DELL

Dell™ | Microsoft Windows Server 2008® Hyper-V™ Reference Architecture

VIRTUALIZATION SOLUTIONS ENGINEERING

September 2008

Table of Contents

Executive Summary

This *Dell™ Virtualization Reference Architecture* (RA) white paper describes Dell validated architectures for *Windows Server 2008® Hyper-V™*. The Virtualization RA is intended to provide customers with example virtualization solution configurations that can be used to consider, evaluate, and select the Dell virtualization solution components that best fit their requirements. This white paper is not intended to be an exhaustive study of specific architectures for every environment. The references to 3rd party software in this white paper do not imply full support from Dell for the software. For a complete evaluation of your datacenter's virtualization requirements, please contact your Dell Sales representative.

Introduction and Scope

Customers are faced with many choices when planning a virtualization deployment. Server, storage, and software configurations can vary depending on workload and feature requirements. This paper proposes several sample virtualization architectures based on Dell's server and storage products. Architectures are divided into three main categories: Small, Medium, and Large. These categories are based on the features and capacity of each product, as well as the complexity of the overall architecture.

- **Small** – Designed with simplicity in mind and focuses on providing basic functionality with minimal hardware. It does not enable advanced virtualization features.
- **Medium** – Designed to meet the production requirements of small and medium businesses by providing economical Storage Area Network (SAN) solutions, enhanced virtualization features, and business continuity options.
- **Large** – A full-featured virtualization solution supporting 1-to-many management, high availability (HA) and enterprise-class server and storage products.

The goals of this white paper are as follows:

- Introduce customers to the Dell sample reference architectures for Hyper-V.
- Clarify, aid, and simplify the decision making process for customers.

Dell Virtualization Advisor Tool

In addition to the general guidance provided in this white paper, Dell has developed a virtualization advisor tool that provides solution guidance to meet specific needs of the customers. This online tool recommends a hardware configuration for a new virtualized environment based on two distinct input paths:

- Information on an existing physical environment to support a consolidation effort *or*
- Information on workload characteristics for a new virtual infrastructure

In either case, the tool provides the flexibility to choose the desired features in the target virtualization environment such as HA, VM migration, management, and business continuity. The input provided is utilized to determine server, storage, and networking requirements for the virtualized solution. The output of the advisor tool is a customized list of Dell supported hardware to meet all the provided requirements. The **Dell Virtualization Advisor** tool is available at **www.dell.com/hyperv**.

NOTE: The virtualization advisor tool is designed as a guide for customers with a comfortable knowledge of virtualization and their server/storage environment. For those customers who prefer a more customized solution, Dell offers a full range of Infrastructure Consulting Services to analyze your specific needs and operational considerations to provide recommendations including future growth. For more information refer to the Dell Services offerings at **www.dell.com/hyperv**.

Hyper-V Solutions Overview

Hyper-V is the hypervisor-based virtualization technology from Microsoft that is integrated into all Dell supported Windows Server 2008 x64 Editions operating systems. As a virtualization solution, Hyper-V allows users to take maximum advantage of server hardware by providing the capability to run multiple operating systems (on virtual machines) on a single physical server.

The availability of Hyper-V as a role in a mainstream Windows operating system offers several key advantages:

- Easily leverage the benefits of virtualization without adopting a new technology
- The new 64-bit micro-kernelized hypervisor architecture leverages the broad device driver support in Windows Server 2008 parent partition to extend support to a broad array of Dell servers, storage, and devices
- Full support for Dell OpenManage in the Windows Server 2008 Parent Partition for physical server management
- Support for Symmetric Multiprocessors (SMP) support in virtual machines
- Offers Virtual machine HA to minimize unplanned downtime
- "Quick Migration" capability to support business continuity during planned downtime
- Robust host-based backup of virtual machines by leveraging the existing Windows VSS VSS-based infrastructure
- Easy extensibility using the standards based Windows Management Instrumentation (WMI) interfaces and APIs
- With its tight integration into Microsoft System Center family of products, customers have end-to-end physical and virtual infrastructure management capability for Hyper-V environments

For in-depth information on Dell support for Hyper-V, read the following documents available at **www.dell.com/hyperv** (or http://support.dell.com/support/edocs/software/HyperV/en)**:**

- *Dell Solutions Overview Guide for Hyper-V*
- *Dell Networking Solutions Guide for Hyper-V*
- *Dell Storage Solutions Guide for Hyper-V*
- *Dell High Availability Solutions Guide for Hyper-V*

System Center Virtual Machine Manager 2008

Microsoft System Center Virtual Machine Manager 2008 (SCVMM 2008) is an 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 include:

- Enterprise-class management suite for managing both Hyper-V and VMware ESX virtualization environments
- Support for intelligent placement of virtual machines

- Integration with System Center Operations Manager 2007 to offer proactive management of both virtual and physical environments through a single console (by leveraging PRO)
- Native capability for Physical-to-Virtual migration and Virtual-to-Virtual migrations
- Integration with Failover Clustering to support HA and Quick Migration of virtual machines
- Easy automation capabilities leveraging Windows PowerShell
- Available in two editions:
  - **Workgroup Edition**: Includes licenses to manage up to 5 physical servers running virtualization software
  - **Enterprise Edition**: Licensed on a per host basis

SCVMM 2008 may be configured in multiple configurations depending on the implementation requirements. A basic configuration will have SCVMM 2008 installed and running on a standalone Dell PowerEdge server with local disks on the server as storage. Attaching a storage enclosure to the standalone server hosting SCVMM is recommended if the deployment requires a relatively large library server. Library server is a capability built into SCVMM for storing VHD templates, inactive VM files, ISO images, etc.

For more information on SCVMM 2008, visit **www.microsoft.com/scvmm**.

Dell Reference Architecture for Hyper-V

The Dell reference architecture for Hyper-V represents sample solutions that provide a customer with options to consider when determining their datacenter requirements. In Dell's reference architecture, Dell server and storage are the foundation on which the Hyper-V infrastructure is built. Specific Hyper-V features should be chosen based on the datacenter needs. Once chosen, these key Hyper-V features will drive hardware requirements. Therefore, the features are as important to the design and decision process as the traditional QoS deliverables. Hyper-V support for virtual machine migration and highly available virtual machines requires that Microsoft Failover Clustering is implemented. In turn, this drives the requirement for shared storage (iSCSI, FS, or SAS storage arrays).

Three sample configurations, Small, Medium and Large, are listed here. These configurations are generic deployments based on solution size and capability and are independent of the target application. The recommendations focus on hardware capacity and software features; they do not attempt to prescribe a particular server model or chipset, as these preferences may vary based on customer requirements.

The typical components of a recommended Hyper-V solution are the following:

- Dell PowerEdge™ servers running Windows Server 2008 Hyper-V.
- Dell Storage to employ such features as Virtual Machine Quick Migration and Virtual Machine HA, VMs have to be stored on external storage arrays, Dell supports a wide array of storage arrays including the Dell PowerVault™ MD3000/MD3000i, Dell EqualLogic™ PS Series, and Dell|EMC CLARiiON® arrays.
- Virtualization Management Software – Basic management can be accomplished through Hyper-V Manager and this option may be appropriate for smaller configurations. However, for leveraging advanced virtualization capabilities, Microsoft System Center Virtual Machine Manager (SCVMM) 2008 is recommended.
- Infrastructure Support - A typical deployment will also require key infrastructure roles such as Microsoft Active Directory, DNS, DHCP, Windows Deployment Server, etc.
- Remote Management Station - A management station is recommended to effectively manage the virtualized infrastructure. Since the role of the management station is to run management software that communicates with the server and storage components, the management station may be a Dell client platform such as a laptop or workstation. The typical management clients will include:
  - Hyper-V Manager MMC
  - SCVMM 2008 Administration Console
  - Failover Cluster Management Console
  - Dell IT Administrator (1-many manager for servers running OMSA)
  - Storage management client software (e.g. Modular Disk Storage Manager, EMC Navisphere Manager, EqualLogic Group Manager)

The following table describes sample components for each configuration. Hyper-V features are listed below and enabled with recommended Dell server and storage. These are examples of baseline architectures that can be bundled together into a datacenter to solve customer problems.

8

Table 1: Hardware and Software Features of the Baseline Configurations

Category	Small	Medium	Large
Description	Simple entry-level configuration	Designed for small & medium business	Large enterprise environments
Servers			
Servers	PE 1950 III PE 2900 III PE R805	PE M600 PE M605 PE 2950 III PE 2970 PE 2900 III PE R805	PE M600 PE M605 PE M805 PE M905 PE 2950 III PE 2900 III PE R805 PE R900 PE R905
CPU	2 Sockets (2/4-Core)	2 Sockets (4-Core)	o 2 Sockets (4-Core) o 4 Sockets (2/4/6-Core)
Minimum Recommended Network Ports	o Three ports for non-HA configurations o Four ports for HA configurations	Six ports	o Six ports for iSCSI arrays o Four ports for FC arrays
DRAC	Optional	Yes	Yes
Internal Storage / RAID Configuration	Internal storage if external storage is attached: 2+ SAS drives (RAID 1) to host WS08 boot volume Internal storage if no external storage is attached: o Boot Volume: 2 SAS drives (RAID 1) o Data Volume: 2+ SAS drives (RAID 1 or RAID 5)	2+ SAS drives (RAID 1) to host WS08 boot volume	2+ SAS drives (RAID 1) to host WS08 boot volume
Internal RAID Controller	PERC 6/i or SAS 6/iR	PERC 6/i or SAS 6/iR	PERC 6/i or SAS 6/iR
Storage			
Storage fabric	• Local Storage *or* • External storage	iSCSI Storage	• Fiber Channel *or* • iSCSI Storage

Storage Device	Local Storage MD1000 MD1120 MD3000	MD3000i AX4-5I PS5000E PS5000X PS5500E	PS5000XV CX4-120 CX4-240 CX4-480 CX4-960
Backup			
Backup Server	N/A	PE2900	PE2900
Backup Software	Microsoft System Center Data Protection Manager 2007	Symantec Backup Exec 12.5	Symantec Backup Exec 12.5
Backup Device	• PowerVault DP100 • PowerVault DP400	• PowerVault TL2000 • PowerVault TL4000	PowerVault ML6000
Virtualization Software			
Windows Server 2008 x64 Edition	o Standard Edition *or* o Enterprise Edition	o Enterprise *or* o Datacenter Edition	Datacenter Edition
Quick Migration / High Availability	o Available with WS08 x64 Enterprise or Datacenter Editions o Supported with all storage arrays listed above (**No support** with Local Storage, MD1000, or MD1120)		
Virtualization Use Rights per WS08 Server License	Standard Edition: 1Physical + 1VM		
	Enterprise Edition: 1 Physical + 4 VMs		
		Datacenter Edition: 1 Physical + Unlimited VMs	
Management Software			
Virtualization Management	• Built-in Hyper-V Manager *or* • SCVMM 2008 WorkGroup Edition	SCVMM 2008 Enterprise Edition	SCVMM 2008 Enterprise Edition
Physical Server Management	Dell OpenManage	• Dell OpenManage • SCOM 2007 with PRO	• Dell OpenManage • SCOM 2007 with PRO

Small Configuration

The Small configuration is an example of an entry-level configuration. With Direct Attach Storage (DAS), the scalability of this configuration is limited. Careful selection of the appropriate storage device is required for key Hyper-V features. The MD1000 and MD1120 do not support shared storage between multiple servers and therefore VM migration and HA are not supported. If those capabilities are required, the MD3000 supports shared storage with up to two highly available hosts attached. The MD3000 provides the capability to support a Microsoft Failover cluster, the backbone for VM migration and HA. In the Small configuration, virtualization management may be either done with the native Hyper-V Manager that is available with Windows Server 2008 Hyper-V or with the SCVMM 2008 WorkGroup Edition that includes licenses to manage up to 5 physical servers running Hyper-V.

Figure 1 shows a sample instance of a Small configuration selected from Table 1. In the specific instance shown in Figure 1, two PowerEdge 2900 servers running Windows Server 2008 Hyper-V are attached to

an MD3000 SAS storage enclosure. In this configuration, management of the Hyper-V servers and the virtual machines running on them is performed from a management station (running Vista SP1) using the Hyper-V Manager console and Remote Server Administration Tools (RSAT).

Figure 1: Sample instance of a SMALL configuration

VM VM - - - - VM VM   VM VM - - - VM VM   Clients

Windows Server 2008 Hyper-V   Windows Server 2008 Hyper-V

Management Station

PowerEdge 2900 III   PowerEdge 2900 III   Network Switch   Network Switch

Network Switch

AD   DNS   DHCP

Infrastructure Support   PowerVault MD3000

───── *Storage Fabric*   ───── *Workload LAN*   ----- *Management Network*
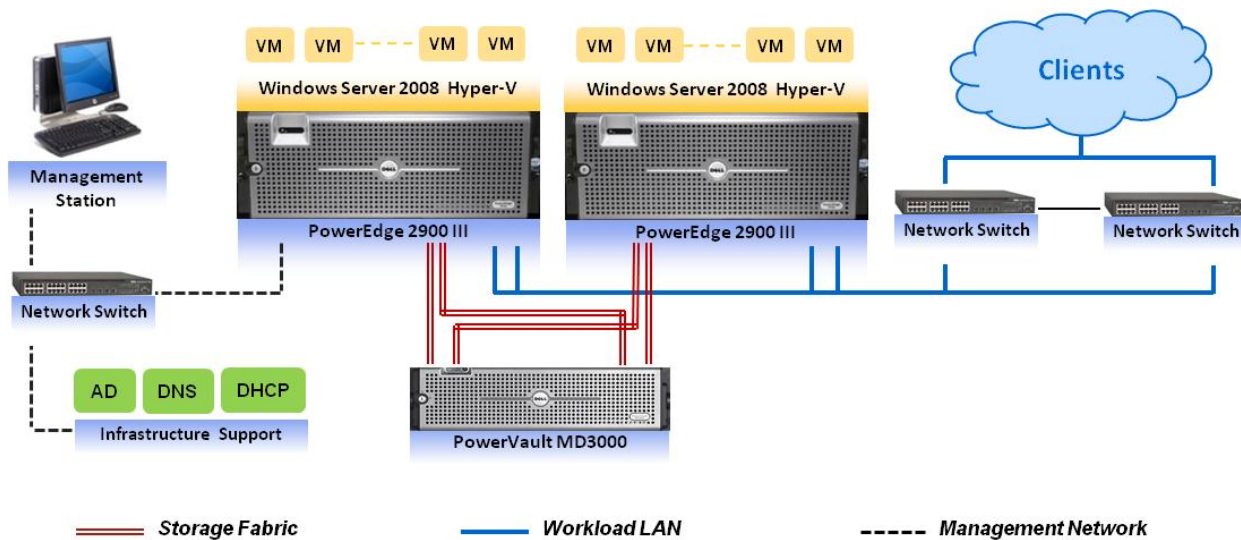
Medium Configuration

The Medium configuration is designed to meet the production requirements of small and medium businesses by providing economical SAN solutions, enhanced virtualization features. The Medium configuration is appropriate for customers that have requirements that the Small configuration cannot meet or require additional scalability. In the Medium configuration, each server running Hyper-V is attached to an iSCSI array to enable features such as quick migration and HA. The Medium configuration has a very broad array of iSCSI storage options – ranging from the entry-level PowerVault MD3000i that supports up to 16 highly-available hosts to the Dell EqualLogic PS5500 that supports up to 2048 hosts per group.

Figure 2 below is a sample instance of a Medium configuration and does not reflect all possible Medium configurations. In this sample instance, the virtualization optimized Dell PowerEdge R805 servers hosting Hyper-V are connected via dedicated iSCSI Ethernet fabric to the Dell EqualLogic PS5500E array. The PS5500E can offer up to 48TB of storage in a single array and additional PS Series arrays can be seamlessly added to the configuration to provide additional capacity and performance. The *EqualLogic Host Integration Kit* for Windows Server 2008 provides an easy-to-use management interface to configure the Hyper-V hosts to connect to the EqualLogic storage arrays and also automatically configures MPIO to deliver HA and high performance. In this configuration, SCVMM 2008 running on a Dell PowerEdge 1950 III is used to configure and manage the Hyper-V virtualized environment.

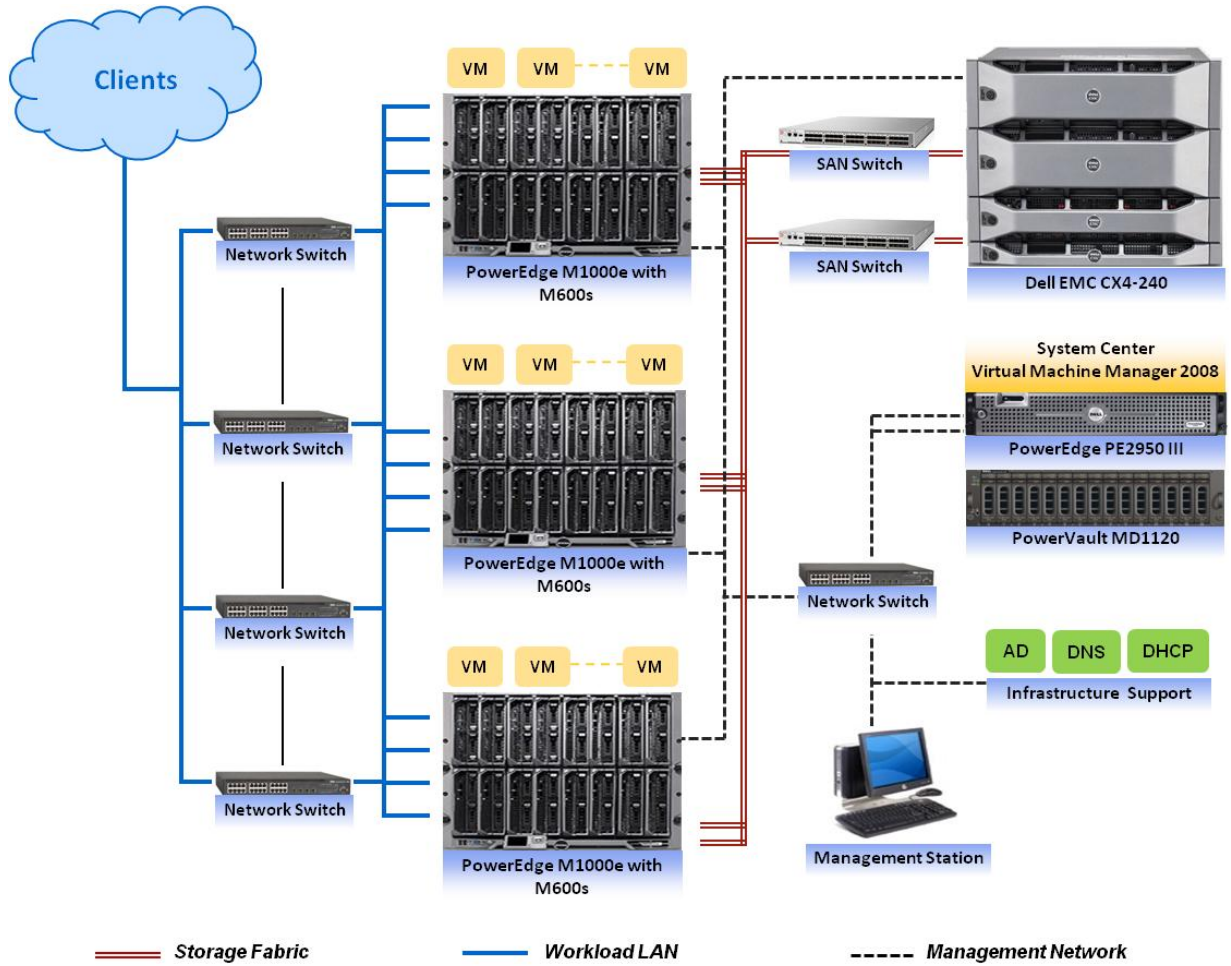Figure 2: Sample instance of a MEDIUM configuration
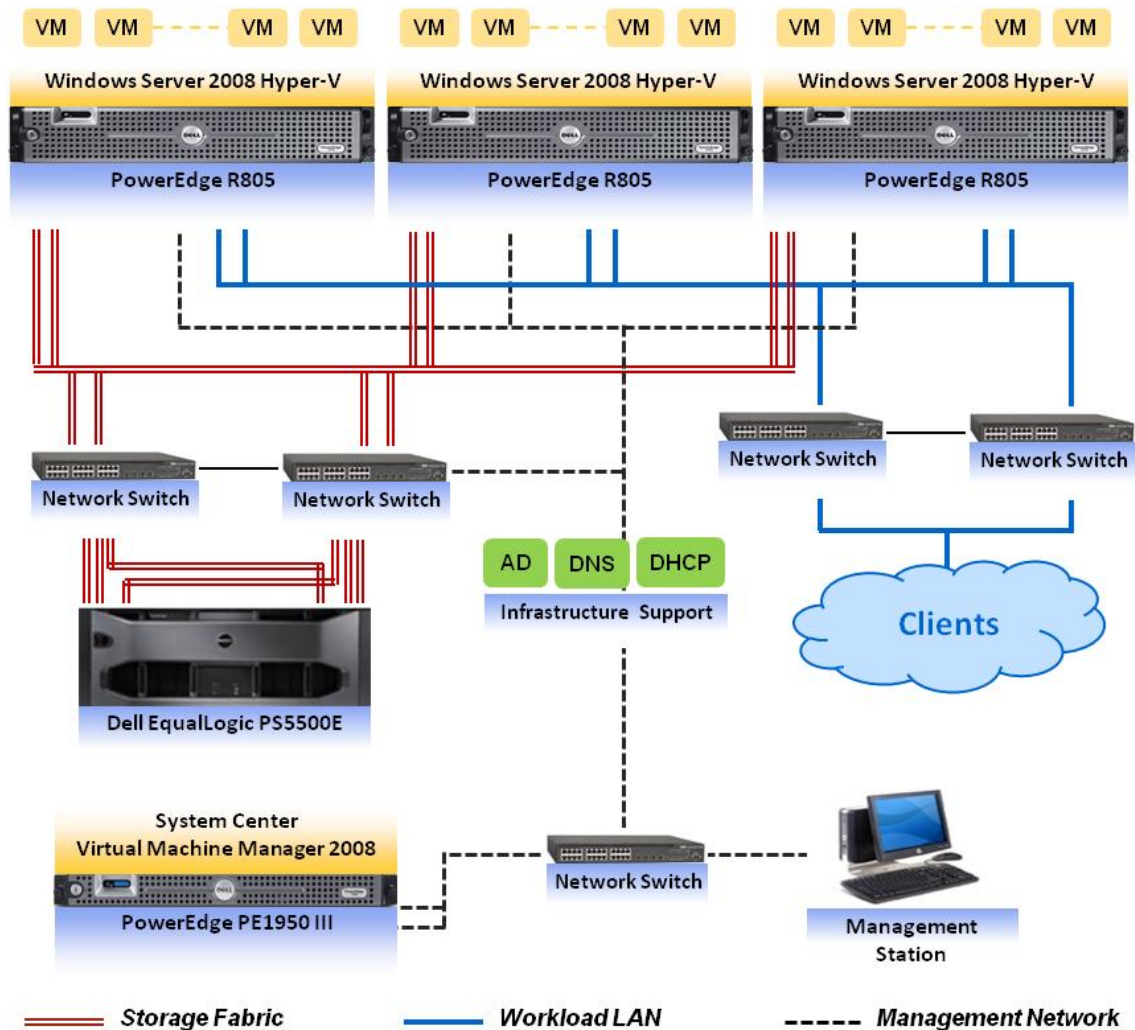
Large Configuration

The Large configuration is a full-featured virtualization solution supporting 1-to-many management, HA and enterprise-class server and storage products. In addition to the feature set provided by the Medium configuration, the Large configuration provides additional processing and storage capabilities required for enterprise-level deployments.

Figure 3 is a sample instance of a Large configuration and does not reflect all possible Large configurations. In this particular instance, Hyper-V is hosted on Dell PowerEdge M600 blade servers which focus on optimizing space, performance, and power consumption. The storage backend is a CX4-240 fiber channel array to provide high performance, host expandability, and storage manageability. The CX4-240 array is part of the new Dell|EMC CX4 series of arrays which also includes the CX4-120, CX4-480, and CX4-960 arrays. In the instance show below, virtualization management is achieved with SCVMM 2008 running on a Dell PowerEdge 2950 III attached to a PowerVault MD1120. The MD1120 offers additional storage space for enabling SCVMM's Library Server to host a large number of images.

Figure 3: Sample instance of a LARGE configuration

Clients

Network Switch

Network Switch

Network Switch

Network Switch

VM VM ---- VM

PowerEdge M1000e with M600s

VM VM ---- VM

PowerEdge M1000e with M600s

VM VM ---- VM

PowerEdge M1000e with M600s

SAN Switch

SAN Switch

Dell EMC CX4-240

System Center
Virtual Machine Manager 2008

PowerEdge PE2950 III

PowerVault MD1120

Network Switch

AD DNS DHCP

Infrastructure Support

Management Station

——— Storage Fabric   ——— Workload LAN   - - - - - Management Network

Business Continuity Options

Backup and Restore in Hyper-V environments is done by leveraging the *Volume Snapshot Service* (VSS) infrastructure native in Windows Server 2008. Several business continuity solutions including Microsoft System Center Data Protection Manager, Symantec Backup Exec, and EqualLogic Auto-Snapshot Manager offer VSS support to provide disaster recovery solutions to Windows environments.

Typically, VSS based backup requires an agent to be running on the operating system in order to be able to backup a system without shutting it down. The same requirement applies to virtual environments and guest operating systems. However, Hyper-V provides the capability to backup guest operating systems and applications within VMs with a single agent in the parent partition and no agents within virtual machines. Hyper-V enables this by using the Hyper-V VSS Writer that runs in the parent partition and communicates with all the child partitions.

Hyper-V VMs running Windows Server 2008 and Windows Server 2003 can be backed up when the VMs are running since these OSes have native support for VSS. Since this process leverages the VSS infrastructure in the guest operating system, it also automatically takes care of quiescing VSS-aware applications (such as Microsoft SQL Server, Microsoft Exchange Server, etc) in the guest operating systems before initiating a backup. For guest operating systems that does not support VSS, the backup operation will automatically take the VM through a save and restore cycle to ensure that the backup is in a consistent state. Note that *Integration Services* have to be installed in the virtual machines for Hyper-V VSS Writer based backups.

> **NOTE**: Certain scenarios will still require backup and restore to be done with the agents running on the guest operating systems. For example, the Hyper-V VSS writer does not support the backup of virtual machines that use pass-through disks (where VMs are configured with direct access to raw physical disks) and so backup has to be initiated within the virtual machines.

Symantec Backup Exec

Symantec Backup Exec 12.5 is a comprehensive business continuity solution that supports backup and restore of both physical and virtual environments. By leveraging the Hyper-V VSS Writer that is natively available in Hyper-V, Backup Exec 12.5 only requires one backup agent to run on the parent partition to support backup and restore of virtual machines. In addition to the cost benefits, the one backup agent per Hyper-V host server model makes the backup infrastructure easier to manage due to the reduced complexity.

For more information, visit **www.backupexec.com**

Microsoft System Center Data Protection Manager 2007

SCDPM 2007 is a disk-to-disk-to-tape business continuity solution that leverages the VSS infrastructure in Windows environments and supports both physical and virtual environments running Windows Server and Microsoft applications. In a future release, SCDPM 2007 SP1 will leverage the Hyper-V VSS writer to provide host-based live backup of Hyper-V virtual machines. In the current release, DPM agents can be

run within the guest operating system to backup Windows Server and Microsoft applications within Hyper-V virtual machines.

For more information, visit **www.microsoft.com/systemcenter/dataprotectionmanager**

EqualLogic Auto-Snapshot Manager/Microsoft Edition

All Dell EqualLogic PS Series arrays come with a comprehensive software toolkit to facilitate the deployment, ongoing management, and protection of Dell EqualLogic iSCSI SANs for Microsoft Windows environments. The PS Series *Auto-Snapshot Manager* (ASM) is a feature-rich application for protecting and recovering Windows data, including NTFS file systems, and Exchange and SQL Server deployments. ASM, included with all PS Series arrays, allows administrators to create NTFS file system, Exchange storage group and SQL Server database Smart Copy snapshots, local database volume clones, and remote replicas. Auto-Snapshot Manager is tightly integrated with Microsoft Volume Shadow Copy Service (VSS) to provide hardware-based snapshots of Windows based applications. In the event that recovery of an NTFS file system, Exchange storage group, or SQL Server database is necessary, Auto-Snapshot Manager provides several quick restore options to maximize the availability of your critical data.

ASM can currently be run on Hyper-V guest operating systems to leverage the benefits mentioned above. In "iSCSI Direct" configurations in which the iSCSI initiators in the guest operating system provision storage LUNs from EqualLogic array directly to the guest operating system, it is strongly recommended that the EqualLogic Host Integration Kit (HIT) be installed in the guest operating systems. Among other components, HIT installs a VSS hardware provider which will be leveraged by the ASM even in virtual machine environments to take snapshots of EqualLogic LUNs provisioned to the guest OS.

For more information, visit **www.equallogic.com/microsoft**

Hardware Considerations for Hyper-V Environments

This section provides general scaling considerations for hardware when designing a virtualized infrastructure. The guidance focuses around the four major hardware subsystems: (1) CPU; (2) memory; (3) disk; and (4) network. These four subsystems are important to understand in the general sense because not planning accordingly for each individual item can lead to overall poor quality of service (QoS) in the datacenter.

In Hyper-V, support for highly available virtual machines (HA VMs) and virtual machine migration, requires that Microsoft Failover Clustering be implemented. This drives additional configuration requirements that need to be taken into account when designing your datacenter.

CPU Subsystem

With multi-core processors, choosing physical processors depends on many factors including the type of workload, number of sockets on the Dell PowerEdge server, CPU utilization goals, Power consumption requirements, etc. Hyper-V is currently supported on systems with up to 24 logical processors.

The number of virtual processors to be assigned to a specific virtual machine depends on the requirements of the workload that runs on the guest operating system. Windows Server 2008 Hyper-V allows up to 4 virtual processors to be assigned to a specific VM (support varies for different guest operating systems). In Hyper-V, virtual processors in VMs do not have a one-to-one mapping with the logical processors on the server. The Hyper-V hypervisor handles the scheduling of virtual processors on any available logical processors. The general guidance is that when the virtual workload is highly processor intensive, using multiple virtual processors in a VM might be effective since more physical processors will be used. Since use of multiple virtual processors also adds additional overhead, careful planning is required in determining the virtual processor allocation to VMs.

For more in-depth information, refer to the *Performance Tuning for Virtualization Servers* section of the *Performance Tuning Guidelines for Windows Server 2008* document at **www.microsoft.com**.

If the Hyper-V hosts will be part of a Microsoft Failover Cluster configuration, Dell strongly recommends that all the processors on all the Hyper-V hosts that are part of that configuration be identical. If not, there is a possibility that migrations of virtual machines between Hyper-V hosts will be unsuccessful. For more information, refer to the ***Dell High Availability Solutions Guide for Hyper-V*** available on **www.dell.com/hyperv**

Based on the engineering evaluations, Dell recommends that dual-socket or quad-socket based PowerEdge servers for all virtualization workloads. Dell provides customers with the choice of many multi-core processors for use on PowerEdge servers.

Memory Subsystem

Virtualization workloads are memory intensive. This is especially true when one of the goals for the virtualization deployment is consolidation. The memory need for a specific Hyper-V host server is driven by the number of virtual machines, the amount of memory needed by each virtual machine, the amount

of memory needed by the hypervisor to manage those VMs, and the memory cushion for migration considerations.

- **Hypervisor and Parent Partition** - The general guidance is to reserve 2GB of memory.
- **Virtual Machines** – Based on the fact that Hyper-V does not share memory between virtual machines, the amount of memory required is the sum of all memory requirements for the running virtual machines on the server. For each virtual machine the following formula should be utilized to determine the memory requirement:
  - If the VM is allocated <= 1GB memory: Amount of memory allocated to the VM + 32MB
  - If the VM is allocated > 1GB memory: Amount of memory allocated to the VM + 32MB + 8MB per GB allocated to the VM for each GB over 1GB

  For example: A VM allocated with 3GB of memory would require a reservation of 3GB + 48MB
- **Migration** – If additional virtual machines may possibly migrate (either planned or unplanned) to the server, memory (per the sizing guidance above) should be reserved for those virtual machines. Failure to do so may result in virtual machines being unable to start on the server or degraded performance for all virtual machines on the server.

Since memory tends to be the first resource to be completely utilized, careful planning will ensure enough capacity to sustain and grow the datacenter.

Disk Subsystem

The storage subsystem needs to provide enough storage capacity while delivering QoS to the datacenter through acceptable IO request response times. In addition, the number of hosts connecting to the disk subsystem and the fabric type need to be factored in order to pick the correct Dell storage enclosure.

- The capacity portion is a simple calculation based on RAID level choice and capacity needs for virtual machines and applications.
- Performance sizing the disk subsystem is a critical aspect to ensure that solution has sufficient disk spindles and bandwidth to handle the IO needs.
- Another design criterion is the need for support of highly available virtual machines and virtual machine migration.

If high availability/Quick Migration is required, then the virtual machine components (disks and configuration files) should reside on a storage array (Dell|EMC CLARiiON, Dell EqualLogic, or Dell PowerVault MD3000/MD3000i). MPIO should be configured and multiple physical I/O paths should exist between each server and the storage array to provide redundancy and improved performance via load balancing.

If high availability/Quick Migration is not a requirement for your configuration, then internal storage or storage enclosures (Dell PowerVault MD1120/MD1000) attached to internal RAID controllers may be appropriate.

For additional information refer to the ***Dell Storage Solutions Guide for Hyper-V*** available on **www.dell.com/hyperv**.

Network Subsystem

The network subsystem needs to deliver QoS on IO requests, connect the datacenter, and enable key hypervisor features. The decision points involve choosing enough NIC ports to handle the data traffic, management traffic, and cluster communication to meet current needs and allow for scalability as the datacenter grows. In addition, if iSCSI storage arrays are utilized in your configuration, then iSCSI traffic drives networking requirements as well. The guidance below is general best practice for each server in your datacenter.

- **Parent Partition / Virtualization Management** – A minimum of one port should be allocated.

  NOTE: This adapter can also be utilized for the public cluster communication network if this Hyper-V host is part of a highly-available cluster

- **Virtual Machine Network** – A minimum of two ports should be allocated for virtual machine networks. Additional adapters may be required based on the number of virtual machines and workloads running in the virtual machines.
- **Storage Network** – If iSCSI storage arrays will be utilized, a minimum of two ports should be allocated to ensure high availability.
- **Cluster Private Network** – One adapter should be allocated for the private cluster network if the Hyper-V host is part of a highly-available cluster.

If two or more ports are utilized for any specific function, then best practice dictates that the ports should be split across physical network adapters to ensure that loss of a single adapter does not result in complete loss of availability.

For additional networking information on Networking in Hyper-V, refer to the ***Dell Networking Solutions Guide for Hyper-V*** available on **www.dell.com/hyperv**. For iSCSI best practices on configuring iSCSI on Hyper-V environments, refer to the ***Dell Storage Solutions Guide for Hyper-V*** available on **www.dell.com/hyperv**.

Additional Information

- *Dell Virtualization Advisor* Tool at **www.dell.com/hyperv**

- Solutions Guidance at **www.dell.com/hyperv** (also available at **http://support.dell.com/support/edocs/software/HyperV/en**)
    - o *Dell Solutions Overview Guide for Hyper-V*
    - o *Dell Networking Solutions Guide for Hyper-V*
    - o *Dell Storage Solutions Guide for Hyper-V*
    - o *Dell High Availability Solutions Guide for Hyper-V*

- Dell *Infrastructure Consulting Services* at **www.dell.com/hyperv**