PETER BAER GALVIN

Pete's all things Sun: VMware vSphere 4 vs. Microsoft Hyper-V R2

Peter Baer Galvin is the chief technologist for Corporate Technologies, a premier systems integrator and VAR (www.cptech.com). Before that, Peter was the systems manager for Brown University's Computer Science Department. He has written articles and columns for many publications and is co-author of the *Operating Systems Concepts* and *Applied Operating Systems Concepts* textbooks. As a consultant and trainer, Peter teaches tutorials and gives talks on security and system administration worldwide. Peter blogs at http://www.galvin.info and twitters as "PeterGalvin."

pbg@cptech.com

LONG GONE ARE THE DAYS WHEN "SUN Microsystems" meant only Solaris on SPARC. Sun is pushing hard to be a platform provider for multiple operating systems, as well as a provider of their own Solaris operating system. In some ways this column is a continuation of my April column (*;login:* April 2009, Volume 34, Number 2), which contained a virtualization guide. That column discussed the virtualization offerings created by Sun. This column explores the rich, controversial, and important terrain of two of the market leaders in virtualization, VMware and Microsoft. The topic is not Sun-specific but is probably of interest to many Sun customers. The Sun x86 servers are certified to run VMware and Windows, as well as Solaris and Linux. In my experience, Sun x86 servers, especially the x4600 with its eight sockets and quad-core CPUs, make excellent virtualization servers. The question then becomes, which virtualization technology to run? OpenSolaris has Xen built in, but many sites want mainstream and well-tested solutions. That brings us to the two contenders discussed in the remainder of this column.

VMware is certainly the company one thinks of when "virtualization" is mentioned, and for good reason. They have the largest market share of virtualization solutions, have had products available for many years, and are leading the way to the virtualized data center through their product features and best practices. Microsoft gets everyone's attention when they enter a market, and although late to the game, they are attacking it fiercely by including virtualization in Windows Server. The question on many minds is, "Which is better?" or even "Is Hyper-V good enough?" In this column I'll discuss the features of the latest server virtualization offerings from both companies—VMware vSphere 4 was recently announced and is already shipping, and Microsoft Hyper-V R2 is part of Windows Server 2008 R2, which is currently in beta test and expected to ship in October. Along with features, the discussion must also include (list) pricing, because much of Microsoft's push is based on the lower cost of Hyper-V.

VMware vSphere 4

vSphere 4 is the name of a suite of products from VMware consisting of the ESX and ESXi type 1 hypervisors installed on servers and the vCenter Server administration software. The important features of vSphere 4 include:

- Distributed Resource Scheduler (DRS): aggregates resources across one or more compute clusters and dynamically allocates them to VMs based on business logic.
- Distributed Power Management (DPM): automates energy efficiency in DRS clusters by optimizing power consumption.
- Virtual Machine File System (VMFS): clustered file system, shares storage among cluster nodes.
- Thin Provisioning: dynamic allocation of storage as needed.
- Virtual Switch: provides advanced networking features per guest on a host.
- vNetwork Distributed Switch: simplifies provisioning, control, and administration of VM networking.
- vMotion: live migration of VMs across servers in a cluster with no disruption or loss of service.
- Storage vMotion: relocates virtual disks among storage resources within a cluster (but not between clusters).
- High Availability (HA): automated restart (within minutes) of VMs on other cluster nodes in the event of server failure.
- Fault Tolerance: a second VM mirrors a primary one in lockstep, providing continued operation if the first VM or its hardware fails (but limits VMs to only 1 vCPU, and use of many other features not allowed).
- Data Recovery: agentless backup of VMs (for small environments).
- vShield Zones: creates and enforces security zones that are maintained even during vMotion.
- VMsafe: enables the use of third-party security products within VMs.
- vApp: logical collection of components of an application, described via OFV format.
- Site Recovery Manager (SRM): automates DR failover between sites and failover testing, via integration with networking and storage components.

Both VMware vSphere 4 and Microsoft Hyper-V manage multiple hosts as clusters of resources. A cluster is the entity into which a VM is deployed. Cluster resources are allocated to VMs. VMware, through vMotion, can move VMs among hosts in a cluster. If a cluster node fails, the VMs that were running on that node can be automatically restarted on another node in that cluster. Cluster hosts share access to storage to allow this functionality. Note that vSphere has no native ability to replicate storage between clusters (such as to a DR site) but, instead, integrates with replication provided by storage vendors (which are usually licensed features of the storage arrays).

There is no standard benchmark of virtualization performance currently available, although the SPEC organization is working on one. VMware has published their own VMmark benchmar, but, because it includes in its testing the performance of Linux running on more than one core and because Hyper-V does not support Linux beyond one core, there is no way to run that test across both virtualization technologies. This lack of standard benchmarks leaves it up to a given site to run tests to determine performance differences. I expect that VMware is more efficient in terms of CPU and memory use, but have not yet proved that via testing.

Pricing of software can be complicated, and virtualization solutions are no exception. Table 1 compares the flavors of VMware vSphere and their list prices.

Specification	Standard	Advanced	Enterprise	Enterprise Plus
Cores per CPU	Up to 6	12	12	12
Virtual cores (per guest)	4	4	4	8
RAM	256GB	256GB	256GB	Unlimited
Failover	0	16	16	16
Consolidation	Hypervisor, agent, thin provisioning, update manager, VCB	Hypervisor, agent, thin provisioning, update manager, VCB	Hypervisor, agent, thin provisioning, update manager, VCB	Hypervisor, agent, thin provisioning, update manager, VCB
Availability	HA	HA, live migration, fault tolerance, vShield zones, data recovery	HA, live migration, fault tolerance, vShield zones, data recovery	HA, live migration, fault tolerance, vShield zones, data recovery
Automated resource management			DRS, DPM, storage vMotion	DRS, DPM, storage vMotion
Simplified operations				3rd-party multipathing, distributed switch, host profiles
Cost	$795 per processor	$2,245 per processor	$2,875 per processor	$3,495 per processor

TABLE 1: VMWARE VSPHERE COMPARISONS

To these product costs must be added any operating system licenses and application licenses. Also needed is a license for one or more copies of vCenter Server: the "Standard" version has no host limits, can link to other vCenter Servers for consolidated management, and includes "Orchestrator," a VMware automation tool. It costs $4,995. The more limited "Foundation" version costs $1,495 and is limited to 3 ESX hosts. ESXi itself can be run free of charge, but optional maintenance can add $495 per year to its cost. Of course many sites execute a site license agreement with VMware, greatly reducing the per-processor cost. In general, a site license for vSphere or any operating systems is not an unlimited license; rather, it is a discount based on a volume purchase of licenses. A "true up" occurs periodically in which the number of instances in use is calculated and the total cost to the site tallied.

Microsoft Hyper-V R2

Microsoft Hyper-V R2 is at the time of this writing in "release candidate" form in Windows Server 2008 R2. Microsoft claims that half of its infrastructure is currently virtualized (via Hyper-V presumably), so clearly Microsoft feels that it is ready for production use. But because it is in release candidate form, it is difficult to draw conclusions about its use in the field, production deployments, and even final features and performance.

Hyper-V is Microsoft's virtualization layer, the technology that allows virtual machines to run within Windows, just as ESX and ESXi are VMware's. Hyper-V is simply a feature of Windows Server. Technically it is a "type 2" hypervisor, as virtual machines run under a host operating system and not just a hypervisor. However, this line is blurry, as ESX also includes a Linux component in its host operating system. According to Microsoft, they provide a

thin type 1 hypervisor layer that runs alongside the full Windows Server software. In their implementation, device drivers have low latency access to the hardware, and therefore type 1-like performance.

Hyper-V is part of the complete virtualization solution from Microsoft. The associated management component is Microsoft System Center, the software generally used by Microsoft infrastructure shops to manage their Windows Server deployments. A new add-in to SC is SCVMM—Microsoft System Center Virtual Machine Manager. SCVMM is able to manage not only Hyper-V-hosted guests but also Virtual Server, VMware Server, and VMware ESX and GSX guests. SVCMM works well in conjunction with the other standard components of System Center, such as the Configuration Manager and Operations Manager. This tight integration is a boon to sites that already make use of those other tools.

SCVMM has a host of features, making it a fairly complete manager in Microsoft environments. For example, it will intelligently place VMs onto the hosts with the most available resources, based on the resource needs of the VMs in question. Also included are physical-to-virtual (P-to-V) tools to take a physical server and generate a virtual machine image from it, and a virtual-to-physical (V-to-P) tool that does the reverse. P-to-V is the way most sites generate their first VMs, capturing existing systems and virtualizing them. The utility of V-to-P should not be overlooked, however. It can be useful for debugging, to test whether virtualization is causing the problem or whether it is virtualization independent. It can also be useful for performance testing. Finally, it ensures that even if an application has been virtualized, there is a back-out plan if that virtualization results in insufficiency.

Other useful features include the full scriptability of SCVMM actions via the standard PowerShell tools. Scripting enables repeatability and transportability—for example, a library of scripts that create and manage virtual machines can be copied between sites to allow uniformity and administration efficiency.

A Hyper-V cluster provides high-availability functionality by restarting VMs on other cluster nodes if a node fails. Hyper-V R1 has a "Quick Motion" feature that allows a VM to be moved between cluster hosts, but it lacks Vmotion's ability to do the move "instantly" (in less than a second). Because the move can take several seconds, network connections to the VM can fail during the move with resulting impact to production uptime. Quick Motion greatly diminishes an administrator's ability to manage resource use in a Hyper-V cluster. A running VM cannot be moved to another server seamlessly. If a server needs maintenance, for example, moving the VMs to another server is a downtime event. Hyper-V R2 has a feature called Live Migration that should address this issue and put it on a par with vMotion.

The features available to Windows administrators depend on the version of Windows being used. The available versions include Web, Foundation, Standard, Enterprise, and Datacenter. There is also an Itanium version that does not support Hyper-V, as well as an HPC version. Fundamentally, Enterprise, Datacenter, and Standard can include Hyper-V, but there are also versions of those operating system flavors that do not include it. A Server Core version of Enterprise, Datacenter, and Standard includes all the functionality but without the GUI. This version is intended for headless servers, decreasing the size of the installation and installation time.

Table 2 shows the Windows Server 2008 R2 versions, features, and limits.

Specification	Standard	Enterprise	Datacenter
X86 sockets (up to 32 cores)	4	8	32
X64 sockets (up to 64 cores)	4	8	64
X86 RAM	4GB	64GB	64GB
X64 RAM	32GB	2TB	2TB
Failover cluster nodes	0	16	16
# client access licenses (CALs) included	5	25	0
Cross-file replication (DFS-R)	No	Yes	Yes
Virtual Image Use Rights	1	4	Unlimited
Cost	$999 per host	$3,999 per host	$2,999 per processor

TABLE 2: WINDOWS SERVER 2009 R2 COMPARISONS

Again, application licenses must be added to these costs, as well as the cost for non-Windows guests and any Windows guests beyond the number granted with the OS license.

"Virtual Image Use Rights" determines how many Windows Server guest virtual machines can be created when the given operating system is the host. Unlimited guests are allowed, but only a limited number of Windows Server guests are granted in the license. Windows Server 2008 Standard Edition can have one Windows Server guest VM, Enterprise can have four Windows Server guests, and Datacenter is limited only by available resources. The Windows Server license includes the use of Windows Server as a guest under Hyper-V on that system.

You can use the various flavors of Windows as guests, depending on licensing terms.

- Windows 2008 without Hyper-V can be a guest and can use 1, 2, or 4 virtual CPUs.
- Windows 2003 can use 1 or 2 virtual CPUs.
- Windows 2000 can use 1 virtual CPU.
- SUSE Enterprise Linux can use 1 virtual CPU.
- Windows Vista can use 1 or 2 virtual CPUs.
- Windows XP can use 1 virtual CPU (although Windows XP Professional with SP3 and XP Professional x64 Edition can use 2 virtual CPUs).

Note that Red Hat and Microsoft have announced a joint support agreement. RHEL will be supported as a guest within Hyper-V, and Windows Server 2008 will be supported within RHEL guest VMs. As of this writing, neither of those options is available for production use.

There is no Microsoft equivalent of ESXi—rather, Windows is installed as well as Hyper-V, with Windows being the virtual machine manager (VMM). The minimum installation of Windows Server Core plus Hyper-V takes 2.6GB of disk space. The more complete Windows Server releases take even more space. ESXi takes 70–100MB of disk space.

A Hyper-V VM consists of a configuration file, the image file (in VHD format), saved state files, and differencing disks (AVHDs). Hyper-V supports full snapshot functions, including creation, deletion, and merging. Merging is needed if snapshots that depend on other snapshots are deleted. Snapshots are just block differences. Each snapshot refers to the previous snapshot and just records differences. If a snapshot is deleted, other snapshots may de-

pend on some blocks in that snapshot, and those blocks must be merged into the remaining snapshots. However, merging snapshots is only possible when a virtual machine is halted. The other snapshot commands may be done on live VMs.

Comparison

Table 3 compares all the major features and resource limits of vSphere 4 and Hyper-V.

Aspect	VMware vSphere 4	Microsoft Hyper-V R2
Host		
CPUs supported	Recent AMD, Intel	Recent AMD, Intel
# CPU cores supported	64	64
Memory supported	1TB	2TB
I/O devices supported	IDE, SCSI, SAS, SATA, FC, 1Gb and 10Gb Ethernet, iSCSI, NFS, FCOE, Infiniband	IDE, SCSI, SAS, SATA, FC, 1Gb and 10Gb Ethernet, iSCSI, CIFS, FCOE, Infiniband
Memory optimization	Over-commit, transparent page sharing, ballooning, large-memory pages	Dynamic memory allocation
Platform support	Fewer vendors	More vendors
Supported storage of guest VMs	Direct, SAN, NAS, iSCSI	Direct, SAN, iSCSI
Number of nodes in a cluster	32 nodes if < 40 VMs per node	16
Guest		
Operating systems supported	Asainux, CentOS, Debian, FreeBSD, OS/2, Solaris 10, SCO OpenServer, SCO Unixware, Windows Server, RHEL, SUSE, MS-DOS, Netware	Windows Server, Vista, XP, SUSE Linux
Operating systems tools provided |(per OS)	Yes, for most guests	Yes, for most guests
# virtual CPUs supported	8	4
# guests per host	256 running	512 (192 running)
Amount virtual memory	256GB	64GB
Virtual NICs	10	Yes, limit unknown
# of snapshots	32 per VM	50 per VM
Types of guests supported	32-bit, 64-bit, simultaneously	32-bit, 64-bit, simultaneously
Ability to hot-add disk images and external storage	Yes	Virtual SCSI devices only, not IDE
Features		
VM move	Live	Live
Direct I/O	VMDirectPath I/O	—
VM synchronization	With limits (1 vCPU, many features disabled)	No

Directly boot from VM image	Only if ESXi installed	Yes
P to V	Included	Included
V to P	Included	Included
HA via clustering and failover	Yes	Yes
Replication	Integration with 3rd-party storage products	Yes (DFS-R)
Performance monitoring	Yes, vCenter Server	Yes, SC Operations Manager
Network features	Virtual switch, VLAN tagging, Network vMotion, Network traffic shaper, IPv6, CDP, NIC teaming	Standard Windows Server 2008 features
Storage features	Thin provisioning, consumption-based monitoring, reports and topology maps, LUN discovery, adaptive block sizing, storage vMotion	Standard Windows Server 2008 features
Patching of guests	vCenter Update Manager (both running and halted guests, Windows and some Unix)	Standard Windows Server 2008 features for booted Windows guests, Offline Machine Servicing Tool for halted Windows guests
Security	Layer 2 security policies, vShield, VMsafe 3rd party security products	Native firewall, 3rd party security products
Backups	Native via VMware Data Recovery, Support from major vendors	Native, Support from major vendors
Resource management	Yes, many options	Yes, some options
Physical server power on / off as needed	Via VMware DRS, DPM	No
ISV support	Strong	Strong
VM format conversion	VMware workstation, Linux, VHD	VHD, VMDK
Market share (new orders, Q2 2008, IDC)	44%	23%
Performance	VMMark results published (no industry standard benchmark exists)	None published
Cost	See VMware section	Included with some Windows Server 2008 editions, see Hyper-V section

TABLE 3: VSPHERE 4 AND HYPER-V COMPARISONS

The list of functions, features, and limits needs to be compared with the needs of a data center. Applying that filter, it could be the case that, for a given deployment or environment, the two options analyzed here are equivalent. For example, the two offerings are relatively the same for a site needing to virtualize Windows Server 2008 on a host with 8 processors, 64 cores, 256GB of memory, needing 4 vCPUs per guest, 8 guests, live migration, H/A, and storage management. Comparisons of cost should also be considered.

To use VMware to accomplish this task, the list price cost would be $2,245 per socket for vSphere advanced, plus $1,495 for vCenter Server Foundation,

plus 8 Windows Server 2008 Standard (no Hyper-V) licenses at $971 each, for a total of $27,223.

To use Windows Server 2008 with Hyper-V to accomplish the same task, the list price cost would be $3,999 for Windows Server 2008 Enterprise (granting 4 guest licenses), plus System Center at $1,497 (although that is already in place at many Windows sites), plus 4 Window Server Standard licenses (for the other 4 guests), for a total of $9,376. Note that this pricing could change if Microsoft changes its licensing terms with the release of Windows Server 2008 RC and SVCMM R2.

There are some similarities and many differences between the features of these two offerings. In many cases, a shortcoming can be redressed by adding a third-party tool to an infrastructure. There are many such tools to chose from, but adding a tool brings with it added complexities, training needs, maintenance efforts, and so on. Also, consider that the virtualization market is very dynamic. Consider that Virtual Iron was an early entry into the virtualization market, but its purchasers were left without any options to expand its use when Oracle purchased the company and decided to terminate sales, even to existing Virtual Iron customers.

Further, datacenter managers, while determining the total cost of virtualizing an environment, need also to consider the impact of virtualization on the entire facility. Virtualization will likely:

- Decrease the number of physical servers.
- Increase the per-physical-server cost.
- Increase the number of OS instances ("virtual server sprawl").
- Decrease overall power and cooling costs.
- Increase power and cooling needed per rack containing virtualization infrastructure.
- Increase network throughput needed per rack, possibly resulting in the need for 10Gb networking.
- Increase storage load (where virtual machines are stored).

Conclusions

It is likely that hypervisors will be "free." Whether as a hardware component (the hypervisor that ships in the firmware) or as a software component (a virtual machine engine shipping as a feature of the operating system), the ability to virtualize will be included. Virtualization will therefore be ubiquitous. A free and ubiquitous feature is difficult for application vendors and infrastructure managers to ignore.

It is also likely that IT infrastructure will migrate toward "cloud" architectures in which systems and storage are resources that are trivially allocated and deallocated as needed based on application demand. Some applications do not lend themselves to cloud technologies, including applications that scale vertically, as a server grows, rather than horizontally, across servers. But those applications that can be implemented, monitored, scaled, and managed via cloud technologies will make the move due to those compelling cloud features and the cloud technologies that leverage virtualization. Networking likewise will evolve to allow fast access among all resources, and easier access to resources at remote sites (such as DR sites). Networking vendors will try to design (and sell) "one connection fits all" infrastructure in which one networking wire (or two for redundancy) handles all network and storage traffic.

Virtualization of applications will likely become the default, assuming virtualization vendors continue down the path of unifying the VM format.

Application vendors will commit to the vision, first illuminated by VMware, in which an application and its operating system are pre-installed, preconfigured, and pre-tuned in a virtual machine. That entity would then be the product shipped by the application vendors, and customers would simply take the virtual machine and deploy it on their infrastructure. The only sticking point in this scenario is how operating system vendors license their products. Sun Microsystems and most versions of Linux already allow free download and use of their operating systems, with payment made only if the customer wants to keep the software and get support. It is therefore allowable to ship a virtual machine containing Solaris and the application to the application's customer. Other vendors (with the notable exception of Microsoft) will likely follow suit, to allow their operating system to be bundled by application vendors.

VMware currently has a clear market and functionality lead, but can they maintain this lead in the face of competition from established vendors, both in features and in price? It is likely that they will have to decrease the premium that data centers have to pay, per CPU socket, to have that socket managed by VMware software.

Hyper-V market share will grow once R2 is released, because the addition of the Live Migration feature enables it to solve many more problems, in many more environments. It will also grow because it is freely included with some versions of Windows Server, and because it is a Microsoft-supported product. Its growth into large data centers will be limited by its scant support for other operating systems.

Currently, datacenter management would be well served to analyze which operating systems they are using, and determine from that which virtualization platform to evaluate using. If there are a large number of Windows Server systems, or a majority of the systems are Windows Server, then Hyper-V becomes a tempting direction. However, the newness of Hyper-V R2 dictates that careful testing, including reliability and performance, be done before any final decisions are made. Certainly its lack of support for Solaris and most Linux releases will limit its use in many environments. Also, installation planning should determine which release of Windows Server best suits the environment and how to deploy that version. VMware posted a video (see References) comparing the installation time and effort of VMware ESXi and Windows Server Core to demonstrate how much more work is involved using standard Windows deployment methods.

The costs and complexities of virtualization, from the tools through deployment and management best practices, are detrimental to datacenter managers. However, many sites are determining that the benefits far outweigh these issues. These benefits include reduced hardware footprint, power, and cooling use; improved application management, reliability, and maintainability; and easier application deployment and disaster recovery. The variations in data centers, priorities, applications, and business drivers require each datacenter management team to evaluate the gains and losses for themselves.

More information about VMware vs. Hyper-V is available in a free (registration required) white paper available from http://ctistrategy.com. In this white paper, I expand on the information in this column by providing analysis of why to virtualize, what to virtualize, more feature details, and a set of next steps for datacenter managers to consider. Also at ctistrategy.com is a decision guide that allows determination of the likely best virtualization fit based on site requirements.

Random Tidbits

The Oracle purchase of Sun Microsystems, although approved by shareholders, has not been consummated as of this writing. Certainly Sun will be changing, whether or not the purchase becomes final. Watch for analysis and updated product information in future versions of this column.

REFERENCES

Cio.com, Virtualization Vendors to Watch in 2009: http://www.cio.com/article/478388/_Virtualization_Vendors_to_Watch_in_.

Comparison of hypervisors by VMware: http://www.vmware.com/technology/whyvmware/architectures.html#c132894.

Hyper-V Glossary: http://blogs.msdn.com/virtual_pc_guy/archive/2008/02/25/hyper-v-terminology.aspx.

Computerworld, "Review: Microsoft's System Center Virtual Machine Manager," October 23, 2008.

Microsoft Hyper-V landing page: http://www.microsoft.com/windowsserver2008/en/us/hyperv-r2.aspx.

Microsoft Hyper-V supported guests: http://www.microsoft.com/windowsserver2008/en/us/hyperv-supported-guest-os.aspx.

Microsoft Systems Center pricing: http://www.microsoft.com/systemcenter/en/us/management-suites.aspx.

Microsoft Windows Server 2008 feature comparison: http://www.microsoft.com/windowsserver2008/en/us/compare-specs.aspx.

Microsoft Windows Server 2008 price list: http://www.microsoft.com/windowsserver2008/en/us/pricing.aspx.

Microsoft, "Windows Server 2008 Hyper-V Technical Overview," January 2008.

David Patterson's SC08 keynote: http://www.theregister.co.uk/2008/11/26/patterson_keynote_sc08/.

Red Hat licensing costs: http://www.redhat.com/f/html/partners_us_skulist.html.

TechAlpha, "Ripple Effects from Virtualization," March 11, 2009.

VMware pricing: http://www.vmware.com/files/pdf/vsphere_pricing.pdf.

VMware video of installation time of Windows Server Core and VMware ESXi: http://www.vmware.com/technology/whyvmware/resources/esxi-hyper-v-installation.html.

VMware vSphere configuration guide: http://www.vmware.com/pdf/vsphere4/r40/vsp_40_config_max.pdf.

VMware vSphere 4 datasheet: http://www.vmware.com/products/vsphere/.

vSphere glossary: http://pubs.vmware.com/vsp40_e/wwhelp/wwhimpl/common/html/wwhelp.htm#href=intro/master_glossary.html&single=true.

Windows as a guest operating system: http://technet.microsoft.com/en-us/library/cc794868%28WS.10%29.aspx.

Windows Virtual PC RC: http://blogs.msdn.com/virtual_pc_guy/.