# Advantages of Dell PowerEdge 2950 Two Socket Servers over Hewlett-Packard Proliant DL 585 G2 Four Socket Servers for Virtualization

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Section 1

# Executive Summary

There is a lot of debate these days around what is the optimal hosting platform for a virtualization deployment. Most of this debate is centered around the decision to deploy either 2 socket or 4 socket building blocks as the basis of the infrastructure. In order to illustrate the advantages of using two-socket servers for virtualization over four-socket servers, a test was conducted with VMware Infrastructure 3 on the Dell PowerEdge 2950 and the HP ProLiant DL585 G2. The results of these tests show that three PowerEdge 2950 two-socket servers can provide up to 44% more performance, 57% more performance per watt and a 95% average advantage in price / performance than two HP ProLiant DL585 G2 four-socket servers.

Another stumbling block to the adoption of one platform over another is the node count and the perceived complexity of managing more nodes in a virtualized farm. With the maturity of VMware's management stack in VMware Infrastructure 3 and in particular with Distributed Resource Scheduler, a new paradigm of pooled resource management is possible. Large farms of servers faced issues with complexity in the past, but the policy based management capabilities of VMware Infrastructure 3 greatly reduce these administrative issues. This then enables the further acceptance of farms of smaller, lower cost building blocks, such as the Dell PowerEdge 2950, as the preferred solution for virtualization deployments.

Section 2

# Introduction

The advantages of server virtualization when used as part of an IT infrastructure have resulted in many customers deploying farms of servers running VMware virtualization software. Over the past few years this has often meant farms of four-socket servers to have the necessary processing power to handle a large number of virtual machines on a single physical server. This allowed for a high degree of consolidation by reducing the number of physical servers. But it also meant load balancing and managing the server farm to deliver the proper level of redundancy and performance across all virtual machines. Adding incremental capacity to grow a four-socket server farm is expensive as four-socket platforms have higher acquisition and software licensing costs when compared to two-socket platforms.

Two-socket servers have long been considered by some as the sweet spot in the server market in terms of price and performance. With the recent introduction of quad-core processors, it is now possible to have a similar amount of processing power in a two-socket server as what is currently available in four-socket servers with dual-core processors because the number of cores is the same. With this high level of processing capacity can also come a lower acquisition cost for hardware and in many instances a reduction in software license cost. VMware is currently licensed per socket and therefore VMware on a two-socket server costs half of what it costs for a four-socket server. Additionally, multi-core processors are well suited to support virtualization because of the multi-process nature of having many virtualized systems running at the same time on a single server. Virtualization software scales very well with multi-core processors within a single server, and a farm of virtualization servers scales in a linear fashion at the node level.

The test in this paper is designed to compare the performance of farms of servers running VMware virtualization software. In order to compare the virtualization performance of two-socket servers and four-socket servers, this paper compares three two-socket Dell™ PowerEdge™ 2950s with two four-socket Hewlett-Packard™ ProLiant DL585 G2s. Or more simply – 6 sockets vs 8 sockets.

In the next section the server and storage hardware used in the test is described. Following that, in Section 4, the virtualization environments and applications used in the test are described in detail. In Section 5 the performance and power consumption of these applications are measured on a single PowerEdge 2950 followed by a single HP ProLiant DL585 G2, and then extrapolated to farms consisting of either 3 PowerEdge 2950s or 2 HP DL 585 G2s.

Section 3

# Hardware

The PowerEdge 2950 is a dual-socket server that supports Intel® Xeon® 5000, 5100, and 5300 series processors. The Dell test team configured one PowerEdge 2950 with two quad-core Intel Xeon X5355 processors at 2.66 GHz. The quad-core Intel Xeon X5355 is basically two Xeon 5160 dual-core processors put together and so has a total of 8 MB L2 cache, with 4MB shared by two cores. The Xeon X5355 has a frontside bus speed of 1333MHz. The PowerEdge 2950 was configured with 16GB of memory using 2GB DIMMs.

| | **HP ProLiant DL585 G2** | **PowerEdge 2950 servers** |
|---|---|---|
| **Virtualization software** | VMware ESX Server 3.0.1 | VMware ESX Server 3.0.1 |
| **Processor** | Four dual-core AMD Opteron 2.8 GHz 8220SE processors with 1 MB L2 caches (per core) | Two quad-core Intel Xeon X5355 processors at 2.66 GHz with 8MB cache (shared) |
| **HyperTransport / Frontside bus** | 1 GHz | 1,333 MHz |
| **Memory** | 32 GB (16x 667 MHz PC2-5300 DDR2 2GB DIMMs) | 16 GB (8x 667 MHz fully buffered 2GB DIMMs) |
| **Internal disks** | Two Serial Attached SCSI (SAS) 73 GB, 15,000 rpm drives | Two Serial Attached SCSI (SAS) 146 GB, 15,000 rpm drives |
| **Network interface card (NIC)** | Two 10/100/1,000 Mbps internal NICs | Two 10/100/1,000 Mbps internal NICs |
| **Disk controller** | Smart Array P400 | PERC 5/i |
| **Hardware Cost** | $28,088 | $13,498 |
| **VMware Licensing Cost** | $13,914 | $7,188 |
| **Source** | http://www.hp.com 12/18/2006 | http://www.dell.com 12/18/2006 |

*This term does not connote an actual operating speed of 1 Gbps. For high-speed transmission, connection to a Gigabit Ethernet server and network infrastructure is required.

Table 1: Configurations for the HP ProLiant DL585 G2 server and the Dell PowerEdge 2950 server used in the test.

The HP ProLiant DL585 G2 is a four-socket server that supports the AMD Opteron 8000 series of processors. The test team configured a DL585 G2 with four 2.8 GHz dual core Opteron 8220SE processors and 32 GB of RAM. Each processor is coupled with RAM and connected to each other via a 1GHz HyperTransport™ bus. This keeps the memory closer to the processors, and in many cases ends up providing faster access because of this direct connection. Configuration details are shown in Table 1.

The hardware prices in Table 1 include the cost of a QLogic 2462 fibre channel adapter for both the PowerEdge 2950 and Proliant DL585 G2. Because the QLogic 2462 is not a selectable option for the DL585 G2 on HP's website, the price for the QLogic adapter from the Dell website of $1,219 was used for both systems.

The PowerEdge 2950 and HP ProLiant DL585 G2 were connected to a storage area network (SAN) with dual-port QLogic 2462 PCI Express host bus adapters (HBA) and utilized storage on a Dell/EMC CX3-80 array with twenty 146 GB, 15,000 rpm disks. The three types of VMs—each running a different workload, as described in the "Test workloads: Microsoft SQL Server 2005, SUSE LAMP, and NetBench" section in this article—were spread across the 20 disks on each storage array. These disks were divided into four 5-disk (4+1) RAID-5 logical units (LUNs). The three types of VMs were evenly divided across the LUNs so that a quarter of each type were on each LUN. Table 2 summarizes the storage configuration used in the test environment.

| | **Dell/EMC CX3-80** |
|---|---|
| **Controller cache** | 10,384 MB (3,072 MB write, 7,312 MB read) |
| **Fibre Channel speed** | Fibre Channel 4 (FC4) |
| **Disk enclosures** | Four DAE3P disk array enclosures |
| **Disks** | Twenty 146 GB, 15,000 rpm disks |
| **LUNs** | Four 5-disk RAID-5 LUNs |
| **Software** | EMC Navisphere® Manager and Access Logix™ software |

Table 2: Configuration of the CX3-80 storage used in the test environment

## Comparison of Dell Two-Socket Servers

For this test the Dell PowerEdge 2950 was chosen as the Dell two-socket server to use because it is a good balance in terms of density and PCI slots for most virtualized workloads. There are two other Dell two-socket servers that are similar to the 2950 in terms of performance, but offer different form factors with variances in some features such as PCI slots, maximum memory configuration, and amount of rack space consumed. While the 2950 is a great mixture of these features, some customers may prefer one of these other Dell two-socket servers due to requirements for additional NIC cards, the need for higher server density,

or a requirement for more RAM per socket. Table 3 compares the hardware features of the Dell two-socket servers.

| | Dell 1950 | Dell 2950 | Dell 2900 |
|---|---|---|---|
| **Sockets** | 2 | 2 | 2 |
| **Rack Units** | 1 | 2 | 5 |
| **PCI Slots** | 2 | 3 | 6 |
| **Max Memory** | 32 GB | 32 GB | 48 GB |

Table 3: Comparison of Dell two-socket servers

There are instances where the Dell PowerEdge 2950 is not the logical choice due to the requirement for I/O diversity, which is most commonly at the NIC level. The PowerEdge 2900 with its six PCI slots would be a better choice to support this high requirement for NICs. If density is the goal then the PowerEdge 1U 1950 would be the logical choice. All three platforms share a common system image and deliver similar performance characteristics.

It is important to remember that VMs are essentially given a processor core as a virtual processor. This means that in the case of a requirement for a four virtual processor VM the comparison between any of the Dell two-socket quad-core processor-based servers and the HP DL585 G2 two-socket dual-core processor-based server is between the same number of cores. The same number and type of multi-virtual-processor VMs could be deployed on all of these platforms.

Section 4

# Virtualization Software Platform for Test Environment

The performance tests used VMware Infrastructure 3 as the virtualization platform; this package includes ESX Server 3 and VirtualCenter 2 as well as features such as load balancing and VMware High Availability (VMware HA). ESX Server allows multiple virtual machines (VMs) to run simultaneously on a single physical server. Each VM runs its own OS, which in turn has its own set of applications and services. Because ESX Server isolates each VM from other VMs on the same physical server just as physical systems are isolated from one another, administrators have flexibility in using ESX Server to run different types of applications and operating systems at the same time. VirtualCenter 2 enables administrators to consolidate control and configuration of ESX Server systems and VMs, which can improve management efficiency in large environments.

The PowerEdge 2950 server and the HP ProLiant DL585 G2 used ESX Server 3.0.1 and were managed by a VirtualCenter 2.0.1 console. All VMs were first tested on the PowerEdge 2950, and then migrated to the DL585G2 and retested.

## Test workloads: Microsoft SQL Server 2005, SUSE LAMP, and NetBench

To compare the relative performance of the PowerEdge 2950 server and the HP DL585 G2, the test team ran three workloads on each server: the Microsoft® SQL Server™ 2005 database platform with an online transaction processing (OLTP) workload, the Novell® SUSE® Linux® Enterprise Server OS with a LAMP (Linux, Apache, MySQL, PHP) stack, and the Microsoft Windows Server® 2003 OS with NetBench® 7.03.[2] To simulate how enterprises typically run applications on VMs using ESX Server in a production environment, the test team increased the number of VMs until processor utilization for the entire physical server was as close to 85 percent as possible, with all tests within a range of 84 to 86 percent—a reasonably high level of usage that still allows for workload spikes. The test team calculated utilization levels by averaging the values from the esxtop utility run on the ESX Server service console during each test.

Each workload ran simultaneously on multiple VMs under the same load. By keeping all settings on the VM and driver systems identical and then observing how many VMs could be run simultaneously, the test team was able to measure how many VMs each physical server could support as well as the total throughput for that workload. Table 4 shows the configuration for each type of VM in the test environment.

| Workload | Memory | Disk | Number of Virtual NICs | Number of virtual processors |
|---|---|---|---|---|
| Microsoft SQL Server 2005 | 512 MB | 10 GB | 1 | 1 |
| SUSE LAMP | 1,024 MB | 10 GB | 1 | 1 |
| NetBench | 512 MB | 10 GB | 1 | 1 |

Table 4: Configurations for the virtual machines used in the test environment

**Microsoft SQL Server 2005.** On the SQL Server 2005 VMs, the test team installed 32-bit versions of Microsoft Windows Server 2003 Release 2 (R2) Enterprise Edition and SQL Server 2005 with Service Pack 1 (SP1).[1] The SQL Server version of the Dell DVD Store database was loaded into SQL Server 2005 using the scripts provided with the DVD Store download to create the medium-size database. The complete DVD Store application code, including SQL Server and LAMP versions, is freely available for public use under the GNU General Public License (GPL) at linux.dell.com/dvdstore. The DVD Store database simulates the database back end of a simple Web-based storefront. The database size is small (approximately 1 GB), and representative of a database used for development or testing.

To simulate a load on the VMs, the test team used the DVD Store driver program, which is included in the DVD Store download. Each SQL Server 2005 VM was driven by four threads of the driver application with a 20-millisecond delay.

**SUSE LAMP.** For the LAMP workload, the test team installed 32-bit versions of Novell SUSE Linux Enterprise Server 9, Apache 2, and MySQL 5 on a VM. The MySQL version of the DVD Store application was loaded into MySQL 5, and the PHP version of the DVD Store application was set up on Apache. In this setup, the Web tier and the database tier ran on the same VM to create a complete LAMP stack.[2]

The driver for the LAMP stack differs from the driver used in the SQL Server testing in that it sends HTTP requests and receives HTML code returned from the Apache/PHP layer, whereas the SQL Server driver communicates directly with the database. However, the LAMP workload measures the same parameters: total orders per minute (OPM) handled by the application, and average response time experienced by the simulated customers. Each SUSE LAMP VM was driven by a single thread of the driver program with a 20-millisecond delay.

**NetBench.** NetBench 7.03, developed by *PC Magazine,* is a benchmark tool designed to simulate a file server workload. The program creates and accesses a set of files according to predefined scripts. NetBench is typically run with an increasing number of client engines running against a single server to measure how much throughput (in megabits per second) can be achieved with a given number of connections.

The NetBench VMs were installed with the 32-bit version of Microsoft Windows Server 2003 R2 Enterprise Edition. To determine how many VMs could run on an ESX Server host, the test team increased the number of VMs and the number of client engines at the same rate until the processor utilization on the ESX Server host reached 85 percent. NetBench 7.03, with the included standard DiskMix script, was used with a 0.6-second think time to connect two client engines to each VM.[3] This simulates multiple file servers on the same ESX Server host, similar to a file server consolidation scenario. The driver systems on which the client engines ran had mapped drives to the test VMs. In NetBench the test directories path file was modified so that as successive client engines were added, they would use the next drive letter, which corresponded to the next VM.

Section 5

# Test Results Measuring Performance, Power Consumption, and Cost

The test team first ran the VMs on the two-socket PowerEdge 2950 server in successive tests, adding VMs in each round as described in the "Test workloads: Microsoft SQL Server 2005, SUSE LAMP, and NetBench" section. Next, they cold migrated the VMs to the four-socket HP DL585 G2 server and repeated the tests. A power meter attached to the servers measured the actual power consumption during these tests. Combining both the performance and power numbers with the system costs allowed for a final calculation of price/performance per watt.

**Performance and Power Consumption**. In terms of performance with virtualization there are two components. The first is a sizing or capacity issue in terms of the number of VMs supported. This immediately leads to the second component, which is the aggregate performance that those VMs are able to achieve. The performance results from the testing that was done are presented both in number of VMs and the sum of the associated performance of those VMs.

The power consumption of systems has become a real issue for customers and needs to be considered as part of the overall server performance. To measure the power consumption of these systems a meter was placed between the power source and the server to get the actual power consumption in watts while the tests were running.

The difference in the number of VMs and the associated performance metric—orders per minute (OPM) for SQL Server 2005 and SUSE LAMP and megabits per second for NetBench—indicated the relative difference in performance. The test team calculated the performance results for the SQL Server 2005 and SUSE LAMP VMs by totaling the OPM from all the VMs running in the test environment; NetBench provides the megabits-per-second metric as part of the results displayed at the end of a test. Table 5 summarizes the performance results including the power consumption for the three workloads on each server.

| | **HP ProLiant DL585 G2** | | | **PowerEdge 2950** | | |
|---|---|---|---|---|---|---|
| **Workload** | Number of VMs | Performance | Power Consumption (W) | Number of VMs | Performance | Power Consumption (W) |
| **Microsoft SQL Server 2005** | 36 | 31,729 OPM | 719 | 32 | 29,346 OPM | 449 |
| **SUSE LAMP** | 46 | 10,093 OPM | 743 | 44 | 9,852 OPM | 447 |
| **NetBench** | 52 | 1,028 Mb/sec | 735 | 42 | 1,001 Mb/sec | 444 |

Table 5: Workload performance results for each server in the test environment

The power consumption numbers captured for these tests were captured by logging the power readings while the test was running and then averaging them. An important factor in any power consumption number is the configuration and load level of the server. The power numbers recorded and reported here are heavily dependent on the amount of RAM, number of PCI adapters, number of internal disks, and the amount of load on the system. All of the configuration options were kept as equal as possible between the systems based on the number of sockets.

Scaling out a virtualization server farm is different from server clustering. In some types of database clusters for example, there is a high amount of coordination between the individual server cluster nodes in order to maintain database integrity. This results in an overhead in performance due to the clustering software that manages this coordination. The servers in a VMware Infrastructure 3 farm are each running many virtual machines which have no interdependence on each other due to the fact that they are in the same server farm. Each server in the farm operates its set of VMs independently of the other servers in the farm. Due to the nature of how a farm of VMware Infrastructure 3 servers operates, performance and power consumption of multiple servers can be extrapolated simply by multiplying the results from single servers shown in Table 5. The extrapolation of these results allows for examination of how the performance of a farm of these servers could perform. This is shown for 2 DL 585 G2s and 3 PowerEdge 2950s in Table 6. Three Dell 2-socket systems outperform two HP 4-socket systems by margins of 39, 46 and 46% on the three workloads, for an average of 44%, while showing a 35% cost advantage.

| | **2 HP ProLiant DL585 G2s** | **3 PowerEdge 2950s** | **Dell Advantage** |
|---|---|---|---|
| **Total Number of Sockets** | 8 | 6 | |
| **SQL Server 2005** | 72 VMs / 63,458 OPM | 96 VMs / 88,038 OPM | 33% / 39% |
| **SUSE LAMP** | 92 VMs / 20,186 OPM | 132 VMs / 29,556 OPM | 44% / 46% |
| **NetBench** | 104 VMs / 2056 Mb/s | 126 VMs / 3003 Mb/s | 22% / 46% |
| **Averaged Cumulative Power Consumption on SQL/SUSE/ Netbench (W)** | 1465 | 1340 | 9% |
| **Hardware Cost** | $56,176 | $40,494 | 39% |
| **ESX Licensing** | $27,828 | $21,564 | 29% |
| **Total Cost** | $84,004 | $62,058 | 35% |

Table 6: Performance and Cost Comparison of 3 PowerEdge 2950 servers over 2 HP ProLiant DL585 G2 servers – all numbers are extrapolated from the single server results in Table 5

The following graph illustrates how the comparison in VM performance and power consumption would work out if an entire industry standard 42U rack was fully populated with either Quad-Core PowerEdge 2950s or Dual-Core Proliant DL 585 G2s. Up to 21 PowerEdge 2950 servers will fit into a rack, whereas only 10 DL 585 G2s will fit because a 2950 consumes half the amount of rack space as a DL585 G2. It is clear from the chart that a rack of the two-socket Dell PowerEdge 2950 will consume less power and produce more VM performance at a higher density than a rack of the HP Proliant DL 585 G2 servers. See Figure 1 where the results from the SQL Server 2005 VM testing are projected out for an entire 42U rack.

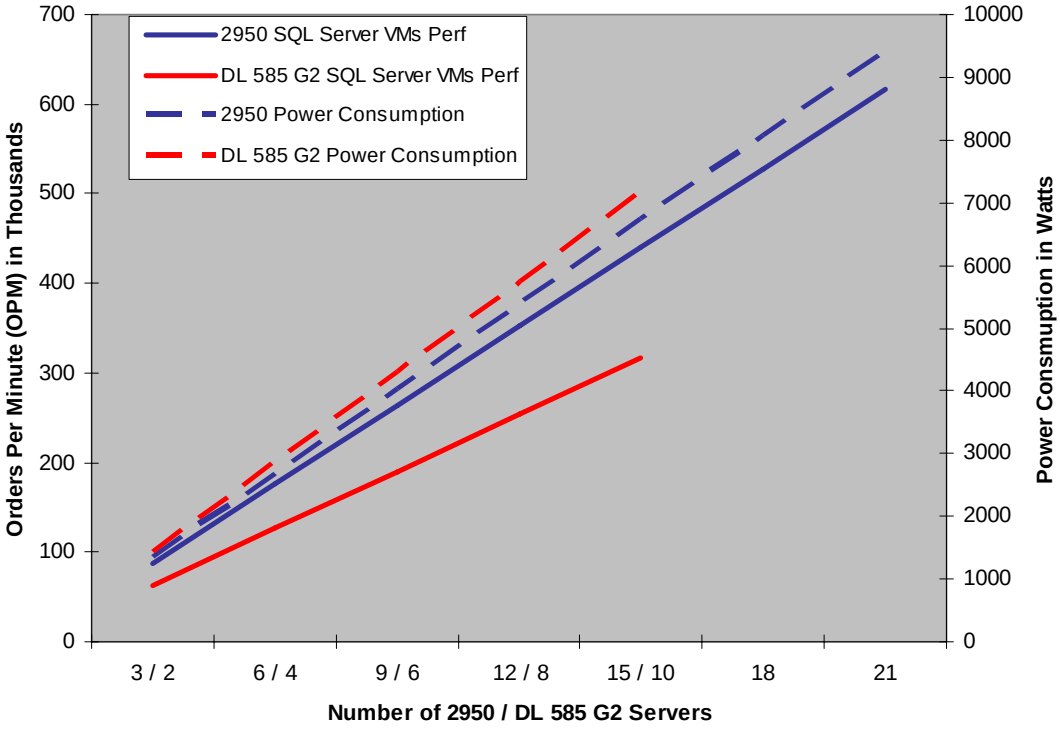


Figure 1 Projected performance and power consumption of 21 PowerEdge 2950 and 10 Proliant DL 585 G2 servers while running SQL Server 2005 VMs for a single 42U rack.

**Performance Per Watt.** In order to understand the relationship between performance and power consumption a simple calculation of the amount of performance achieved per watt of power consumed is needed. This is referred to as performance per watt and higher numbers are better as more performance per watt is good. Table 7 shows the performance per watt calculations for all three VM workloads on both servers tested (based on the workload and power consumption results in Table 5). Averaged across all three workloads the Dell PowerEdge 2950 can deliver 57% more work per unit of power consumed than the HP DL585 G2.

| | HP ProLiant DL585 G2 | PowerEdge 2950 | Dell Advantage |
|---|---|---|---|
| **SQL Server 2005** | 44.1 OPM / watt | 65.4 OPM / watt | 48% |
| **SUSE LAMP** | 13.6 OPM / watt | 22.0 OPM / watt | 62% |
| **NetBench** | 1.4 Mb/s / watt | 2.3Mb/s / watt | 61% |
| | | | 57 % Average |

Table 7: Performance per watt comparison

**Price/Performance.** In addition to getting more virtualization performance with less power, the two-socket server approach also costs less. The two HP ProLiant DL585 G2s cost about 35% more than the three Dell PowerEdge 2950 servers used in this test. Another important factor is software licensing for these systems. Primarily because VI3 is licensed by socket, it is 41% more expensive to license eight sockets across the two DL585 G2s than it is to license six sockets across the three 2950s. As seen in Table 8 , on average the HP four-socket solution is nearly twice as expensive (95% more expensive) per unit of work attainable than the Dell two-socket solution.

| | 2 HP ProLiant DL585 G2 | 3 PowerEdge 2950s | Dell Advantage |
|---|---|---|---|
| **SQL Server 2005** | $1.32 / OPM | $ .70 / OPM | 88 % |
| **SUSE LAMP** | $4.16 / OPM | $2.09 / OPM | 98 % |
| **NetBench** | $40.86 / Mb/s | $20.67 / Mb/s | 98 % |
| | | | 95 % Average |

Table 8: Price / Performance comparison.

**Availability Advantages.** Two-socket platforms also provide an availability advantage over 4-socket solutions in terms of cost. The solutions illustrated in this study wouldn't be suitable in a production environment due to the lack of availability of each overall solution. Because each platform is operating at around 85% utilization if a node experienced a problem that required an outage the other remaining node or nodes would not be able to sustain the failed node's workload, resulting in an unacceptable solution. So in each instance one more node is required to properly load balance the solution and provide acceptable availability. When these availability requirements are taken into account and an additional server is added to both solutions, the cost advantages of Dell PowerEdge 2950 servers improves to an overall 69% cost advantage from the previous 35%. The largest factor is the savings in software license cost where the cost advantage improves to 94%. Table 9 illustrates the price analysis when an additional node is added to provide enough capacity to maintain availability in the event of a server failure.

| | 3 HP ProLiant DL585 G2s | 4 PowerEdge 2950s | Dell Advantage |
|---|---|---|---|
| **Total Number of Sockets** | 12 | 8 | |
| **Hardware Cost** | $84,264 | $53,992 | 56% |
| **ESX Licensing** | $55,656 | $28,752 | 94% |
| **Total Cost** | $139,920 | $82,744 | 69% |

Table 9 Availability Advantages

Section 6

# Conclusions

In terms of performance, power consumption, and costs the Dell PowerEdge 2950 two-socket, quad-core servers are a much better solution for virtualization than the HP Proliant DL 585 G2 four-socket dual-core servers. This is shown in the results of the testing with the two-socket virtualization solution from Dell providing up to 44% more performance, 57% more performance per watt and a 95% average advantage in price / performance than the HP four-socket solution.



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1 The use of Microsoft SQL Server 2005 in these tests does not indicate that Dell or Microsoft has tested or certified SQL Server with VMware virtualization software. As described at support.microsoft.com/?kbid=897615, Microsoft typically does not support problems with Microsoft operating systems or applications that run on VMs using non-Microsoft virtualization software unless the same problem can be reproduced outside the VM environment.

2 The LAMP stack has been fully documented in “MySQL Network and the Dell PowerEdge 2800: Capacity Sizing and Performance Tuning Guide for Transactional Applications,” by Todd Muirhead, Dave Jaffe, and Nicolas Pujol, Dell Enterprise Product Group, April 2005, www.dell.com/downloads/global/solutions/mysql_network_2800.pdf.

3 The NetBench client driver systems were two Dell PowerEdge 6650 servers with four Intel Xeon processors at 2.8 GHz, nine Dell PowerEdge 1855 servers with two dual core 2.8 GHz processors, and two Dell PowerEdge 1950 server with two dual core Xeon 5160 3.0 GHz processors. All client driver systems had 8 GB of RAM, Intel Gigabit Ethernet adapters, and Windows Server 2003,. The NetBench client driver systems and ESX Server hosts were connected to a Dell PowerConnect™ 5224 Gigabit Ethernet switch. The NetBench controller ran Windows Server 2003 Enterprise Edition and used an Intel Gigabit Ethernet adapter.