Virtualization: Transforming the IT Landscape

By Diane Greene
President, VMware
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Industry-Wide IT Adoption

The 1990s set the stage for the current demand for virtualization software. Contributing factors included the availability of standardized, high-volume, and increasingly fast Intel and AMD processors, ubiquitous Microsoft and Linux operating systems, low cost storage and memory, full distributed systems support, Ethernet, NFS and the World Wide Web.

VMware revisited the virtual machines that IBM pioneered for mainframe systems in the late 1960s and early 1970s. Since the x86 architecture did not support virtualization and using virtual machines on mainframes required a proprietary operating system and hardware, the technology did not achieve market success.

VMware changed this by enabling virtualization on industry standard components without requiring changes to industry-standard processors or operating systems. VMware invented the hosted model for desktop virtualization software with VMware Workstation. The company added bare metal virtualization for servers in 2001 with ESX Server and invented VMotion for the live migration of virtual machines. VMware also introduced virtual appliances—pre-installed and pre-configured application and operating system environments that run on virtual machines—that are distributed in a similar fashion to the popular software as a service (SaaS) distribution model.

VMware’s newest offering, VMware Infrastructure 3, provides a true distributed virtualization platform for the data center.

Modern Virtualization in Two Phases

VMware recently entered a second phase for advancing virtualization software and technology. The first phase started in 1998. During this period the company focused on evangelizing the benefits of virtualization and delivering highly robust and functional products to the marketplace. More than eight years later, virtualization is now one of the hottest trends in the IT industry. People trust virtualization and are well acquainted with the benefits—including cost savings, simplified resources and the freedom to choose the hardware or software that users want to operate. VMware no longer needs to evangelize the value of virtualization. For the second phase, VMware is articulating the value of its products and setting the agenda for the future of virtualization. The company continues to deliver phenomenal advances to our customers. Our products transform how VMware customers run their systems and manage their software—providing ROI within 3-6 months of their virtualization investment.
ESX Server

In 2001, with the release of ESX Server, VMware introduced a single node hypervisor. ESX Server allows users to partition a physical machine and run multiple operating system application combinations within a virtual environment. ESX Server enables users to increase the CPU utilization of their server hardware from 5-15 percent to up to 60-85 percent. ESX Server also lets IT departments provision new servers in a matter of minutes instead of days.

Virtual Machines

VMware virtual machines run on any hardware configuration, whether a 2-way CPU, a 32-way CPU, a blade system or a laptop. This removes much of the logistical overhead burden when implementing system-wide initiatives such as disaster recovery.
Provisioning
With the advent of VMware virtual infrastructure users can provision virtual machines onto a single software layer that can span different hardware components.

VMotion
With VMotion, users can take a running virtual machine and move it without service interruption across physical machines. For example, a company can be serving a movie and the clients receiving the feed will experience no loss of picture quality as the movie server is moved from one machine to another. VMotion also allows IT departments to service a machine in the middle of the day without client interruption. VMware virtual infrastructure and VMotion offer capabilities far beyond the single node hypervisor.
Virtualization Has Become Mainstream

Today, more than one million servers are virtualized into VMware virtual machines.

Those systems are highly stable. For example, VMware has a large pharmaceutical customer that has been running ESX Server continuously with no reboots or faults for over 800 days. VMware is also doing its part to sustain the planet. The company estimates that VMware virtual machines cumulatively have saved over 5 billion Kilowatt hours of power. As cooling and space become mission critical issues for the data center, the consolidation and power saving capabilities of VMware software are increasingly important.

Server, Storage and Network Consolidation

In 2003, the IT service department of a leading North American utility company started a server consolidation project using VMware software. More than 1,000 servers were migrated to 50, 8-socket capable IBM x440 servers.

Virtualization-based consolidation not only affects servers, it also raises the quality and service levels of the entire data center—including storage, network and facilities.

For the utility company example, storage was consolidated from silos of internal disks to a highly available tiered storage solution—a Hitachi SAN. There was also a 10:1 consolidation of network ports. The customer experienced dramatic cost savings in their facilities and hardware infrastructure.
Impact

The net impact of this customer example includes over $8M in quantifiable cost savings. While data center power savings is a popular topic—what goes unnoticed is the tremendous cost avoidance virtualization brings to power.

At the same time, customers deploying virtualization solutions are starting to realize that virtualization is not an ROI-based one-time consolidation/cost avoidance project, but rather an ongoing strategy for operational efficiency.

For instance, in just the hardware refresh cycle alone, the customer in this example saves 10 thousand man hours per year, allowing resources to be reallocated to more strategic tasks.

VMware customers often overlook the incredible resource utilization capabilities and cost savings. They are now looking at their virtualization stack as a means to simplify IT resources and make their processes more efficient.

While hard cost savings are important and proven in virtualization deployments, VMware customers are increasingly asking for the efficiency benefits of virtualization. IDC says labor, and in most IT organization resources, surpass capital spending by more than 3:1. Meanwhile, management and administration labors costs are growing at 10 percent year over year verses 3 percent for industry standard infrastructure.

Transforming Hardware and Capacity Management

This example shows traditional servers and static provisioning. People will look back in a few years on these systems and the methods for maintaining them as “old fashioned” and the “old way.”

On physical servers, an application is carefully and statically provisioned onto a “roughly right” hardware box. The resources typically end up “siloed” with over-provisioned capacity that was defined by the chosen hardware. Capacity planning and estimation in most cases is not done, at all. If users need to re-provision or upgrade capacity these resources are inflexible and require application downtime and manual hardware/application migration.

The earlier generation of virtualization software offered a much better situation for provisioning resources, with hardware provisioned separately from the application. The robust single node resource management capabilities built into VMware ESX Server allows applications to dynamically and fairly share capacity of modern generation industry standard hardware. Using VMware VMotion and networked storage, users can manually re-provision or migrate a workload to new servers without any downtime.
This eliminates the problem of over-provisioning and gives users the operational flexibility of non-disruptive re-provisioning of a workload, leading to the dramatic cost saving discussed earlier.

While the boundaries of hardware resources have started to blur there is still room for improvement. In maintaining a virtualized environment, IT administrators still need to think about which physical hardware a virtual workload resides, or on which physical server the workload needs to be placed. When rebalancing workloads, administrators need to be aware of the physical nature of the system (is it an old CPU, a 2-way system or 8-way system) as well as the status of the existing workloads on given server hardware.

Now, with VMware Infrastructure 3, IT organizations can enable a true utility model for delivering compute capacity for multiple application groups and businesses. IT labor around capacity management is dramatically simplified, and IT organizations and their customers can eliminate the problems of maintaining physical hardware.

VMware Infrastructure 3 introduces two ground breaking technologies that take the labor and thought out of capacity management, enabling a true utility model for managing shared hardware. VMware Distributed Resource Scheduler (DRS) intelligently allocates resources for virtual machines across a farm of physical servers. A Logical Resource Pool is a facility that defines logical, flexible resource and service level policies, and allows VMware DRS to distribute capacity to varying business needs. Administrators and their customers no longer need to worry about the underlying physical nature or configuration of the server farm.
Logical Resource Pools

From the physical resource pool accessed by VMware Infrastructure 3, users can create any number of logical resource pools. IT organizations and their customers can specify a logical sub-quantity of hardware capacity that is then intelligently and automatically mapped into the physical resource pool.

IT organizations can aggregate a collection of industry standard systems and treat them as one large computer that can then flexibly meet varying business needs and service levels.

VMware DRS

VMware DRS dynamically allocates and balances computing capacity across a physical resource pool.

VMware DRS continuously monitors utilization across resource pools and intelligently allocates available resources among the virtual machines based on pre-defined rules that reflect business needs and changing priorities.

IT managers no longer need to think about where capacity resides or on which physical server a workload is running. Their only concern is the quantity of compute capacity that a given business group or set of applications require.
**Automate Resource Assurance for Critical Applications**

With VMware DRS, hardware becomes a truly distributed, pooled resource where applications get all of the computing cycles they need to execute with peak performance. IT organizations can run mixed workloads on industry standard systems and guarantee that the highest priority applications will get the resources needed for optimal performance. CPU capacity, disk size, network bandwidth, and memory capacity are assigned to each virtual machine in accordance with its peak load requirements. This allocation can occur for a group of applications, as well. If the applications are not using peak load, they will share the resources with less important task operations.

For example, if an application is mission critical and has been allocated nearly all of the CPU cycles and memory available from the first server, as it starts to use all available resources, the system will automatically take the other virtual machines on that system and move them to another system that has the headroom to support them. The highest priority application will be guaranteed to receive the resources it needs. Note: this is not policy-based. Meaning, it does not use a pre-defined behavioral constraint as means of management control. However, it will allow users to determine the resources required by each application and guarantee that those resources are available.
Non Disruptive Capacity on Demand

Using VMware DRS, potential problems are diagnosed and corrected as soon as they occur—when an application experiences increased load, and before it experiences a serious performance issue, VMware DRS detects the event, and provides more resources to the virtual machine. This capability enables a self-adjusting, self-optimizing data center.

System administrators can allocate available resources depending on the value of the applications they support. Not all applications are created equal—some are more important than the others. With VMware DRS administrators can ensure that the important applications always take precedence if there is competition for resources.
Automatic Availability for all Applications

VMware has added built-in cluster management to VMware Infrastructure 3. This means that any application, by virtue of operating inside a VMware virtual machine, will have automatic restart. If the hardware fails, the virtual machines will be automatically restarted on a server that has the headroom to handle the application load of those virtual machines.

Transform Availability Service Levels

Traditional cluster management is a heavy overhead configuration process with an application specific configuration. It does handle state so that at restart, no state is lost. However, with typical cluster management less than 10 percent of applications have fault handling capabilities.

With VMware cluster management, a failure will cause the application to be restarted on a running machine so that every application will have application availability through automatic restart. This increases the level of availability without adding any complexity to the system and without requiring administrators to have special application knowledge.
Backup Anytime

VMware Infrastructure 3 also includes an agentless backup—where users do not need to install a separate agent per virtual machine. The backup feature uses VMware virtual machine snapshot technology to backup from a host while the application is online.

Backup can be conducted at any time, because it is completely separate from production virtual machines, with no agents running in the virtual machines to hinder network traffic or clog the LAN. The backup process is moved off the virtual machine and the network onto a separate proxy server that does not interfere with the performance of the production systems.

This reduces the load on ESX Server installations, allowing them to run more efficiently and run more virtual machines.
Fault Tolerant Data Center

VMware Infrastructure 3 offers a true, distributed virtualized data center and it is based on “industry commodity” parts. If a part fails, the only consequence is a few less resources are available for the time that the part is down. Other than that, the fault is transparent and everything continues to run. Systems can be added or removed and workloads can be increased or decreased without requiring any manual reconfiguration of the system.

All physical resources are managed separately from how resources get allocated to individual workloads or applications. Scaling up or down in storage, network and server resources happens independently of how those resources are mapped to individual applications. Workloads and applications simply consume their allocated percentage of physical resources. If a resource pool suddenly shrinks, they will continue to run, but they will only use a fraction of the previously available resources. If the resource pool grows, they can dynamically grow their resource consumption to take advantage of the extra capacity.

As a result, the resources of an enterprise can be efficiently managed to meet application service level agreements without excessive downtime, maintenance windows or change management. If an Exchange Server is struggling, for example, and IT decides to scale its resource allocation, it can get additional computing, networking and storage resources without any form of downtime. If IT wants to take resources away from one application to support another, they can do so, on the fly and without incurring downtime on either of the applications. It is, simply, a far better way to manage data center resources.
Extend Virtual Infrastructure to End-User Desktops

Another important area for customers is securing and centralizing enterprise desktop management. Customers have been using VMware virtual infrastructure to host virtual machine desktops from a server for several years now and many customers host thousands of virtual machines. This capability is particularly useful for organizations with remote workers, temporary workers, and test and development teams. Since the virtual machine runs a full instance of unmodified Windows or Linux, every application runs as it would on real hardware. Recently companies have been evaluating virtual enterprise desktops for emergency situations (for example, a natural disaster or flu epidemic) when employees would be required to work from home.

With the added capabilities of VMware Infrastructure 3, hosted desktops will get automatic load balancing and high availability plus scalability and performance. VMware has also added a per-client licensing framework for hosted desktops.

Application Lifecycle Management

Customers have been using VMware products for over seven years to accelerate test and development, decrease the burden of configuring for possible test scenarios and increase their ability to support the growing number of possible operating system combinations. Many VMware Infrastructure customers are using our products to streamline their entire software life cycle. These customers take the developed software and test it in a virtual machine so no differences are introduced in the installation and configuration process. The same virtual machine can go to staging and production. Production can be rolled back if necessary and also incorporate the never-ending cycle of updates. Software companies are also using virtual machines to pre-install and configure their software for delivery to customers. It is a full software life cycle that is streamlined and made consistent through the use of virtual machines.

Recently VMware announced the acquisition of Akimbi, a small company devoted to building tools that streamline the virtual machine software life cycle. VMware will continue to invest in this area to expand the significant software life cycle benefits that VMware products and technology already make possible.
Virtual Applications Changing the Role of the OS

The traditional software stack is comprised of hardware, an operating system and an application. Traditionally, the operating system must manage both the hardware and the application. This is a highly complex job. VMware virtualization is a tremendous simplifying agent here. If we personify the software stack it might look like this: One person takes new hardware from the loading dock and gets it installed. Another person might get the operating systems installed and configured and there someone else architects the application stack to run on top. It would be a highly complex job for one person to do all of these things. In effect, this is what VMware does with adding the virtualization layer.

The hypervisor takes care of the hardware and the operating system takes care of the application.

Application designers choose the operating system that is optimal for their application. Say they have a highly secure application, they will chose a highly secure operating system. Alternately, if designers have a high workload, then they will use a very low overhead, bare bones operating system. Instead of a one-size-fits-all operating system, the industry will see many operating systems tailored to the applications that they run. This will also result in more stable operating systems as they will be built for specific application loads. In this scenario, virtual appliances offer an ideal solution and a simpler model. The operating system bundle can be contained in a virtual appliance, running on the virtual infrastructure and underneath, the hardware.
The Distribution of Virtual Appliances

Users will group their virtual appliances in a Web service or in multiple instances of email. Virtual appliances will be provisioned and resources for them will be allocated in a similar fashion.

VMware has set up a portal for virtual appliances and we now have hundreds available. Appliances are available for safe Web browsing, network firewalls, IP telephones, fax applications and more. VMware launched the Ultimate Virtual Appliance Contest a few months ago with $200,000 in prize money. VMware has hundreds of submissions and a highly esteemed outside panel of judges will select the winner, to be announced at Linux World in August.
The Value of VMware Infrastructure

In summary, traditionally there are servers, storage arrays, routers, and lots of cables all carefully and statically hooked together. Applications are provisioned to a single server with its available, attached other resources. Once they are running, they are left alone with the hope that the workload does not change and the systems remain stable.

With VMware infrastructure everything becomes "hardware:"

VMware infrastructure sits on top of all that hardware and exports it to the virtual appliances as a single pool resources—100MHZ of cycles, 100GBytes of memory, etc.
This simple model takes great complexity out of the data center while also adding significant utilization optimization and better data continuity through more ubiquitous availability and online backup.

VMware builds robust and highly functional products. We are first and foremost a partnering company. We also will continue to invent and develop with new ways to leverage our fundamental virtualization building blocks.

VMware is interested in seeing an open industry. The company views this as a unique moment in time where we can have an industry where customers choose solutions based on functionality, quality, and price. They are not forced into a solution through arbitrary lock-in or control points.

To that end, VMware is investing heavily and proactively working toward standards that are license free and governed by an independent industry standards body. We have the de facto standard, over 1M servers virtualized in our virtual machines. But we also feel very well equipped to compete where there is freedom of choice and no lock-in.

**Virtualization Standards**

There are three standards that are relevant right now to the virtualization industry.

First, is the interface between the operating system and the hypervisor.
When VMware started out there was no possibility for altering an operating system to work better with a hypervisor. Our first prototype worked with a modified Linux kernel but we knew that we had to have a product that would work with existing Linux, Windows, Solaris, Novell—and now Mac operating systems. No matter what, we want virtualization software that runs legacy workloads without requiring any porting or modifications.

Now that virtualization is accepted, operating system vendors are also building hypervisors and they are modifying the operating systems to run more optimally. The interface should be open, license free, and governed by a third-party standards body. Any operating system should run optimally on any hypervisor without arbitrary licensing restrictions.

The next interface is around the management of the virtual machines. The management software needs to be able to communicate with the hypervisor to manage and manipulate the virtual machines. This too should be governed by open and third party standards body. VMware has offered its interfaces and APIs—based on more than seven years of production product experience—to be available and governed by an industry-neutral body. We have done the same around the hypervisor/OS interface.

Finally, the third standard is for the format of the virtual machine itself.
It does not particularly matter what the interface is but the standards will be used to determine how a virtual machine is backed up, patched, recovered, etc. The format should not require a license as it would be an arbitrary control point. The virtual machine format should likewise be governed by a neutral standards body.

VMware is also working to establish an industry-wide, standardized set of benchmarks. Our goal is to establish benchmarking standards that give meaningful workload information so customers and partners can make clear "apples-to-apples" comparisons between different virtualization solutions.

Continuing to Lead Where VMware Is Going
VMware Vision

VMware virtualization has moved way beyond the single node hypervisor. With VMware virtualization, users can wrap an entire service-oriented application with all its moving parts into a virtual appliance. This appliance can be directly placed in a resource pool. The virtual appliance is equipped with built-in provisioning, resource management, availability, security and data protection features. The dial on all these capabilities can be turned up or down at the click of a mouse.