem with one physical server could affect multiple applications at once?
- Could virtualization improve our disaster recovery plans?
- Do we have the resources to train administrators and managers to take advantage of the flexibility that virtualization provides?
- Can our budget tolerate potential increases in licensing fees?
- Do we want to implement grid computing?
- Would virtualization help advance our SOA objectives?
- Are we in danger of outgrowing our data center?
- Is our administrator-to-server ratio below 30:1?

4 Hidden costs

Adopting a virtualization infrastructure requires money. Servers might need to be purchased. Software and support contracts will need to be purchased. The IT department will need to put in additional hours in order to provision those servers. While these expenses are all obvious, there are some that are less obvious. And in some areas, such as energy costs and HVAC, virtualization results in some additional expenses that must be offset in order to determine the net savings potential.

Energyand HVA C According to San Francisco-based utility company Pacific Gas & Electric, energy and HVAC costs for running a server amount to somewhere between $300 and $600 per year[2]. So, by removing a server from your infrastructure you'd save between $300 and $600 per year, right? Not necessarily. A server that hosts multiple virtual servers uses more energy and produces more heat than a non-virtualized server.

While virtualization will certainly result in a net reduction in energy and HVAC expenses, it would be incorrect to assume that that reduction can be calculated simply by referencing the number of physical servers that are to be decommissioned. How much will it actually cost you to run a virtualized server? That will depend entirely on the model of the server on the number of virtual servers it will host.

To work out the specifics, you need to consult the manufacturer's documentation. Management Virtualization can certainly simplify management, but it can also introduce additional complexities. While the benefits of a consolidated and reduced physical server base are obvious, not so obvious are some of the difficulties that virtualization can bring to everyday management functions.

Licensing

Licenses restrict the number of occasions on which an application can be installed. While certain licenses make exceptions for virtual installations, others do not. In a virtual environment where images of operating systems and applications can be easily and speedily deployed, ensuring license compliance can become an arduous and time consuming process.

Maintenance

Finding a time slot to patch and reboot a non-virtualized server isn't usually too problematic. Finding a time slot to patch and reboot a server that is hosting several virtual servers can be much more difficult. And at the enterprise level, where there might be hundreds of physical servers each running multiple heterogeneous operating systems, establishing a maintenance schedule can be horrendously complicated job that requires extensive planning.

Security

While a virtualized infrastructure can be inherently more secure than a non-virtualized infrastructure, virtualization nonetheless results in security becoming a more complicated matter. Not only must administrators ensure that physical systems are secure, they must also ensure that virtual systems are secure. The additional tier that virtualization introduces to an infrastructure can make managing security a more difficult and time consuming process.

Training and retraining Virtualization and business rationalization often to go hand-in-hand. A business adopting virtualization has the opportunity to consolidate more than just its physical servers; its people and its processes can be consolidated too. While restructuring and rationalization can result in improved operational efficiency, it can also result in staff being moved into areas where they lack familiarity and require retraining.

Staff also needs to be able to deploy, manage, secure and troubleshoot within the virtual environment. Specialist knowledge is required and so, depending on the level of expertise that already exists within a business, product training may be a necessity. Each virtualization vendor offers a number of training packages but, of course, it costs time and money to have staff attend. Virtual servers sprawl One of the main benefits of virtualization is the ability to create virtual servers quickly and easily, but this can also lead to problems.

The fact that it costs next to nothing to provision a new virtual server has resulted in some businesses failing to exercise any form of real control over the process.

The result? Virtual server sprawl. Each virtual server requires space on its physical host and requires much of the same management work as a physical server (patching, permissions, etc.). To allow the unchecked and unnecessary creation of virtual servers will result in invariably additional costs, eroding the savings which were achieved through the elimination of physical server sprawl.

In order to prevent sprawl and avoid unnecessary costs, virtual server "acquisition" should be subject to similar rules to physical server acquisition. Backup and Migration Backup can become more of a challenge in a virtualized environment. Determining what needs to be backed up, how often it needs to be backed up and establishing the necessary windows in which to schedule backups without resource contention can all prove difficult. Does the entire server need to be backed up or only the individual virtual machines? The former is more simplistic but less reliable and results in extremely large backup.

The latter is more reliable and results in smaller backups, but could be difficult to schedule (parallel backups of virtual machines running on the same physical host will cause resource contention and even a nonparallelbackup might limit the resources available to other applications on the host).

Transportability is another area of difficulty. A backup of a virtual server cannot easily be restored to a physical environment, and vice versa. This can result in a limited range of recovery options.

After all, some applications that run fine when first deployed could become resource hogs later on and require migration back to a physical server. The problems are far from insurmountable, but backup strategies must be carefully planned in order to ensure that reliable backups while avoiding resource contention.

5 Conclusion

While the process of planning and deploying virtualization can be challenging, the benefits of migration can be significant. Organizations are now beginning to use virtualization technologies to better protect their most valuable asset: the data contained within their servers. Other benefits include driving down hardware and software licensing costs, reduced utility bills, simplifying and rationalizing management processes, minimizing expensive downtime, and improved security of computer systems.

As your company grows, your needs will change. Remember, the application that you virtualize today — such as a SQL database — might need to be moved back to a physical environment later on as the database grows and requires more CPU cycles or priority. When selecting your best-of-breed tools for migrating to a virtual environment, make sure you select tools for moving back to a physical server or migrating to dissimilar hardware on a different virtual machine.

Virtualization involves turning a number of physical hardware computing and networking devices into software and loading them onto a common high-powered hardware platform. When deployed in enterprise data centers, it affords a number of cost and energy-conserving benefits. Still, organizations can hardly go into a virtualization project without assessing how such a project will impact traditional operations, both technically and organizationally.

Getting executive support, particularly from corporate financial executives, is critical for success. Administrative rights and models will have to be reviewed, along with roles and responsibilities, as individuals traditionally in charge of one or two applications might require access to a number of physical machines in the new scenario.

In addition, enterprises must make sure that their capacity planning and monitoring tools are up to the job of regularly assessing utilization and application performance in a virtualized environment. From there, enterprises can calculate the software-to-hardware ratios that allow enough spare cycles to accommodate a potential VM failover while still yielding the savings ROI that makes the project worth the organization's while. Data center security strategies must account for both the physical devices as well as the virtual devices.

They must also consider that the hypervisor software or firmware selected plays a pivotal role in virtualization and work with the virtualization vendor or service provider (depending on whether they bring projects in-house or outsource them to a professional services organization) to determine the level of risk and protection needed at the hypervisor layer.

Virtualization will also have some impact on the physical infrastructure in terms of the compute power needed in the physical devices supporting multiple VMs, as well as in the network capacity required to shuttle requests among virtual and physical machines.

Virtualization has proven to be an effective means of consolidating hardware resources, but it is still limited to the non-critical areas of data center operations.

That means most organizations are quickly approaching a brick wall in their consolidation efforts: The technology is there to continue the process, but the drop in performance is too great to justify the cost savings.

But that may be about to change, as a new generation of technologies improves both the speed and performance of critical apps and the ability to manage them.

These are a lot of considerations, and it can behoove enterprises to engage with a vendor or services partner upfront to make sure that all the variables are taken into account before the virtualization project is in progress.

Despite the hidden costs described in this paper, virtualization has the potential to provide a business with real and substantial benefits. However, in order for those benefits to be maximized and for the virtualization project to deliver the maximum ROI, it is essential that the project be thoroughly planned and all possible costs and complications factored into the budget and roadmap.

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