



How a Hypervisor-Converged Software-Defined Data Center Enables a Better Private Cloud

WHITE PAPER

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Accelerate IT Response to Business Needs

IT organizations must be more flexible and innovative to rapidly address competitive threats and satisfy user demands. They need to deliver higher levels of efficiency and responsiveness to business stakeholders and compete with low-cost, on-demand services from external suppliers. At the same time, IT organizations must continue to provide reliability, security, and governance for all applications and services the business requires. Cloud computing provides a more efficient, flexible, and cost-effective model for computing. Businesses of all kinds and sizes are implementing private clouds within their data centers to deliver IT infrastructure and applications on demand while maintaining control.

Given the significant operational and business advantages of cloud computing, the interest in cloud infrastructure software has expanded quickly. Multiple private cloud platforms are available. However, the differences among vendor platforms are considerable. VMware combines the advantages of virtualization with physical infrastructure in a complete, proven, and reliable hypervisor-converged platform. The VMware® platform provides what IT needs to build, operate, and manage a private cloud to achieve greater business agility at lower TCO. This white paper details reasons why a VMware private cloud offers distinct advantages over offerings from Microsoft and other vendors.

“With the VMware solutions, we spend more of our day focusing on strategic initiatives, which in turn helps IT drive real value back into the business.”

— Jim Shipley, Chief Information Officer, Dierbergs

Other vendors promise software-defined data center services, but VMware uniquely implements those services in the VMware vSphere® software layer running closest to the server hardware, directly on the “bare metal.” The industry’s wide adoption of vSphere for compute virtualization enables customers to use that same hypervisor for storage and network virtualization services provided by VMware. Only VMware customers achieve the benefit of a hypervisor-converged approach that locates critical storage and network services in a thin and hardened software layer as close as possible to the server hardware for optimal performance and scalability. Software-defined storage and networking services from other vendors lack that advantage and must run in less efficient virtual appliances or operating-system applications many layers removed from the core hardware.

Best Hypervisor Architecture for Security and Reliability

VMware is not constrained by the need to retrofit virtualization into a legacy operating system. VMware is focused on the future of IT infrastructure. When an organization builds on the VMware platform, it is building on a secure, reliable, and purpose-built virtualization platform, not a feature bolted on as an afterthought (see Figure 1).

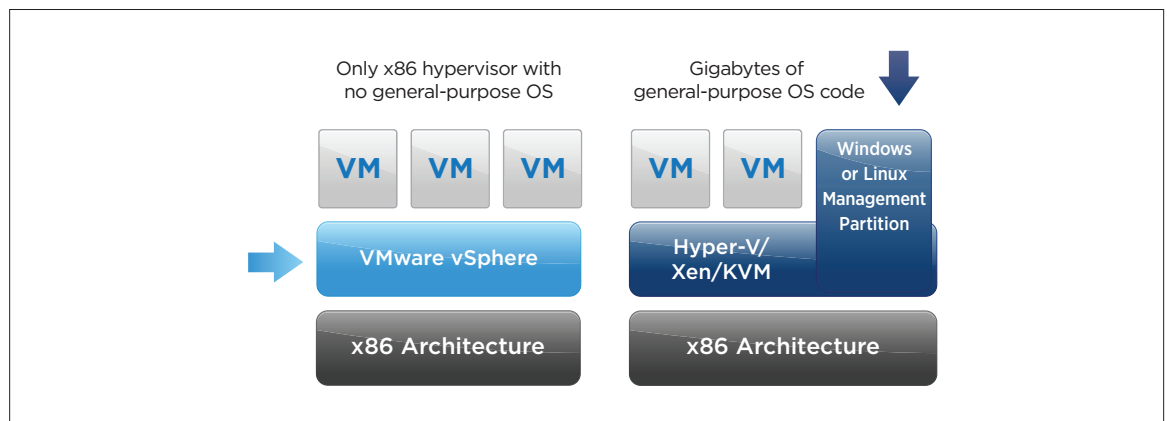


Figure 1: Comparing Hypervisor Architectures

The differences among leading hypervisor architectures are most apparent when you compare disk footprints (see Figure 2). A smaller disk footprint is essential because every line of code potentially introduces a vulnerability. The smaller VMware hypervisor disk footprint reduces the attack surface for external threats. And it can drastically lower the number of patches and maintenance tasks required, providing a more reliable product and a more stable data center.

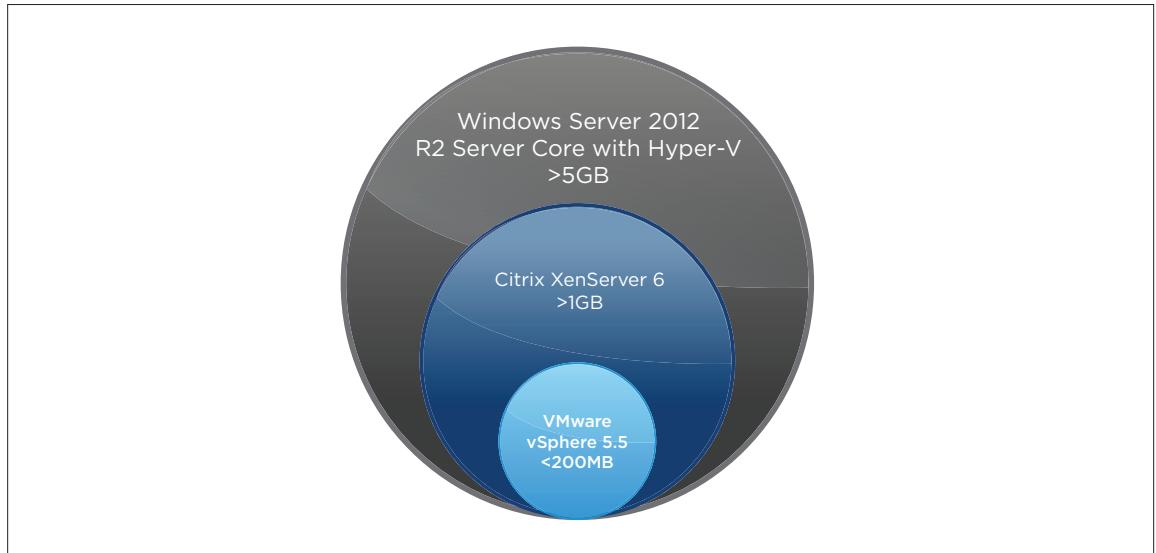


Figure 2: Relative Hypervisor Disk Footprints

Now in its fifth generation, vSphere includes a thin, purpose-built hypervisor designed for the sole purpose of virtualization. Table 1 compares the hypervisor and security features in vSphere to those in Windows Server 2012 with Hyper-V.

“We did a VMware versus Hyper-V assessment and found the maturity of VMware meant it was a superior product. You need to be 100 percent sure you can provide a service to the guys competing. You cannot delay the race for five minutes while you reboot a server or a storage device.”

— Michael Taylor, Director of IT, Lotus F1 Team

TABLE 1. COMPARISON OF KEY HYPERVISOR AND SECURITY FEATURES BETWEEN VIRTUALIZATION PLATFORMS

HYPERSVISOR ATTRIBUTES	VMWARE VSPHERE 5.5	WINDOWS SERVER 2012 WITH HYPER-V R2
Disk footprint	<200MB	>5GB with Server Core installation >10GB with full Windows Server installation
OS independence	No reliance on general-purpose OS; stateless provisioning	Relies on Windows 2012 in parent partition, which has a much larger attack surface and can become a single point of failure
Drivers	Optimized with hardware vendors	Generic Windows drivers
Memory management	Ability to reclaim unused memory, deduplicate memory pages, compress memory pages, swap to disk/SSD	Only uses ballooning; dynamic memory requires specific guest OSs with limited Linux support; can do hot-add of virtual machine RAM only in specific circumstances

HYPERVISOR ATTRIBUTES	VMWARE VSPHERE 5.5	WINDOWS SERVER 2012 WITH HYPER-V R2
CPU management	CPU capacity on a host is assigned to virtual machines on a “fair share” basis, and CPU resource controls also allow an absolute minimum level of CPU capacity to be provided to critical virtual machines	Limited: Hyper-V lacks resource pools and top-level management of resources
Storage management	vSphere Virtual Machine File System optimized for virtual disk files	Uses general-purpose Windows file system
Virtual security technology	Enables hypervisor-level security introspection; security applied at the hypervisor level with solutions such as offloading antivirus and antimalware processing for virtualized environments	Minimal adoption of Microsoft’s security standard; in-guest agents required
Resource allocation	Hot-add virtual machine vCPUs and memory, VMFS volume growth, hot-extend virtual disks, hot-add virtual disks	No comparable features
Profile-driven automation	Host profiles and autodeploy reduce complexity	More complex because requires provisioning complete Windows OS
Patching	No unrelated patching; image-based patching with rollback capabilities provides clean and simple host patching; 2013 security patch review shows vSphere had only three patches in 2013, saving administrators time	Subject to frequent patching related to the Windows OS required by Hyper-V; complex patching architecture requires additional effort and complexity; 2013 security patch review shows every “patch Tuesday” included important and critical security updates to Microsoft Hyper-V Server Core that were unrelated to virtualization and required a reboot of the host

VMware remains committed to making vSphere the industry-leading virtualization platform with the best hypervisor available. All current and future vSphere hypervisor features and architectural decisions are designed to keep the virtualization layer secure and reliable.

Most Comprehensive Solution for Greater Business Responsiveness

VMware solutions enable IT organizations to virtualize applications, desktops, and the complete data center infrastructure: servers, storage, networking, and security. Their deep functionality enables IT to instantly provision data center and other IT services throughout the enterprise, directing resources to where they can create the most value. By virtualizing with VMware solutions, enterprises can also run any application—even legacy applications—on a private cloud or a hybrid cloud that uses the VMware platform, which powers most public clouds and VMware vCloud® Hybrid Service™. Organizations can also use VMware solutions to build modern, cloud-based applications.

Software-Defined Data Center Approach Pioneered by VMware

For more than a decade, enterprises worldwide have used vSphere to significantly improve IT efficiency and performance. The mobile-cloud era presents new challenges. Increasing business demands require IT organizations to virtualize all data center resources—compute, network, storage, and security—so all infrastructure services become as inexpensive and easy to provision and manage as virtual machines. As the ideal architecture for private, public, and hybrid clouds, the software-defined data center extends recognized virtualization concepts—abstraction, pooling, and automation—to all data center resources and services (see Figure 3). The software-defined data center combines virtualized services for compute, storage, networking, and security in software that is deployed as an integrated unit with each infrastructure server. Components of the software-defined data center can be implemented together or in phases.

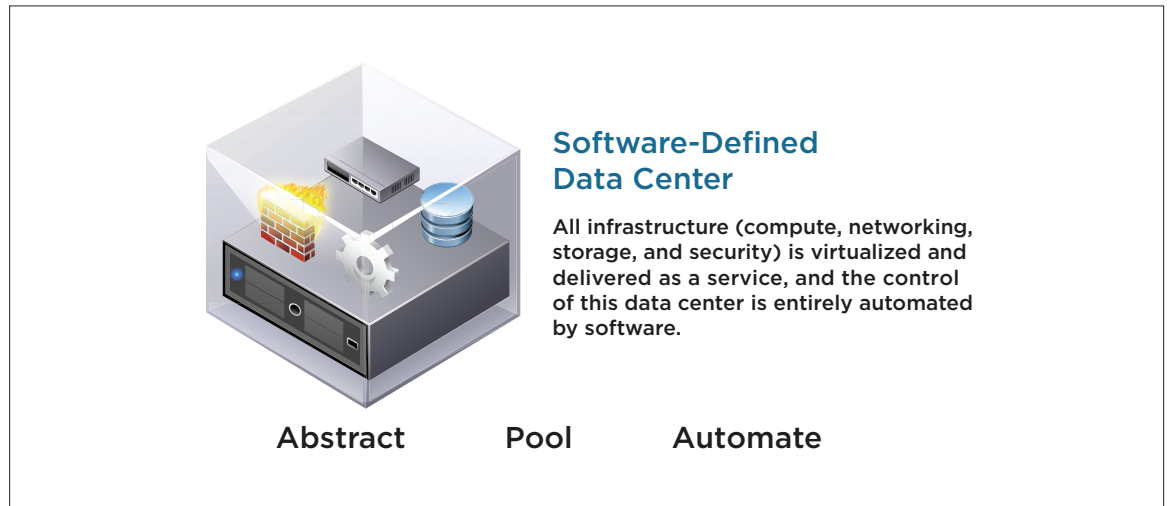


Figure 3: Virtualized Services Converged into a Single Software Layer Deployed as an Integrated Unit with Each Infrastructure Server

All Components for Building and Running a Private Cloud Infrastructure

VMware vCloud Suite is the unifying technology foundation for a software-defined data center approach. It gives organizations the flexibility to seamlessly span on-premises and off-premises environments with a converged management, orchestration, networking, and security model. No competitor can match the functionality or the benefits of vCloud Suite, which enables IT to build and run a private cloud based on vSphere that delivers

- **Operational efficiency throughout the data center** – vCloud Suite brings together virtualized compute and analytics-based operations management to drive greater resource utilization and staff productivity, leading to CapEx and OpEx savings.
- **Infrastructure agility at business speed** – vCloud Suite enables on-demand IT services deployment in minutes with full control over critical-business and IT policies. It automatically matches infrastructure resources to continually changing business demand and workload needs.
- **Operational and business-aware control** – vCloud Suite delivers the highest levels of application uptime through automated business continuity with virtualization-aware security and compliance. It enables greater control over the cost of, access to, and placement of IT services.

vCloud Suite is complemented by VMware Virtual SAN™ and VMware NSX™. Virtual SAN is radically simple hypervisor-converged storage with breakthrough technology that pools and automates local storage and turns it into shared storage. NSX delivers comprehensive security and network virtualization that is fully decoupled from hardware and built into the vSphere hypervisor layer for optimum efficiency.

Before deciding to move to a private cloud, small and midsize organizations interested in incrementally deriving more value from virtualizing IT production and business-critical applications can deploy vSphere® with Operations Management™. The solution's capacity-planning, health-monitoring, and alerting capabilities give IT operational insight into vSphere to reclaim unused capacity, right-size virtual machines, improve utilization, and increase consolidation ratios. Using vSphere with Operations Management, organizations can optimize capacity and expand virtual environments with confidence while gaining visibility into workload health to improve availability and performance.

VMware offers several options for implementing the software-defined data center architecture in a private data center and beyond:

vCloud Suite – Turn the data center into a private cloud based on vSphere using the software-defined data center architecture, delivering the best SLAs for all applications through software-defined services, policy-based provisioning, and automated operations management.

vCloud Hybrid Service – Gain the fastest route to a seamless hybrid cloud by extending a data center with public infrastructure-as-a-service (IaaS)—built using VMware technology enabling a software-defined data center—operated and supported by VMware and fully compatible with an existing data center environment.

Public cloud services from VMware partners – Deliver robust, secure, and flexible IT services built on the VMware foundation from a global ecosystem of certified VMware service providers.

Purpose-Built, Highly Automated Management Solutions

The robust, resilient vSphere architecture improves the uptime of business applications. Yet IT is still responsible for the ongoing management, performance, and security of these critical applications. Included in vCloud Suite, VMware vCenter™ Operations Management Suite™ acts as the control plane for the software-defined data center, providing control over both automation and operations management.

vCenter Operations Management Suite delivers intelligent operations management in physical, virtual, and cloud infrastructures from vSphere and Hyper-V to Amazon Web Services. It correlates data from applications to storage in a unified, easy-to-use management tool. The suite provides control over performance, capacity, and configuration, with predictive analytics driving proactive action and policy-based automation. VMware purpose-built operations management solutions are integrated with the vSphere hypervisor layer and are virtualization-aware to enable IT to accurately identify and proactively address infrastructure performance and capacity issues before they negatively impact the business, unlike competing management solutions that were built to solve problems in physical infrastructure.

VMware vCloud Automation Center™ provides the agility that businesses need by automating the delivery of personalized IT services. It is a single solution for application-release automation with support for various DevOps automation tools, abstracted from diverse infrastructure services. Through a self-service catalog, users request and manage a wide range of multivendor, multicloud applications, infrastructure, and custom services. Policy-based governance helps ensure that users receive the right-size resources for the task that must be performed across the service life cycle. A flexible automation approach provides agility in deploying new IT services while leveraging existing investments by mapping into current infrastructure, processes, and environments.

vSphere in combination with operations management capabilities adds value in the core areas of infrastructure management, application availability, capacity planning, and visibility across layers. In a 2014 benchmark study, key performance metrics increased by 20–40 percent. vCenter Operations Management Suite customers experienced

- 34 percent improvement in capacity utilization
- 30 percent more uptime on tier 1 applications
- 26 percent additional cost savings on IT infrastructure management

Customers also reported strong ROI, averaging 2.4 times the return on their investment for a vCenter Operations Management Suite deployment, with a majority of respondents reporting that it took fewer than six months to realize the value.¹

1. Management Insight. “Quantifying the Incremental Value of VMware vCenter Operations Management Suite,” January 2014.

The combination of a resilient platform and deep management insight enables organizations to trust the VMware platform to increasingly virtualize business-critical applications (see Figure 4).

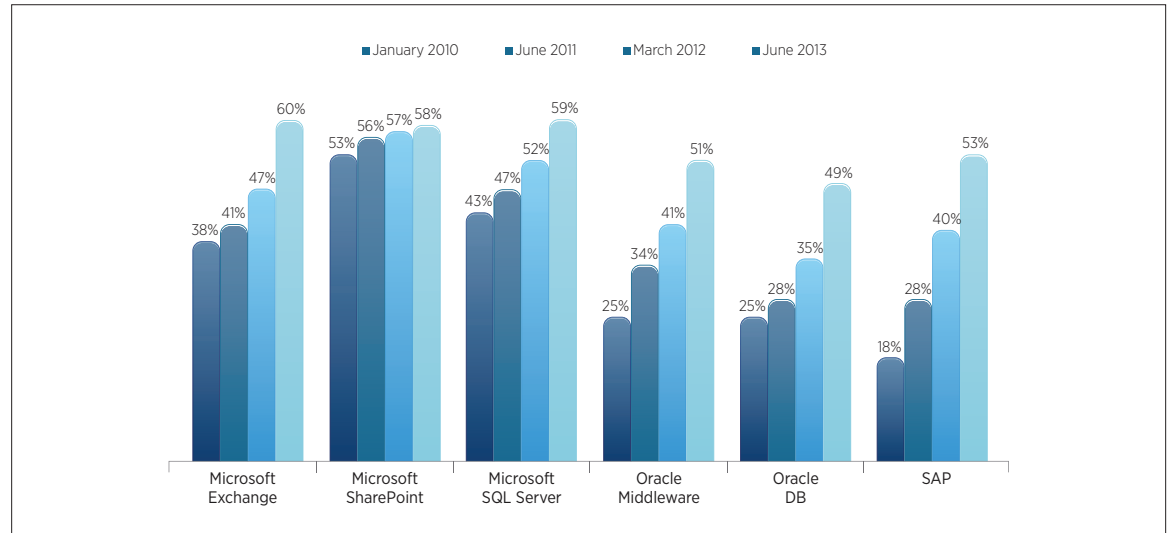


Figure 4: Virtualization Levels of Business-Critical Applications²

When compared to the Microsoft private cloud offering, vCloud Suite delivers a more comprehensive and automated approach to IT management (see Table 2).

TABLE 2. VMWARE DELIVERS COMPREHENSIVE APPROACH TO MANAGEMENT

MANAGEMENT		
VMWARE ADVANTAGES	VMWARE VCLLOUD SUITE	MICROSOFT PRIVATE CLOUD
Automated virtual and cloud infrastructure management	✓ Policy-based management	✗ Basic predictive and capacity management
Proactive application provisioning and monitoring	✓ Proactive operational management	✗ Reactive management, restricted by platform
Complete IT business management	✓ Aligned IT and business, complete chargeback capabilities	✗ Basic chargeback

“The flexibility and scalability enabled by our private cloud powered by VMware help us address business needs by accelerating the delivery of business-critical applications and services. Our investment in VMware cloud management helps us simplify and automate the management of our cloud. This powerful combination means that Columbia Sportswear is able to respond to business and market opportunities faster than ever before.”

— Fred Pond, Vice President and CIO, Columbia Sportswear

2. VMware. “VMware Journey to IT as a Service” customer surveys, January 2010, June 2011, March 2012, and June 2013.

Software-Defined Storage Capabilities Enable New Converged Storage Tier

VMware and leading storage technology partners provide a three-component architecture for software-defined storage. It includes a policy-driven control plane where IT can set policies for capacity, performance, and availability requirements on a per-virtual machine basis and apply those policies to the rest of the virtualized infrastructure. It also includes virtualization of the data plane, which enables IT to abstract and pool the heterogeneous capabilities of the underlying storage infrastructure and advertise those capabilities to that software-driven control plane. Finally, it includes virtualization of application-centric data services, which are tightly bound to the hardware arrays, to enable a rich set of virtualized data services. By optimizing storage—often considered a premium resource—software-defined storage makes enabling a private cloud more affordable.

VMware Virtual SAN extends the hypervisor to pool compute and storage using local storage and flash technology as a new converged-infrastructure data-storage tier. When compared to the Microsoft private cloud offering, vCloud Suite delivers a faster, easier, more comprehensive, and lower TCO approach to storage (see Table 3).

TABLE 3. VMWARE DELIVERS NEW APPROACH TO SOFTWARE-DEFINED STORAGE

STORAGE		
VMWARE ADVANTAGES	VMWARE VCLLOUD SUITE	MICROSOFT PRIVATE CLOUD
Lower TCO derived from logical pooling of storage tiers and software-defined storage	<p>✓ Ability to create, manage, and consolidate different storage tiers</p> <p>VSAN integrates compute and storage with VMware vCenter management</p> <p>Use existing x86 and storage capabilities at a much lower cost</p>	<p>✗ No logical pooling: overprovisioning of resources and lower resource utilization</p> <p>No equivalent capability</p> <p>Storage Spaces is a traditional SAN replacement and is not a converged or software-defined solution; it is out of band from the virtualization infrastructure and requires separate maintenance</p>
Faster provisioning, performance guarantees, and simplified, policy-based storage management	<p>✓ Accelerated virtual machine placement and reduced time to provision using Storage Distributed Resource Scheduler (Storage DRS)</p> <p>Automatic enforcement of per-virtual machine SLAs across different storage classes</p> <p>Performance isolation for virtual machines, prevention of noisy neighbor problems, protection of service levels for applications</p> <p>Tiered storage based on performance characteristics using profile-driven storage</p>	<p>✗ Limited storage DRS capabilities require manual administrative action, leading to increased management effort and time to provision</p> <p>Storage QoS provides per-virtual machine disk IOPS limits, but does not have any cluster-level awareness of the data storage</p> <p>No profile-based automation</p> <p>Storage tiering requires the use of Storage Spaces</p>
Mature ecosystem storage capabilities	<p>✓ Tighter integration with broad storage ecosystem through APIs</p>	<p>✗ No ability to use storage information from arrays for policy enforcement</p>

Proven Leadership in Network Virtualization Delivers Speed and Efficiency

When storage is aligned with application demands, enterprises can begin to empower their customers and employees by virtualizing the network for speed and efficiency. IT can free workloads from physical network infrastructure and free their own resources from slow, error-prone provisioning processes by abstracting network functionality from underlying hardware.

Using a software-defined model, enterprises can transform networking so that it is programmatic and automated, and helps increase IT agility. NSX is built to support any application, any cloud management system, any hypervisor, and any network hardware. When compared to the Microsoft private cloud offering, vCloud Suite offers a more credible, easier, and superior technological approach to network virtualization (see Table 4).

TABLE 4. VMWARE DELIVERS TRANSFORMATIVE APPROACH TO NETWORK VIRTUALIZATION

NETWORK VIRTUALIZATION		
VMWARE ADVANTAGES	VMWARE VCLLOUD SUITE	MICROSOFT PRIVATE CLOUD
Backed by leading network vendors	✓ VXLAN supported by leading network vendors such as Arista Networks, Broadcom, Cisco, Citrix, and Red Hat	✗ Limited ecosystem support
Better network performance and load balancing	✓ Better load balancing, better link usage and network utilization	✗ GRE protocol tends to direct traffic to the same link, resulting in manual, cumbersome load balancing and degraded performance in dense environments
Simplified backup and recovery	✓ Virtual networks resilient to management failures Easy backup and recovery of network server configurations	✗ Additional costs to get the same level of availability—SCVMM required to be highly available
Superior technology	✓ VXLAN and NSX provide leading network virtualization solution for any cloud environment	✗ Poor Microsoft track record with networking protocols (Direct Access, ISATAP, Teredo)

Virtualization-Aware Security Provides More-Robust Protection

Software-defined security helps automate and scale out security, reducing the need for specialized devices, lowering costs, and simplifying management. VMware is the only virtualization expert leading innovation and development in virtualization- and cloud-ready security. All major security vendors have implemented their technologies on the VMware platform. Other virtualization vendors continue to recommend legacy physical solutions that are static and difficult to manage at cloud scale.

VMware security products enable leading third-party antivirus solutions to offload antivirus and antimalware processing, protecting guest virtual machines without the use of bulky agents. VMware solutions also enable security services such as edge and vNIC-level firewalls, NAT, and SSL VPN to be applied exactly where they are needed without hardware. When compared to the Microsoft private cloud offering, vCloud Suite offers a more virtualization-aware and easier-to-manage approach to security (see Table 5).

TABLE 5. VMWARE DELIVERS VIRTUALIZATION-AWARE APPROACH TO SECURITY

VIRTUALIZATION-AWARE SECURITY		
VMWARE ADVANTAGES	VMWARE VCLLOUD SUITE	MICROSOFT PRIVATE CLOUD
Virtualization-aware	<p>✓ Policies associated with hypervisor and remain intact when virtual machines move from one host to another</p> <p>Applications with different security requirements can share the same infrastructure</p>	<p>✗ No native centralized management for virtual machine network and security policies</p> <p>Applications with different security requirements are segregated into rigid silos</p>
Agentless	<p>✓ Security with performance-improved antivirus model that prevents antivirus storms, reducing performance overhead</p>	<p>✗ Legacy, in-guest antivirus model that leads to antivirus storms and high performance overhead</p>
Virtualization-aware firewall	<p>✓ Hypervisor-based firewall monitors and controls traffic at vNIC level; rules can be established in software for scalability</p>	<p>✗ Limited virtualization-aware firewall</p> <p>Scaled-limited solution in which applications with different security requirements are in silos</p>

Maximum Application Availability and Business Continuity for Greater Reliability and Reduced Business Risk

For IT professionals, system availability is paramount, often even more important than TCO. VMware provides the only virtualization platform proven in years of production enterprise environments. It is purpose-built for data center virtualization and cloud delivery. With VMware technology, IT gets an unmatched level of reliability and consistent performance. No other provider matches the robustness of VMware architecture and high-availability solutions. In the event of unplanned downtime, VMware provides a broad range of solutions that keep business-critical applications up and running (see Table 6).

TABLE 6. VMWARE SOLUTIONS MAXIMIZE UPTIME

BUSINESS-CONTINUITY AND DISASTER-RECOVERY (BC/DR) CAPABILITIES	BC/DR SOLUTIONS
High availability	Designed specifically for a virtual environment, vSphere High Availability and vSphere with App HA effectively recover systems from hardware, OS, and application failures. Microsoft uses a general-purpose clustering solution (based on Windows Failover Clustering) that must be enabled per virtual machine. In contrast, VMware HA can be enabled at the cluster level.
Fault tolerance	vSphere Fault Tolerance provides continuous availability by creating a live shadow instance of a virtual machine in lockstep with the primary instance. Instantaneous failover occurs between the two instances in the event of hardware failure, eliminating data loss, downtime, or disruption. Neither Microsoft nor Citrix products offer built-in fault tolerance.
Data protection	vSphere Data Protection™—an agentless architecture that protects against data loss in a virtual environment—enables fast backups to disk and fast, complete recovery with built-in deduplication to minimize the backup disk space used. Microsoft Windows Hyper-V relies on System Center Data Protection Manager (DPM) for virtual-machine backups. This requires enterprises to install agents on all protected virtual machines. Moreover, agents only exist for Windows-based virtual machines and a small set of Linux guests. Because DPM does not deduplicate backup data at all, enterprises incur increased costs. Citrix and Red Hat recommend using agent-based third-party backup solutions because both lack agentless backup capabilities.
Server or storage array maintenance	vSphere vMotion® and vSphere Storage vMotion® migrate virtual machines and virtual-machine disk files to other resources to enable enterprises to perform maintenance on a server or storage array—without any downtime. They also dynamically rebalance workloads across available resources, maximizing efficiency and ensuring that service-level agreements (SLAs) are met. Although other cloud platforms support live migration, only VMware provides the time-saving automation of vSphere Storage DRS™.
Hot-add	When applications require more resources than originally expected, vSphere with Operations Management can dynamically add CPU, memory, and storage resources to running virtual machines. Microsoft Windows Hyper-V requires enterprises to shut down virtual machines to add more CPUs.
Replication	vSphere fully supports array-based replication of virtual machines, and, for users without that SAN feature, vSphere Replication enables powered-on virtual machines to be replicated over the network from one vSphere host to another. Windows Hyper-V has a replica feature, but it must be managed one virtual machine at a time. Also, enterprises cannot manage replication via System Center Virtual Manager (SCVMM), and it requires disparate interfaces dependent on whether the hosts are clustered or not. Microsoft also supports only host-based replication.
Disaster recovery	vCenter Site Recovery Manager™ offers simple and reliable disaster protection for all virtualized applications. It leverages cost-efficient vSphere Replication or storage-based replication to provide centralized management of recovery plans, enable nondisruptive testing, and allow automated site recovery and migration processes. Microsoft Hyper-V Recovery Manager lacks support for the high-performance SAN-based replication needed for large-scale disaster-recovery failovers.

Lowest TCO for Highest Resource Utilization and Administrator Productivity

TCO studies prove that virtualizing with VMware solutions costs less than with Microsoft.³ VMware optimizes hardware utilization, provides superior management and policy-based automation, and enables a highly available and resilient infrastructure that minimizes downtime costs. By freeing IT resources to innovate for the business and drive growth—while also providing the most capable platform for cloud initiatives—VMware can deliver lower cost and greater business value than Microsoft.

Microsoft might claim a lower-cost solution, but its comparisons consider only virtualization and OS software licenses—a small portion of overall solution costs. When the cost of System Center management tools, 24x7 technical support, and data center infrastructure are accounted for, the Microsoft acquisition costs are similar even for small-business deployments. Compared to Microsoft, VMware substantially lowers OpEx with several advanced features and more-streamlined management that provide far higher levels of resource utilization and administrator productivity. CIOs can fuel business growth with the resources they currently have without requiring additional hours or an army of consultants. To accurately compare TCO, enterprises must evaluate both CapEx and OpEx (see Figure 5).

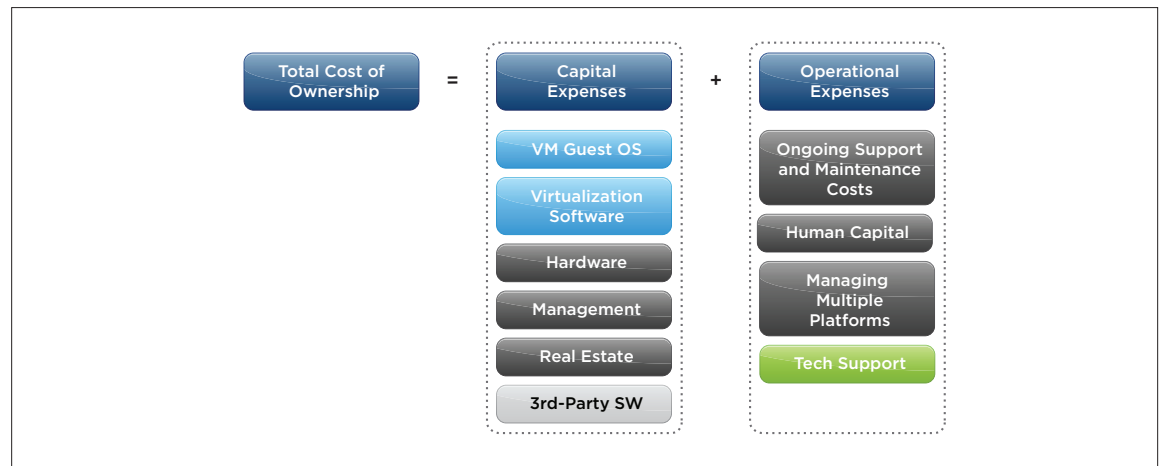


Figure 5: Accurate TCO Analyses Include Both Capital and Operational Expenses

For private-cloud decisions, CapEx includes all of the acquisition costs associated with implementing a solution. OpEx includes the time IT administrators spend managing that solution. VMware reduces CapEx with its superior virtual-machine density—how many virtual machines can run per host, which reduces the numbers of servers and software licenses that must be acquired. VMware provides a density advantage over the competition through more advanced resource management. vSphere uses memory better by employing sophisticated multilayered memory management that includes compression, ballooning, transparent page sharing, and hypervisor-level swapping. In contrast, Microsoft Hyper-V provides only dynamic memory and only virtual machine boot-time host swapping. vSphere also excels at cluster-level virtual machine load balancing. Customers using both vSphere and Hyper-V regularly report that they are able to operate with higher virtual machine densities on vSphere.

Sources of OpEx savings are derived from

- Platform installation and configuration
- Deploying new tenant users
- Creating self-service cloud portals
- Configuring and running chargeback reports
- Management and monitoring
- Responding to network security attacks
- Patching and updating
- Adding storage and balancing capacity
- Isolating “noisy neighbor” virtual machines
- Performing regular disaster-recovery tests

3. Studies available from VMware on request.

Another factor increasing Microsoft costs is the need for various third-party software products to fill functionality gaps that exist between vSphere with Operations Management and a Hyper-V with System Center solution (see Figure 6). Products that add features such as better monitoring, network virtualization, backup, and disaster recovery are required to make up for Microsoft shortcomings.

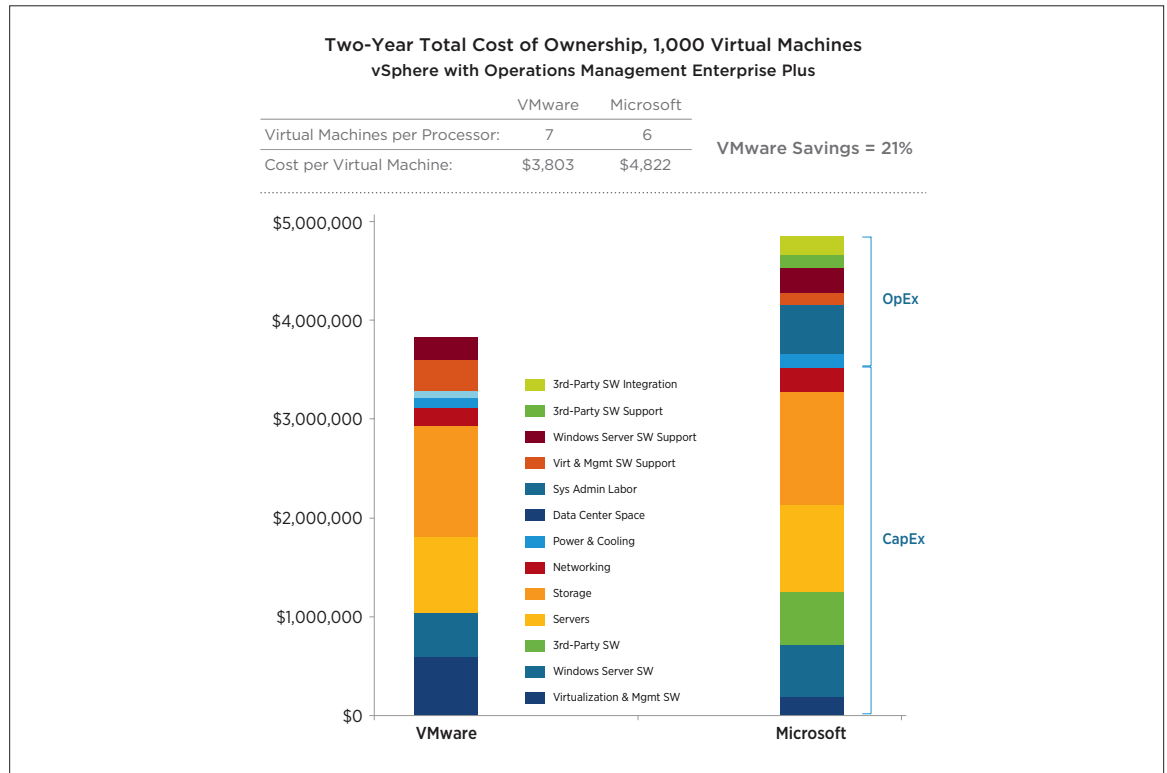


Figure 6: VMware Delivers Lower TCO⁴

VMware provides a [TCO Comparison Calculator](http://www.vmware.com/go/tcocalculator) for small and large enterprises to evaluate the true costs of the best server virtualization and private cloud solution. Within the calculator, inputs include the number of virtual machines, baseline virtual machine density, VMware product edition, and server and storage hardware profiles. The calculator provides a detailed breakdown of

- CapEx cost components such as software licenses, physical infrastructure, and third-party software plus integration costs
- OpEx cost components including system administrator labor expenses and annual software support and maintenance

For enterprises considering or already running more than one hypervisor, analysts warn that managing multiple hypervisors adds complexity. Switching virtualization platforms can also be an expensive undertaking because of the hidden costs associated with designing a parallel software infrastructure, setting up duplicate hardware infrastructure, and testing each virtual machine as it is migrated. Moreover, many management tasks automatically performed in vSphere must be handled manually in competing systems, which can increase a system administrator's workload.

4. VMware. "TCO Comparison Calculator," <http://www.vmware.com/go/tcocalculator>.

Most Proven, Trusted, and Widely Deployed Virtualization Platform Supporting Private Clouds, Hybrid Clouds, and Desktops

More than a decade of innovation has firmly established vSphere as the virtualization and cloud-infrastructure platform leader as recognized by customers, influencers, analysts, and the media. For four years running, VMware has been positioned in the Leaders Quadrant of the [Gartner Magic Quadrant for x86 Server Virtualization Infrastructure](#).⁵ VMware has also earned [hundreds of awards](#) for innovation and product excellence, further illustrating the technology gap between VMware and competitors.

“We have already saved \$2.1 million since moving to VMware vSphere, and expect to see these savings grow over the next few years. We have consolidated our servers at a 20:1 ratio, significantly reducing hardware costs. We have saved energy and space. We have even saved time because VMware technology has eliminated the extra time, steps, and costs of procuring and provisioning physical servers. From an operational and capital expense standpoint, going with VMware vSphere made a lot more sense.”

— Tom Hines, Chief Information Officer, Trilliant

VMware is behind some of the largest and most successful cloud environments in the world, including private cloud implementations and a global network of public cloud service providers leveraging VMware technology for a common infrastructure. Cloud services from VMware and more than 250 vCloud service providers enable enterprises to move applications seamlessly between a VMware private cloud and offsite environments—without worrying about application incompatibility or service provider lock-in often associated with other cloud services.

vCloud Hybrid Service—based on the software-defined data center architecture and owned and operated by VMware or a franchise partner—integrates existing applications and infrastructure with next-generation applications and the agility of the public cloud. Rolling out in specific markets across the world, it is the best and fastest route to hybrid cloud. It enables IT to quickly and seamlessly extend the data center into the cloud using the tools and processes already on hand. There is no need to rewrite code or change existing applications.

Because a private cloud is used to empower end users, VMware also provides VMware Horizon™ solutions. Horizon solutions do a better job than competing solutions in connecting end users to their data, applications, and desktops on demand—across multiple devices, both business and personal. Based on vSphere, Horizon technologies help businesses meet the needs of increasingly mobile workforces without sacrificing IT control and security.

World’s Most Successful Companies Run VMware

VMware is the proven choice for virtualization, from the desktop to the data center to the cloud. More than 500,000 customers of all sizes have chosen VMware as their virtualization platform, including

- 99 percent of Fortune 100 companies
- 99 percent of Fortune 500 companies
- 100 percent of Fortune Global 100 companies
- 99 percent of Fortune Global 500 companies

VMware virtualization leadership extends to large and small enterprises. Within small and medium-sized businesses (fewer than 1,000 employees), VMware has 75 percent market share.⁶

5. Gartner “Magic Quadrant for x86 Server Virtualization Infrastructure,” by Thomas J. Bittman, George J. Weiss, Mark A. Margevicius, Philip Dawson, June 27, 2013. Gartner does not endorse any vendor, product, or service depicted in its research publications, and does not advise technology users to select only those vendors with the highest ratings. Gartner research publications consist of the opinions of Gartner’s research organization and should not be construed as statements of fact. Gartner disclaims all warranties, expressed or implied, with respect to this research, including any warranties of merchantability or fitness for a particular purpose.

6. Spiceworks. Server Virtualization Market Share, February 2014.

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