

# Microsoft<sup>®</sup> | Virtualization

## Optimized Storage Solution for Enterprise Scale Hyper-V Deployments

*End-to-End Storage Solution Enabled by Sanbolic Melio FS<sup>®</sup> and LaScala<sup>®</sup> Software and EMC SAN Solutions*

Proof of Concept

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**Abstract:** This white paper describes an end-to-end storage solution for enterprise scale Windows Server 2008 R2 Hyper-V<sup>™</sup> deployments. This optimized storage solution demonstrates scalable performance and high availability that is required when deploying a very large number of VMs in a Microsoft<sup>®</sup> virtualized environment.

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## Executive Summary

Large enterprise Hyper-V™ deployments with a large number of virtual machines (VMs) can be demanding on the storage infrastructure. In these environments, there is a lot of concurrent input/output (I/O) that contends for network and disk resources. This is especially true, for example, in virtual desktop infrastructure (VDI) deployments, when many machines might boot concurrently at the beginning of the work day. That activity, commonly referred to as a “boot storm” requires a specialized storage platform with the scalable performance and capacity to meet the needs of the company. In addition, ease of deploying images, identifying and eliminating I/O bottlenecks, effectively protecting corporate data, and providing sufficient storage performance to limit user latency perceptions are all important administrative considerations for this type of deployment.

This white paper introduces the components that provide an optimized and scalable storage solution necessary for an enterprise class Hyper-V deployment. The new capabilities of Microsoft® Windows Server® 2008 R2 and Hyper-V combined with the scalable performance of the EMC® CLARiiON® CX4 platform and the flexible shared storage access provided by the Sanbolic® Melio® Data Center Suite provide an effective solution. This solution is intended for mid to large-size organizations.

The key benefits that an organization using this solution can experience include:

- **Scalable performance:** The solution is capable of handling a large number of VMs due to:
  - **Fully symmetrical architecture:** Eliminates storage bottlenecks associated with a virtualized server environment. All servers are equal members of the cluster.
  - **No overhead:** The full EMC storage platform performance is maintained while scaling to large numbers of VMs because Melio has no overhead.
  - **Enterprise scale host support:** Melio supports more than 200 hosts per cluster. This enables multiple Hyper-V clusters to be deployed on a single storage volume.
- **Fully distributed VSS snapshots:** Provide flexible data protection including:
  - **Flexible snapshot granularity:** Any host can take a snapshot of the entire environment or a specific VM.
  - **Flexible backup support:** Snapshots can be handed off to standard VSS-based backup software or copied to second tier storage.
- **Centrally managed unified storage platform:** Management is simplified with:
  - **Microsoft toolset support:** Administrators can centrally assign storage to VMs using Active Directory® and Windows security tools.
  - **Dynamic volume expansion:** Storage volumes can be dynamically expanded.
  - **Granular performance management:** Performance can be managed on a per server or per process basis.

This paper is written for those who have a working knowledge of Microsoft Windows Server 2008 R2 and virtualized Windows Server environments. This paper also assumes

that the reader has a basic understanding of SAN environments, storage virtualization, and clustering terminology.

## Introduction

The significant benefits of virtualization are well known in the IT community. By breaking the link between software and hardware, companies are creating a foundation for a more dynamic, flexible, and efficient data center. However, there are a few important storage related considerations that need to be addressed before transitioning to a virtualized data center.

First, the selection of a storage platform that organizations deploy to support a virtualized computing environment is very important and should be carefully considered. The right storage system platform should ensure low latency for maximum performance, provide scalable capacity and bandwidth as application demands change, and automatically balance application workloads as needed. The storage system platform should also provide organizations with the tools necessary to simplify their virtualized storage environments. In addition, the right platform should provide the pooling of disk resources to optimize and protect the application environment as well as to eliminate any storage silos.

Second, the scale of the deployment must be matched to the storage platform performance capabilities. Large enterprise deployments of Hyper-V with a large number of VMs can be demanding on the storage infrastructure. These environments can generate a significant amount of input/output (I/O) requests. The selected storage platform needs to include capabilities that can satisfy all conditions and scale to meet the performance needs of the company. This white paper provides a solution that meets these requirements.

Microsoft Windows Server 2008 R2 Failover Clustering and Hyper-V, coupled with the EMC CLARiiON CX4 storage platform and Sanbolic's Melio Shared Storage Suite can be used to build an optimized, highly scalable storage solution that is perfect for supporting a large number of VMs.

## Solution Components

An optimized solution for enterprise scale Hyper-V deployments can be created by correctly combining Microsoft, EMC, and Sanbolic technologies. This section discusses the relevant technologies required.

### Microsoft Virtualization Technologies

Microsoft virtualization provides an architecture that can profoundly affect nearly every aspect of the IT infrastructure management lifecycle. It can drive greater efficiencies, flexibility, and cost effectiveness throughout the organization.

A standard Microsoft virtualization implementation is typically structured using the Windows Server 2008 R2 Hyper-V role to enable virtualization and Windows Server Failover Cluster to handle high availability and disaster recovery requirements. System Center Virtual Machine Manager (SCVMM) is typically used to simplify virtualization management.

## Windows Server 2008 R2 Hyper-V

Hyper-V is the hypervisor-based virtualization technology from Microsoft that is integrated into all Windows Server 2008 R2 x64 Edition operating systems. As a virtualization solution, Hyper-V enables users to take maximum advantage of the server hardware by providing the capability to run multiple operating systems (on VMs) on a single physical server. The availability of Hyper-V as a role in a mainstream Windows operating system provides several key advantages:

Features	Benefits
Built-in Windows Server 2008 R2 technology	Enables enterprises to easily leverage the benefits of virtualization without adopting a new technology.
Broad device driver support	The new 64-bit micro-kernelized hypervisor architecture leverages the broad device driver support in the Windows Server 2008 R2 parent partition to extend support to a broad array of servers, storage types, and devices.
Symmetric Multiprocessor (SMP) support	Hyper-V supports SMP on VMs.
Host high availability	Windows Server 2008 R2 clustering provides high availability to VMs to minimize unplanned downtime.
Shared storage high availability	Microsoft MPIO dynamically routes I/O to the best path and protects against connection failures at any point between a Hyper-V host and shared storage including NICs/adapters, switches or array ports.
Easy VM migration	Live migration capability is available to support business continuity during planned and unplanned downtime and over distances.
Volume Shadow Copy support (VSS)	Provides a robust host-based backup of VMs by leveraging the existing Windows VSS-based infrastructure.
Easy extensibility	Easy extensibility is available by using the standards-based Windows Management Instrumentation (WMI) interfaces and APIs.
Simplified integrated management	With its tight integration into the Microsoft System Center family of products, customers have end-to-end physical and virtual infrastructure management capability for Hyper-V environments.

Table 1: Hyper-V features

## Windows Server Failover Clustering

Failover clustering in Windows Server 2008 R2 helps to ensure that mission-critical applications and services such as e-mail and line-of-business applications are available when needed. Important capabilities of Windows Server Failover Clustering for disaster recovery solutions include:

Features/Capabilities	Benefits
Limitless single subnet	Enables cluster nodes to communicate across network routers. The need to connect nodes with VLANs is no longer necessary.
Configurable heartbeat timeouts	Provides the ability to increase timeouts to extend geographically dispersed clusters over greater distances as well as providing the ability to decrease timeouts to detect failures faster and take recovery actions for more efficient failover.
Common toolset	Provides a similar management experience to managing a local cluster to simplify the process.
Automated failover	Provides automatic failover in the event of a complete disaster in one site.
VSS	Provides the ability to back up cluster settings.
Automation support	Automation provided by Windows Server 2008 R2 and PowerShell® simplifies system administration.
Cross-site replication tools	Provides mirrored storage between stretched locations in addition to seamless integration with partner hardware or software-based data replication solutions.

**Table 2. Windows Server Failover Clustering features**

## System Center Virtual Machine Manager

Microsoft SCVMM 2008 R2 is enterprise-class management software that enables administrators to easily and effectively manage both the physical and virtual environments from a single management console and thus avoiding the complexity of using multiple consoles typically associated with managing an IT infrastructure. The key capabilities of SCVMM 2008 R2 include:

Features/Capabilities	Benefits
Enterprise-class management suite	Manages both Hyper-V and VMware® ESX® virtualization environments.
Intelligent VM placement	Provides support for the intelligent placement of VMs.
System Center Operations Manager 2007 integration	Integrates with System Center Operations Manager 2007 to provide proactive management of both virtual and physical environments through a single console by leveraging PRO.
Native P2V/V2V migration	Provides native capability for physical-to-virtual migrations and virtual-to-virtual migrations.
Failover integration	Provides integration with failover clustering to support high availability and the live migration of VMs.
Automation	Provides easy automation capabilities leveraging Windows PowerShell.

**Table 3. System Center Virtual Machine Manager features**

## EMC CLARiiON CX4 Storage Platform

The EMC CLARiiON CX4 series delivers industry leading innovation in midrange storage with the fourth generation CLARiiON CX storage platform. The unique combination of flexible, scalable hardware design and advanced software capabilities enables EMC CLARiiON CX4 series systems, powered by Intel® Xeon® processors, to meet the growing and diverse needs of today's midsize and large enterprises. Through innovative technologies like flash drives, EMC UltraFlex™ technology, and CLARiiON Virtual Provisioning™, customers can reduce costs and energy use while optimizing server availability and virtualization.

All these technologies are available with a choice of systems ranging from affordable entry level supporting solutions to high performance, maximum capacity configurations for the most demanding requirements. The powerful CX4 series includes the CX4 model 120, CX4 model 240, CX4 model 480, and CX4 model 960. All models come pre-configured with Fibre Channel and iSCSI connectivity enabling customers to choose the best connectivity for their specific applications.

Delivering up to twice the performance and scale as the previous CLARiiON generation, CLARiiON CX4 is the leading midrange storage solution with the ability to meet a full range of needs from departmental applications to datacenter class, business critical systems.

The following all inclusive feature set provides enterprise functionality at an affordable price.

Features/Capabilities	Benefits
Next generation architecture	Provides leading performance, new levels of scalability, and higher resiliency.
Consolidates twice the workload in a single system.	Reduces total cost of ownership. Investments in storage infrastructure are secured through UltraFlex technology.
Power saving technologies	Maximizes power efficiencies with power saving technologies such as flash drives, low power SATA drives, and improved drive spin-down options.
CLARiiON five nines availability	Provides multi-path data access, automated system diagnostics, online upgrades, and global hot spare technology. CLARiiON eliminates all single points of failure.
Virtualized environment optimization	Provides Hyper-V integration that includes reliability, high availability, and the software functionality required for all virtualized environments.
Advanced information protection capabilities	Provides local snapshots, clones, and continuous data protection options including synchronous and asynchronous remote replication.
EMC Navisphere <sup>®</sup> software	Provides powerful storage management that enables administrators to manage, discover, monitor, and configure CLARiiON systems from a Web browser.
Replaceable components	Replaceable components such as non-disruptive disk drive replacement, power supplies, fans, and small form factor pluggable optical transceivers are available.

Table 4. EMC CLARiiON enterprise functionality

## Sanbolic Clustered File System

The combination of Sanbolic's Melio FS<sup>®</sup> and LaScala<sup>®</sup> software provide an optimized file system solution for enterprise scale Hyper-V deployments using a high performance shared Logical Unit Number (LUN) for Hyper-V hosts. It also provides a shared application data LUN for Hyper-V VMs.

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**Note:** When configuring Hyper-V clusters within SCVMM 2008 R2, the shared storage resource is selected by highlighting the "Clustered Shared Volumes" storage option. It is important to note, however, that Melio FS is a standalone file system and a separate product from Microsoft's Clustered Shared Volumes.

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Melio FS is a 64 bit cluster file system that provides multiple servers with simultaneous access to data stored on the same storage partition or LUN on a SAN. As a general

purpose cluster file system, Melio FS supports access to all data types stored on the LUN and can support LUNs as large as 18 million terabytes. Employing advanced transaction managers, symmetrical architecture, full journaling, and dynamic clustering capabilities, Melio FS ensures the integrity of the data stored on the shared LUN by controlling read/write access by multiple servers at any given time.

LaScala Cluster Volume Manager is a host-based volume manager that incorporates advanced transaction management, locking, and clustering technology based on the Melio FS technology. Using LaScala, multiple hosts can share access to and administer storage volumes spanning multiple storage controllers. Access to volumes for each host can be defined using native Windows ACLs and Active Directory. Used in conjunction with Sanbolic's Melio FS, LaScala provides high performance shared access to data on volumes striped across many disks residing on multiple storage controllers.

The key benefits of using Melio FS and LaScala as a shared resource for Windows Server 2008 R2 Hyper-V and SCVMM 2008 R2 deployments include:

Features	Benefits
Live Migration support	Provides a shared LUN solution for Windows Server 2008 R2 Hyper-V. Windows Server 2008 R2 Hyper-V supports Quick and Live Migration.
Concurrent shared access	Concurrent shared access to application data on SAN storage from VMs improves flexibility and availability, plus application scale-out for high I/O applications.
Centralized configuration	Central configuration and dynamic storage assignment using LaScala Clustered Volume Manager.
Supports over 200 hosts per LUN	Supports large host clusters. Is able to provide shared access to a LUN containing VHDs to more than 200 hosts. This allows multiple Hyper-V clusters to be deployed on a single storage volume.
Unlimited volume size	There are no volume size limitations.
Monitoring and quality of service (QoS) capabilities	Provides storage performance monitoring and QoS assignment.
Distributed snapshots	Snapshots of the entire environment or of any individual VM can be made from any Hyper-V host in the cluster.
Easy installation	Melio FS and LaScala install easily using any vendor's SAN storage.
Microsoft Virtualization integration	Designed for easy integration with Windows Server 2008, Windows Sever 2008 R2, and SCVMM 2008 R2.

**Table 5. Melio FS and LaScala functionality**

## Blueprint

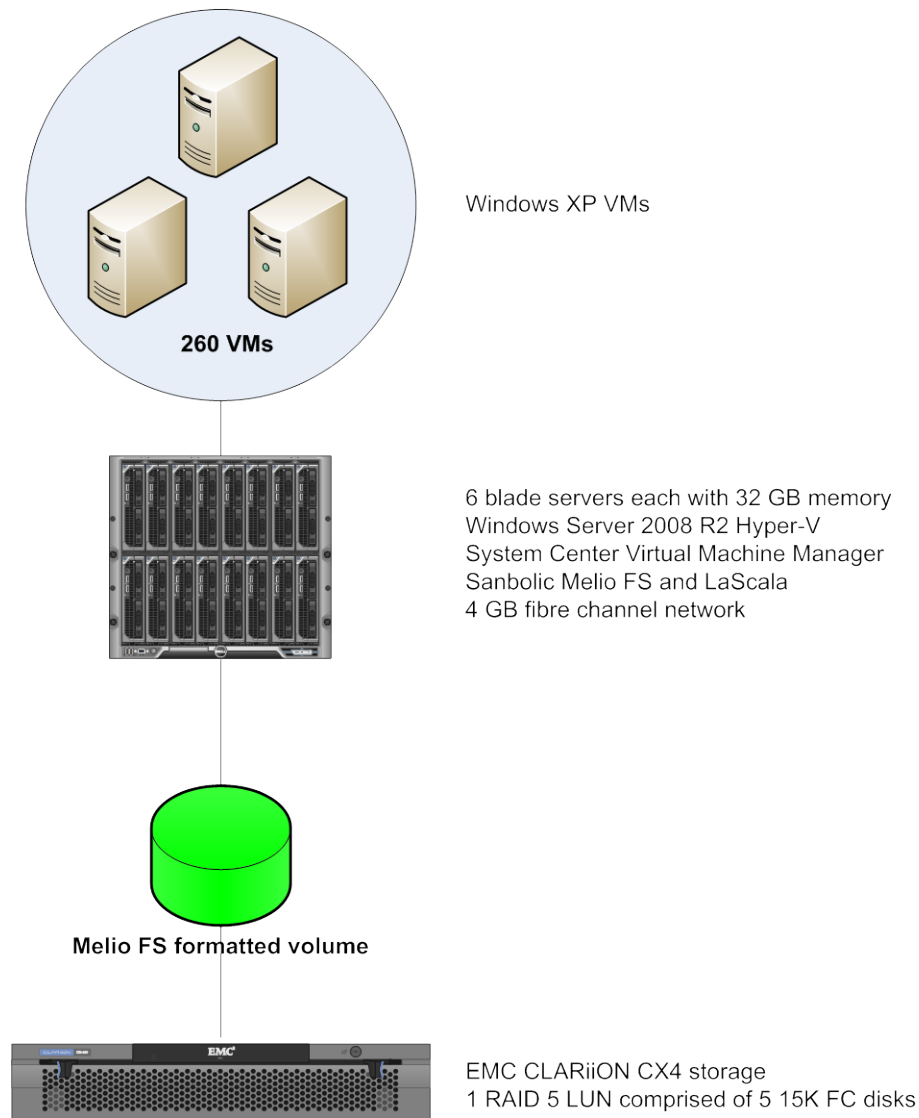
This proof of concept was conducted to illustrate an easily scalable storage framework for companies to review when considering a large enterprise Windows Server 2008 R2 Hyper-V infrastructure deployment. To demonstrate the scaling capabilities and features of the design, the design was recreated in the lab in order to test it. The lab demonstrations are discussed in the lab section of this paper.

### Configuration

The lab was configured using six Dual Xeon quad core blade servers, each with 32GB of memory, connected to a CLARiiON CX4 storage array using a 4GB Fibre Channel network. One LUN was created on the CLARiiON using 5 15K RPM Fibre Channel disks, and was exposed to each of the blade servers. The number of spindles was intentionally constrained. A production environment would typically be configured with additional spindles to optimize the user experience.

Windows Server 2008 R2 Hyper-V was installed on each blade server with failover clustering. Sanbolic's Melio Clustered File System and LaScala Clustered Volume Manager were then installed on each server. LaScala Clustered Volume Manager was used to bring the CLARiiON LUN under management and format it with Melio. Once this was done, all of the blade servers had read-write access to the Melio volume. EMC Power Path<sup>®</sup> 5.2 was used on the CLARiiON.

260 VMs, each with 500MB of memory were created. This pool of VMs was managed using SCVMM 2008 R2.



**Figure 1. Lab demonstration infrastructure**

## Technology Integration

EMC's enterprise level storage capabilities have been proven over time to be extremely effective at supporting large Microsoft virtualized infrastructures. However, when deploying extremely large numbers of VMs, such as in a VDI environment, the scaling capabilities of Sanbolic's clustered file system can be used to optimize the storage solution.

Sanbolic's Melio Data Center Suite is designed to fully utilize the capabilities of the CLARiiON storage while integrating easily with Hyper-V and SCVMM, as well as with Window application servers running on VMs. To provide enterprise level scalability, the Melio Data Center Suite uses fully symmetrical architecture, so all Hyper-V hosts in the storage cluster have concurrent read/write access to a shared LUN over the SAN fabric. In addition, Melio is designed for several hundred hosts accessing a shared LUN concurrently and for a volume and file size of up to 18 exabytes. Therefore, the

CLARiiON CX4 retains full performance with essentially no lock overhead when Melio is used to provide access to VHD files on a shared LUN from multiple Hyper-V hosts. Furthermore, QoS management allows specific hosts or VMs to have priority access to storage bandwidth in the event that a constraint does occur.

Sanbolic has worked closely with Microsoft to ensure that Melio works seamlessly with Hyper-V. Both Windows Server 2008 R2 Hyper-V and SCVMM R2 recognize Sanbolic storage volumes as active-active storage resources. This simplifies the configuration of Hyper-V host clusters. Live and Quick Migration are both fully supported. After initially creating the VMs using Melio, Hyper-V host clusters can be configured and managed from within SCVMM R2.

The integrated management benefits of using Melio Data Center Suite when deploying large numbers of Hyper-V VMs are discussed in the following three sections.

### **Volume Management**

Sanbolic's software is designed for a shared storage environment. Therefore, all servers in the shared environment can observe the entire volume structure and automatically see any changes made to it. All operations are fully transactional so multiple changes can be made to the disk structure and then committed simultaneously. Melio Data Center Suite uses Windows ACLs to define access rights at the volume level in addition to the disk and the file level. Logical volumes can be remotely configured and assigned to physical or virtual servers using the standard Windows security interface.

Sanbolic's Data Center Suite uses only basic disks for all operations. Sanbolic's basic disks support stripe sets, volume sets, and mirror sets using either Fibre Channel or iSCSI LUNs. These disks can be dynamically expanded. Therefore, a Hyper-V deployment using CLARiiON and Sanbolic can expand the storage of an active environment either by expanding the LUN on the storage array, or by adding another LUN to the logical volume on the host. These changes can be made while an active I/O is present.

### **VSS-based Snapshots**

In a large enterprise environment, data protection is a key consideration. The CLARiiON CX4 utilizes features like EMC RecoverPoint for a block-based disaster recovery solution of the entire environment. Melio provides a flexible distributed snapshot capability that uses a VSS interface to provide a more granular and flexible data protection architecture and compatibility with existing VSS-based backup products.

Melio is able to create a snapshot of the entire Hyper-V environment or of individual VMs from any of the Hyper-V hosts. This snapshot capability can be used by any industry standard VSS backup tool or through the Melio interface. The snapshot can also be mounted as a file share on any of the hosts in the cluster and automatically copied to another location. This can provide flexible options for recovering individual VMs while utilizing existing storage capacity. Melio Data Center Suite also allows snapshots to be scheduled and then automatically copied to a designated location.

### **Performance Monitoring and Quality of Service Management**

Performance monitoring and QoS management can be a key task in a large environment where performance bottlenecks can occur at the storage layer. Storage layer bottlenecks are often difficult to identify. Melio natively supports full perfmon and sysmon statistics that can be used to identify bottlenecks or exported to other reporting tools. If storage related bottlenecks are discovered such as with a runaway VM, Melio QoS management can be configured to prevent the problem server or process from limiting storage bandwidth performance available to critical servers. QoS can be assigned on a per host or on a per VM basis.

CLARiiON has another tool called the Navisphere<sup>®</sup> Analyzer that can help pinpoint performance issues. It provides detailed real time and historical performance information about the CLARiiON array enabling administrators to investigate performance patterns and trends before problems occur.

## **Lab Metrics**

The lab testing was intended to provide an initial demonstration of a large enterprise Windows Server 2008 R2 Hyper-V infrastructure using EMC and Sanbolic technologies to provide a scalable storage solution. The initial proof point was not intended to be an exhaustive functional and performance test, but rather to show the ease of deployment and manageability under load. The lab tests are described below.

### **Test 1: 260 VM Bootstorm**

This test was designed to simulate the I/O requirements of multiple virtual desktops booting up at the beginning of the work day. The disk resources were intentionally limited to observe performance when there is contention for the storage resources. With those goals in mind, the storage was not optimized to minimize boot times.

The test procedure was to boot 260 VMs concurrently to ensure that when constrained, all VMs would boot successfully. The test was considered to be a success as all VMs booted in an appropriate amount of time.

## Test 2: LaScala Volume Expansion

The ability to add storage while the system is operating enables better storage efficiency as it does not require any downtime for storage management. The storage can be expanded either by adding an additional LUN or by expanding the existing LUN on the CLARiiON array.

The test procedure was to perform a volume expansion using LaScala while 260 VMs were running and booting to show that this would not affect the I/O performance. The test was considered to be a success as all VMs continued to operate properly and the I/O performance was not noticeably affected.

## Test 3: Live Migration

Live Migration enables active workloads on VMs to be migrated between physical host machines for load balancing, availability, or system maintenance. The application remains available during the migration, but response time latency might increase while the migration is taking place.

The test procedure was to perform 10 consecutive Live Migrations of a VM running on the Melio formatted volume to show that this could be done in a reasonable timeframe. The test was considered to be a success as the average Live Migration time was nine seconds.

## Test 4: Quick Migration

During a Quick Migration, the state of a running VM is stored, the VM is suspended, and then the VM and its state are restarted on a different physical host. This operation creates downtime as the VM is migrated for load balancing, availability, or host maintenance.

The test procedure was to perform 10 subsequent Quick Migrations of a VM running on the Melio formatted volume to show that this could be done in a reasonable timeframe. The test was considered to be a success as the average Quick Migration time was seven seconds.

## Test 5: Snapshots

Snapshots provide protection for the virtual environment. Melio can take a snapshot from any host in the cluster of either the entire environment or of any individual VM. This snapshot can then be mounted as a file share and copied to secondary storage, or handed off to any VSS backup software for tape backup. This provides users with flexible options for protecting and recovering a virtual environment.

The test procedure involved taking and accessing a Melio FS host-based snapshot of the volume while 260 VMs were running to show that it could be done without affecting system performance. The test was successful because the snapshot functionality was demonstrated without affecting system performance.

## Conclusion

Large enterprise deployments of Hyper-V with a high VM count benefit from an optimized SAN storage solution to deal with the increased demand on network and disk resources. The solution outlined in this document is unique because Sanbolic's fully symmetrical architecture enables the infrastructure to scale to enterprise performance levels. The symmetrical architecture maintains the full performance of the EMC storage platform as the deployment is scaled due to its lack of overhead or performance bottlenecks.

The lab testing demonstrated the ease of the solution deployment and the management of a large Windows Server 2008 R2 Hyper-V environment. The testing also demonstrated good system performance despite the intentionally constrained storage resources while all functional tests performed as expected. LaScala provided simplified centralized management of the Hyper-V logical storage environment, and SCVMM provided simplified central management of the VM environment running on a shared Melio volume.

Organizations with enterprise license environments that provide access to Windows Server 2008 R2 Hyper-V should consider evaluating Hyper-V virtualization for large deployments and demanding workloads. In these environments, enterprise storage solutions such as the EMC CLARiiON CX4, the Sanbolic Melio Clustered File System, and the LaScala Clustered Volume Manager should be considered as options to provide performance scalability, additional data availability, and management features.

## Additional Information

For those interested in implementing the blueprint provided by this paper, please contact Sanbolic, EMC, or a Microsoft certified partner to discuss specific needs. To learn more about the technologies involved, please see the related links below.

### **For more information, see:**

Microsoft Virtualization solutions:

<http://www.microsoft.com/virtualization/solutions>

EMC CLARiiON CX4 series:

<http://www.emc.com/products/series/cx4-series.htm>

Sanbolic Clustered File System for Hyper-V

<http://www.sanbolic.com/Hyper-V.htm>