CONSOLIDATION

REPORT

HOW-TO GUIDE: CONSOLIDATING MULTIPLE SQL SERVER® SYSTEMS ONTO DELL™ POWEREDGE™ SERVERS USING MICROSOFT'S HYPER-V™

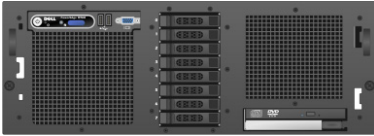A Principled Technologies report commissioned by Dell

Principled Technologies®
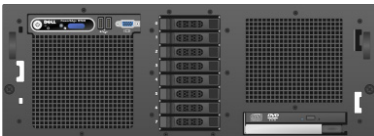
DELL

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Virtualization and consolidation overview

Dell PowerEdge R900

Dell PowerEdge R905

This guide provides concepts and procedures that will help you successfully consolidate your Microsoft® SQL Server® instances from multiple machines onto a single Windows Server® 2008 system using Microsoft's Hyper-V™. In this guide, we use the Dell™ PowerEdge™ R900 and PowerEdge™ R905 as target servers. Depending on the version of SQL Server you are using (2000, 2005, or 2008), please refer to the accompanying Guide for the specifics that will help you complete the migration process.

Principled Technologies® (PT) has performed hands-on testing and research and drawn on real-world experiences to document best practices and help you take advantage of the features of Hyper-V to consolidate multiple SQL Server instances onto a single physical system.

This document covers the key overall concepts and procedures you need to setup and configure your virtualized Hyper-V platform. It reviews in detail the approach that PT and Dell recommend for a tested and validated installation of Windows Server 2008 and Hyper-V. In accompanying Guides, we cover concepts and procedures specific to three versions of SQL Server: SQL Server 2000, SQL Server 2005, and SQL Server 2008.

The Dell PowerEdge R900 supports up to 24 logical processors, or cores, and the Dell PowerEdge R905 supports 16 logical processors. The release version of Microsoft Hyper-V supports a maximum of 16 logical processors. See http://technet.microsoft.com/en-us/library/cc816844.aspx for more details on Hyper-V hardware considerations.

NOTE: Microsoft released an update in September 2008 to increase this maximum to 24 logical processors. For more details, and to download this update, visit http://support.microsoft.com/kb/956710.

Because we use both the Dell PowerEdge R900 and R905 in this Guide, we refer to the target server as the PowerEdge, and note specifics to each platform where they apply.

What is virtualization? How can I use it to consolidate, and what are the benefits?

Generally speaking, *virtualization* is the ability to run multiple operating system environments or machine environments on one physical system. There are two basic types of virtualization. Type 2 virtualization is a hosted solution, where the virtual machines run inside another operating system, and thus are several layers above the hardware. Type 1 virtualization products, such as Microsoft's Hyper-V, run much closer to the "bare metal" of the server and interact with hardware directly through a control program known as the hypervisor. By working closer to the hardware, Type 1 products typically can provide better performance than Type 2 offerings.

Generally speaking, *consolidation* refers to the process of combining multiple things to make a single, more effective unit. In this Guide, we discuss combining the concepts of virtualization and consolidation to achieve your overall goals.

In an IT context, you can consolidate several types of things, including the following:

Physical servers. In this Guide, consolidation typically means consolidating servers. After a successful consolidation, all applications should run on fewer servers than before, and those applications should run at least as well as they did previously. The other types of consolidation we mention below may happen as a consequence of consolidating physical servers, but they are not our primary focus.

Storage. As you follow the procedures in this Guide, you will consolidate storage to some degree by moving software and data from a number of servers to a large, locally attached, disk storage subsystem in a new server in the form of virtual hard drives. Larger-scale storage consolidations, such as implementing a storage area network (SAN), are outside the scope of this Guide.

Locations. As you consolidate servers through virtualization, you may reduce the number of locations you need for servers. Planning for consolidating geographic locations is also beyond the scope of this Guide.

This Guide focuses on consolidation via virtualization. For details about consolidation at the SQL Server instance or database level, see our earlier Guide, *Consolidating SQL Server 2000 and SQL Server 2005 databases to SQL Server 2008 on Windows Server*

2008 Enterprise on Dell Servers
http://www.principledtechnologies.com/Clients/Reports/Dell/Consol
idating_SQLServer_databases_onto_a_Dell_server.pdf.

Why consolidate?

Done well, consolidation yields a more economical environment
with more consistent management practices, better use of
hardware, and all applications performing at least as well as they
did previously. An effective consolidation effort improves reliability
and security while bringing great savings to your organization.
Some of the ways consolidation can stretch your technology dollar
include the following:

Hardware savings. Buying, powering, and supporting fewer
servers brings obvious savings to your organization. Less obvious
are the other significant cost savings that fewer servers mean over
time, such as fewer hardware replacement purchases as these
consolidated servers age out. In other words, your future purchase
growth rate may decrease. Other potential hardware cost savings
areas include racks and network switches; as the number of
servers decreases, these costs decrease as well.

Software license savings. Like traditional consolidation, Hyper-V
virtualization technology allows your organization to reap
significant software licensing savings. While licensing structures
and fees vary by product, the following example illustrates the
possibilities.

Windows Server 2008 Enterprise Edition limits the number of guest
OS instances to four, so this pricing example uses Windows Server
2008 Datacenter Edition (which allows unlimited guest OS
instances) and the per-processor licensing model of SQL Server
2008. Details on licensing Windows Server 2008 are available for
download here, and details on licensing SQL Server 2008 are
available for download here.

NOTE: Each version of SQL Server has its own licensing
specifications, so you should consult with your Microsoft
sales representative on the specifics of licensing SQL
Server in a virtual environment. This example uses SQL
Server 2008 to show cost savings.

Our PowerEdge R900 and PowerEdge R905 each have four physical
quad-core processor sockets. Licensing Windows Server 2008
Datacenter Edition with SQL Server 2008 Enterprise Edition lets us

create an unlimited number of virtual environments, all running
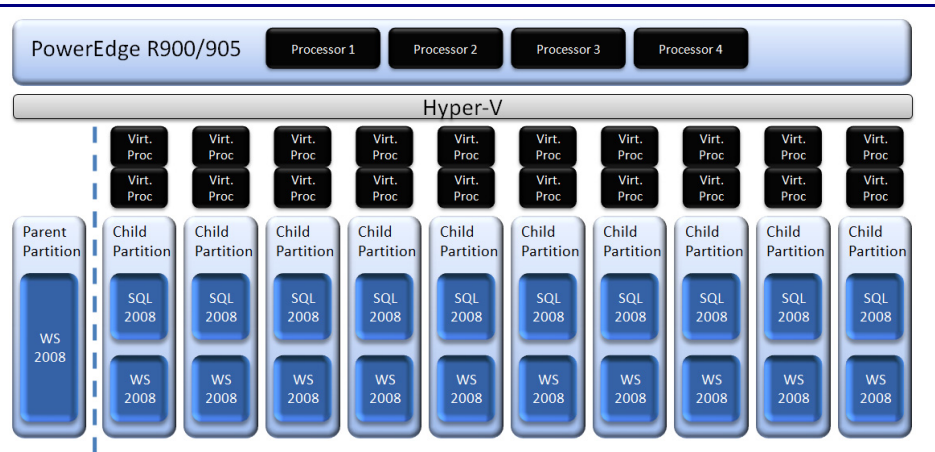SQL Server 2008. Figure 1 shows a possible configuration.

**Figure 1. Sample configuration of 10 virtual machines running on
the Dell PowerEdge, each with two virtual processors.**

In our previous Guide, *Consolidating SQL Server databases from
Dell PowerEdge 2650 servers to a Dell PowerEdge 2950 server*
http://www.principledtechnologies.com/Clients/Reports/Dell/Consol
idating_2650_to_2950.pdf, we determined that, without
virtualization, we could successfully consolidate 10 identical
workloads onto a PowerEdge R900 with a PowerVault MD1000
storage array. Each of these 10 workloads on the PowerEdge R900
met or exceeded the performance of the single workload on the
PowerEdge 2650. Therefore, we use 10 as a reasonable
consolidation estimate in the example below.

In our example, we migrated our 10 physical SQL Server
environments to 10 virtualized SQL Server environments running
on a single server and allocated two virtual CPUs to each of the 10
virtualized environments. That is a total of 20 virtual CPUs, but our
new four-socket host machine has only 16 cores. This usage is not
a problem, however, because Hyper-V handles the sharing of
resources among the virtual machines. In this example, because
we have purchased the Datacenter Edition of Windows Server 2008
and Enterprise Edition of SQL Server 2008, we can create as many
virtual environments as we want.

NOTE: The cost analysis below shows only licensing
savings related to SQL Server. Windows Server 2008
licensing is independent of SQL Server, so check with
your Microsoft sales representative about complete costs
of both products.

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Figures 2 and 3 present a brief cost analysis showing SQL Server cost savings based on the configuration in Figure 1. The non-consolidated environment assumes 10 Enterprise Edition SQL Server instances, each running on a dedicated two-socket server, and they use list prices. The virtualized environment assumes a quad-core four-socket machine running SQL Server Enterprise Edition. Because Microsoft counts each socket as a processor for licensing purposes, the virtualized environment requires only one-fifth the numbers of licenses as the non-consolidated environment, yielding considerable savings.

Virtual disk	Non-consolidated environment	Consolidated Hyper-V environment
Description	10 two-socket dual-core servers, each running SQL Server enterprise	1 four-socket quad-core server, running Hyper-V and SQL Server Enterprise; assumes licenses for 4 physical processors
Cost	2 sockets x $25,000 per-processor retail enterprise license x 10 servers = **$500,000** in SQL Server licensing; $50,000 per SQL instance	4 sockets x $25,000 per-processor retail enterprise license x 1 server = **$100,000** in SQL Server licensing; $10,000 per SQL instance

Figure 2. Comparing SQL Server list licensing costs: 10 non-virtualized two-socket servers versus a single four-socket server running 10 dual-processor virtual machines. For licensing purposes, Microsoft counts one socket as a processor.
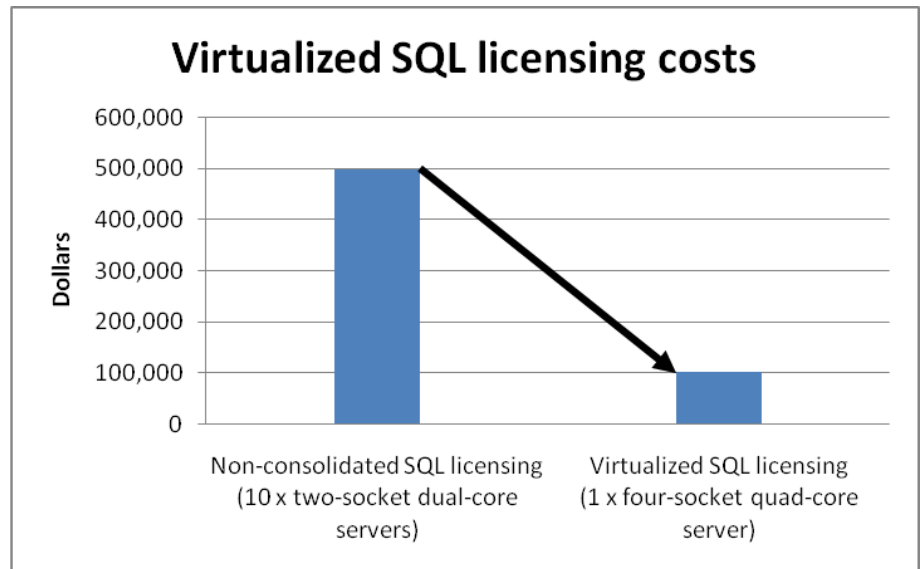
Virtualized SQL licensing costs

Figure 3. Example SQL Server licensing savings when consolidating from 10 two-socket servers to a single four-socket server running Hyper-V. For licensing purposes, Microsoft counts one socket as a processor.

Maintenance and staff savings. A consolidated and virtualized infrastructure offers many opportunities for staffing, support, and maintenance cost savings. Less hardware and associated equipment means fewer servers that require security patches and monitoring.

Reduced staffing requirements. Regardless of your server-to-full-time-employee (FTE) administrator ratio, fewer servers mean fewer system administrators. Also, consolidation efforts often improve standardization across servers, simplifying administration for the Windows® system administrator, network engineer, and SQL Server database administrators (DBAs). Virtualization and consolidation can also provide greater opportunities for automation, further reducing the FTE requirements. Because the growth in the number of servers can slow when you consolidate, these savings can compound over time.

Reduced support costs. The cost of a given level of support is usually proportional to the size of the installation. By reducing the number of servers, the costs of your support agreements go down as well.

Power and cooling savings. Consolidating servers saves power in several ways:

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- **Fewer servers.** Obviously, fewer servers consume less power.
- **More efficient servers.** Modern servers are typically more efficient than those of a few years ago, so you are likely to consume less power per server.
- **Less air conditioning.** Fewer, more efficient servers produce less heat. Moreover, you can house them in a smaller space, thus reducing air conditioning costs even further.

Rent savings. Consolidation reduces the floor space IT requires. By reducing the number of servers, you reduce the space required to hold the racks and the associated space necessary for servicing and airflow. You require less cooling and so save on the space the air conditioners would require. Finally, consolidation may allow you to reclaim space, make more efficient use of the space you have, and thus delay expansion.

Regulatory compliance savings. With fewer physical devices storing data and more uniform management, a consolidated environment can make the process of complying with regulatory requirements such as Sarbanes-Oxley and the Health Insurance Portability and Accountability Act (HIPAA) less expensive, easier, and more secure.

Sizing and baseline performance. Sizing is one key to a successful consolidation. The process of sizing involves gathering different performance baselines so you have at least an approximate set of requirements the new consolidated servers must meet. You do this by looking at the performance characteristics of existing hardware during normal business operations, and then applying growth and scalability estimates. The performance baselines you gather are useful when setting the configuration options on your Hyper-V virtual machines when it comes to the number of virtual processors and the amount of memory.

Among the characteristics to examine on each server are the following:

- Processor utilization
- Memory requirements of the OS and applications
- Disk layout
- Database size
- Expected database growth
- Maximum concurrent users

- Types and rates of transactions against the databases

The server you choose for virtualization and consolidation must do more than match the combined capacity of all the other current servers today. It must have enough excess capacity to still perform well at the end of its expected life span. Fortunately, given the improvements we note below, finding such servers is entirely possible. Also, given the flexibility that virtualization provides, future hardware upgrades are easier; you can move virtual machines from host to host and even migrate them to newer equipment if you so choose.

Another reason for consolidation is one that plays a role in sizing: the typical enterprise is not using its servers at anywhere near capacity. As Ben Pring, Research Vice President for Gartner, noted at the Gartner Symposium ITxpo 2007, "Server utilization was also low—at an average 18 percent in large organizations."

In recent years, server capabilities have greatly increased. Here are some of the improvements that make it possible to consolidate multiple servers into a single system:

- **More processors.** Modern quad-core processors double or even quadruple the number of processing cores available per socket without increasing the physical size of the server.
- **More processing power per core.** While clock speeds have not changed dramatically, processors have undergone a generational shift. Industry-standard benchmarks, such as SPECint, show today's processors are much faster than their counterparts of three to five years ago.
- **64-bit address space.** Five years ago, many processors did not support 64-bit addressing. Windows Server 2003 did not support 64-bit addressing on x64 processors until 2005.
- **Faster memory.** The memory in a modern system may be as much as two to three times as fast as that in a three- to five-year-old system.
- **Faster storage.** The performance of storage subsystems have continued to improve.
- **Cheaper storage and greater capacity.** Disk capacity has greatly increased, while the cost per GB has decreased. Moreover, external storage arrays radically increase the amount of storage available to a server.

We further discuss sizing at a conceptual level in the Getting ready section.

Hyper-V overview

Microsoft includes its hypervisor, Hyper-V, in certain editions of Windows Server 2008. Generally speaking, a hypervisor is a Type 1 virtualization product: a thin layer of software enabling virtual machines to run on one physical machine and allowing direct access to most hardware.

Requirements for running Hyper-V

The PowerEdge R900 and PowerEdge R905 both support the features Hyper-V requires, which include the following:

- An AMD64® or Intel® 64-based processor
- A 64-bit Windows Server 2008 version (Standard, Enterprise, or Datacenter)
- Hardware Data Execution Protection (DEP) enabled
- Hardware-assisted virtualization, specifically processors that include the Intel-VT or AMD-V features. Figures 4 and 5 show the virtualization feature enabled on our PowerEdge R900 and PowerEdge R905. Note that the BIOS uses the term "Virtualization Technology" on both systems.
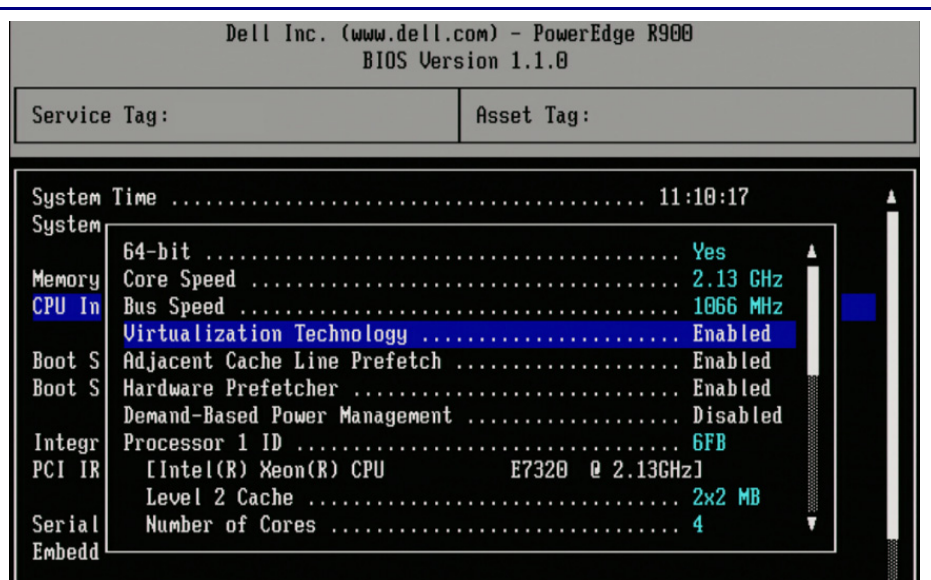
```
            Dell Inc. (www.dell.com) - PowerEdge R900
                         BIOS Version 1.1.0

 Service Tag:                        Asset Tag:

 System Time ........................................ 11:10:17    ▲
 System
        ┌──────────────────────────────────────────────────────┐
 Memory │ 64-bit ............................................ Yes│ ▲
 CPU In │ Core Speed ................................... 2.13 GHz│
        │ Bus Speed .................................... 1066 MHz│        ▉
        │ Virtualization Technology ..................... Enabled│
 Boot S │ Adjacent Cache Line Prefetch .................. Enabled│
 Boot S │ Hardware Prefetcher .......................... Enabled│
        │ Demand-Based Power Management ................ Disabled│
 Integr │ Processor 1 ID ................................... 6FB│
 PCI IR │   [Intel(R) Xeon(R) CPU         E7320  @ 2.13GHz]│
        │   Level 2 Cache .............................. 2x2 MB│
 Serial │   Number of Cores ............................... 4│ ▼
 Embedd └──────────────────────────────────────────────────────┘
```

Figure 4. Example BIOS configuration for the PowerEdge R900 showing virtualization technology enabled.
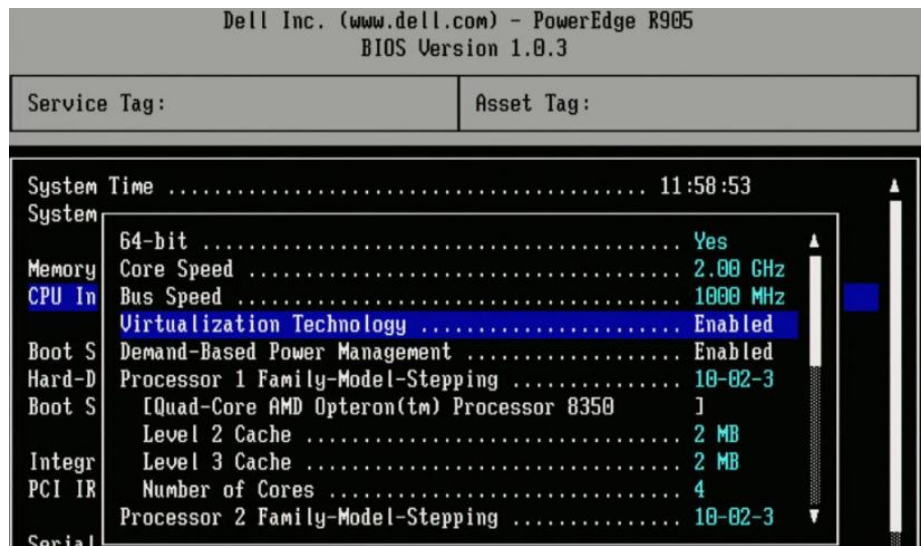
Figure 5. Example BIOS configuration for the PowerEdge R905 showing virtualization technology enabled.

Features of Hyper-V

Below, we list some of Hyper-V's noteworthy features.

- **High availability and quick migration.** You can couple virtualization with failover clustering to achieve a highly available virtualization environment. Then, with just a few clicks, you can quickly migrate virtual machines from host to host with almost no downtime.
- **Installation on Windows Server core.** If you so choose, you can run Hyper-V over just a core Windows Server 2008 installation. This allows you to incorporate all the flexibility that virtualization provides while keeping your host OS footprint small. Note: Installing the server core is outside the scope of this Guide.
- **Import/export capabilities.** Using the built-in import and export capabilities, you can easily provision new virtual machines.
- **Linux support.** As of this writing, Hyper-V supports SUSE Linux Enterprise Server as a guest OS. You can find more information on supported guest operating systems here: http://www.microsoft.com/windowsserver2008/en/us/hyperv-supported-guest-os.aspx.

> **NOTE:** Microsoft sells a tool, System Center Virtual Machine Manager, that provides additional capabilities such as physical to virtual (P2V) conversion, virtual to virtual (V2V) conversion, and machine cloning. Use of

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the System Center Virtual Machine Manager is outside
the scope of this Guide.

Resource allocation in Hyper-V

Consolidation using Hyper-V allows your organization to save
money on hardware. Consolidation brings competition for physical
resources, such as CPU cycles, RAM, and NIC bandwidth. The
Hyper-V manager allows system administrators to allocate
resources as they see fit to reflect virtual machine workloads.

- **Memory allocation.** Hyper-V manager allows you to adjust
  the memory you allocate to virtual machines. On our
  PowerEdge with 64 GB, we could assign from 8 MB to
  65,529 MB of memory to a virtual machine.
- **CPU allocation**. You can assign one or more virtual
  processors to a virtual machine and then use more granular
  resource controls to allocate and balance CPU resources
  amongst multiple VMs. Figure 6 shows the Hyper-V
  manager settings for the virtual CPUs. You can set the
  number of virtual CPUs. Additionally, you can reserve a
  percentage of the physical CPU by setting the VM reserve
  percentage (minimum). You can also cap the amount of CPU
  available to the VM by setting the VM limit percentage
  (maximum). Lastly, you can use the relative weight value to
  prioritize certain VMs over others. Note: You can assign a
  maximum of four virtual CPUs to a VM, but not all guest
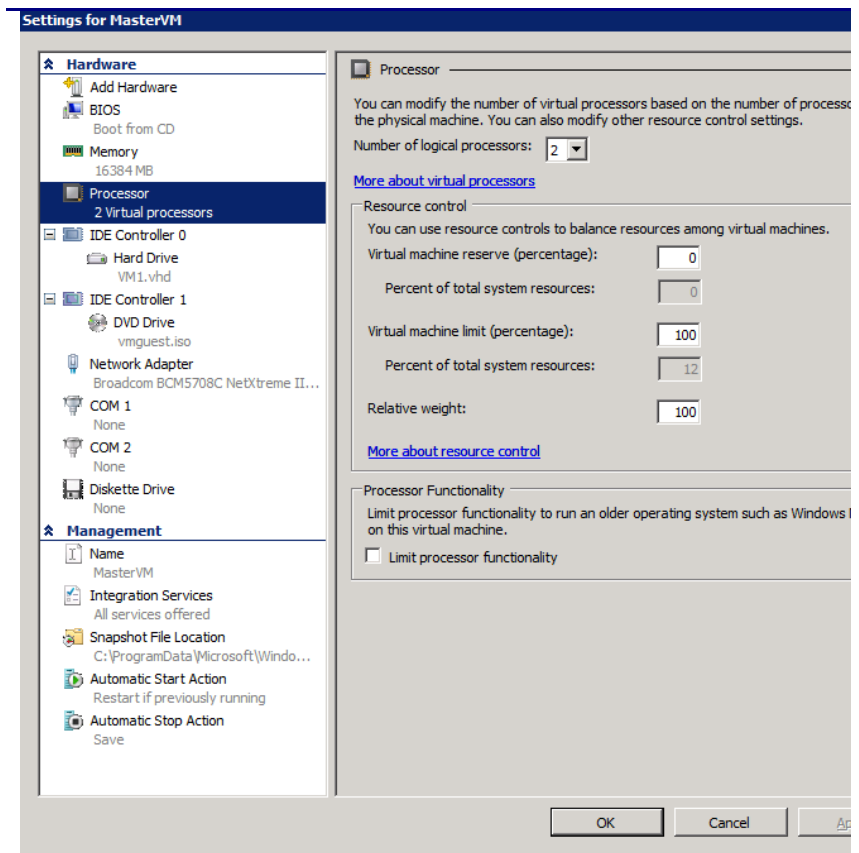 OSs support four virtual CPUs.

Figure 6. CPU settings for a sample virtual machine in Hyper-V Manager.

Monitoring and tuning Hyper-V

When you install the Hyper-V role in Windows Server 2008, the installation automatically creates Hyper-V-specific performance counters at the same time. You can use these performance monitor counters to monitor your VM resource utilization and then adjust your resource controls as necessary. Note: Do not rely on the traditional performance counters inside a guest OS. In a virtualized environment, the utilization numbers may not be completely accurate. According to Microsoft, this is because of clock timing issues. Be sure to use the Hyper-V specific counters from the host OS.

Two sample counter sets are as follows:

- **Hyper-V Hypervisor Logical Processor counters.** This set of counters contains information regarding the logical processors in your system. For our systems, the number of logical processors is equal to the number of processor cores. Because we are using a quad-processor quad-core system, we have 16 logical processors.

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- **Hyper-V Hypervisor Virtual Processor counters.** This set of counters contains information regarding the virtual processors specific to each virtual machine in your system.

> **NOTE:** The number of virtual processors is the sum of the numbers of virtual processors you have allotted to all currently running VMs. The number often exceeds the number of logical processors.

Regarding storage, several Microsoft whitepapers show that pass-through disks will offer optimal performance, with the next best performance being fixed-size virtual hard disks (VHDs) attached to the Hyper-V SCSI controller for that virtual machine. The Microsoft documents also note that the fixed-size VHDs are easier to administer, so we use fixed-size VHDs in this Guide. For more information, see the whitepaper here: http://download.microsoft.com/download/d/9/4/d948f981-926e-40fa-a026-5bfcf076d9b9/SQL2008inHyperV2008.docx.

Getting ready

Evaluating your servers for virtualization and consolidation

You must be aware of many specific details related to each physical server you target for consolidation, including the maintenance window in which you migrate the server to a virtual environment, the users the move affects, and the configuration tasks necessary to assimilate the databases into your consolidated environment. A more comprehensive example survey appears in Appendix A. Information to gather before consolidation may include the following:

- Server OS version and patch level
- SQL Server version and patch level
- Number of logins on this SQL Server instance, and what type of logins these are (Windows or SQL)
- Current backup strategy and schedule for the databases on this server
- Replication details for this SQL instance, if any
- Detailed information regarding permissions and roles
- SQL Agent jobs on this SQL Server

Just as in a traditional migration, after moving your database to a virtual machine, you must make sure that any system or application using the database has updated connection information. This includes logins, permissions, applications, SQL Agent jobs, third-party backup solutions, and so on.

Gather baseline performance data
During your research phase, you should use Performance Monitor, SQL Server Profiler, and other tools to gather data on the typical query load and performance statistics on the database server you are considering moving to a virtual environment. This practice serves two purposes. First, it provides a prime opportunity to

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identify potential problems before you move to a Hyper-V based solution. Second, you can use the information you gather to map out your resource allocation needs, which you can then use to configure your Hyper-V virtual machine memory and CPU settings.

Poor candidates for consolidation

Not every database is a good candidate for consolidation. Here, we present examples of databases that possibly should remain on dedicated servers.

Databases with critical performance requirements. If your database has stringent performance requirements, it may be best to leave it on a dedicated server. On a dedicated server, it is much easier to find any bottlenecks that might occur. It is also much simpler to address any problems when you need not worry about disrupting other work on the same server. If you do decide to proceed with consolidation, try to avoid consolidating two performance-critical databases on the same server, because it may not be possible to achieve acceptable performance for both of them.

Databases with critical uptime requirements. Avoid consolidating multiple highly critical databases on a single server. To do so greatly magnifies the effect of a single server failure. While high-availability measures such as clustering can help mitigate this risk, it is often better not to have too many critical resources vulnerable to a single point of failure.

Databases with critical security requirements. You may need to isolate databases with highly sensitive data. You may be able to handle some critical requirements by putting such a database in a dedicated virtual machine, but you may decide that some databases are sufficiently sensitive that you need to keep them on dedicated physical servers.

Databases with specialized requirements. Some databases may have requirements you cannot fulfill in the new environment, such as applications that depend on highly specialized file layouts or direct access to specific hardware.

Of course, you must also be sensitive to circumstances unique to your organization. Contractual obligations, for example, might require you to keep a given database on an isolated server.

Finally, you may want to avoid mixing contrasting types of work. For example, the usage patterns and schema designs for Online Analytical Processing (OLAP) and Online Transaction Processing

(OLTP) applications differ significantly. Each of these environments employs different optimization techniques, and those techniques may not mix well. If you consolidate your OLAP relational data warehouse files physically alongside your OLTP database files, you may find that OLTP performance suffers when bulk data loading or report generation occurs against your data warehouse databases.

Preparing your server
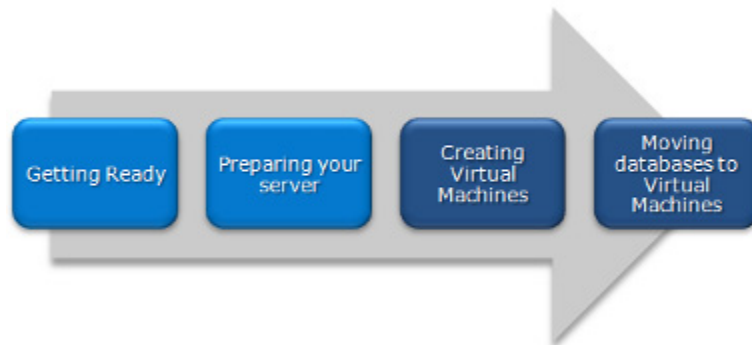
Defining our environment

We used a Windows domain containing a Windows Server 2008 server running the Hyper-V role and an Active Directory® server.

Specifically, our example Hyper-V server was a Dell PowerEdge R900 or PowerEdge R905 running Windows Server 2008 Enterprise Edition SP1 x64 and the Hyper-V role. We connected a Dell PowerVault™ MD1000 direct-attached storage array to the PowerEdge. Our Active Directory server was a Dell PowerEdge 1950 running Windows Server 2003 R2 Enterprise Edition SP2. We connected all components via a gigabit Ethernet switch. Figure 7 illustrates our setup.
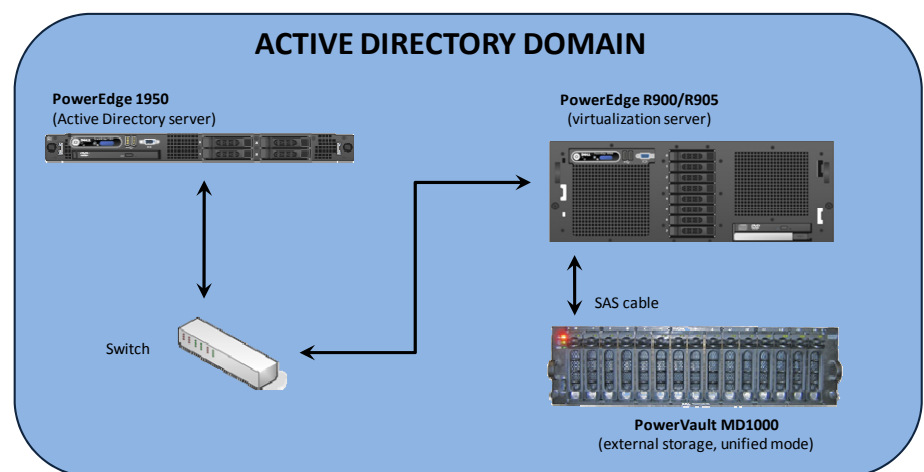

Figure 7. The setup we used in our hands-on testing and research for this Guide.

Figures 8 and 9 present the hardware and software we used to

simulate an Active Directory domain and Hyper-V consolidation server.

Server	Processor	Memory	Disk drives
Dell PowerEdge 1950 (Active Directory server)	2 x Quad-Core E5440 Intel Xeon® (2.83 GHz)	16 GB	2 x SAS, 15K RPM, 146 GB
Dell PowerEdge R900 (Hyper-V consolidation server)	4 x Quad-core E7320 Intel Xeon (2.13 GHz)	64 GB	8 x SAS, 15K RPM, 73 GB
Dell PowerEdge R905 (Hyper-V consolidation server)	4 x Quad-Core 8350 AMD Opteron™ (2 GHz)	64 GB	8 x SAS, 15K RPM, 73 GB

Figure 8. Servers we used in our hands-on testing and research for this Guide.

Server	Operating system
Dell PowerEdge 1950 (Active Directory server)	Windows Server 2003 Enterprise Edition R2 SP2 x86
Dell PowerEdge R900	Parent partition: Windows Server 2008 Enterprise Edition SP1 x64 (Please see the relevant accompanying Guide for instructions on configuring child partitions)
Dell PowerEdge R905	Parent partition: Windows Server 2008 Enterprise Edition SP1 x64 (Please see the relevant accompanying Guide for instructions on configuring child partitions)

Figure 9. Software we used in our hands-on testing and research for this Guide.

We used the following storage and networking devices:

Dell PowerVault MD1000—15 x SAS, 15K RPM, 146GB disk drives

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Gigabit switch—16-port gigabit Ethernet

> **BEST PRACTICE:** Use the latest tested and validated software, firmware, and driver versions for NICs, storage arrays, and other components. You can find these software components at http://support.dell.com/support/downloads/index.aspx?c=us&l=en&s=gen.

Configuring the physical RAID disk layout

Overview
Following Microsoft's recommended best practices, we planned to separate our virtualized disk activity, just as we would with a physical machine. By placing our VHDs on separate physical drives, we were able to separate the different types of file work, as Microsoft recommends.

> **NOTE:** Plan on at least 10 minutes for drive configuration on the server.

A note on virtualized storage
In a Hyper-V environment, you have three options available for storage: pass-through disks, fixed-size VHDs, and dynamically sized VHDs. If speed is your primary concern, pass-through disks are the best option. However, pass-through disks require you to allocate a dedicated disk to a virtual machine, making pass-through disks less flexible. We chose to use fixed-size VHDs. This gave us the flexibility of virtualizing our disks and better performance over dynamically sized VHDs. You can find more information on storage performance considerations in the Microsoft SQL Server and Hyper-V whitepaper here:
http://download.microsoft.com/download/d/9/4/d948f981-926e-40fa-a026-5bfcf076d9b9/SQL2008inHyperV2008.docx.

> **BEST PRACTICE:** Hyper-V requires that the operating system VHD be on an IDE controller. For better performance, you should attach your other virtual hard disks to a virtual SCSI controller instead of to virtual IDE controllers.

Tempdb database
SQL Server creates the tempdb system database, which all databases on the SQL instance share. SQL Server uses the tempdb database for such purposes as temporary tables, table variables, work files for hash operations, sorting, building aggregates for

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GROUP BY or ORDER BY clauses, index builds, INSERTED and DELETED tables that triggers use, and cursor processing. We assumed that our database activity makes heavy use of the tempdb, and so chose to put our VHD containing the tempdb database on an isolated set of physical disks. However, if your tempdb does not experience heavy use, then you may not need dedicated disks.

Transaction log files
Each database has one or more transaction log files. A transaction log file stores the details for all transactions in a SQL Server database. This information is critical for restoring database consistency in the event of a failure. We chose to put our VHD containing SQL Server transaction logs on an isolated set of physical disks.

User database files
These data files contain the data and objects for each user-defined database. Their contents include database objects that you can define, such as tables, indexes, and stored procedures. We chose to put our VHD containing SQL Server user database files on an isolated set of physical disks.

When possible, group files with similar I/O characteristics. For example, consolidate all logs. Because heterogeneous workloads can have very different and even competing I/O characteristics, combining heterogeneous workloads can hurt overall performance. In this scenario, by storing the VHDs on separate disks, we have still grouped the disk activity into heterogeneous groups; therefore, the system directs sequential log activity to one set of physical disks, and random database read/write activity to a different set of physical disks.

> ★ **BEST PRACTICE:** When possible, separate the tempdb, transaction log files, and user database files onto their own physical disks on separate disk groups. Doing so can yield better I/O performance by ensuring that these files do not share the same physical disks.

Below, we illustrate the exact drive layout we used (see Figure 10), and briefly describe each disk group. We cabled the server's external RAID controller to the IN port of Enclosure Management Module (EMM) number one on the PowerVault MD1000. We then toggled the front switch upward on the MD1000 to indicate that we were running in unified mode, and turned on the enclosure.

For detailed instructions on how we configured the RAID disk groups, see Appendix B.

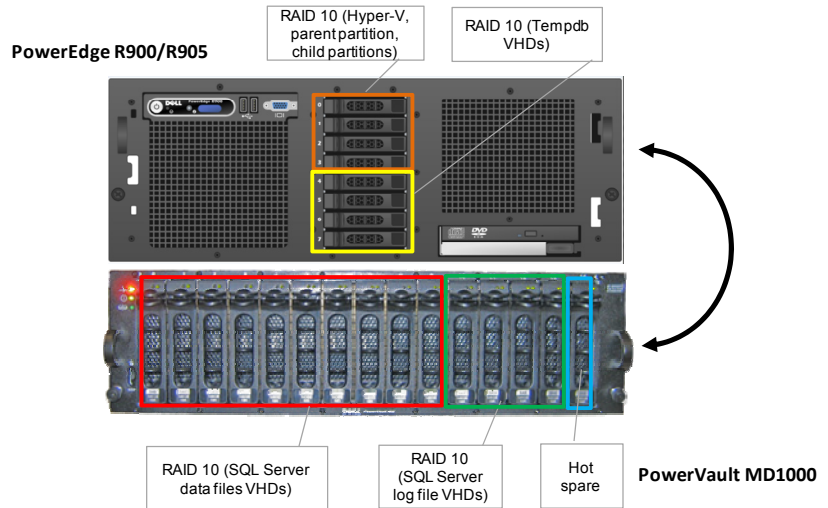**Physical disk configuration – PowerEdge with PowerVault MD1000**

Figure 10. The physical drive configuration we used in the virtualization consolidated server in our hands-on testing and research for this Guide.

Internal disk drives

Our PowerEdge servers each contained eight drives. We configured the first four internal server drives using RAID 10 for both the parent partition, which holds the host OS, and for the child partitions, which hold the virtual machines. We also stored the SQL Server binaries in VHDs on this RAID. We also configured the next four internal drives as a RAID 10, and dedicated it to the VHD that would contain the SQL Server tempdb files.

External disk drives

The PowerVault MD1000 contained 15 drives. We allocated 10 drives to a RAID 10 disk group that held the VHDs we assigned to hold SQL Server user-defined databases. We then created another RAID 10 disk group, consisting of four drives, to hold the VHD that contained SQL Server transaction log files. We left one drive unallocated and assigned it as the hot spare.

Installing Windows Server 2008

Hyper-V requires some form of Windows Server 2008 to be running in the parent partition—either the full installation or the core installation. For simplicity and ease of installation, we chose to install the full version of Windows Server 2008.

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This section provides an overview of the Windows Server 2008 installation process on the Dell PowerEdge. We include approximate wait times for each step. ([Appendix C](#) provides complete, detailed installation instructions.)

> **NOTE:** Plan on at least 60 minutes for installing Windows Server 2008 Enterprise Edition on the Dell PowerEdge server. Each step below takes at least 1 minute. We provide the approximate amount of time each step takes in parentheses. These times exclude data entry time. The time to install updates—11 minutes in our setup—will increase over time as Microsoft releases additional OS updates.

1. Insert the Microsoft Windows Server 2008 Enterprise Edition DVD into the DVD drive, and reboot the system. If a message appears telling you to press any key to boot from CD or DVD, do so. During the boot, a message that Windows is loading files appears, followed by a Windows booting loading bar. (6 minutes)

2. Set the basic location information, and enter your product key, if applicable. For Hyper-V, you must install Standard, Datacenter, or Enterprise Edition. We chose Enterprise Edition. Proceed with installation, and enter the information the installation software requires (see Figure 11). (20 minutes, during which Windows resets the server twice)
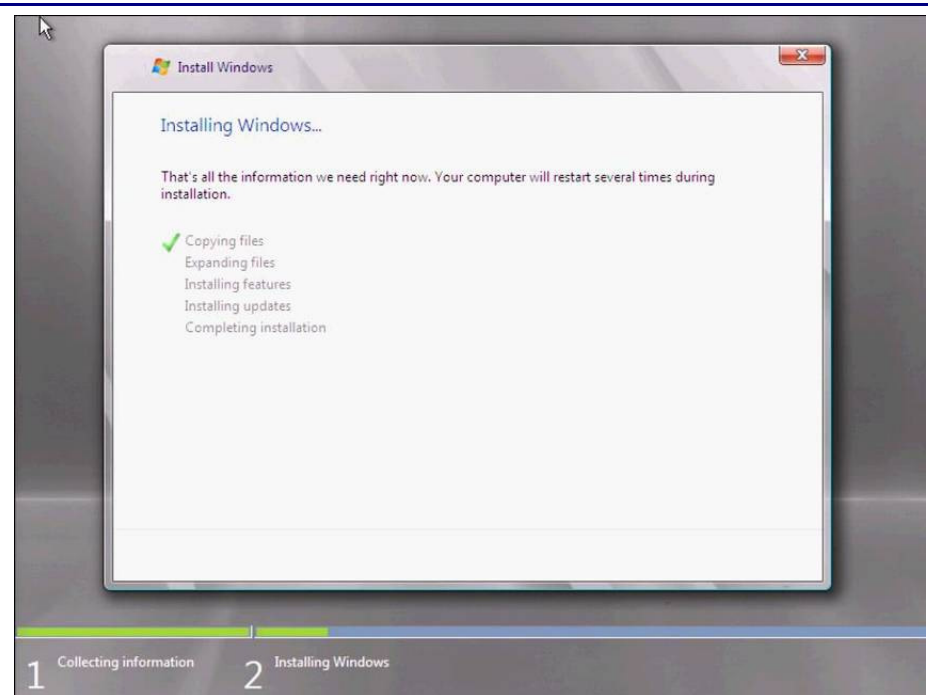
Figure 11. Windows Server 2008 installation progress.

3. Set your password; enter configuration information, including the IP addresses and domain information; and reboot the system. (3 minutes)

4. Download and install updates (see Figure 12). It is critical at this point that you download and install the update related to Knowledge Base article KB950050, which updates Hyper-V. (10 minutes; download times vary)
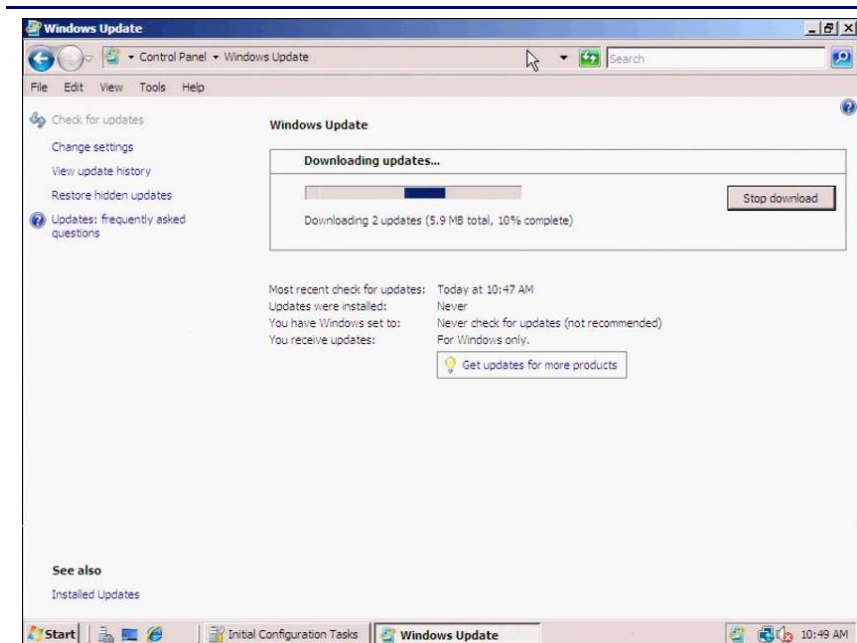
Figure 12. Installing Windows Server 2008 updates.

5. Reboot after the update installation completes. (3 minutes)

Configuring the physical system drives

The next step is to configure the remaining drives in your physical server using the Disk Management utility that is part of the Windows Server 2008 Enterprise Edition Administrative Tools. Format all non-OS volumes as NTFS, including those you will use to hold your VHDs (see Figure 13).

Virtual disk	Drive location	Raid level	No. of drives	Contents
1	PowerEdge	10	4	Hyper-V, parent partition, child partitions (virtual machines)
2	PowerEdge	10	4	VHDs for tempdb files
3	PowerVault MD1000	10	10	VHDs for SQL Server user data files
4	PowerVault MD1000	10	4	VHDs for SQL Server log files

Figure 13. Drive configuration and contents.

In previous Guides, we recommended that you choose a 64KB allocation unit size for your drives, as Microsoft recommends. This recommendation remains, even in a virtualized environment.

Installing the Hyper-V role

The enabling of Hyper-V on your Windows Server 2008 installation is very straightforward, and you can do it in just a few short steps.

> **NOTE:** Plan on at least 12 minutes for installing the Hyper-V role on your Dell PowerEdge server. Each step below takes at least 1 minute. We provide the approximate amount of time each step takes in parentheses. These times exclude data entry time.

1. Click Start, and then click Server Manager. Under Roles Summary, choose Add Roles.
2. Click Hyper-V (see Figure 14). Configure your networking as you desire, and then proceed to install the Hyper-V role. (1 minute)
3. The installation requires a reboot upon completion, after which the Hyper-V role finishes installing. (11 minutes, including the reboot)
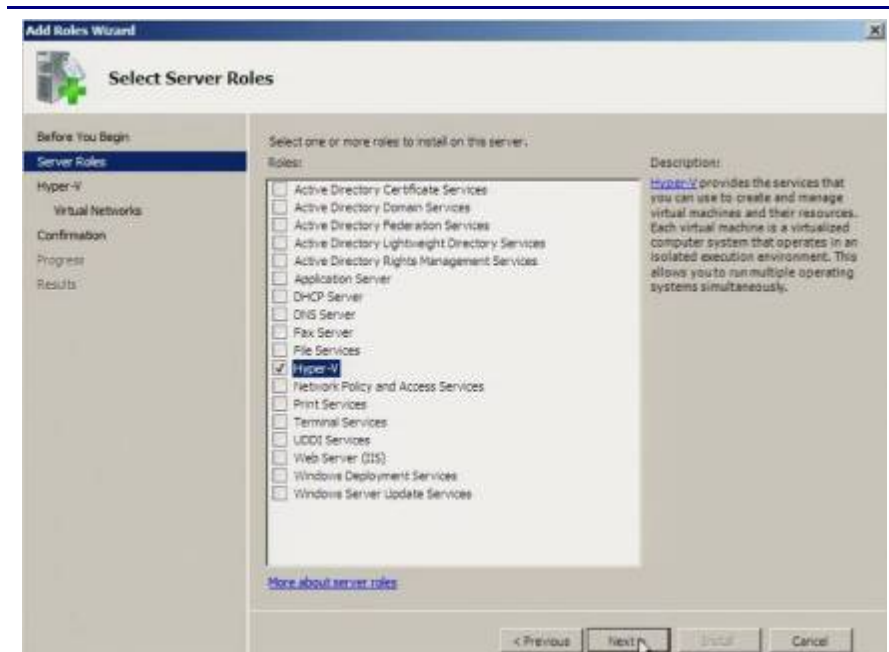
Figure 14. Installing the Hyper-V role in Windows Server 2008.

Summing up

As this Guide has explained, the process of preparing your Windows Server 2008 server and installing Hyper-V for a virtual SQL Server environment on a Dell PowerEdge Server is relatively straightforward; you can perform a basic installation and set up the Hyper-V role in under a few hours. We still recommend, however, that you first invest ample time in the pre-consolidation planning phase, because doing so can help you avoid potential problems during your consolidation.

For details and procedures on actually creating the child partition, installing SQL Server, and migrating your databases from your physical environment to your virtual environment, see our accompanying Guides.

Appendix A. Example server and database consolidation survey

In this appendix, we give an example survey of detailed information you may want to gather about the SQL Server instances and databases you are targeting for consolidation. While this survey is a good starting point, it may not contain every relevant detail for your particular environment.

1. Hardware level
   a. CPU
      i. Vendor
      ii. Model
      iii. Number of cores per socket
   b. Memory
      i. Total quantity in GB
      ii. Memory speed
   c. Storage
      i. Quantity, both current and projected data growth (see database section)
      ii. Disk speed
      iii. Disk interface (SCSI, SAS, etc.)
2. OS level
   a. Server name
   b. IP address, subnet, etc.
   c. Domain information
   d. Operating system version, build number, and service pack
   e. Drive letter information and layout
3. SQL instance level
   a. Whether it is clustered, version, edition (Workgroup, Standard, Enterprise), 64-bit or 32-bit (and if 32-bit, with or without AWE), and service pack. Different licensing models apply depending on what edition you choose as well.
   b. Authentication mode (Windows only or mixed mode?)
   c. Instance name (if not a default instance)
   d. SQL port number (i.e., is it the default 1433 or another port? If a named instance, what is the port?)
   e. Communication protocol (named pipes or TCP/IP?)

      f. Service account and all service permission information (does SQL Agent run under a different service account?)

      g. Are there any non-default master or model database objects?

      h. Are there any linked server objects?

      i. Are other SQL modules involved or dependent on this instance (e.g., Analysis Services, Reporting Services, etc.)?

      j. Default installation directories, data directories, and log directories

      k. Tempdb – Is it highly volatile? Slightly volatile? Medium usage?

4. Database level

      a. Database properties and options

      b. Recovery model, auto-shrink, etc.

      c. Files and filegroups

        i. Size

        ii. Location

5. Backups

      a. How many full backups, and on what schedule?

      b. How many differential backups, and on what schedule?

      c. How many log backups, and on what schedule?

      d. Current backup window?

      e. Can backup window shift to accommodate the consolidated backup window?

      f. Other backup issues

6. Other issues

      a. Is this database in a replication configuration?

      b. Do any SQL Server Integration Services (2005/2008)/Data Transformation Services (2000) packages reference this database?

      c. Do any SQL Agent jobs reference this database?

7. Users/Logins

      a. Number of users this database affects

      b. Would this database require a login whose name conflicts with another name on the target consolidation server? If so, you would need to create the login and map the database user using `sp_change_users_login`.

Appendix B. Creating the RAID disk groups

For our installation, we used four RAID groups, which we allocated as follows:

- Parent partition operating system files, child partition/virtual machine operating system files, and SQL Server executable files
- SQL Server tempdb system database
- SQL Server user database files
- SQL Server transaction log files

We explain below how we configured these four disk groups. The directions assume you have not configured any virtual disks on your RAID controllers.

Cabling and storage

Allow at least 3 minutes to connect the PowerVault MD 1000 to the PowerEdge R900 or PowerEdge R905.

1. Connect the SAS cable from the external PERC 6/E controller on the PowerEdge to the IN port on EMM 1 on the PowerVault MD1000.
2. If necessary, toggle the switch on the front of the PowerVault MD1000 upwards so that the PowerVault MD uses unified mode.
3. Turn on the MD1000.

Creating the RAID groups for the PowerEdge R900 or PowerEdge R905

In these instructions, we use the names and numbers of the controllers as our test setup displayed them. Thus, on our PowerEdge, the PERC 6/i showed as Controller 0 and the PERC 6/E showed as Controller 1. The numbering on your system might differ.

Allow at least 10 minutes to complete the creation of the RAID groups on the PowerEdge R900 or PowerEdge R905.

1. Turn on the server.
2. During the boot sequence, the message Press <Ctrl><R> to Run Configuration Utility appears. Press <Ctrl><R>. Note: You have only a few seconds to do this.

3. Configure the RAID 10 for the OS and VMs. Select the controller for the internal drives, which is the PERC 6/i, and press Enter.
4. While highlighting Controller 0, press F2, and select Create New VD.
5. While highlighting the RAID level field, press Enter to open the drop-down list, and select RAID 10.
6. Using the Tab key to navigate, move to the Physical Disks section, and use the space bar to select the first four drives (Drives 0, 1, 2, and 3). Then tab to highlight OK, and press Enter.
7. A message box appears telling you that initializing the RAID is highly recommended, but destructive. Press Enter to clear the message.
8. Configure the RAID 10 disk group for the SQL Server tempdb database. Highlight Controller 0 again, and press F2. Select Create New VD.
9. While highlighting the RAID level field, press Enter to open the drop-down list, and select RAID 10.
10. Using the Tab key to navigate, move to the Physical Disks section. Use the space bar to select the remaining four drives (Drives 4, 5, 6, and 7). Then tab to highlight OK, and press Enter.
11. A message box appears telling you that initializing the RAID is highly recommended, but destructive. Press Enter to clear the message.
12. Highlight Virtual Disk 0, and press F2.
13. Select Initialization, then press Enter, and then select Fast Init. When the system prompts you with any warnings, highlight OK, and press Enter.
14. Highlight Virtual Disk 1, and press F2.
15. Select Initialization, press Enter, and then select Fast Init. When the system prompts you with any warnings, highlight OK, and press Enter.
16. Press F12 to return to the main level of the configuration utility.
17. Select the controller for the drive array (in our case, the PERC 6/E), and press Enter.
18. Configure the disk group to hold the SQL Server user databases. Highlight controller 1, press F2, and select Create New VD.
19. While highlighting the RAID level field, press Enter to open the drop-down list, and select RAID 10.
20. Using the Tab key to navigate, move to the Physical Disks section. Use the space bar to select the first

ten drives (Drives 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9).
Then tab to highlight OK, and press Enter.

21. A message box appears telling you that initializing
the RAID is highly recommended, but destructive.
Make sure to select OK, and press Enter.

22. Configure the RAID 10 disk group to hold SQL Server
transaction log files. Highlight Controller 1 once
again, and press F2. Select Create New VD, and
press Enter.

23. While highlighting the RAID level field, press Enter to
open the drop-down list, and select RAID 10.

24. Using the Tab key to navigate, move to the Physical
Disks section. Use the space bar to select the next
four drives (Drives 10, 11, 12, and 13). (Note that
the drives you allocated earlier no longer appear in
the available list.) Then tab to highlight OK, and
press Enter.

25. A message box appears telling you that initializing
the RAID is highly recommended, but destructive.
Click OK.

26. To use the remaining disk as a hot spare on the
PowerVault MD1000, follow these steps:

   a. Press <Ctrl><N> to navigate to the Physical
   Disk page of the RAID setup. Press the down
   arrow key to select the last disk, which should
   have no Disk Group assigned.

   b. Press F2, and then select Make Global HS. Press
   Enter. If you see a message box asking if you
   want the global hot spare to give priority to the
   enclosure in which it resides, click Yes. This disk
   is now a global hot spare for both Disk Groups
   on the external storage array.

27. Press <Ctrl><P> to navigate back to the Virtual Disk
Management screen. Highlight each Virtual Disk, and
press F2. Select Initialization, and then select Fast
Init. Accept OK when the system prompts you with a
warning. After you select Fast Init, a progress bar
appears briefly, and then disappears.

28. Exit the RAID utility, and reboot the server.

Appendix C. Installing Windows Server 2008 Enterprise Edition as the host OS

Install Microsoft Windows Server 2008 Enterprise Edition by following these steps. We provide approximate times for each group of steps in the first step of that group.

To complete the installation of Windows Server 2008, allow 34 minutes on the PowerEdge R900 or 50 minutes on the PowerEdge R905.

1. Insert the Microsoft Windows Server 2008 Enterprise Edition DVD into the DVD drive, and reboot the system.
2. Once the boot process begins, press F2 to enter setup.
3. In setup, scroll down to CPU Information, and press Enter.
4. Enable Virtualization Technology, if necessary.
5. After you have checked the BIOS settings, press Escape to continue the boot. (4 minutes)
6. During the boot, a Windows is loading files message appears, followed by a Windows booting loading bar. (2 minutes)
7. At the Install Windows Server 2008 screen, accept the defaults of English language, English time and currency format, and US keyboard or input method by clicking Next.
8. Click Install now. (1 minute)
9. At the Type your product key for activation screen, enter your activation key, and click Next.
10. At the Select the edition of Windows that you purchased screen, click Windows Server 2008 Enterprise Edition (Full Installation), check the I have selected the edition of Windows that I purchased box, and click Next.
11. At the Please read the license terms screen, check the I accept the license terms checkbox, and click Next.
12. At the Which type of installation do you want? screen, for Type of install, click Custom (Advanced).
13. In the Where do you want to install Windows? screen, click Drive options (Advanced).

14. Highlight the partition, and click Next to start the installation. (18 minutes on the PowerEdge R900; 20 minutes on the PowerEdge R905, during which Windows restarts twice)
15. When the system indicates that you must change the user's password before you log on the first time, click OK.
16. Enter a strong password in both the New password and Confirm password fields, and click the arrow.
17. At the Your password has been changed prompt, click OK. Windows then prepares the desktop. (less than 1 minute)
18. Set the time zone.
19. Set the IP address, subnet mask, and domain information as per the steps in the next section.
20. Install Windows updates. We installed all updates, including the optional ones. Depending on your particular environment, you may need to change the default firewall settings for Windows update to work. (8 minutes on the PowerEdge R900; 11 minutes on the PowerEdge R905, during which Windows restarts twice; download times vary)
21. Reboot the server. (3 minutes)

Setting IP address, subnet mask, and domain information

After rebooting, set the static IP addresses and subnet mask using the following process:

1. Click Start.
2. Right-click Network, and select Properties.
3. In the Network Sharing Center, click Manage network connections.
4. Right-click the Local Area Connection, and select Properties.
5. In the Local Area Connection Properties dialog, highlight Internet Protocol Version 4 (TCP/IPv4), and click Properties.
6. Click the radio button next to Use the following IP address.
7. Type the IP address you want the server to have, the Subnet mask, and the Preferred DNS server, and click OK.
8. Close the Network Connections window.

9. From the Start menu, right-click Computer, select
   Properties, and then select Advanced system
   settings.
10. Select the Computer Name tab.
11. Click Change.
12. Enter the server name.
13. Click the Member of Domain radio button.
14. Enter the domain name.
15. Enter the user name and password when the system
    prompts you to do so. (less than 1 minute)
16. When the Computer Name/Domain Changes window
    appears, click OK to close it.
17. Click OK to go past the warning to restart.
18. Click OK to close the System Properties window.
19. Click Restart Now to reboot the server. (3 minutes)

Configuring data drives

Configure each of the three non-operating system RAID drives on
the server using the following steps:

1. Click Start.
2. Expand Administrative Tools, and click Computer
   management.
3. In the left panel, expand Storage, and select Disk
   Management. If the Initialize Disk dialog box
   appears, click OK.
4. Right-click the unallocated disk, and select New
   Simple Volume.
5. On the Welcome to the New Simple Volume Wizard
   screen, click Next.
6. Leave the volume size at the default, and click Next.
7. Leave the drive letter at the default, and click Next.
8. On the Format Partition screen, do the following:
   a. Leave the File System as NTFS.
   b. Set the Allocation Unit size to 64 K. (Note:
      Windows Server 2008 Enterprise Edition grays
      out the option to compress the drive.)
   c. Fill in a volume name if you want the disk to
      have one.
   d. Optionally, select the quick format checkbox.
9. Click Next.
10. On the Completing the New Simple Volume Wizard
    screen, click Finish.

Adding the Hyper-V role

Allow at least 12 minutes for adding the Hyper-V role.

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1. Click Start.
2. Expand Administrative Tools, and click Server Manager.
3. Right-click Roles, and select Add Roles.
4. On the Before You Begin page, click Next.
5. On the Select Server Roles page, select Hyper-V. Click Next.
6. On the Hyper-V page, click Next.
7. On the Create Virtual Networks page, select the appropriate Local Area Connections, and click Next.
8. On the Confirm Installation Selections page, click Install. (1 minute)
9. On the Installation results screen, click Close.
10. Click Yes when Windows prompts you to reboot the server. (3 minutes)
11. After the boot, you will see the Resuming Configuration window.
12. When you see the Installation Results page, click Close. (8 minutes)

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