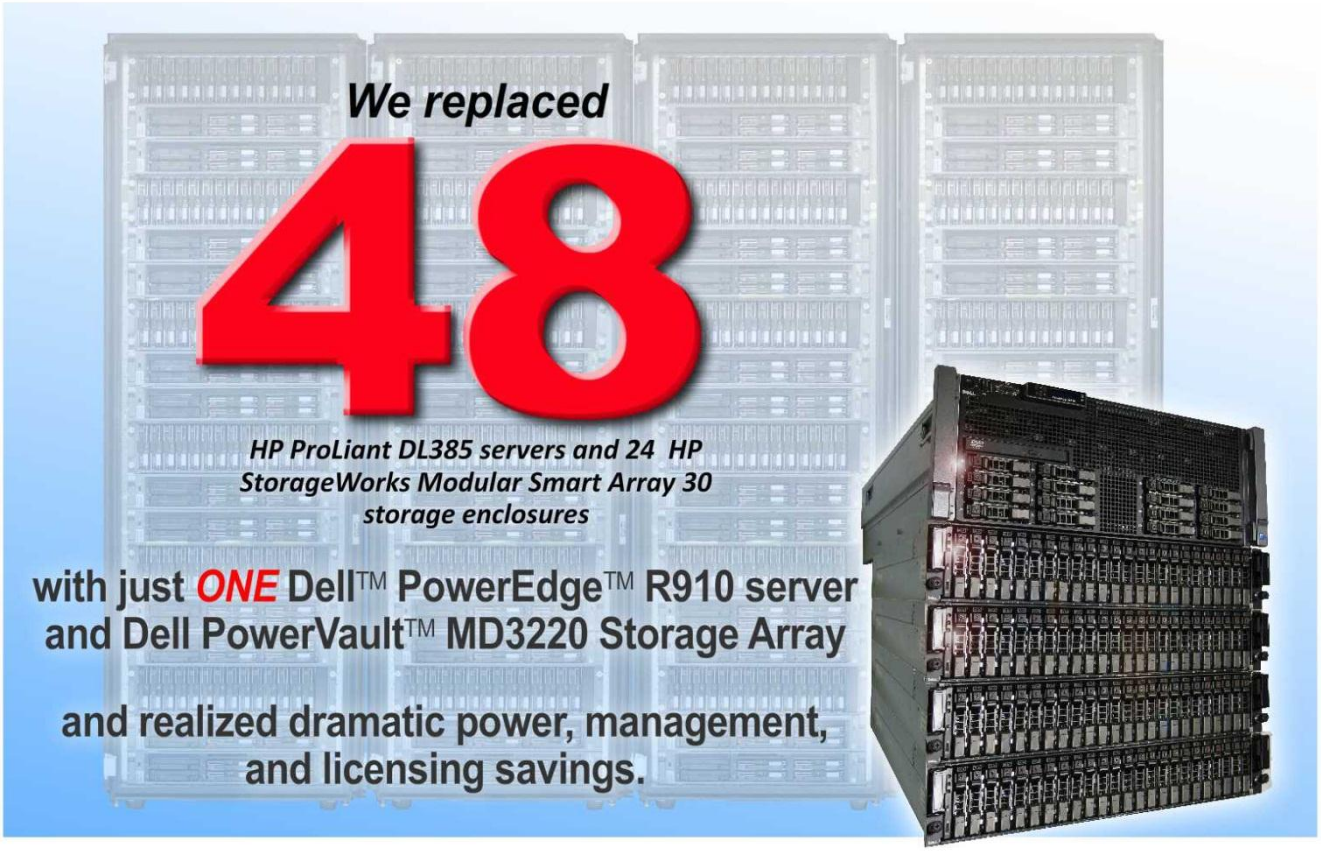
SERVERS: VIRTUALIZED DATABASE CONSOLIDATION ON A DELL POWEREDGE R910 SERVER USING HYPER-V



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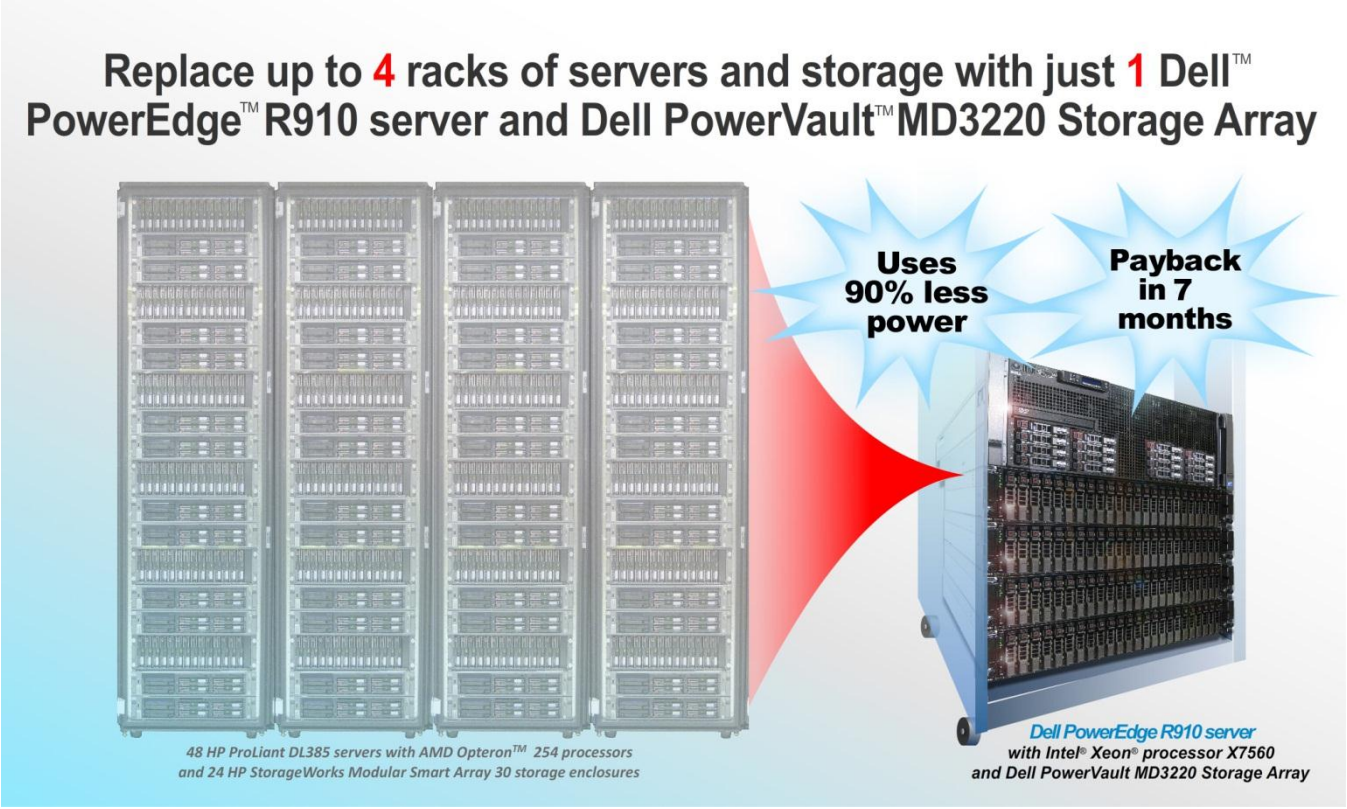

Executive summary

Advances in processor, server, and database technologies enable enterprises to reduce costs by consolidating multiple older databases onto a single newer, faster server. The new Dell PowerEdge R910, Microsoft® Windows Server® 2008 R2 Hyper-V™, the latest Intel Xeon processor 7500 series, and the new Dell PowerVault MD3220 SAS Storage Array (which we refer to as the Dell PowerEdge R910 solution) can let organizations realize significant consolidation savings.

This Principled Technologies (PT) Guide is the result of performance tests and consolidation procedures we performed. We provide concepts and procedures that will help you successfully consolidate your Microsoft SQL Server 2000 instances from multiple older servers onto a single Microsoft Windows Server 2008 R2 system running Hyper-V with Microsoft SQL Server 2008 R2 running inside virtual machines (VMs). We compared the performance and power consumption of the new and old solutions, and then we analyzed these and other factors to gauge the level of savings you could realize by consolidating servers.

As the results from our hands-on tests show, the Dell PowerEdge R910 solution can run as many as 48 older database workloads, each of which will perform as well as if it were on an older dedicated server-and-storage solution. Such virtualized consolidation saves space, reduces system management costs, lowers licensing costs, and decreases power consumption by over 90 percent. The result is an estimated payback period of less than 7 months and a 3-year return on investment (ROI) of 318 percent.

NOTE: In addition to the above study, we tested a high-capacity scenario, increasing the server's RAM to 512 GB, and achieved a consolidation ratio of 60:1, and an OPM increase of 67:1. See Appendix L for details.

New Dell technology makes major savings easy

The Dell PowerEdge R910, featuring the latest Intel Xeon processor 7500 series and the latest Hyper-V technology from Microsoft, lets you consolidate numerous servers and an unprecedented number of SQL Server database workloads onto a single server, resulting in significant savings.

Features of the new Dell PowerEdge R910

The Dell PowerEdge R910 offers many new features for maximizing performance on database and other applications and for minimizing operational expenses. These include the following:

Power. The Dell PowerEdge R910 includes enhancements that let it use less energy than many older servers. When you consolidate many legacy servers onto a single Dell PowerEdge R910, the potential power savings are dramatic.

Processors. The Dell PowerEdge R910 uses the Intel Xeon processor 7500 series. These processors automatically adjust their speed and energy usage to meet the requirements of your applications, improving performance and saving power. These features, combined with support for ever-increasing amounts of memory, provide an excellent platform for implementing Microsoft Hyper-V and consolidating many individual database workloads onto one machine.

Management. The Dell PowerEdge R910, like all late-model Dell servers, comes with the Dell Lifecycle Controller. This tool simplifies management by providing a single interface for management functions and by storing critical system information in the system itself. There are no CDs or USB keys to keep track of for drivers or firmware.

Features of the Intel Xeon processor 7500 series

The Intel Xeon processor 7500 series offers businesses a number of advantages, including the following:

Larger cache. The Intel Xeon processor 7500 series contains up to 24 MB of shared L3 cache, increasing the previous-generation processors' cache amounts by a significant margin.

Greater scaling power. The newest generation of Intel processors brings eight processing cores to each chip, along with hyper-threading, totaling 16 logical processors per physical processor.

QuickPath. Intel QuickPath Technology provides fast access to the increased memory addressable by these processors.

Turbo Boost Technology. Intel Turbo Boost Technology automatically allows processor cores to run faster than the base operating frequency if the server is operating below power, current, and temperature specification limits.

Reliability, Availability, and Serviceability (RAS) features. Intel adds new RAS features to the Intel Xeon processor 7500 series platform, such as Machine Check Architecture (MCA). Now the CPU can isolate issues on the chip or in memory in real time, alert the operating system to log the error, and avoid crashes.

Features of the new Dell PowerVault MD3220

The Dell PowerVault MD3220 SAS Storage Array offers many new features for providing affordable performance with simple management tools, including the following:

Performance. The Dell PowerVault MD3220 uses the next-generation 6Gbps SAS back-end technology to provide maximum performance for each drive. Four SAS ports and 2GB cache per controller provide maximum performance for any application. Base and turbo-mode performance options allow customers to save on upfront costs and upgrade to turbo mode to provide additional performance when needed.

Flexibility and scalability. The Dell PowerVault MD3220 allows you to mix and match drives and Dell PowerVault MD1220 or Dell PowerVault MD1200 enclosures to provide the flexibility of a tiered storage environment. This allows you to utilize up to 96 disks—2.5" disks, 3.5" disks, or any combination of the two.

System management. The Dell PowerVault MD3220 uses the new MD Storage Manager software, which provides an easy-to-use

interface. The MD Storage Manager lets you manage multiple MD storage arrays in a single window and the wizard-based array management lets you manage your array with ease.

Availability and optional data protection. The Dell PowerVault MD3220 provides fully redundant power supplies and dual controllers with write-cache mirroring; this means data is always highly available, even in the case of a component failure, and no data loss or corruption occurs. The optional snapshot feature lets you take up to 128 snapshots per system as well as unlimited virtual disk copies.

Features of Microsoft Windows Server 2008 R2 Hyper-V

Hyper-V, a role included in Microsoft Windows Server 2008 R2, provides a scalable and robust virtualization platform for businesses to consolidate legacy environments via virtualization. Among its key features are the following:

Increased processor support. Hyper-V in Windows Server 2008 R2 now supports hosts with up to 64 logical processors in the host processor pool, which increases your flexibility in running demanding workloads on fewer hosts. At the VM level, Hyper-V lets you assign one to four vCPUs to virtual machines.

Live migration enhancements. Hyper-V now supports migrating VMs from one node to another across different CPU versions within the homogenous processor families.

Dynamic memory (available in SP1). The addition of the dynamic memory feature in Windows Server 2008 R2 SP1 lets the hypervisor host dynamically adjust guest RAM allocations based on real usage.

Features of Microsoft SQL Server 2008 R2

SQL Server 2008 R2 is the latest release of the Microsoft database management platform. As with each release, Microsoft has added new features to expand on the capabilities of their Database Management System (DBMS) platform. Where earlier versions of SQL Server required database administrators to largely rely on either in-house applications or third-party tools to monitor multiple instances, SQL Server 2008 R2 simplifies multi-server management. SQL Server 2008 R2 also introduces the SQL Server Utility, offering a rapid enterprise view of the complete environment and utilization statistics. Microsoft Hyper-V completely

supports virtualizing SQL Server 2008 R2 by allowing flexible and dependable consolidation.

The power of consolidation

What is consolidation?

Generally speaking, *consolidation* is the process of combining multiple items to make a single, more effective unit. In an IT context, you can consolidate the following:

Physical servers. After a successful server consolidation, all applications should run on fewer servers than before. Ideally, those applications should run at least as well as they did previously and potentially better.

Storage. Depending on your setup, consolidating servers may also let you consolidate storage by moving data from a number of servers to a single large-disk storage subsystem in a new server.

Space. As you consolidate servers, you will likely reduce the number of racks or even the number of locations that house servers.

In this Guide, we address the consolidation of multiple stand-alone SQL Server 2000 server-and-storage solutions to a virtualized server-and-storage solution powered by the Dell PowerEdge R910, the Dell PowerVault MD3220, and Microsoft Windows Server 2008 R2 Hyper-V. As we will demonstrate, consolidating multiple servers to one virtualized environment saves on space, hardware costs, licensing costs, power, cooling, and administrative overhead.

Why consolidate?

An effective server-and-storage solution consolidation effort has the potential to yield an environment with more consistent management practices and improved reliability, security, and hardware utilization—all while maintaining the previous level of application performance.

Consolidation can also yield a variety of cost savings, including the following:

Hardware savings. Buying, powering, and supporting fewer servers brings obvious savings. Other potential hardware cost savings include the need for fewer racks and network switches: as the number of servers decreases, these costs decrease as well.

Software license savings. Consolidation can save organizations significant money in software licenses.

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

Reduced support costs. The cost of a given level of support is typically proportional to the size of the installation. By reducing the number of servers, support costs are also likely to decrease.

Power and cooling savings. Consolidating servers saves power and cooling by using fewer more efficient systems.

Sizing and baseline performance

One key to a successful consolidation is sizing, the process of gathering different performance baselines so you have an approximate set of requirements the new hardware platform must meet. You do this by determining the performance characteristics of existing hardware during normal business operations, and then applying growth and scalability estimates.

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

- Processor utilization
- Memory requirements of the operating system and applications
- Disk layout
- Database size
- Expected database growth
- Maximum concurrent users
- Types and rates of transactions against the databases

The server you select for consolidation must do more than match the combined capacity of your older servers today - it must also have enough excess capacity to still perform well at the end of its expected life span.

The Dell PowerEdge R910 we tested for this Guide is a high-performance server that can readily support significant consolidation. It has four Intel Xeon processors X7560 with eight cores each, 256 GB of RAM, and has been optimized to reduce both power consumption and heat dissipation. In addition, the Dell PowerVault MD3220 gives the server access to multiple terabytes of enterprise storage.

Running the numbers

Under 7-month payback

Payback period

As we discuss above, consolidating older database server-and-storage solutions lets you reduce energy usage, save data center space, reduce software license costs, and lower management costs. Tests in PT's labs show that a four-socket Dell PowerEdge R910 server with 256 GB of RAM and the Dell PowerVault MD3220 Storage Array, supplemented by three Dell PowerVault MD1220 expansion enclosures, could consolidate four full racks of older database servers and storage, including 48 AMD Opteron™ 254-based HP ProLiant DL385 servers with 4 GB of RAM, with each pair sharing one of 24 HP StorageWorks Modular Smart Array (MSA) 30 storage enclosures (we refer to these as the 48 HP ProLiant DL385 solutions). Such consolidation would deliver rapid return on investment (ROI) and a quick payback.

We used the open-source DVD Store (DS2) benchmark to provide a workload representative of a real-world database application. With it, we measured the database performance of an older server-and-storage solution running Microsoft Windows Server 2003 R2 with Microsoft SQL Server 2000. We then measured how many of those workloads the new Dell PowerEdge R910 solution running Hyper-V could host. The new server ran Microsoft Windows Server 2008 R2 Hyper-V, with Microsoft Windows Server 2008 R2 and Microsoft SQL Server 2008 R2 running inside each VM. We detail the test results in The Dell PowerEdge R910 performance story section of this Guide. The Dell PowerEdge R910 solution was able to consolidate 48 of these database workloads while still maintaining the same average orders per minute (OPM) as the solutions it replaced. We also show a high-capacity scenario with 512GB of RAM that consolidates 60 database workloads in Appendix L.

The 48-workload consolidation could deliver payback in less than 7 months and an ROI of 318 percent after 3 years.

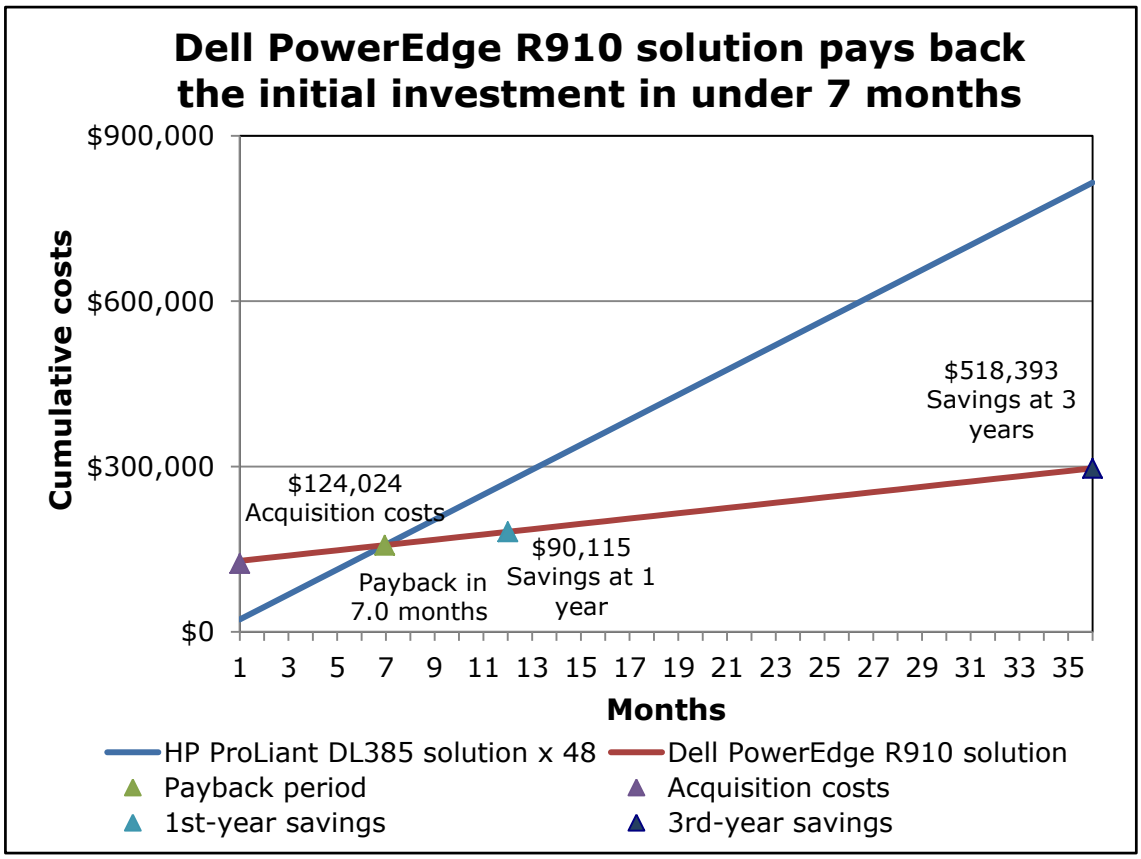

Figure 1. The payback period and accumulated estimated costs for the 48 HP ProLiant DL385 solutions and the Dell PowerEdge R910 solution. The Dell PowerEdge R910 solution delivers payback and savings in the first 7 months. Lower costs and higher savings are better.

Figure 1 graphs the payback period and the 3-year cost savings of the Dell PowerEdge R910 solution. The line representing the Dell PowerEdge R910 solution accumulates the initial investment cost and the monthly costs of the solution. The initial investment cost includes the list price of the server and the storage array as well as the costs of migrating from the HP ProLiant DL385 solutions to the newer Dell PowerEdge R910 solution. The line for the HP ProLiant DL385 solutions shows the accumulated costs of these solutions. The lines cross at the end of the payback period, the point at which solution savings equal the initial investment. Savings continue after the payback period. By the end of year one, we project savings of $90,115 with the Dell PowerEdge R910 solution.

The Dell PowerEdge R910 solution uses a little less than 1/12th the power under typical load, 1/12th the Microsoft SQL Server licenses and Microsoft Windows Server licenses, and about 1/14th the data center rack space of the 48 HP ProLiant DL385 solutions, and requires less administrator time to manage fewer servers and storage arrays.

See Appendix A for more information on these savings and calculations.

318 percent ROI in 3 years

We calculate the return on the investment in the Dell PowerEdge R910 solution by dividing the savings after 3 years ($518,393) by the acquisition costs ($124,024) and subtracting 1. ROI is 318 percent after 3 years.

The Dell PowerEdge R910 performance story

48 databases, 16 virtual machines, 1 server

Our virtualized testing with DVD Store

Using our new hardware environment, which consisted of a single Dell PowerEdge R910 and Dell PowerVault MD3220, we configured multiple virtual machines in Hyper-V, installed Windows Server 2008 R2 on those VMs, and finally installed SQL Server 2008 R2 on the VMs. To simulate a real-world virtualization effort, we configured 16 VMs on the Dell PowerEdge R910, each running one instance of SQL Server 2008 R2 with multiple database workloads. The total number of legacy workloads we were able to consolidate on the Dell PowerEdge R910 with 256 GB of RAM while still maintaining, on average, the same overall throughput as before, was 48. Again, for a high-capacity scenario with 512 GB of RAM, see Appendix L.

About DVD Store

DVD Store Version 2 is an open-source application with a back-end database component, a front-end Web application layer, and a driver layer that actually executes the workload. DS2 models an online DVD store. Simulated customers log in; browse movies by actor, title, or category; and purchase movies. The workload also creates new customers. Browsing movies involves select operations, some of which use full-text search and some of which do not. The purchase, login, and new customer stored procedures involve update and insert statements, as well as select statements. The DS2 benchmark produces an orders-per-minute metric (OPM), which we report in this Guide. For more details about the DS2 tool, see http://www.delltechcenter.com/page/DVD+Store.

Our test bed setup

On the HP ProLiant DL385 server running Windows Server 2003 R2 with SP2 and one instance of SQL Server 2000, we used 4 GB of RAM, allocating 3 GB of RAM to user processes via the boot.ini

/3GB switch as was typical in a server of its time. We used four internal hard drives (73GB 15,000 RPM SCSI) that we configured in two RAID 1 volumes, installing the OS on one volume and using the other volume for SQL Server logs. We configured the external storage as one large RAID 5 LUN containing seven 146GB 10,000 RPM disks in an HP StorageWorks MSA30 storage enclosure. Because our goal was to emulate a 3- to 5-year-old database server, we chose RAID 5 for the external storage, a configuration typical of the time.

On the Dell PowerEdge R910 server running Windows Server 2008 R2 Hyper-V and 16 VMs, we used 256 GB of RAM, allocating 15,000 MB of RAM to each VM in Hyper-V Manager. We used 4 internal hard drives (146GB 15,000 RPM 6Gb SAS) in a RAID 5 configuration and installed the host OS on that internal volume. We used 12 additional internal drives in a RAID 10 configuration for virtual hard drives (VHDs) to hold SQL Server logs for the VMs (146GB 15,000 RPM 6Gb SAS). All internal drives were attached to the PERC H700 internal 6Gb SAS storage controller. We configured a Dell PowerVault MD3220 Storage Array and three Dell PowerVault MD1220 expansion arrays into four separate RAID 10 disk groups with 24 disks in each group and one volume per group. We created 48 VHDs: 16 for guest OS partitions, 16 for SQL Server logs, and 16 for SQL Server data. We placed the OS VHDs on the Dell PowerVault MD3220 volume for capacity reasons. We placed the 16 SQL Server log VHDs on the internal volume. Finally, we distributed the 16 SQL Server data VHDs across the four trays of storage evenly (one Dell PowerVault MD3220 and three Dell PowerVault MD1220 trays).

We ran only one database workload on the single SQL Server 2000 instance on the HP ProLiant DL385 because the system memory and disk subsystems of the system were saturated with just one database workload. We ran 16 VMs on the Dell PowerEdge R910, each with one SQL Server 2008 R2 instance, and added database workloads evenly across the VMs making sure the average OPM across all the workloads exceeded the original OPM on the HP ProLiant DL385.

In Figure 2, we show the disk layout on the Dell PowerEdge R910 solution. All of the VMs' data resided on the Dell PowerVault MD3220 array and the Dell PowerVault MD1220 expansion arrays.

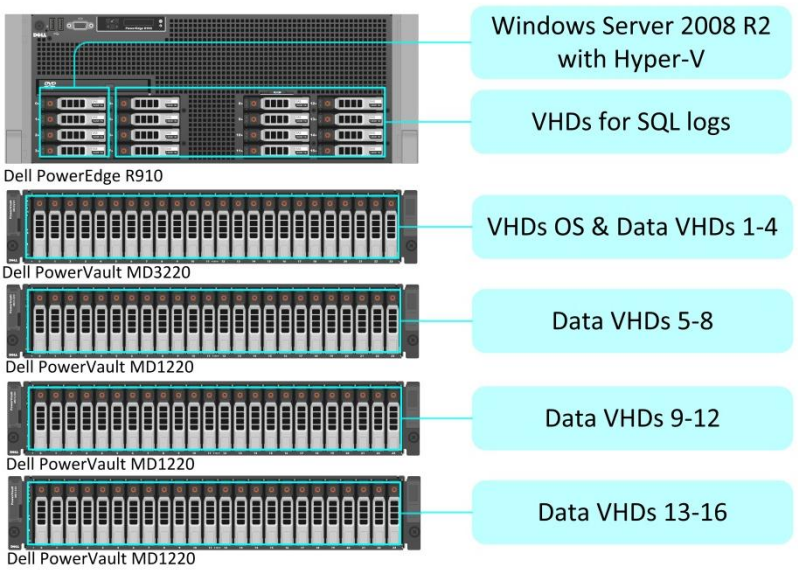

Figure 2. Disk layout for our virtualized SQL Server 2008 R2 testing.

For client machines, we used desktop systems running Windows Server 2003 R2 with SP2. Each of these client machines ran the DS2 workload, which spawned 32 threads against each database workload and ran with no think time. On the HP ProLiant DL385 server, we used one client and one SQL Server 2000 instance, containing one database. When testing the Dell PowerEdge R910 server, we used 23 virtual Hyper-V clients and one physical client to ensure that the virtualization of the client machines did not affect the results. Each client targeted two databases. This simulated a heavily loaded environment on all of our databases.

We ran the DS2 benchmark with a 10GB database. On average, each SQL Server 2008 R2 database workload on the Dell PowerEdge R910 solution delivered better performance than did the same workload on a single HP ProLiant DL385 solution. We then estimated the monthly costs for maintaining the 48 HP ProLiant DL385 solutions and the single Dell PowerEdge R910 solution, and estimated the payback period for the investment in the Dell PowerEdge R910 solution.

Our testing results

As Figure 3 shows, we were able to run 48 SQL Server 2008 R2 database workloads (3 databases on each of 16 SQL Server instances on each of 16 VMs), all simultaneously achieving an average throughput greater than the HP ProLiant DL385 solution's OPM score. The average OPM delivered by each of the 48

workloads on the Dell PowerEdge R910 solution was 7,059, while the average OPM delivered by a single workload on the HP ProLiant DL385 solution was 6,639.

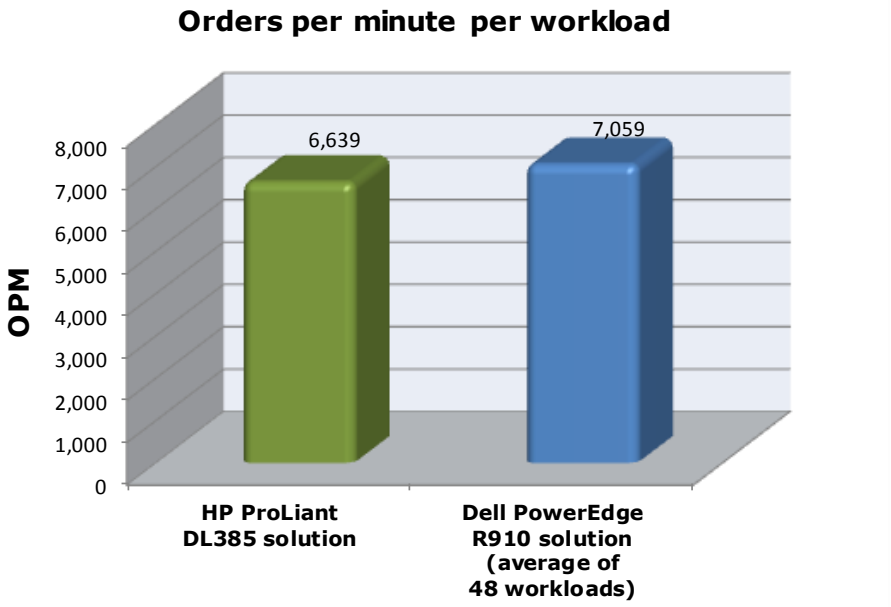

Figure 3. Average OPM of 48 database workloads on the Dell PowerEdge R910 solution versus a single database workload on the HP ProLiant DL385 solution. Greater OPM is better.

As Figure 4 shows, the combined OPM of 48 SQL Server database workloads on the Dell PowerEdge R910 solution was over 50 times greater than the OPM of a single HP ProLiant DL385 solution database workload.

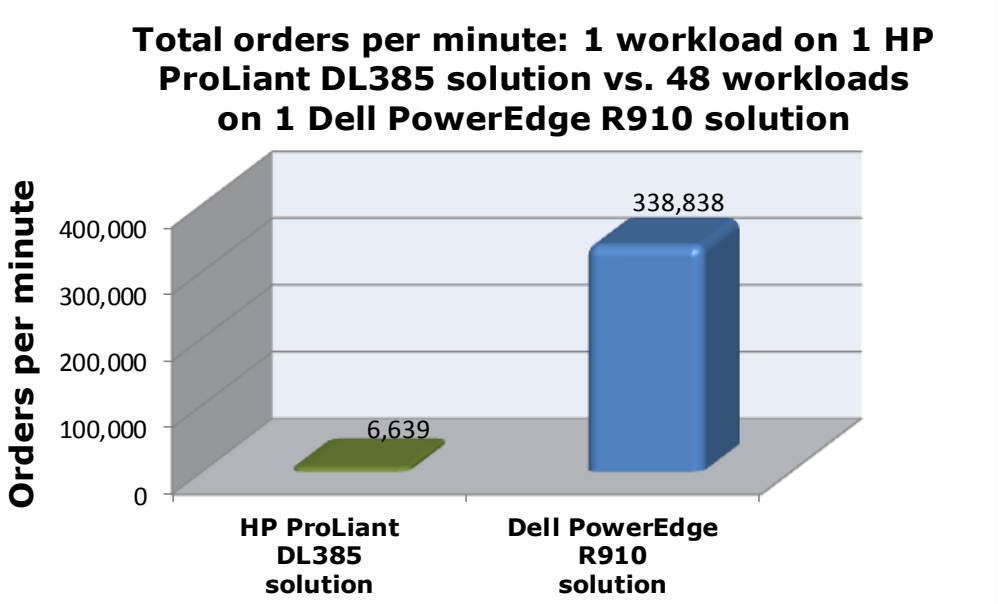

Figure 4. Combined orders per minute of 48 database workloads on the Dell PowerEdge R910 solution versus a single database workload on the HP ProLiant DL385 solution. Greater OPM is better.

Power savings

As Figure 5 shows, assuming we were running 48 HP ProLiant DL385 servers, each using half of a HP StorageWorks MSA30 external enclosure, for a total of 24 enclosures, we would significantly reduce our power consumption. Power consumption at idle and under load both decreased by over 90 percent when switching to the Dell PowerEdge R910 solution. We calculated this by measuring the wattage of a single HP ProLiant DL385 solution, then multiplying the server wattage times 48 and the storage wattage times 24. We contrast this with the total power consumption of the Dell PowerEdge R910 solution. Lower wattage is better.

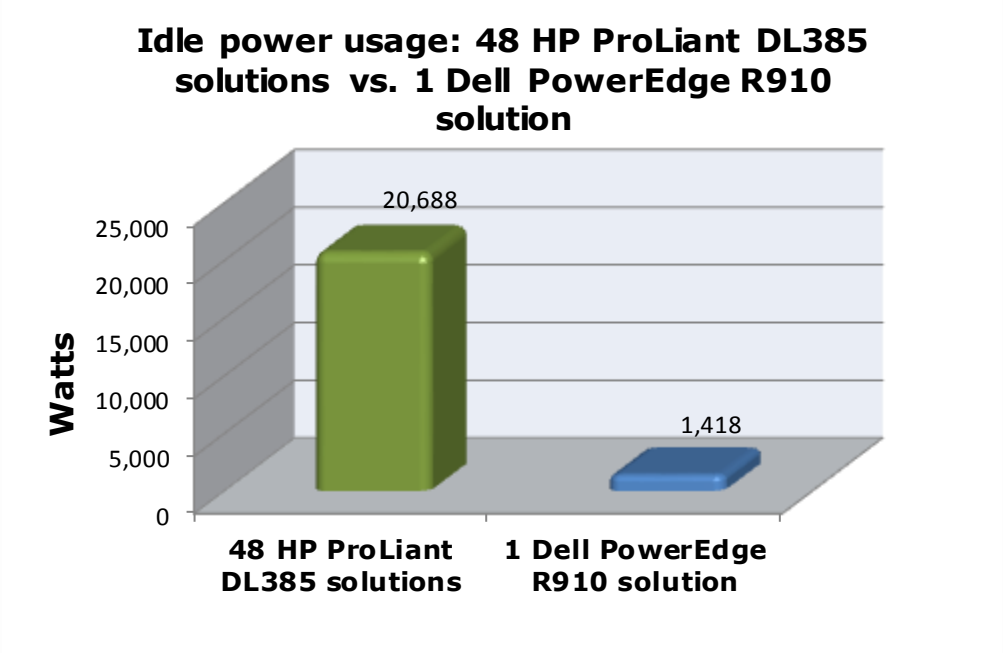

Figure 5. Simulated idle power savings – 48 HP ProLiant DL385 solutions versus a single Dell PowerEdge R910 solution. Lower idle power is better.

We show you how: Preparing for the move

We have shown why you should consolidate your older databases to a single Dell PowerEdge R910 solution with Microsoft Windows Server 2008 Hyper-V and SQL Server 2008 R2. Now we address the next question: How to accomplish this? We discuss planning issues, setup of the Dell PowerEdge R910 with Dell PowerVault MD3220 storage, setting up Hyper-V, the actual migration using a simple backup/restore method, and post-migration considerations.

Evaluating your databases

As with any migration or consolidation, planning is a key element. You must be aware of many specific details related to each physical server you target for consolidation, including the maintenance window in which you will migrate the server to its new environment, the users the move will affect, and the configuration tasks necessary to assimilate the databases into your consolidated environment. A more comprehensive example survey appears in Appendix B. Information to gather before consolidation includes 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

After moving your databases to their new SQL Server instance, 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 products, and so on.

Gathering 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 databases you are considering moving to the new environment. This effort serves two purposes. First, it provides a prime opportunity to identify potential problems before you move to a consolidated solution. Second, you can use the information you gather to map out your resource allocation needs, which you can then use to configure your new VMs in Hyper-V Manager, either by using memory allocations or virtual CPU allotments.

Configuring your storage

In our test bed, we used one Dell PowerVault MD3220 SAS Storage Array with three Dell PowerVault MD1220 arrays attached. This section provides an overview of the Dell PowerVault MD3220 configuration process when used in conjunction with the Dell PowerEdge R910. Appendix C provides complete, detailed installation instructions.

1. Power on the Dell PowerVault MD3220 array and all the attached Dell PowerVault MD1220 arrays. Install the MD Storage Manager software and use it to set up the array.
2. Connect the Dell PowerVault MD3220 array to the three Dell PowerVault MD1220 arrays and to the Dell PowerEdge R910. Use two cables between each Dell PowerVault MD1220 array and four between the Dell PowerVault MD3220 and Dell PowerEdge R910.

3. Use the MD Storage Manager's Automatic setup utility to create necessary volumes. Add a host and map the volumes and the Dell PowerEdge R910 to that host.

Installing Windows Server 2008 R2

This section provides an overview of the Windows Server 2008 R2 installation process on the Dell PowerEdge R910. (Appendix D provides complete, detailed installation instructions.)

NOTE: Plan on around 30 minutes for installing Windows Server 2008 R2 Enterprise Edition on the Dell PowerEdge R910 server. The time to install updates will increase over time as Microsoft releases OS updates for Windows Server 2008 R2.

1. Insert the Microsoft Windows Server 2008 R2 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.
2. For Hyper-V, you must install Standard, Datacenter, or Enterprise Edition. We chose Enterprise Edition. Accept the license terms, proceed with the installation, and enter the information the installation software requires.
3. Set your password; enter configuration information, including the public IP address and domain information; and reboot the system.
4. Download and install updates. (Download times will vary based on number and size of updates.)

Enabling the Hyper-V role

Enabling Hyper-V on your Windows Server 2008 R2 installation is very straightforward, requiring just a few short steps. We provide detailed instructions in Appendix E.

1. Click Start, and click Server Manager. Click Roles, and choose Add Roles.
2. Click Hyper-V. (See Figure 6.) Configure your networking as you desire, and proceed to install the Hyper-V role.
3. The installation requires one or more reboots upon completion, after which the Hyper-V role finishes installing.

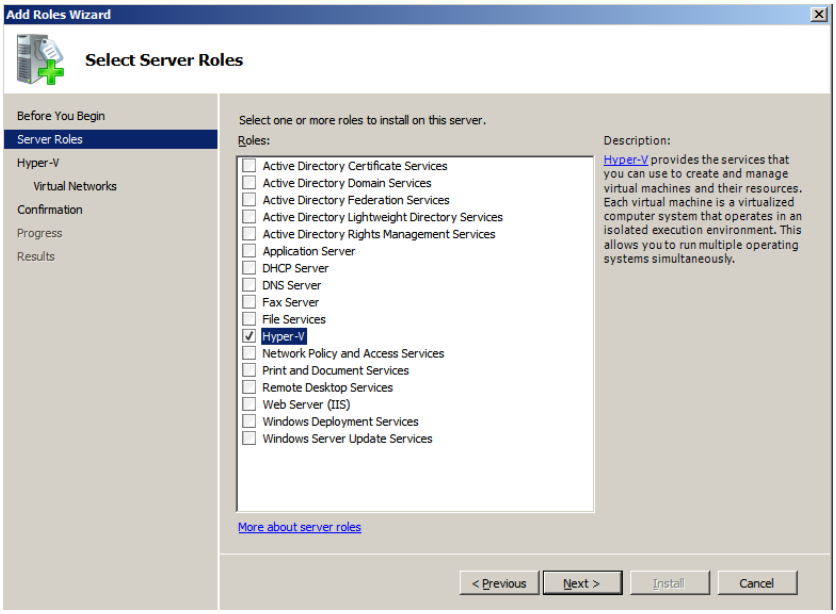

Figure 6. Installing the Hyper-V role in Windows Server 2008 R2.

Creating and configuring the virtual machines

To complete your preparation for your SQL Server installation in your new virtualized environment, you must finally create virtual machines on which to run the database software. Here, we provide an overview of the steps required to create your first virtual machine using Hyper-V Manager. For detailed steps on this process, see Appendix F.

1. Click Start→Administrative Tools, and click Hyper-V Manager.
2. Create a new VM, assigning two virtual processors, 15,000 MB of RAM, and create a 25GB VHD for the operating system to be installed on. Create additional VHD files if necessary. You may vary your resource allocations, such as virtual processors and RAM amounts, based on your specific needs. See Figure 7 for an example of the VM properties screen.
3. Insert the Windows Server 2008 R2 installation media, and attach the physical media to the VM.
4. Start the VM, and install Windows Server 2008 R2, which will require several reboots of the VM.

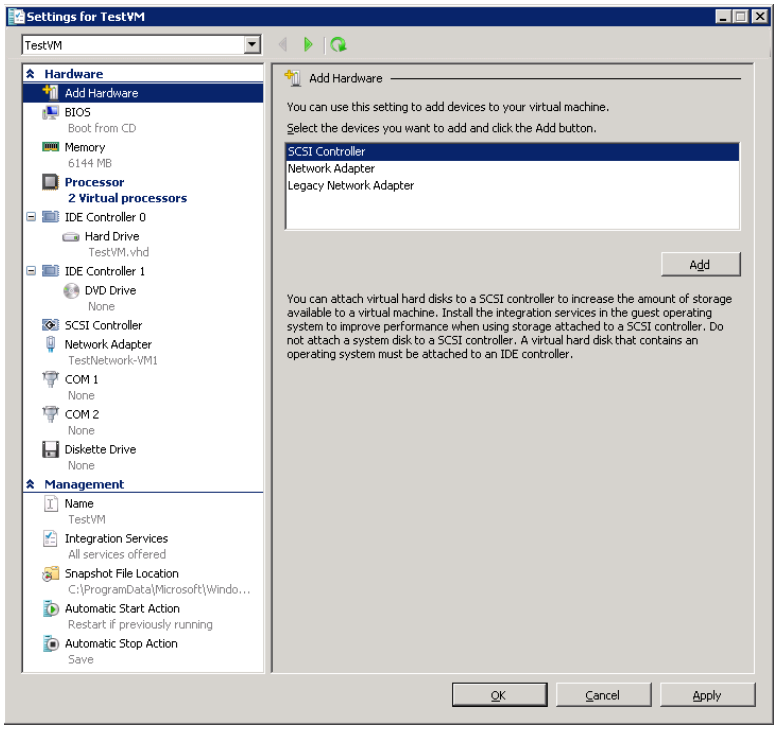

Figure 7. Virtual Machine configuration in Hyper-V.

Installing SQL Server 2008 R2 on the virtual machines

Although not required, you should, when possible, deploy SQL Server 2008 R2 in an Active Directory domain. Do not make the SQL Server service domain accounts members of the Domain Administrators group. In fact, grant only the necessary rights on the local server to the SQL Server service account as part of your pre-installation checklist. The SQL Server installation software creates the local groups it needs for its security purposes.

This section provides an overview of the SQL Server 2008 R2 installation process. Appendix G provides full, detailed installation instructions.

1. Insert the SQL Server 2008 R2 DVD into the physical DVD drive and mount the DVD to the relevant VM. Open the VM console. If prompted to enable the .NET Framework Core role, click OK.
2. On the Installation Center screens, choose Installation, and choose to proceed with a new installation. (See Figure 8.)

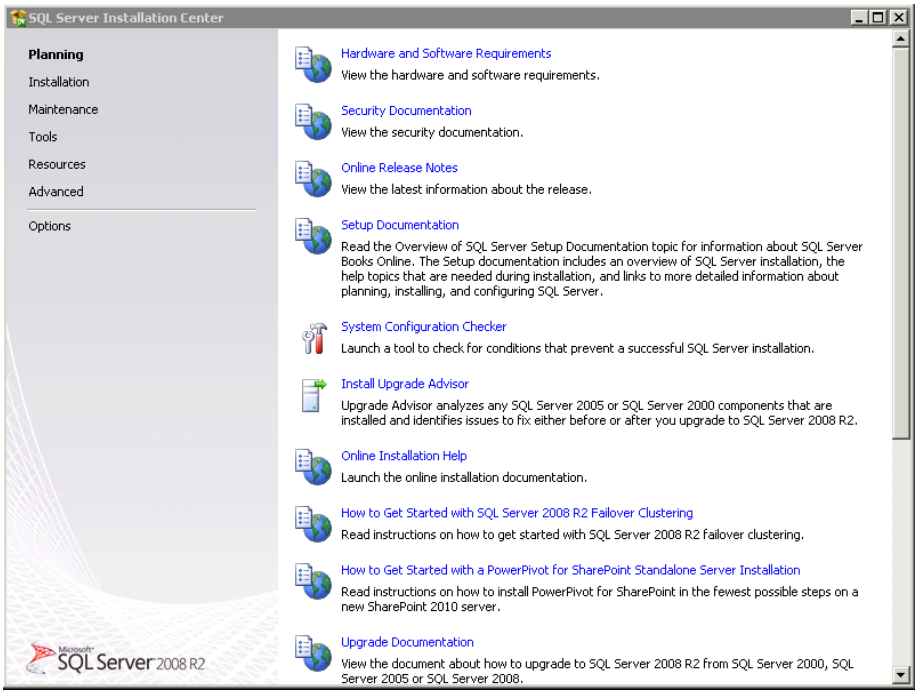

Figure 8. SQL Server 2008 R2 Installation Center options.

3. Proceed through the first several installation steps, entering license information, and installing prerequisites with default options specified. On the Setup Role screen, choose a SQL Server Feature Installation.
4. Proceed through the first several installation steps, entering license information, and installing prerequisites with default options specified. On the Setup Role screen, choose a SQL Server Feature Installation.
5. On the Feature Selection screen, select only what you need for your particular configuration. (See Figure 9.) In our case, we chose the Database Engine with Full-Text search and the management tools.

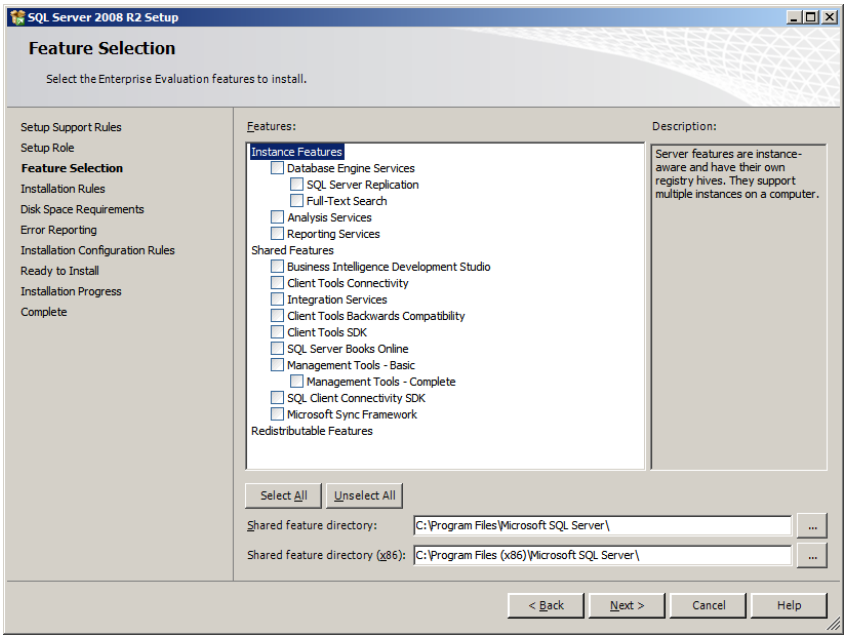

Figure 9. Choosing features for installation.

6. Choose to install the default instance unless installing multiple instances on the same VM.
7. Configure the credentials of the SQL Server service account and SQL Server Agent accounts.
8. Specify SQL Server administrators and also specify the authentication mode desired for your configuration. Microsoft recommends Windows Authentication mode, but legacy applications may require SQL Server authentication.
9. Complete the installation.

We show you how: Making the move

Upgrade Advisor makes it easy

The SQL Server 2008 R2 Upgrade Advisor is a major aid in migration research. This utility, which the SQL Server 2008 R2 setup wizard includes, scans legacy databases and SQL Server components for compatibility issues, features, and syntax the newer DBMS does not support, as well as many other critical components. The utility lets you view reports quickly in the Upgrade Advisor interface or save reports for later review.

You can install and execute the Upgrade Advisor on machines running Windows XP SP3, Windows Vista® SP1, Windows Server

2003 SP2, or Windows Server 2008. The Microsoft .NET™ framework is also a requirement.

BEST PRACTICE: Use the Upgrade Advisor tool on your SQL Server 2000 database and import a trace file to the Upgrade Advisor tool for analysis. The trace file lets the Upgrade Advisor detect issues that might not show up in a simple scan of the database, such as TSQL embedded in applications. Your migration research and planning must account for such instances. You can capture traces of TSQL using SQL Server Profiler on your SQL Server 2000 server during typical hours and analyze these traces using the Upgrade Advisor.

To install the Upgrade Advisor, use the following steps:

1. Insert the SQL Server 2008 R2 DVD. On the splash screen, click Install SQL Server Upgrade Advisor.
2. Click Next to begin the installation wizard, accept the licensing terms, and click Next.
3. Click Next to accept the default Registration information, click Next to accept the default installation path, and click Next to begin the installation.

Once you have installed the SQL Server 2008 R2 Upgrade Advisor, you can use this software to scan your SQL Server 2000 instances for potential migration issues. This section provides a brief walkthrough; Appendix H gives more detailed instructions.

1. Select Start | All Programs | Microsoft SQL Server 2008 R2 | SQL Server 2008 R2 Upgrade Advisor.
2. Click the Launch Upgrade Advisor Analysis Wizard link, and click Next to begin.
3. Enter the SQL Server 2000 server name, and select the features you want the Upgrade Advisor to analyze. Alternatively, click Detect to have the Upgrade Advisor remotely scan the SQL Server 2000 server and detect which components are running on the SQL Server 2000 server. (See Figure 10.)

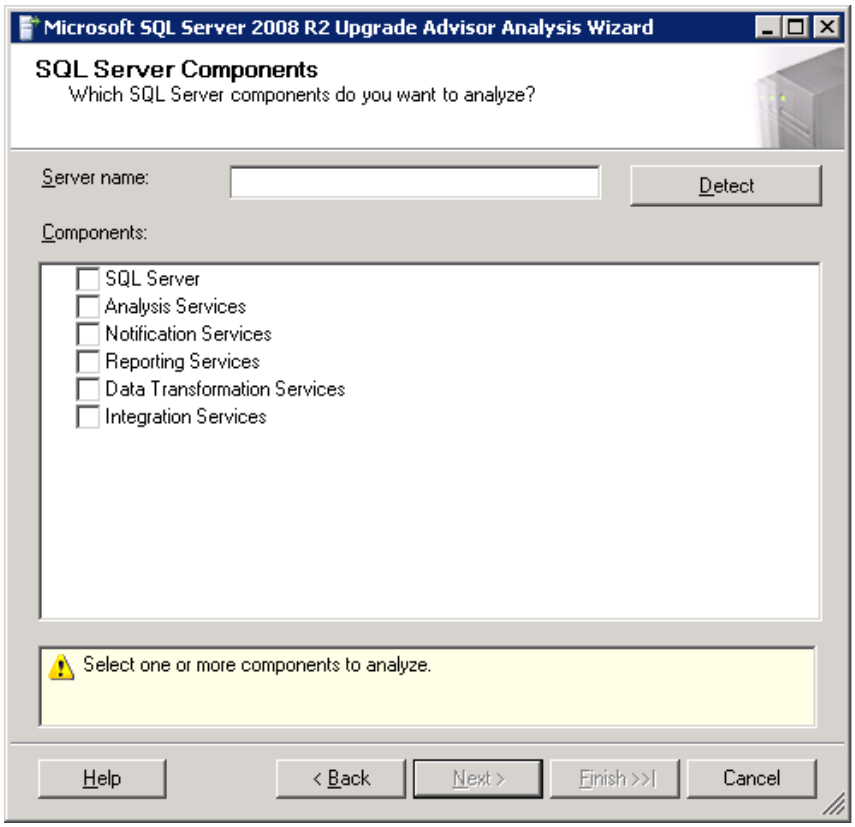

Figure 10. Upgrade Advisor component selection.

4. Provide proper authentication to SQL Server 2000, and select the database you want to analyze. If necessary, you can also input SQL script files and trace files here.
5. You may have legacy Data Transformation Services (DTS) packages on the SQL Server 2000 server. The DTS packages may be present in the file system or in the database itself. If you selected DTS, or if the Upgrade Advisor automatically detected the presence of DTS packages, you must now select the DTS location you want to analyze. Click Run to start the analysis. Run times vary.
6. Following the analysis of your SQL Server 2000 server, you can view the Upgrade Advisor report, which lists warnings and errors. (See Figure 11.)

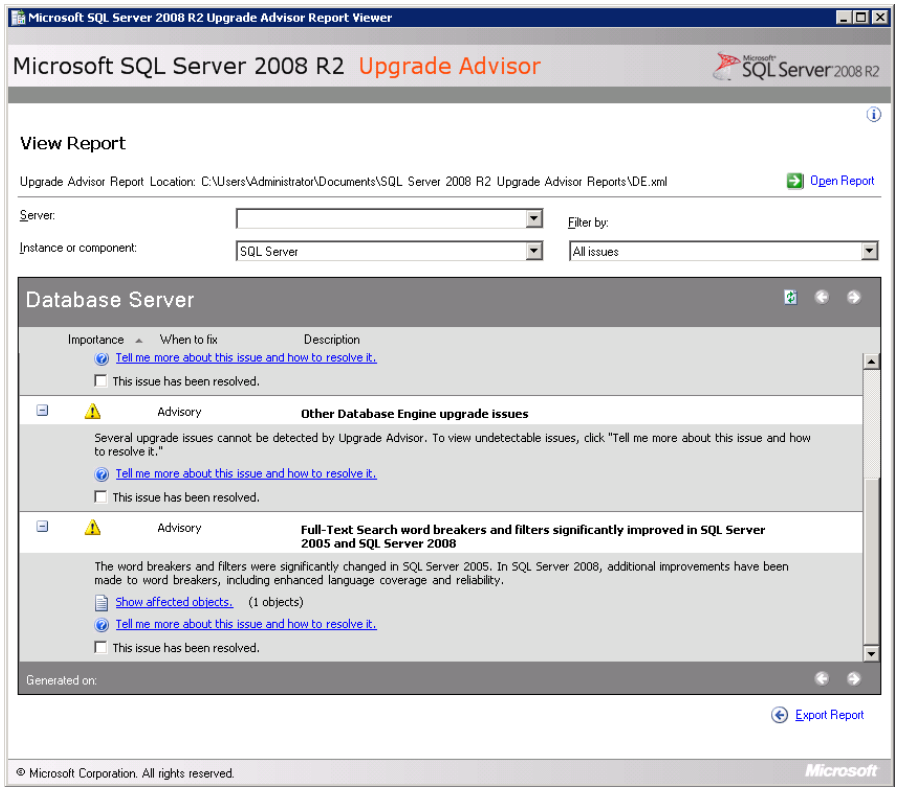

Figure 11. Sample Upgrade Advisor output report.

Side-by-side migration

In this section, we provide an overview of the processes involved in migrating your database from SQL Server 2000 to SQL Server 2008 R2 on the VMs residing on the Dell PowerEdge R910. We provide detailed instructions in Appendix I.

We performed all SQL Server 2000 administration using Query Analyzer and Enterprise Manager, the two main tools in the SQL Server 2000 environment. Likewise, we performed all administration for the SQL Server 2008 R2 installation using SQL Server Management Studio, the main administration interface for SQL Server 2008 R2.

NOTE: Be aware that various methods exist for migrating databases between instances and versions of SQL Server, including detach/attach, backup/restore, and the copy database wizard. We chose to use the backup/restore method.

Backing up your SQL Server 2000 database

Using the SQL Server 2000 server, take the following steps to back up your database. Backup times vary.

1. To keep users from issuing updates during the migration process, you can either set the database to read-only mode or set the access property to SINGLE_USER. Both choices immediately sever all user connections. See Appendix J for details on setting the database to single-user mode.
2. Perform a full backup of your SQL Server 2000 database, as we did in Figure 12. See Appendix J for details.

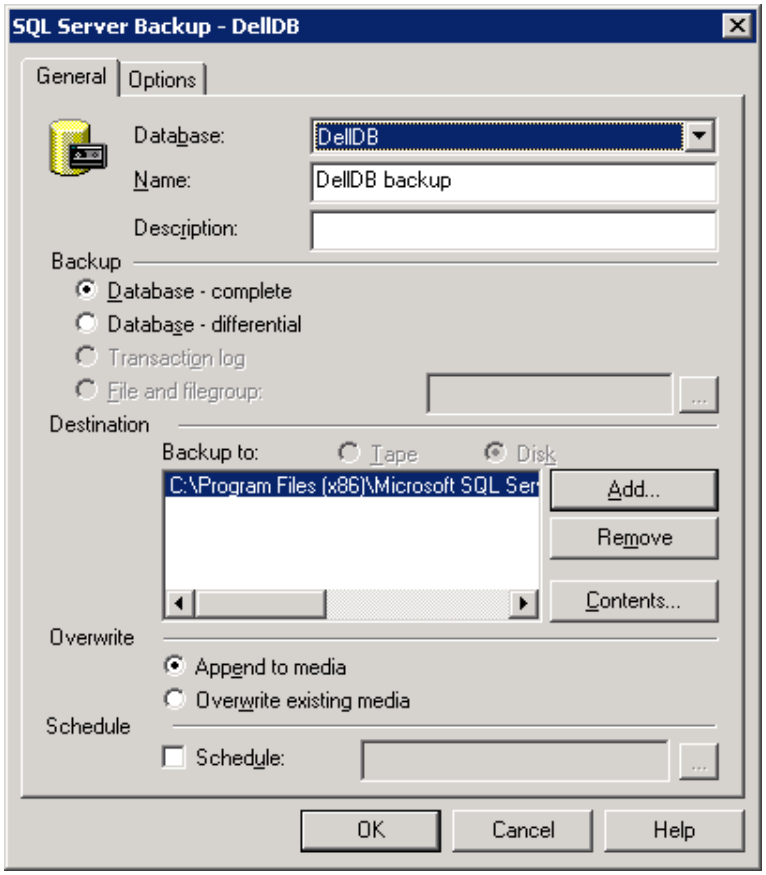

Figure 12. SQL Server 2000 backup configuration.

NOTE: If the time a full backup requires is unacceptable given your migration maintenance schedule, you can take the full backup at a previously scheduled time, and at this point of the migration take only a differential or transaction log backup. If the transaction log size is small relative to the data file size, this approach can decrease migration time significantly. If you go this route, however, be certain to keep your backup chain intact.

Restoring your database to SQL Server 2008 R2 server

Copy the backup to the relevant SQL Server 2008 R2 VM. Then, on the SQL Server 2008 R2 VM, take the following steps:

1. Open SQL Server Management Studio, connect to the SQL Server 2008 R2 instance, and restore the database. (Restore times vary.) See Appendix J for details.

NOTE: At this step, you must give your new database the same name as your SQL Server 2000 database. Changing the name could break applications that refer to the database by name.

2. While in SQL Server Management Studio, reset the database access property to multi-user, and set the compatibility level to SQL 2008 (level 100). See Appendix J for details.

We show you how: After the move

After you have completed your side-by-side migration, you typically will need to perform some post-migration tasks. Your specific list of tasks will depend heavily on your pre-migration research and planning. In this section, we briefly discuss a couple of the most common tasks.

Logins and dependencies

Windows and SQL Server logins

As in past versions of SQL Server, there are two methods of authenticating to SQL Server 2008 R2: Windows logins and SQL Server logins. You create and administer Windows logins at the Active Directory domain level, and you can assign those logins rights to SQL Server resources. You create and manage SQL Server logins, however, within SQL Server. The processes for extracting login information and creating the transferred login entities on the migration server is very similar for both Windows authenticated logins and SQL Server authenticated logins. You should, however, take some extra steps to ensure a smooth migration for SQL Server logins.

Below, we describe how to script both Windows authenticated logins and SQL Server authenticated logins to a query window and recreate them on the new SQL Server 2008 R2 VM. Step 6 refers solely to the SQL Server login type.

Please see Appendix J for details on transferring Windows logins and Appendix K for details on transferring SQL Server logins.

To transfer logins, take the following steps on the SQL Server 2008 R2 VM. Note that steps 1 through 5 apply to both Windows logins and SQL Server logins.

1. In SQL Server Management Studio, in the Object Explorer pane, connect to both your SQL Server 2000 server and your SQL Server 2008 R2 server. Be sure to have the Object Explorer Details tab open (View | Object Explorer Details).
2. Expand the tree view of the SQL Server 2000 server, browse to the security tab, and click the logins node. In the Object Explorer Details, you will now see a list of all logins on the SQL Server 2000 server.
3. If necessary, use the sorting and filtering options in the Object Explorer Details tab, and take note of which logins you would like to migrate. Select them by clicking; use the standard Windows controls (Ctrl key, Shift key, etc.) to select multiple logins.
4. Right-click the logins you selected, and choose Script Login As | Create To | New Query Window. Be sure to change the connection of this query window to connect to your new SQL Server 2008 R2 VM, if it is not doing so already, by right-clicking and selecting Change Connection.
5. Execute the script on your SQL Server 2008 R2 VM to create the logins. If you are transferring Windows-based logins, the process is complete. If you are transferring SQL Server logins, continue with Step 6 below.
6. For SQL Server logins, the script you executed in Step 5 creates the login, marks it as disabled, and assigns it a random password, but the script does not map the login to the database user. To avoid having a database user that is "orphaned" from a login, use the sp_change_users_login stored procedure, to view orphaned users and to map a user to a login. Appendix K provides an example of this process.

SQL Server Agent jobs

Almost all installations schedule SQL Server Agent jobs that run against their databases. You must migrate these jobs to your new SQL Server 2008 R2 VM. Locate the jobs you need to migrate in SQL Server Management Studio (on your SQL Server 2000 server) under the SQL Server Agent, right-click them, and choose Script Job As | Create To | New Query Window. Connect to the SQL Server 2008 R2 VM, and run the resulting script in a query window.

Other external dependencies

Your pre-migration research may have yielded a list of items for you to implement now; the list might include references to file shares, database mail or SQL Mail configurations, stored procedures in system databases, and/or linked servers. Addressing these external dependencies will ensure a smooth finish to your migration.

Summing it all up

The Dell PowerEdge R910, running Microsoft Windows Server 2008 R2 Hyper-V and powered by Intel's latest generation Xeon processor 7500 series, offers a compelling case for consolidation of your SQL Server resources from a legacy SQL Server 2000 environment to a new environment with SQL Server 2008 R2. As this Guide has explained, payback is provided in less than 7 months, application throughput increases, and power consumption drops dramatically as a result of this migration. In addition, the tools provided by SQL Server 2008 R2 simplify the migration of your databases. With careful planning, you can execute many migrations with little difficulty and with no interruption of service to users.

Appendix A. Return on investment

This section estimates the return on investment and expected payback period for a hypothetical enterprise that plans to consolidate SQL Server databases from multiple legacy servers and storage solutions onto a single newer, more powerful Dell server-and-storage solution.

The payback period is an estimate of how many months it would take to recapture initial investment costs when consolidating multiple 4-year-old HP ProLiant DL385 solutions onto a single Dell PowerEdge R910 solution.

The ROI analysis projects costs over 3 years for both the legacy and newer solution and calculates the ratio of the acquisition costs of the newer solution to the 3-year cost savings.

Test case

We consider the following specific legacy environment running Microsoft SQL Server 2000 on Microsoft Windows Server 2003 R2 with Service Pack 2:

- 48 AMD Opteron 254-based HP ProLiant DL385 servers with 4 GB of RAM and 24 HP StorageWorks MSA30 storage enclosures

We calculate the cost savings for a migration to the following Dell solution running Microsoft Windows Server 2008 R2 Hyper-V with VMs running Microsoft SQL Server 2008 R2 on Microsoft Windows Server 2008 R2:

- One Dell PowerEdge R910 with four Intel Xeon processor X7560s and 256GB of RAM and one Dell PowerVault MD3220 SAS Storage Array, supplemented by three Dell PowerVault MD1220 expansion enclosures.

Consolidation factor

We used benchmark results from our DS2 testing to determine the number of older servers with accompanying storage that a Dell PowerEdge R910 solution could replace. Our results showed that an enterprise could replace 48 HP ProLiant DL385 solutions with a single Dell PowerEdge R910 solution. We use 48 as our consolidation factor. In our tests, one HP ProLiant DL385 server used half of a HP StorageWorks MSA30 enclosure. We therefore assume that two HP ProLiant DL385 servers can share each HP

storage array for a total of 48 HP ProLiant DL385 servers and 24 HP StorageWorks MSA30 enclosures.

Power savings

We measured power to the test servers and storage when idle and while running the benchmark under peak load. We measured energy usage of the HP StorageWorks MSA30 with both a full enclosure and a half enclosure and use the full enclosure results for this ROI analysis. We averaged the idle and peak load results to estimate a power usage under typical load for the test configurations. We then calculated solution totals for the Dell PowerEdge R910 solution and the 48 HP ProLiant DL385 solutions that we compare in this ROI analysis. Figure 13 shows our results.

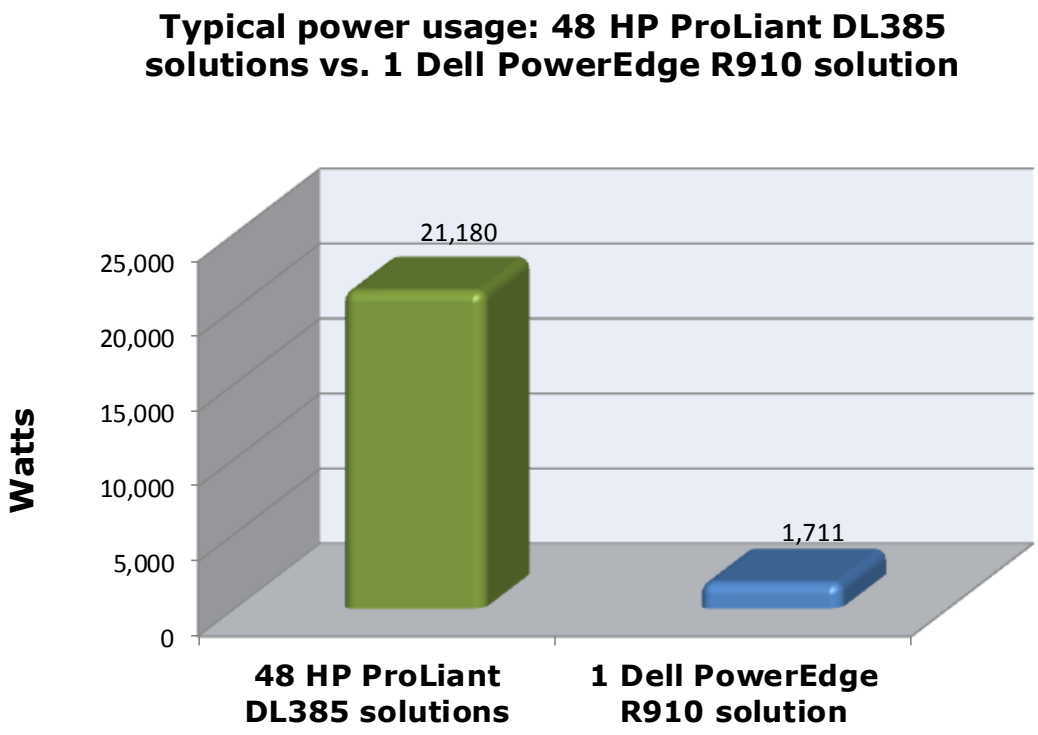

Figure 13. Estimated power usage under typical load for the single Dell PowerEdge R910 solution and 48 HP ProLiant DL385 solutions. Typical power is the average of idle power and power under load. Lower results are better.

Three-year cost savings

We estimated acquisition costs and ongoing operating costs for the two solutions over a 3-year period. In this analysis, the Dell PowerEdge R910 solution delivered payback within 7 months,

offsetting its acquisition costs by major savings in operating costs and delivered a significant ROI over 3 years.

Acquisition costs include the purchase price of the server and storage hardware for the Dell PowerEdge R910 solution as well as the labor costs to plan and carry out the migration.

Operating costs include hardware support costs, software licenses and support agreements, facility costs for space and data center ports, energy costs, and management costs. We assume operating costs are the same for each of the 3 years. We do not calculate net present value, internal rate of return, or use other discounted cash flow methods that factor the time value of money into the evaluation.

Figure 14 shows the 3-year costs for the two configurations. Specifically, it shows that acquisition costs of the Dell PowerEdge R910 server are offset by its savings in operating costs.

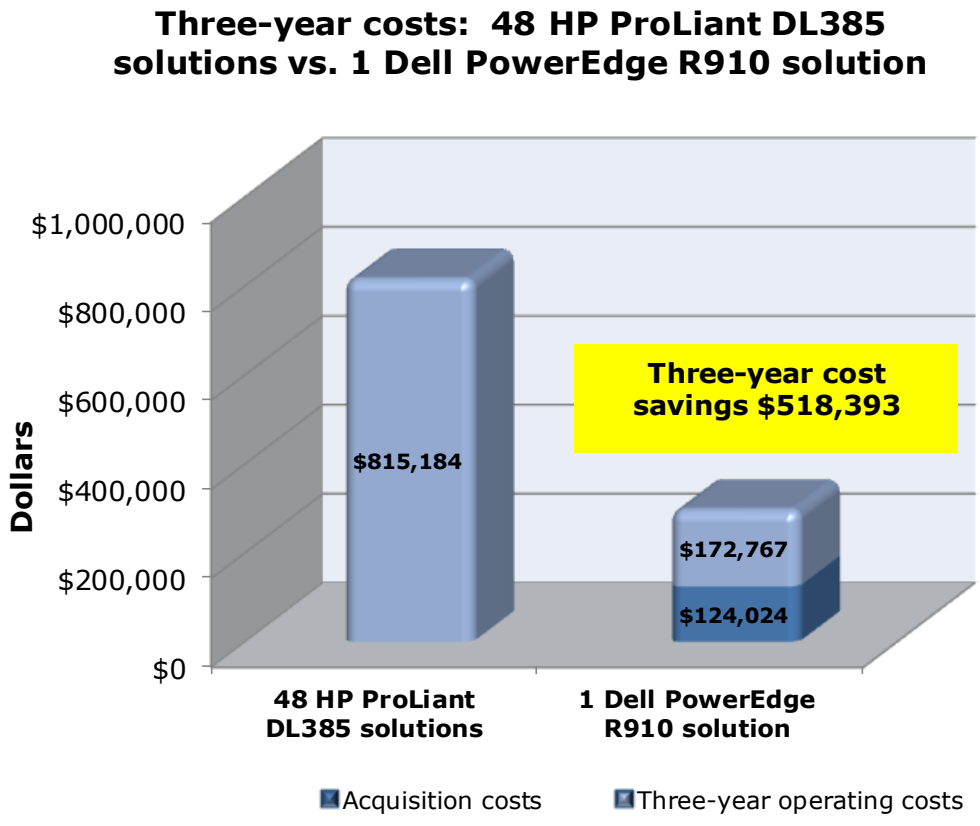

Figure 14. Estimated 3-year costs for the 48 HP ProLiant DL385 solutions and a single Dell PowerEdge R910 solution. Lower costs are better.

Five key benefits of the Dell PowerEdge R910 solution drive the cost savings for this solution:

- **Replaces up to 48 HP ProLiant DL385 servers and 24 HP StorageWorks MSA30 storage enclosures.** The increased capabilities of the Dell PowerEdge R910 solution enable consolidation of multiple older systems for the specific workload we tested.
- **Fewer servers and storage arrays lower system administration labor costs.** There is significant savings for this consolidation in labor costs for server and storage administration. We estimate that the 48 older servers and 24 older storage arrays require over 19 times more administration time than the new Dell PowerEdge R910 solution.
- **Energy consumption is about 1/12th that of the 48 HP ProLiant DL385 solutions it replaces.** The Dell PowerEdge R910 solution provides considerable energy savings over the older HP ProLiant DL385 solutions that it replaces.
- **Requires only 4 Windows Server licenses and 4 Windows SQL Server licenses instead of 48 of each for the legacy solution.** Consolidation provides immediate savings for the organization that maintains software assurance agreements. We assume the enterprise maintains Microsoft Software Assurance agreements for the Microsoft Windows Server 2003 version. After the migration, the enterprise will realize savings by not renewing the software agreements, which we assume are due for renewal. We include both per-server license costs and Software Assurance costs for four licenses, one for every four VMs, for Windows Server 2008 Enterprise edition for the new solution. We assume that the enterprise, which is running SQL Server 2000 on the legacy servers, would not maintain Software Assurance on a software version that old. We therefore don't include any ongoing SQL Server 2000 costs for the legacy solution. We include both per-server license costs and Software Assurance costs for Windows SQL Server 2008 R2 Enterprise edition on the new solution, assuming four licenses, one for each VM. Even with that license cost, the enterprise saves on software with the consolidated solution through the savings in Software Assurance costs for retired licenses.
- **Requires 1/14th of the data center rack space.** The legacy solution requires 2u of rack space for each server and 3u of rack space for each storage array. The HP ProLiant DL385 solutions use a total of 168u, filling four 42u racks; the Dell PowerEdge R910 solution requires a total of only 12u for one 4u server and one 2u Dell PowerVault MD3220 array, and 2u for each of three Dell PowerVault MD1220 arrays, filling less than one-third of a 42u rack.

Acquisition costs

Figure 15 details the acquisition costs for the Dell PowerEdge R910 solution.

Category	Description	Dell PowerEdge R910 solution
Server cost	One Intel Xeon processor X7560-based Dell PowerEdge R910 server	$45,524
Storage cost	One PowerVault MD3220 array with 24 146GB 15,000 RPM drives and three PowerVault MD1220 arrays with 24 73GB 15,000 RPM drives per array	$59,833
Migration planning and execution	336 hours of staff time for migration	$18,667
Total investment	**Server, storage, and migration planning and execution costs combined**	**$124,024**

Figure 15. Acquisition costs for the Dell PowerEdge R910 solution.

Hardware prices are list prices as shown on the Dell Web site on January 24, 2011.

We used our experience to estimate the migration costs. We assume that the enterprise consolidates the 48 older servers onto one Dell PowerEdge R910 server-and-storage solution using the easy and efficient processes described in this document. We estimate 80 hours of staff time for migration planning and 256 hours to carry out the migration. We include migration of the hardware, operating system, and SQL Server software, and the 10GB databases we included in our testing. We also include OS and SQL Server software updates. Migration of additional software would add to the migration time, as would any factors that add to the complexity of the migration. We estimate all staff costs based on a loaded annual system administrator cost of $100,000.

Operating cost savings

Figure 16 shows the 3-year operating costs and operating cost savings of the Dell PowerEdge R910 solution for the five categories of operating costs that we consider in this analysis.

Savings category	Costs for 1 Dell PowerEdge R910 solution	Costs for 48 HP ProLiant DL385 solutions	Three-year operating cost savings for Dell PowerEdge R910 solution
Hardware support - Servers and storage arrays	$7,485	$87,696	$80,211
Software costs - Microsoft Windows Server and Microsoft SQL Server	$127,368	$84,096	-$43,272
Facility costs - Rack space and port costs	$1,179	$29,664	$28,485
Energy costs - Power and cooling	$9,234	$73,728	$64,494
Management costs - Labor for server and storage array administration	$27,501	$540,000	$512,499
Total	**$172,767**	**$815,184**	**$642,417**

Figure 16. Three-year operating cost savings for the single Dell PowerEdge R910 solution vs. the 48 HP ProLiant DL385 solutions.

Payback period

The payback period identifies the point at which we estimate the operating cost savings equal the acquisition costs and the acquisition starts to show a cost benefit or profit. In calculating the estimated payback period, we assume that investment costs occur at the beginning of the year of the acquisition and annual or 3-year operating costs spread evenly across the months.

Figure 17 shows the payback calculation for the Dell PowerEdge R910 solution and the 48 HP ProLiant DL385 solutions.

Payback category	Dell PowerEdge R910 solution	48 HP ProLiant DL385 solutions	Difference
One-time initial investment (includes server, storage hardware, and migration costs)	$124,024	$0	$124,024 (HP ProLiant DL385 is lower)
Monthly cost (annual costs divided by 12; includes hardware support, maintenance and service contracts, software support agreements, facility costs, energy costs, and management costs)	$4,800	$22,644	$17,844 (Dell PowerEdge R910 is lower)
Payback period	**6.95 months** ($124,024/$17,844=6.95)		

Figure 17. Payback calculation for the Dell PowerEdge R910 solution vs. the 48 HP ProLiant DL385 solutions.

Assumptions

We made many assumptions about the hypothetical enterprise that drives the costs in this analysis. Different assumptions would create a different cost picture. We made the following assumptions in estimating acquisition costs:

- The enterprise would dedicate the entire newer Dell PowerEdge R910 server and the Dell PowerVault MD3220 array to the tasks carried out by the 48 HP ProLiant DL385 solutions it was replacing.
- The log files would be on two internal disks on each legacy server, and on 12 internal disks on the new server.

We made the following assumptions in estimating the support, maintenance, and service contract costs for hardware:

- The enterprise would typically select a 3-year support package with 7-day, 24-hour mission critical coverage, and 4-hour on-site response time for newer servers and a 3-year support package with next business day on-site service for storage arrays, and would take over support internally after those agreements expire. Therefore, for the Dell PowerEdge R910 solution, we included the costs for 3-Year ProSupport for IT and mission critical 4HR 7x24 onsite pack in our cost estimates. For the Dell PowerVault MD3220, we included 3-Year ProSupport for IT and non-mission critical 4HR 7x24 service. That support level was not available for the Dell PowerVault MD1220 arrays using the pricing tools on the Dell Enterprise Web site. Instead, we selected 3 Year ProSupport and next-business day on-site service for those arrays. For each of those support agreements, we divided the costs by 3 to show the annual cost.
- The enterprise would dedicate the HP ProLiant DL385 servers and storage enclosures to the tasks our benchmark tests model.
- For the HP ProLiant DL385 solutions, we estimated an annual in-house support cost of $400 per server and $418 per storage array to maintain the array and replace failed disks based on PT estimates of a 4 percent annual disk replacement rate.

We made the following assumptions in estimating the costs of software support agreements:

- The HP ProLiant DL385 solutions used Windows Server 2003 R2 Enterprise Edition with per-server licenses, and the enterprise kept up-to-date software assurance agreements for that software.
- The business updated the Dell PowerEdge R910 operating system to Windows Server 2008 R2 Enterprise Edition by purchasing one license and software assurance agreement for each set of four VMs.
- The enterprise saved the cost of the freed up software assurance agreements. These agreements were due for renewal at the time of the solution acquisition.
- The enterprise purchased four SQL Server 2008 R2 Enterprise Edition per-server licenses for the Dell PowerEdge R910 solution and software assurance agreements for those licenses.
- The enterprise already owned the necessary Client Access Licenses (CALs). We did not include CAL costs in this analysis.

We made the following assumptions in estimating facility costs, which include rack-based space costs and Ethernet port costs:

- We estimated a fixed data center cost per rack, prorated by the percentage of the rack the solution used. We estimated an annual per-server data center ports cost of $129 based on PT's experience.

We made the following assumptions in estimating energy costs:

- We measured energy costs for active and idle power consumption and used the average of the active and idle power to calculate year-round power.
- Average cost per kWh of power. Source: National commercial average for 2010 reported in January 2011 from http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html. The 2010 average was $0.1026 per kWh.
- We estimated the energy cost of cooling the servers and storage arrays to be equal to the energy cost required for running the systems.

We used the following assumptions in estimating the management costs:

- Support costs are separate from administration costs and are included under 3-year support, maintenance, and service contract costs for newer hardware.

Appendix B. Example database survey

In this appendix, we provide an example survey of detailed information you may want to gather about the SQL Server instances and databases you're 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 growth.
      ii. Disk speed
      iii. Repository type (Fibre Channel SAN, iSCSI SAN, SCSI direct-attached)
      iv. 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's clustered, version, edition (Workgroup, Standard, Enterprise), 64-bit or 32-bit (and if 32-bit, with or without AWE), and service pack level
   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 – highly volatile? Slightly volatile? Medium usage?

4. Database level
   a. Database properties and options
   b. Recovery model, auto-shrink, etc.
   c. Files and filegroups (size and location)
   d. Backups
      i. How many full backups, and on what schedule?
      ii. How many differential backups, and on what schedule?
      iii. How many log backups, and on what schedule?
      iv. Current backup window?
      v. Can backup window shift to accommodate the consolidated backup window?
   e. Other database issues
      i. Is this database in a replication configuration?
      ii. Is this database a partner in a mirroring session (2005/2008 only)?
      iii. Do any SSIS/DTS packages reference this database?
      iv. Do any SQL Agent jobs reference this database?
   f. Users/Logins
      i. Number of users this database affects
      ii. 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 C. Preparing the storage

For the testing we conducted for this Guide, we used one Dell PowerVault MD3220 array with three Dell PowerVault MD1220 arrays attached, which we connected to our server directly using two Dell 6Gbps SAS Adapters with two cables connected to each adapter. Below are the specifics of setting up your Dell PowerVault MD3220.

Setting up the storage

1. Connect two SAS cables between each storage controller and the Dell PowerEdge R910.
2. Connect the Dell PowerVault MD3220 management ports to the Dell PowerEdge R910.
3. Follow the MD Storage Manager wizard to perform the initial setup of the array.
4. Use the Automatic Discovery feature of the MD Storage Manager to find and manage the array.
5. Click Storage Array→Configuration→Automatic.
6. Use the Automatic setup wizard to create a custom configuration with 24 disks per RAID group, RAID 10, and 1 volume per RAID group.
7. Select the Mappings tab, right-click the Storage Array MD3220, and select Define→Host.
8. Enter a host name, click Next, and add the SAS Initiators to the host.
9. Click the Undefined Mappings, right-click each volume, select Define mapping, and select the R910 host.

Configuring the Dell PowerEdge R910 storage

On our server, we used 16 internal 6Gbps 15,000 rpm 146GB SAS disks. We configured four of the disks in a RAID 5 configuration and the remaining 12 disks in a RAID 10 configuration. Below, we cover the specifics on configuring the internal storage, and then connecting to the storage from Windows Server 2008 R2.

Configuring the internal storage

1. On boot, Press Ctrl+R to enter the RAID controller BIOS. Our controller was a PERC H700.
2. Highlight the controller, press F2, and choose to create the new virtual disk.
3. Provide the desired RAID setting, such as RAID 1, 5, 10, and so on. Choose the relevant disks for this volume.
4. Press OK to complete the volume configuration.

5. Highlighting the new virtual disk, press F2, Initialization, and Start Init. This will fully initialize your virtual disk
6. Repeat steps 2 through 5 for the remaining virtual disks in your server.

Configuring the storage in Microsoft Windows Server 2008 R2

1. Choose Storage, and choose Disk Management.
2. Right-click the uninitialized internal or external volume, choose Initialize Disk, and choose MBR.
3. Right-click the volume, and choose New Simple Volume. Click Next.
4. Keep the default drive space, and click Next.
5. Assign the appropriate drive letter, and click Next.
6. Choose NTFS, assign a 64KB allocation unit size, and check the Perform a quick format checkbox.
7. Click Next, and click Finish.
8. Repeat steps 2 through 7 for the remaining internal or external volumes.

Appendix D. Installing Windows Server 2008 R2

Allow 25 minutes on the Dell PowerEdge R910 to complete the installation of Windows Server 2008 R2.

1. Insert the Microsoft Windows Server 2008 R2 DVD into the DVD drive, and reboot the system.
2. During the boot, 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 save settings and reboot.
6. During the boot, a Windows is loading files message appears, followed by a Windows booting loading bar.
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.
9. At the Select the edition of Windows that you purchased screen, click the appropriate edition, and click Next.
10. At the Please read the license terms screen, check the I accept the license terms checkbox, and click Next.
11. At the Which type of installation do you want? screen, for Type of install, click Custom (Advanced).
12. At the Where do you want to install Windows? screen, click Drive options (Advanced).
13. Delete any existing partitions, recreate a partition, and format it. Highlight the partition, and click Next to start the installation.
14. When the system indicates that you must change the user's password before you log on the first time, click OK.
15. Enter a strong password in both the New password and Confirm password fields, and click the arrow.
16. At the Your password has been changed prompt, click OK. Windows then prepares the desktop.
17. Set the time zone.
18. Set the IP address, subnet mask, and domain information as per the steps in the next section.
19. Install Windows updates if applicable. (Download times will vary based on number and size of updates.)
20. Reboot the server after any updates install.

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 adapters.
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. Enter the IP address you want the server to have, enter the Subnet mask, and enter the Preferred DNS server. Click OK.
8. Close the Network Connections window.
9. From the Start menu, right-click Computer, select Properties, and select Change 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, if applicable.
15. When the system prompts you to do so, enter the user name and password
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 Restart Now to reboot the server.

Appendix E. Installing the Hyper-V role

Follow the steps below to install Hyper-V on Windows Server 2008 R2. Allow around 10 minutes for adding the Hyper-V role.

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, and click Next.
6. On the Hyper-V page, click Next.
7. On the Create Virtual Networks page, select the appropriate Local Area Connection, and click Next.
8. On the Confirm Installation Selections page, click Install.
9. On the Installation results screen, click Close.
10. When Windows prompts you to reboot the server, click Yes. The server will reboot twice.
11. When you see the Installation Results page, click Close.

Appendix F. Creating virtual machines

Below, we provide detailed steps on creating your virtual machines using Hyper-V manager. Note that drive availability and required number of VHD files may vary based on your environment.

1. Click Start→Administrative Tools→Hyper-V Manager.
2. From the Action menu, select New→Virtual Hard Disk.
3. Choose Fixed Size, assign 25GB for size, and place the VHD in the appropriate folder on the server or storage.
4. Repeat Step 3 for the remaining VHDs necessary for your VMs. On our SQL Server VMs, for flexibility, we created a VHD for the OS, a VHD for SQL Server data, and a VHD for SQL Server logs.
5. From the Action menu, select New→Virtual Machine.
6. On the Before You Begin page, click Next.
7. On the Specify Name and Location page, enter the name for your new virtual machine, and click Next.
8. On the Assign Memory page, enter the RAM amount.
9. On the Configure Networking, choose the network assigned to VM traffic, and click Next.
10. Choose to add a virtual hard disk later.
11. On the Installation Options page, accept the default of Install an operating system later, and click Next.
12. On the Completing the New Virtual Machine Wizard page, click Finish.
13. Right-click the virtual machine, and choose Settings.
14. Click Processors, and choose the number of virtual processors. We chose two virtual processors for our database virtual machines.
15. Click the virtual IDE controller 0.
16. Click Add, and click Hard Drive.
17. Browse to the first VHD you created in Step 3, and choose that VHD for the guest OS VHD.
18. Click Apply.
19. Click the SCSI controller.
20. Click Add, and click Hard Drive.
21. Browse to the second VHD you created in Step 4, and choose that VHD for the SQL Server data VHD.
22. Click Apply.
23. Repeat steps 19 through 22 for the remaining SQL Server related VHDs.
24. Power on the VM, and then proceed to install Windows Server 2008 R2 on each VM, following the instructions from the above Installing the operating system section.

Appendix G. Installing SQL Server 2008 R2 on the virtual machines

Install an instance of Microsoft SQL Server 2008 R2 by following these steps. This installation walkthrough only covers the installation of the Database Engine and Management Components. For other components, such as Reporting Services, Integration Services, or Analysis Services, see Microsoft documentation at http://msdn.microsoft.com/en-us/library/ms143219(SQL.105).aspx.

Allow at least 30 minutes to complete the installation.

1. Insert the installation DVD for SQL Server 2008 R2 into the physical host's DVD drive.
2. Connect to the VM via Hyper-V Manager and mount the DVD to the VM.
3. If autoplay does not begin the installation, navigate to the SQL Server 2008 R2 DVD, and double-click.
4. If prompted with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
5. At the SQL Server Installation Center screen, click Installation.
6. Click New installation or add features to an existing installation.
7. At the Setup Support Rules screen, click OK.
8. At the Product Key screen, enter your licensing information, if applicable, and click Next.
9. At the License Terms screen, accept the license terms, and click Next.
10. At the Setup Support Files screen, click Install.
11. At the Setup Support Rules screen, click Next.
12. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
13. At the SQL Server 2008 R2 Feature Selection screen, select the features which your organization requires. The features we chose for our testing were the following: Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete. Click Next.
14. At the Installation Rules screen, click Next.
15. At the Instance Configuration, enter the appropriate details for your configuration. For a default instance, leave the defaults selected.
16. At the Disk Space Requirements screen, click Next.

17. At the Server Configuration screen, choose the service account, preferably an Active Directory domain account, fill in a password if necessary, and click Next.
18. At the Database Engine Configuration screen, choose an authentication mode. If your legacy servers use SQL Server logins at all, then select Mixed Mode. If you exclusively use Active Directory domain accounts in your SQL Server environment, then choose Windows Authentication.
19. If necessary, enter a password for the system administrator (SA) account, click Add Current User, and click Next.
20. At the Error Reporting screen, click Next.
21. At the Installation Configuration Rules screen, click Next.
22. At the Installation screen, click Install.
23. At the Complete screen, click Close.
24. After the SQL Server 2008 R2 installation process completes, check Microsoft's Web site for the latest SQL Server service pack. There were none at the time we wrote this Guide.
25. Repeat this process on the necessary number of VMs for your environment.

Appendix H. Installing Upgrade Advisor

In this example, we walk through the steps to install and run the SQL Server 2008 R2 Upgrade Advisor and save reports.

1. Insert the SQL Server 2008 R2 DVD. On the Planning screen, click Install SQL Server Upgrade Advisor.
2. Click Next to begin the installation wizard, accept the licensing terms, and click Next.
3. Click Next to accept the default Registration information, click Next to accept the default installation path, and click Next to begin the installation.
4. At the Completing the Microsoft SQL Server 2008 R2 Upgrade Advisor screen, click Finish to exit the setup.
5. Start the Upgrade Advisor by selecting Start | All Programs | Microsoft SQL Server 2008 R2 | SQL Server 2008 R2 Upgrade Advisor.
6. Click the Launch Upgrade Advisor Analysis Wizard link.
7. On the Welcome screen, click Next.
8. On the SQL Server Components screen, by default the Upgrade Advisor populates the server name field with the local computer name. If you need to scan a remote server, type the computer name or IP address of the SQL Server you want to analyze and do one of the following:
   - Click Detect to allow the Upgrade Advisor to scan the components on the SQL Server instance you specified. (We chose this option.)
   - Select the components of the SQL Server instance you would like the Upgrade Advisor to scan.

   NOTE: If you are analyzing an instance of SQL Server Reporting Services, you must install and run the SQL Server 2008 Upgrade Advisor software on the hardware where SQL Server 2000 Reporting Services is running, because the Upgrade Advisor cannot scan Reporting Services resources across the network. Do not enter the SQL Server instance name. The Upgrade Advisor will scan the server you specify and check for multiple instances of SQL Server.
   If you are scanning clustered components of SQL Server on a failover cluster SQL Server instance, enter the failover cluster instance name. If you are scanning non-clustered components, such as the workstation tools, on a failover cluster, enter the computer name of the specified node.

9. On the Connection Parameters screen, specify the Authentication Type and credentials if necessary.

10. On the SQL Server parameters screen, select one or more databases and, if you so desire, supply a trace file or SQL script file to analyze. Should you wish to use a trace file, you must generate it before you begin the Upgrade Advisor. For instructions about how to generate a trace file, see http://msdn2.microsoft.com/en-us/library/ms187929(SQL.105).aspx
11. If you specified analysis of Data Transformation Packages (or if the detection process discovered DTS on the SQL Server 2000 server), you should now choose whether you want the Upgrade Advisor to scan for (a) DTS packages on the SQL Server 2000 server or (b) DTS package files stored on the file system. We kept the default of Analyze DTS packages on Server. Click Next to continue.
12. On the Confirm Upgrade Advisor Settings screen, review your choices, and click Run to begin the analysis.
13. When the analysis completes, click Launch Report to view the analysis report.
14. You can now use the drop-down filter tools to view report items by component or by issue severity.

NOTE: If you want to export the report to comma separated value (CSV) format, click Export Report in the lower right corner of the Upgrade Advisor interface.

Appendix I. Migrating databases

In this appendix, we give detailed instructions about a basic side-by-side migration of a user database from a SQL Server 2000 server to a virtual machine running SQL Server 2008 R2. There are multiple methods of accomplishing this task, including using TSQL commands and automated tools. Here, we discuss performing the database migration using the graphical interface tools Microsoft provides with SQL Server 2000 and SQL Server 2008 R2.

1. Log into Windows on the SQL Server 2000 server as either an administrative user or a user with full rights on SQL Server 2000.
2. Start Query Analyzer by selecting Start | All Programs | Microsoft SQL Server | Query Analyzer.
3. Enter your server name, and select Windows Authentication.
4. Set the database to single-user mode to ensure no updates occur.

NOTE: Setting the database to single-user mode immediately disconnects all users, causing them to lose any work in progress. You must notify your users well in advance of setting the database to single-user mode.

5. To set the database to single-user mode, in the query window, paste the following command, where <DatabaseName> is the name of the database you are migrating:

```
USE [master]
GO
ALTER DATABASE [<DatabaseName>]
SET SINGLE_USER WITH ROLLBACK IMMEDIATE
GO
```

6. Press F5 to execute the query.
7. Close Query Analyzer. When Query Analyzer gives you the chance to save the query, click No.
8. To back up the database and prepare for migration, open Enterprise Manager by selecting Start | All Programs | Microsoft SQL Server | Enterprise Manager.
9. In the left pane, expand Microsoft SQL Servers | SQL Server Group | (local) (Windows NT) | Databases.
10. Right-click the database, and select All Tasks | Backup Database.
11. Keep the default of complete backup.

12. Click Add… to add a backup device, then the "…" button to browse to the backup location you want to use. Select a folder, and enter a filename, such as DatabaseNameMigrationBackup.bak.
13. Click OK to close the Backup Device Location window, and click OK to close the Select Backup Destination window.

NOTE: To simplify moving the database later, we recommend creating the backup in a shared local folder.

14. Optionally, on the Options tab, select the checkbox to Verify your database backup upon completion.

NOTE: This option increases backup time but checks the integrity of the backup file. We chose to verify the backup.

15. Click OK to begin the SQL Server 2000 database backup. (Backup times vary with database size and backup device configuration.)
16. After the backup completes, in Enterprise Manager, under Databases, right-click the database, and choose All Tasks | Take Offline. The old database is now offline, so SQL Server 2000 will not allow any connections to it.
17. Log out of Windows on the SQL Server 2000 server.
18. Log into Windows on the VM running SQL Server 2008 R2.
19. In Windows Explorer, navigate to either the shared network location or the portable storage device that you used to store your database backup.
20. Copy the backup file, and paste it to a local directory of your choice. (Copy time varies with network speed and file size.)
21. On the VM, open SQL Server Management Studio by selecting Start | All Programs | Microsoft SQL Server 2008 R2 | SQL Server Management Studio.
22. Select Database Engine for Server type, and type the server name in Server name. For Authentication, we used Windows Authentication.
23. In the Object Explorer pane, right-click Databases, and select Restore Database.
24. Enter the name of the database in the To database box.

NOTE: It is critical to use the same database name as on your SQL Server 2000 server. If the database name does not match, applications that depend on the database name may break.

25. Click the From device radio button, and click "…" to browse to the local folder where you copied the backup file.

26. Click Add to add the backup file location. Browse to the appropriate folder, find the backup file, select it, and click OK. Click OK to return to the Restore Database window.
27. Select the checkbox that now appears in the Restore column. Optionally, click Options on the left, and ensure the file locations are appropriate in the Restore As column.
28. Click OK to begin the restore. Note the progress indicator in the lower left of the Restore window. (Restore time varies with database size and server and disk subsystem speed.)
29. After the restore is complete, you must change the database access state back to multi-user and upgrade the compatibility level by performing the following steps:

    a. Right-click the database in Object Explorer, and select Properties.
    b. Click Options on the left side to access database options.
    c. Change Compatibility level to SQL Server 2008 (100).
    d. Scroll down to Restrict Access, and change to MULTI_USER.
    e. Click OK.
    f. Click Yes to agree to shutting down other connections.

Appendix J. Transferring Windows logins

In this appendix, we provide detailed instructions for migrating transferring Windows-based logins from a SQL Server 2000 server to a virtual machine running SQL Server 2008 R2 in an Active Directory environment. For information about transferring logins when using SQL Server authentication, see Appendix K.

1. On the VM running SQL Server 2008 R2, log into Windows, and open SQL Server Management Studio by selecting Start | All Programs | Microsoft SQL Server 2008 R2 | SQL Server Management Studio.
2. On the Connect to Server screen, select Database Engine for the server type, enter the computer name of your physical SQL Server 2000 server, and click Connect.
3. Select View | Object Explorer Details to bring up the Object Explorer Details tab.
4. In the Object Explorer pane, expand the Security folder, and highlight the Logins folder.
5. Add the Login Type column to the display by right-clicking the column-header area in the Object Explorer Details pane and selecting Login Type. Now Windows Logins appear as Login Type 0. Optionally, use the column headers to sort by Default Database, or use the filter button to find only logins that you are interested in migrating.
6. Using the standard Windows multi-select key combinations (Ctrl key or Shift key), highlight the logins you are interested in migrating.
7. Right-click the highlighted logins, and select Script Login as | CREATE To | New Query Editor.
8. On the Connect to Database Engine screen, change the Server name to your VM running SQL Server 2008 R2, and click Connect.
9. Click Execute to run the resulting script.

Appendix K. Transferring SQL Server logins

In this appendix, we give detailed instructions on transferring SQL Server logins from a SQL Server 2000 server to virtual machine running SQL Server 2008 R2. For information about transferring logins when using Windows authentication, see Appendix J.

Transferring logins

1. On the VM running SQL Server 2008 R2, log into Windows, and open SQL Server Management Studio by selecting Start | All Programs | Microsoft SQL Server 2008 R2 | SQL Server Management Studio.
2. On the Connect to Server screen, select Database Engine for the server type, enter the computer name of your SQL Server 2000 server, and click Connect.
3. Select View | Object Explorer Details to bring up the Object Explorer Details tab.
4. In the Object Explorer pane, expand the Security folder, and highlight the Logins folder.
5. Add the Login Type column to the display by right-clicking the column-header area and selecting Login Type. Now SQL Server Logins appear as Login Type 2. Optionally, use the column headers to sort by Default Database, or the Filter button to find only logins that you are interested in migrating.
6. Using the standard Windows multi-select key combinations (Ctrl key or Shift key), highlight the logins you are interested in migrating.
7. Right-click the highlighted logins, and select Script Login as | CREATE To | New Query Editor Window.
8. On the Connect to Database Engine screen, change the Server name to your VM running SQL Server 2008 R2, and click Connect.
9. Click Execute to run the resulting script.

Mapping transferred logins to database users

After transferring SQL Server logins from server to server, you must map those logins to the database users that you migrated during the restore process.

1. On the VM running SQL Server 2008 R2, log into Windows. Open SQL Server Management Studio by selecting Start | All Programs | Microsoft SQL Server 2008 R2 | SQL Server Management Studio.
2. On the Connect to Server screen, select Database Engine for the server type, enter the computer name of the VM running SQL Server 2008 R2 server, and click Connect.

3. Right-click the relevant database, and select New Query.
4. Enter the following command, and click Execute:

```
EXEC sp_change_users_login 'Report';
```

5. For each user output from the above step, map these "orphaned" users to the appropriate matching SQL Server login by taking the following steps:
   a. Open a query window on the VM running SQL Server 2008 R2 using steps 1 through 3 above.
   b. For each login you wish to map, enter the following command, and click Execute:

```
EXEC sp_change_users_login
'Auto_Fix','SQLLogin';
```

6. The above command maps the database user SQLLogin to the SQL Server login of SQLLogin. This procedure assumes that the database user and SQL Server login have the same value.
7. To reset the password and enable the account, enter the following command, and click Execute:

```
USE [master]
GO

ALTER LOGIN [SQLLogin] WITH PASSWORD=N'Password1'
GO

ALTER LOGIN [SQLLogin] ENABLE
GO
```

NOTE: This process assumes that you have already migrated the applicable database to the new server.

Appendix L. High-capacity scenario testing

In this appendix, we offer a high-capacity scenario, showing our test results when testing with more system RAM. This shows even greater consolidation ratios and higher system processor utilization.

To evaluate consolidation ratios using greater amounts of RAM, we doubled the RAM installed in the Dell PowerEdge R910 to 512GB, filling each DIMM slot of the Dell PowerEdge R910 with 8GB memory sticks. We then adjusted our VM resource allocations and configurations as follows:

- 3 virtual CPUs instead of 2 allocated to each VM
- 24GB RAM instead of 14.6GB allocated to each VM

Because we had greater amounts system RAM available, we chose to create an additional 4 VMs, bringing the total to 20 VMs, each running three database workloads. This produced a workload consolidation ratio of 60:1, when comparing to the legacy HP ProLiant DL385 solution.

We spread the database disk activity evenly over the external storage, as we describe in the main body of this report. With this number of VMs, this allowed us to use up to 95 percent of the processing power, and almost 100 percent of the system RAM.

Our 60-workload testing results

As Figure 18 shows, we were able to run 60 SQL Server 2008 R2 database workloads (3 databases on each of 20 SQL Server instances on each of 20 VMs), all simultaneously achieving an average throughput greater than the HP ProLiant DL385 solution's OPM score. The average OPM delivered by each of the 60 workloads on the Dell PowerEdge R910 solution was 7,449, while the average OPM delivered by a single workload on the HP ProLiant DL385 solution was 6,639.

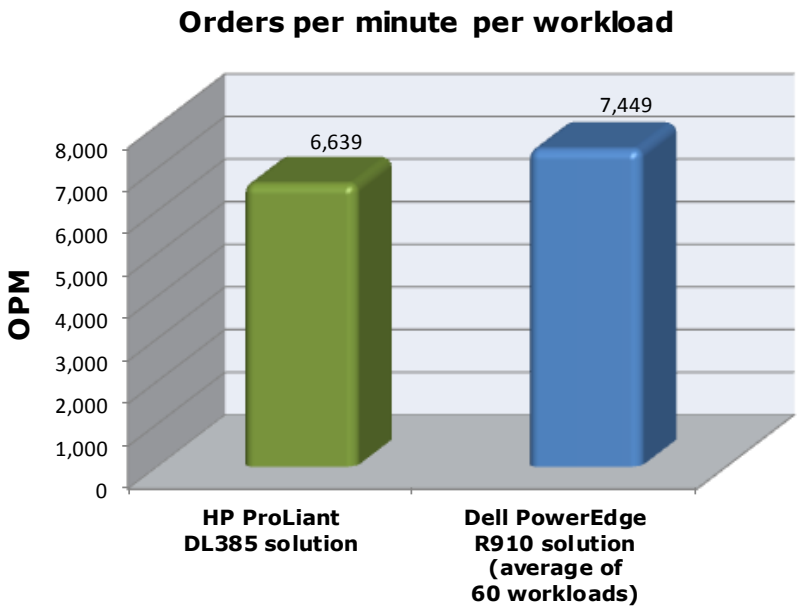

Figure 18. Average OPM of 60 database workloads on the Dell PowerEdge R910 solution versus a single database workload on the HP ProLiant DL385 solution. Greater OPM is better.

As Figure 19 shows, the combined OPM of 60 SQL Server database workloads on the Dell PowerEdge R910 solution was over 67 times greater than the single HP ProLiant DL385 solution database workload.

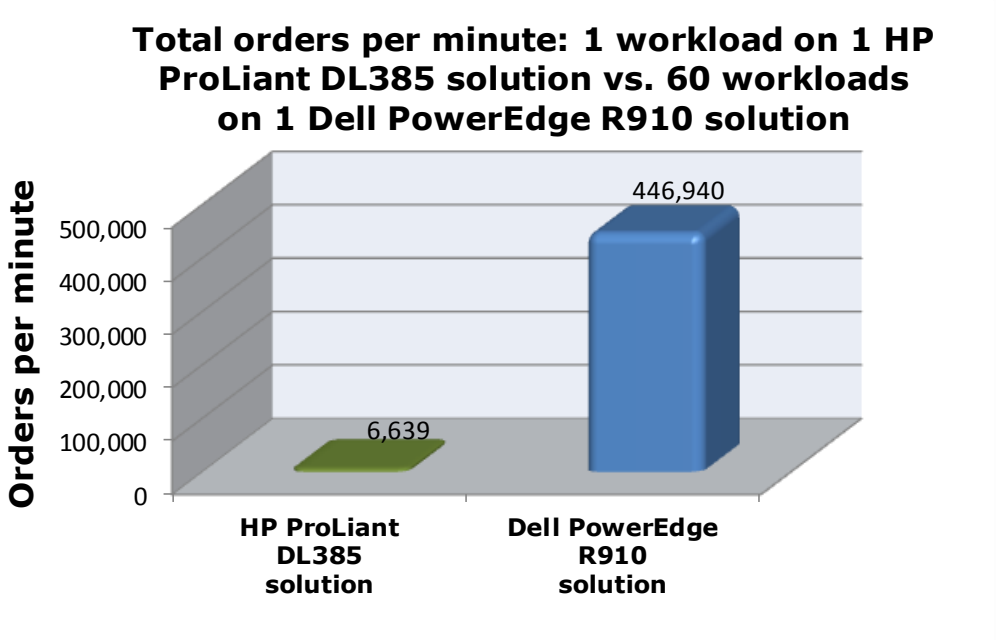

Figure 19. Combined orders per minute of 60 database workloads on the Dell PowerEdge R910 solution versus a single HP ProLiant DL385 solution database workload. Greater OPM is better.

About Principled Technologies

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