Dell PowerEdge R820 and HP ProLiant DL580 G7 SQL Virtualization Comparison

Measuring performance and power improvements of the new Intel Xeon processor E5-4600 product family for Dell PowerEdge servers

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Executive summary

Dell's Solutions Performance Analysis team conducted a study to measure performance and performance per watt in a virtualized environment to compare the Intel® Xeon® processor E5-4600 product family on the Dell™ PowerEdge™ R820 against the HP™ ProLiant™ DL580 G7 with Intel Xeon processor E7-8800/4800 product families. The configurations chosen provided maximum performance by equipping each server with the top-speed processors available, a 10 Gb network connection to a backend iSCSI SAN, and optimal performance memory configurations for both processor architectures tested. Using this data, the team conducted a full total cost of ownership (TCO) and return on investment (ROI) analysis to compare the real world value of each system in a data center.

The study indicates that the PowerEdge R820 offers similar performance to the HP ProLiant DL580 G7 while operating with much higher processor efficiency (performance per watt). The PowerEdge R820 is also able to provide much greater processing density, supporting almost two times the number of virtual machines (VMs) per rack space unit (U) and orders per minute (OPM) per unit at optimal performance. Each rack space unit (U) is 1.75 inches (or 4.45 mm) and will be referred to for the remainder of this study by its abbreviation.

Key findings of the study include:

- The Dell PowerEdge R820 with Intel Xeon E5-4650 processors:
  - **Provided 148% higher virtualized online transaction processing (OLTP) performance per U** than the HP ProLiant DL580 G7 with Intel Xeon E7-8837 processors.
  - **Provided 80% higher virtualized OLTP performance per U** than the HP ProLiant DL580 G7 with Intel Xeon E7-4870 processors.
  - **Obtained 323,605 orders per minute (OPM) per U** in a virtualized environment, as compared to the DL580 G7 configuration, which scored 130,459 OPM per U with the E7-8837 processors and 179,346 OPM per U with the E7-4870 processors.
- The Dell PowerEdge R820 with Intel Xeon E5-4650 processors:
  - **Provided 220% more virtual machines (VMs)** per U at optimal performance than the HP ProLiant DL580 G7 with Intel Xeon E7-8837 processors and 60% more VMs per U than the HP ProLiant DL580 G7 with Intel Xeon E7-4870 processors.
  - **Supported 16 VMs per U** as compared to the DL580 G7 configuration, which supported five VMs per U with the E7-8837 processors and 10 VMs per U with the E7-4870 processors.
- The Dell PowerEdge R820 with Intel Xeon E5-4650 processors:
  - **Obtained 42% higher performance per watt** than the ProLiant DL580 G7 with Intel Xeon E7-8837 processors
  - **Obtained 17% higher performance per watt** than the ProLiant DL580 G7 with Intel Xeon E7-4870 processors.
  - **Obtained a performance per watt score of 920 OPM/watt in a virtualized environment**, as compared to the DL580 G7 configuration with E7-8837 processors:
    - Achieved a performance per watt score of 648 OPM/watt and the DL580 G7 configuration with E7-4870 processors
    - Achieved a performance per watt score of 784 OPM/watt
- The HP ProLiant DL580 G7 with the Intel Xeon processor E7-8800/4800 product families:

  - **Used 178% more overall power at system idle** than the Dell PowerEdge R820 with Intel Xeon E5-4650 processors.
  - **Used an average of 195W at idle**, as compared to the ProLiant DL580 G7 configuration, which used an average of 543W with the Intel Xeon E7-8837 processors and an average 545W at idle with the Intel Xeon E7-4870 processors.

- The HP ProLiant DL580 G7 with Intel Xeon E7-8837 processors:
  - **Used 15% more power running the DVD Store 2 benchmark** than the Dell PowerEdge R820 with Intel Xeon E5-4650 processors and the HP ProLiant DL580 G7 with Intel Xeon E7-4870 processors used 30% more power running the benchmark compared to the Dell PowerEdge R820 with Intel Xeon E5-4650 processors.
  - **Used an average of 703W at runtime**, compared to the ProLiant DL580 G7 configuration, which used an average of 806W with the Intel Xeon E7-8837 processors and an average 915W with the Intel Xeon E7-4870 processors.
- In four units of rack space (4U), two Dell PowerEdge R820s with Intel Xeon E5-4650 processors:
  - **Provided 148% higher virtualized online transaction processing (OLTP) performance** than one HP ProLiant DL580 G7 with Intel Xeon E7-8837 processors and 80% higher virtualized OLTP performance than one HP ProLiant DL580 G7 with Intel Xeon E7-4870 processors.
  - **Obtained 1,294,420 orders per minute (OPM) in a virtualized environment**, as compared to the DL580 G7 configuration, which scored 521,835 OPM with the E7-8837 processors and 717,384 OPM with the E7-4870 processors.
- In four units of rack space (4U), two Dell PowerEdge R820s with Intel Xeon E5-4650 processors:
  - **Provided 220% more virtual machines (VMs)** at optimal performance than one HP ProLiant DL580 G7 with Intel Xeon E7-8837 processors and 60% more VMs than one HP ProLiant DL580 G7 with Intel Xeon E7-4870 processors.
  - **Supported 64 VMs**, as compared to the DL580 G7 configuration, which supported 20 VMs with the E7-8837 processors and 40 VMs with the E7-4870 processors.

Introduction

In order to provide a better understanding for virtualization performance, this study describes specific application performance in a virtualized environment. The servers used in this study are the Dell PowerEdge R820 with the Intel Xeon processor E5-4600 product family and the HP ProLiant DL580 G7 with the Intel Xeon processor E7-8800/4800 product family. This study compares Microsoft® SQL Server™ virtualization performance using the DVD Store workload, which measures the total orders per minute (OPM) a server can achieve using multiple virtualized instances of the benchmark. Raw performance, total power draw at 100% and idle, as well as the density each product offers are measured to provide a comprehensive picture of the relative performance, density, and cost of each system.

Considerations include:

- Comparing Microsoft SQL Server virtualized performance between the Dell PowerEdge R820 with the Intel Xeon processor E5-4600 product family and the HP ProLiant DL580 G7 equipped with the Intel Xeon processor E7-8800/4800 product family. The optimal number of VMs for each system is determined by calculating the total operations per minute (OPM) while scaling out the number of VMs assigned to each server.
- Comparing the power utilization of the Dell PowerEdge R820 server with the Intel processor Xeon processor E5-4600 product family and the HP ProLiant DL580 G7 server with the Intel Xeon processor E7-8800/4800 product family at idle and 100% CPU utilization levels.
- Comparing the performance per watt of the Dell PowerEdge R820 server with the Intel Xeon processor E5-4600 product family and the HP ProLiant DL580 G7 server with the Intel Xeon processor E7-8800/4800 product family.
- Comparing the total number of VMs and orders per minute (OPM) you can support per rack unit (U) between the Dell PowerEdge R820 server with the Intel Xeon E5-4600 product family and the HP ProLiant DL580 G7 server with the Intel Xeon E7-8800/4800 product family.
- Comparing the total cost of ownership (TCO) of both the Dell PowerEdge R820 server with Intel Xeon E5-4600 product family and the HP ProLiant DL580 G7 server with Intel Xeon E7-8800/4800 product family through their full life cycle as well as the number of months it would take to realize a full return on investment (ROI) when choosing to purchase the new Dell PowerEdge R820 instead of the older HP ProLiant DL580 G7.

Test description

DVD Store Version 2 (DS2) is a complete online e-commerce test application with a back-end database component, a web application layer, and driver programs. The goal in designing the database component as well as the mid-tier application was to use many advanced database features (for example, transactions, stored procedures, triggers, and referential integrity) while keeping the database easy to install and understand. The DS2 workload can be used to test databases or as a stress tool for any purpose.

The distribution includes code for Microsoft SQL Server, Oracle®, and MySQL™ databases. Included in the release are data generation programs; shell scripts to build data for 10 MB, 1 GB, and 100 GB

versions of the DVD Store; database build scripts and stored procedures; PHP web pages; and a C# driver program.[1]

Database workload sizes can be small, medium, or large, depending on environment setup. See Table 1 for details.

Table 1. DVD Store database size description

Database	Orders	Size	Products	Customers
Small	10 MB	20,000	1,000/month	10,000
Medium	1 GB	2,000,000	100,000/month	100,000
Large	100 GB	200,000,000	10,000,000/month	1,000,000

Sample environment characterization

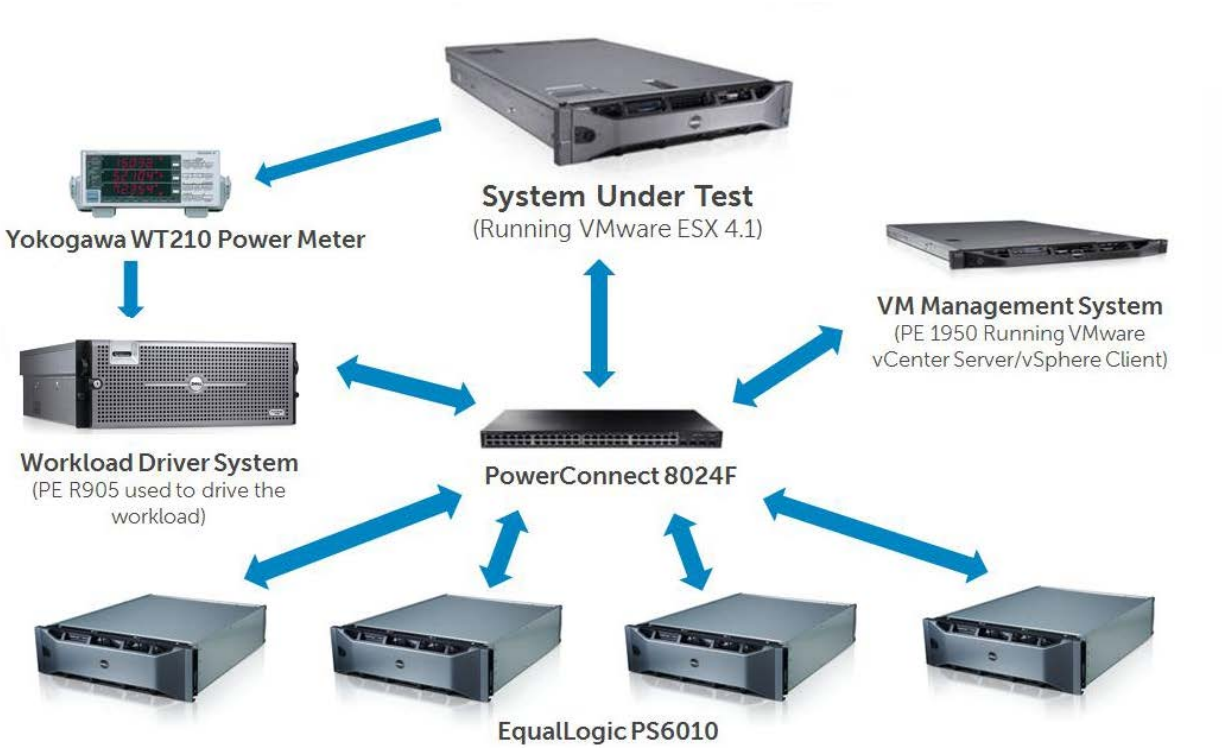
To measure consolidated VM infrastructure host performance in a simulated e-commerce scenario, a full end-to-end solution was implemented. This environment consists of a physical server (host) running VMware® ESXi™ 4.1 update 2. In the diagram in Figure 1, this is referred to as the system under test (SUT).

In addition to the SUT, the environment contains an environment controller system and a workload driver system. The environment controller is running Windows Server® 2008 SP1. The intent of this system is to manage the VMware vCenter™ and vSphere™ client and act as a logging device for the power analyzer. The workload driver system is running Windows Server 2008 R2 Enterprise. This system is used to create simultaneous SQL user workload instances on the VMs that are being tested.

In addition to these three physical systems, the environment contains a 10Gb Ethernet Dell PowerConnect™ 8024F switch, four Dell EqualLogic™ PS6010 SANs, and a Yokogawa WT210 power analyzer. The PowerConnect switch enables communications between the VMs and controller systems (workload driver and environment controller), and between the SUTs and the iSCSI-based EqualLogic storage backend. The power analyzer is connected to the environment controller system through a serial cable. The power analyzer takes one-second snapshots of all power readings and the controller logs this data during both the idle and active portions of the benchmark runs.

[1] Test description information from Dell Enterprise Technology Center website: http://en.community.dell.com/techcenter/extras/w/wiki/dvd-store-readme.aspx

Figure 1. DVD Store test environment



Virtualized SQL system configurations

Configurations used in the test environment are shown in Table 2 and Table 3.

Table 2. System test configurations

Platform	PowerEdge R820	ProLiant DL580 G7
Hypervisor Operating System	VMware ESXi 4.1 Update 2	
Processor Model	4x Intel Xeon E5-4650	4x Intel Xeon E7-8837 and E7-4870
Processor Frequency	2700 MHz	2700 MHz and 2400 MHz
Memory Details	32x 8GB 2Rx4 LV RDIMMs	
Memory Frequency	1333 MT/s	
Internal Storage	2x2.5-inch 300GB 10k rpm SAS (RAID1)	
BIOS Power Management Setting	Maximum Performance and System DBPM	
Physical Cores	32	32 and 40
Logical Processors	64	64 and 80
# 2-vCPU VMs (Optimal OPM)	32	20 and 40

Table 3. Supporting infrastructure configurations

Environment controller system	SQL workload driver system
PowerEdge 1950 Windows Server 2008 Enterprise SP1 2 x Intel Xeon Processor E5410, 2.33 GHz Memory: 16 GB RAM Disk configuration: 2 x 73 GB SAS (RAID 1)	PowerEdge R905 Windows Server 2008 R2 Enterprise 4 x AMD Opteron™ 8435, 2.60 GHz Memory: 96 GB RAM Disk configuration: 2 x 146 GB SAS (RAID 1)
Networking	**Power analyzer**
PowerConnect 8024F running at 10GbE 1 network power used per EqualLogic SAN (4 total) 1 network power used for SUT 1 port used as management port (via vSphere) Jumbo frames enabled on switches and SANs	Monitors SUT only Measures all power data during active portion of the benchmark Average watts during active and idle periods measured during official run

Test methodology

Overview

The following methodology was used in the testing procedure:

- Determined the optimal number of virtual machines that each SUT can support. Each SUT was tested with 20, 24, 28, 32, 36, 40, and 44 VMs and the total OPM recorded. The number of VMs that provided the highest total OPM was the number of VMs chosen to test that particular server for the remainder of the study.
- Exercised all enabled VMs for a 10-minute run time.
- Recorded performance metric, SUT Performance counters, and power measurements.

Note: The performance metric recorded is OPM (orders per minute) — a measure of the number of orders processed during the benchmark runtime.

Data collection overview

The following steps were used in collecting data:

1. Determined the number of VMs to enable during testing by scaling the number of VMs from 20 to 44 VMs and recording the total OPMs for each level.
2. Built a medium-size SQL database on each VM using DVD Store scripts.
3. Backed up each SQL database to a restore file, allowing the database to be restored from a pristine state, and then deleted all VM databases.
4. Restored all databases from the backup restore file and rebooted all VMs.
5. Performed a warm-up run to prepare databases for the official run, allowing each database to warm up individually and allowing a 10-minute idle period after warm-up to allow VMs to return to a steady state.
6. Performed the official run starting all VMs simultaneously using a script. The power analyzer began measuring system power at the start of the official run and an ESX host was triggered to start ESXtop batch session during the official run.

   (Note: The VMware ESXtop tool gathered system-related performance counters for profiling CPU usage during official run.)
7. Checked the official run data for performance stability, collecting data if stable, and restarting the process if high variation was present.

Data collected during the official run included:

- Average watts used during the official run (power metric)
- Average of the total ESXtop CPU counters during the official run (CPU percentage)
- VM throughput in OPM; the metric used in this study is an aggregate OPM measurement of all enabled VMs and is represented as performance in the test results

Because ESXtop was actively logging performance counters during these runs, the numbers published in this study are not directly comparable to other published DVD Store results by either Dell or its competitors.

Test results

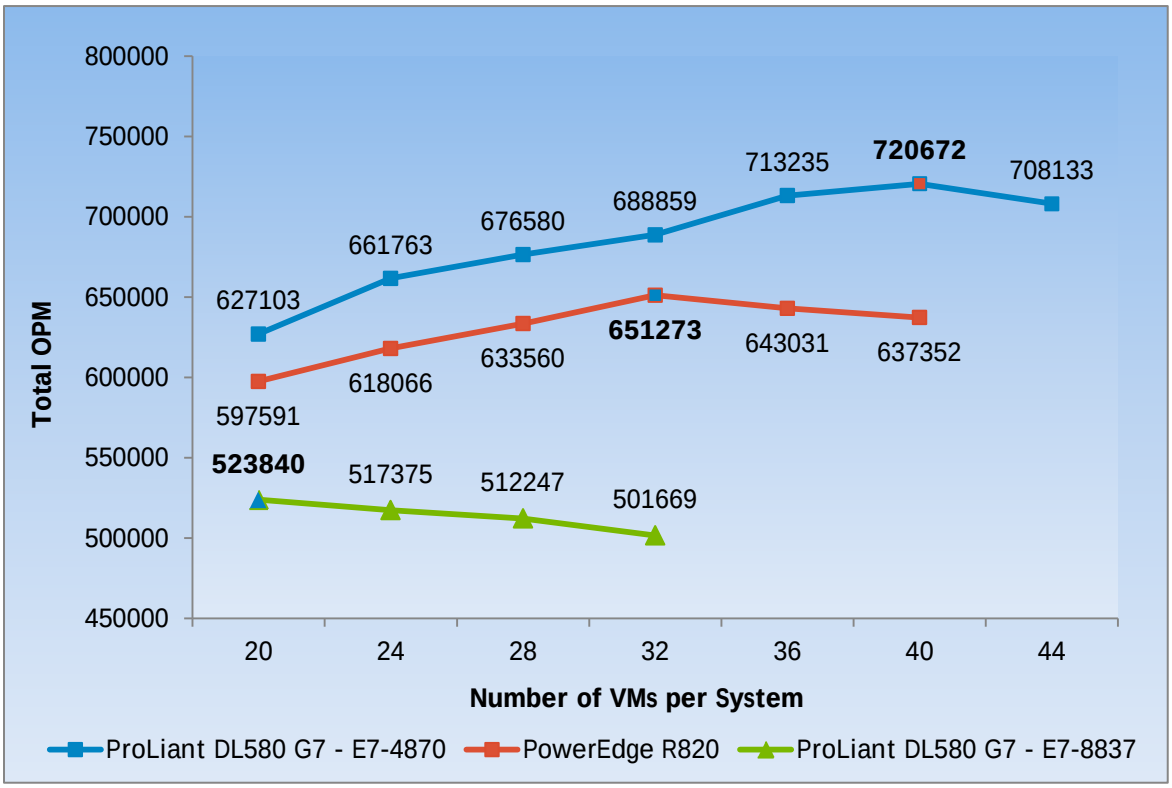
Virtual machine scaling to determine optimal load for each system

In comparing the Dell PowerEdge R820 server with the HP ProLiant DL580 G7 server, it was necessary to determine the optimal loading of VMs on each system due to the architectural differences in the processors. The R820 features the new Intel Xeon processor E5-4600 product family and the DL580 G7 comes equipped with the Intel Xeon processor E7-8800/4800 product family. The Intel Xeon E5-4650 processor has 8 physical processing cores with 20 MB L3 cache, while the Intel Xeon E7-8837 processor has 8 physical processing cores with 20 MB L3 cache, and the E7-4870 processor has 10 physical processing cores with 30 MB L3 cache. The first test in this study was to determine how many VMs to assign each server for the remainder of the testing.

To allow each system to perform at its highest level for the scaling study, each system was set to Maximum Performance mode in the BIOS and configured with 2 DIMMs per memory channel. The Intel Xeon E5-4650, Xeon E7-8837, and Xeon E7-4870 processors all have 4 memory channels per processor. For a quad processor configuration, this means the R820 and DL580 G7 are both configured with 32 DIMMs each. Later in this study, when power measurements are taken, the servers will be set to System Demand Based Power Management (System DBPM) BIOS mode for the R820 and Balanced Power and Performance BIOS mode for the DL580 G7.

The results of this scaling study, as illustrated in Figure 2, show that the DL580 G7 with E7-8837 processors produces a maximum OPM (523,840) at 20 VMs and the DL580 G7 with E7-4870 processors produces a maximum OPM (720,672) at 40 VMs. The R820 generated a maximum OPM (651,273) at 32 VMs. This optimal number of VMs is used for the rest of this study for each system.

Figure 2. OPM scaling by number of VMs per SUT



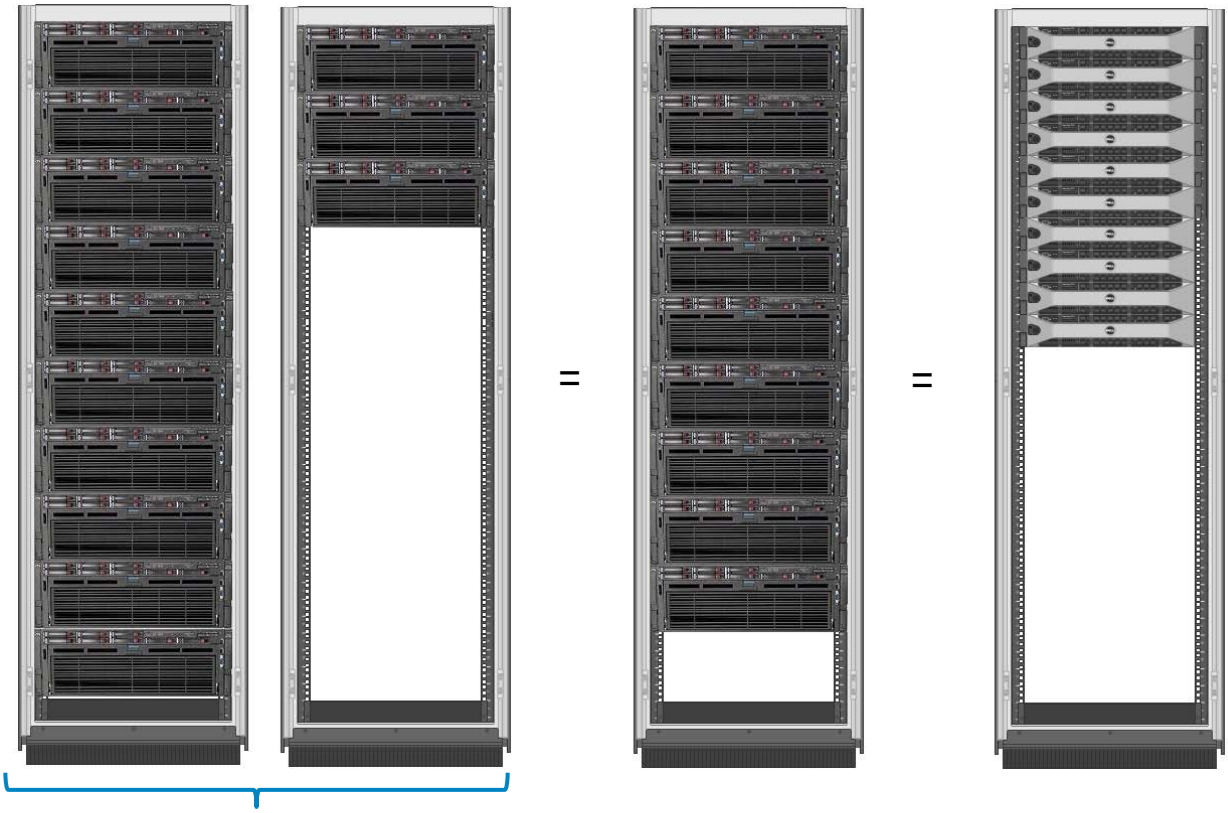
This first comparison highlights a very important feature of the new R820 with the Intel Xeon E5-4650. When compared to the DL580 G7 with the E7-8837 processor having the same number of cores, the E5-4650 scores 24% higher and supports 60% more VMs. When compared to the DL580 G7 E7-4870, which has 25% more cores, the R820 with the Xeon E5-4650 scores within 10% of the top number despite the difference in cores. The PowerEdge R820 provides equivalent performance to the DL580 G7 in half the rack space consumed.

Performance translates to server consolidation and density

Using orders per minute (OPM) as a performance metric is very useful because total OPM is calculated by totaling the performance of each active VM, regardless of how many physical servers are present. Although OPM or raw throughput data is a key metric in performance discussions, an alternative way to view performance is to look at the performance metric in terms of consolidation and density. In this instance, the comparison would be how many ProLiant DL580 G7 servers can be consolidated into one PowerEdge R820 and how much rack space would each server take up in the data center?

In terms of relative performance, PowerEdge R820 scores 24% higher than ProLiant DL580 G7 with the Intel Xeon E7-8837 processors and 10% lower than the ProLiant DL580 G7 with E7-4870 processors, but in half the rack space (2U versus 4U). As visualized in Figure 3, ten PowerEdge R820 servers in a 20U rack space is equal to nine ProLiant DL580 G7 servers with Xeon E7-4870 processors in a 36U rack space and equal to thirteen ProLiant DL580 G7 servers with Xeon E7-8837 processors in a 52U rack space.

Figure 3. Performance ratio in server consolidation and rack density format



At normalized performance levels, Figure 3 illustrates server consolidation transitioning from the HP ProLiant DL580 G7 with Intel Xeon E7-8837 processors on the left, to the HP ProLiant DL580 G7 with Intel Xeon E7-4870 processors in the middle, and finally the Dell PowerEdge R820 with Intel E5-4650 processors on the right. As you can see, the PowerEdge R820 provides a solution that performs on par with the HP servers and takes up much less data center space than either ProLiant DL580 G7 offering.

Performance density

As shown in the previous section, the PowerEdge R820 provides much greater compute density compared to the ProLiant DL580 G7. Because there is a price premium for every inch of data center space, this is a very important variable to consider. In a 4U rack space you can get either one ProLiant DL580 G7 or *two* PowerEdge R820 servers. Because of this greater compute density, the performance and number of VMs per U you can achieve with the PowerEdge R820 is much greater than the DL580 G7.

In a 4U server rack space you can achieve 148% more OPM with the PowerEdge R820 compared to the DL580 G7 with E7-8837 processors and 80% greater OPM compared to the DL580 G7 with E7-4870 processors. Figure 4 shows this performance comparison.

Figure 4. Performance achieved in a 4U rack space

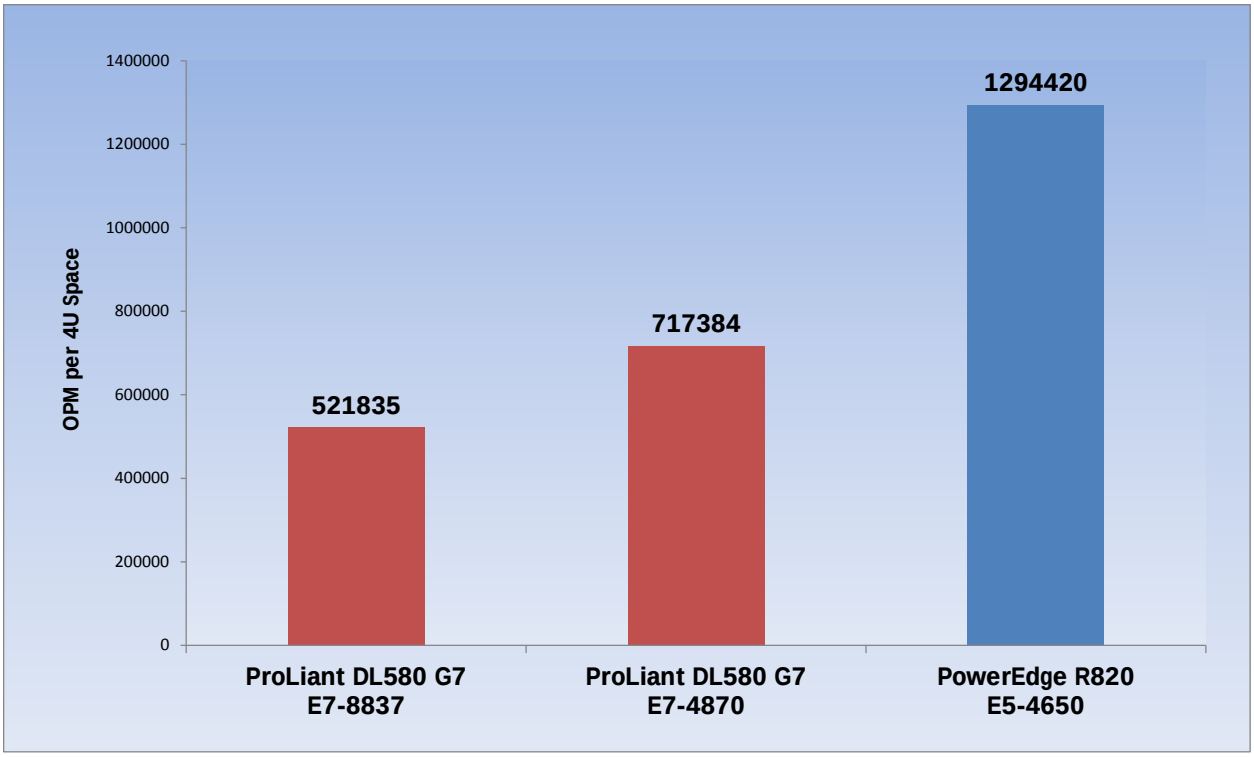


Table 4. OPM per 4 Us of rack space

R820 E5-4650	DL580 G7 E7-8837	DL580 G7 E7-4870
1,294,420	521,835	717,384
PowerEdge R820 Advantage	**148%**	**80%**

Virtual machine density

The increased performance density shown in the previous section also applies to the number of virtual machines you can support. At optimal performance, the PowerEdge R820 provides a much greater number of virtual machines compared to the ProLiant DL580 G7.

In a 4U server rack space, you can achieve 220% more virtual machines with the PowerEdge R820 compared to the DL580 G7 with E7-8837 processors and 60% more virtual machines when compared to the DL580 G7 with E7-4870 processors. Figure 5 shows this virtual machine density comparison.

Figure 5. Virtual machines supported in a 4U rack space

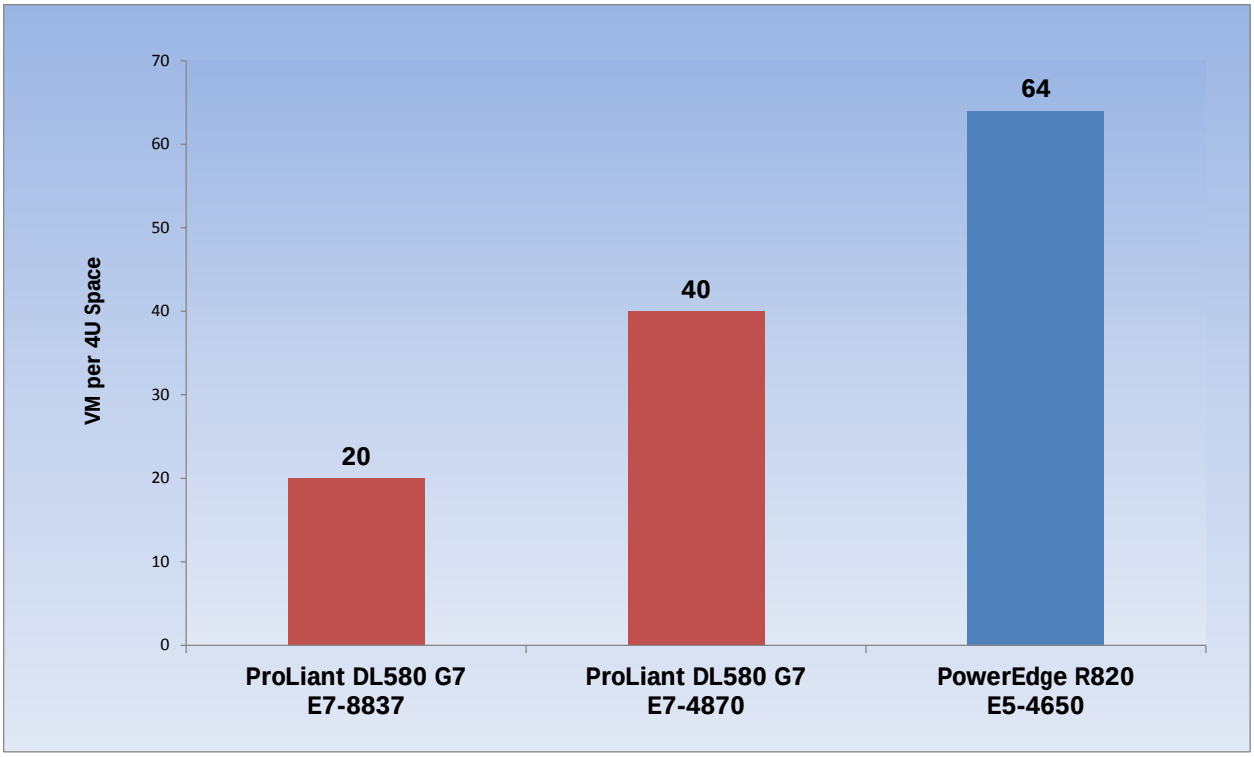


Table 5. Virtual machines per 4U rack space

R820 E5-4650	DL580 G7 E7-8837	DL580 G7 E7-4870
64	20	40
PowerEdge R820 Advantage	**220%**	**60%**

Idle power draw comparison

The idle power usage of the three systems is the first power comparison to consider. The PowerEdge R820 server was set to System DBPM mode in the BIOS and the ProLiant DL580 G7 server was set to Balanced Power and Performance mode in the BIOS. The hardware installed on the systems remained the same. Power measurements were then taken when the systems were at complete idle, having set inactive for 10 minutes between runs.

The PowerEdge R820 drew 195 watts at system idle; the ProLiant DL580 G7 server drew 543 watts at system idle with the E7-8837 processors and 545 watts at system idle with the E7-4870 processors. Lower power draw is better in this comparison and the ProLiant DL580 G7 consumed 178% and 179% more power at system idle than the PowerEdge R820 depending on which processor it was configured with.

Figure 6. PowerEdge R820 and DL580 G7 — idle power draw (lower is better)

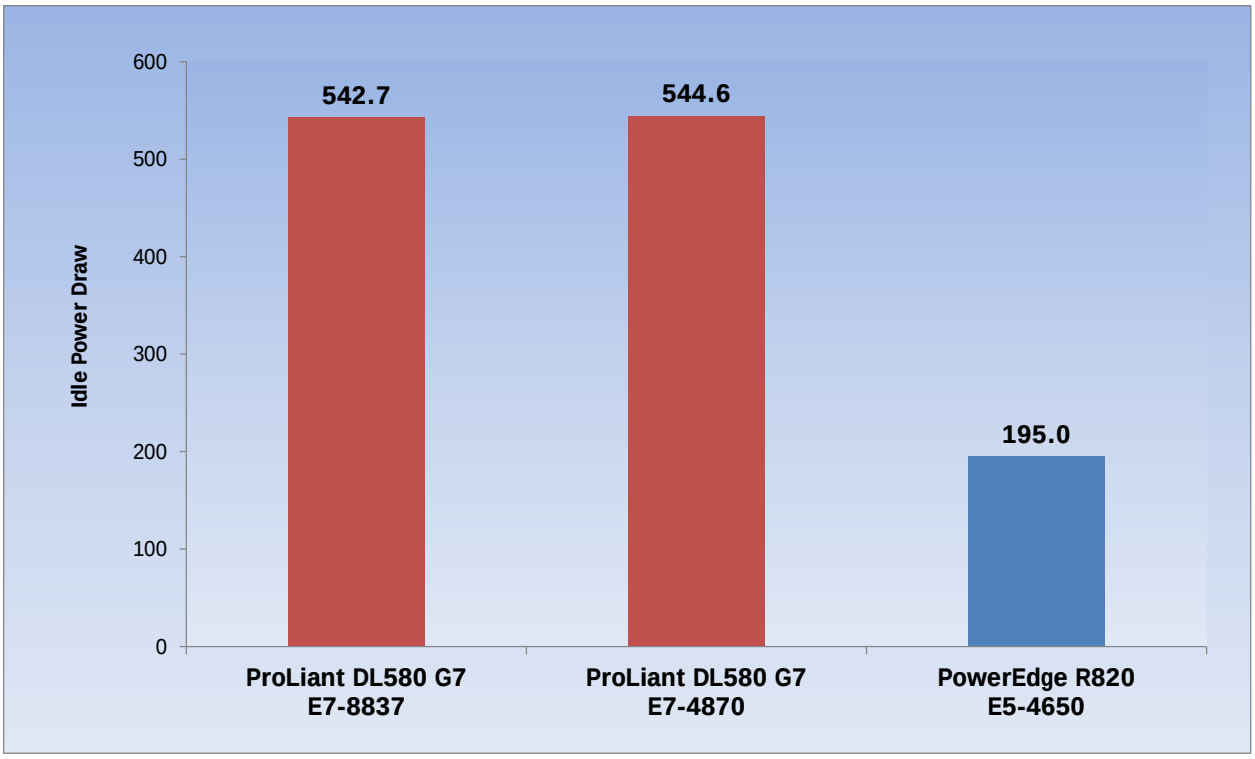


Table 6. Idle power draw

R820 E5-4650	DL580 G7 E7-8837	DL580 G7 E7-4870
195	542.7	544.6
PowerEdge R820 Advantage	**178%**	**179%**

Performance per watt

The idle power measurement comparison tells only half the story of power usage. When the server is actively running, the benchmark of the power draw goes up considerably. Not only do customers want a system that performs at a high level, but also one that does so while drawing the least amount of power possible. Calculating the total OPM/watt shows the measure of a system's processing efficiency. The formula for calculating OPM/watt is as follows:

Aggregate performance (OPM) / Average power consumed = OPM per watt (OPM/watt)

The Dell PowerEdge R820 provided better performance per watt than the HP ProLiant DL580 G7. The R820 scored 920 OPM/watt compared to the DL580 G7, which scored 648 OPM/watt with E7-8837 processors and 784 OPM/watt with E7-4870 processors. This gives the R820 an 42% advantage compared to the DL580 G7 E7-8837 configuration and a 17% improvement over the DL580 G7 E7-4870 configuration. Not only does the R820 offer higher processing density than the DL580 G7, but it does so more efficiently as well.

Figure 7. PowerEdge R820 and ProLiant DL580 G7 performance per watt

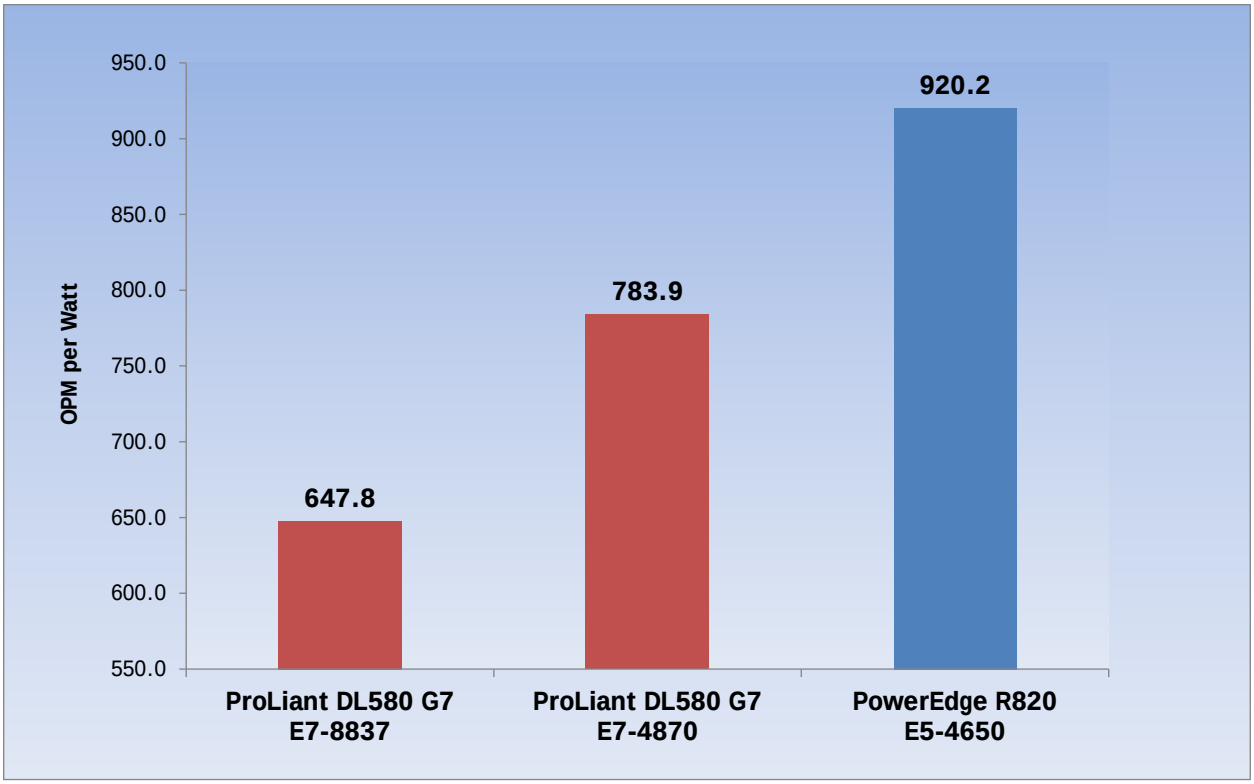


Table 7. Performance per watt (OPM/W)

	R820 E5-4650	DL580 G7 E7-8837	DL580 G7 E7-4870
Average Active Power	703.3 W	805.6 W	915.1 W
PowerEdge R820 Advantage	-	**15%**	**30%**
OPM per Watt	920.2	647.8	783.9
PowerEdge R820 Advantage	-	**42%**	**17%**

Total cost of ownership and return on investment

Getting the most out of every dollar spent toward operational expenses is important to any business or organization and the pressure on IT executives to deliver to that charter is greater than ever before. As a result, many IT organizations focus heavily on the cost of acquisition because these savings are not only easily measured but they are immediately realized. However, if a lower cost of acquisition doesn't result in greater efficiencies in the long term. The short-term gains can be lost in less than a year. Comparing the Dell PowerEdge R820 to the HP ProLiant DL580 G7 demonstrates this perfectly.

Total cost of ownership (TCO) methodology

We calculated TCO using the cost of hardware, software, support, and energy use over a three-year period for the Dell PowerEdge R820 and the HP ProLiant DL580 G7. We then used this data to calculate the TCO savings using the same Dell and HP rack servers and their respective configurations and costs.

The calculations for the cost of hardware, software, and warranty support are at full retail price as of April 2012 and do not include any contract pricing or discounts.

Return on investment (ROI) methodology

We calculated ROI by comparing the performance and the expenditures for hardware, software, support, rack space, and energy for each server over a 36-month ownership cycle. The calculated date for a full return on investment is the month that the total infrastructure efficiencies provided by the server exceed their initial relative cost.

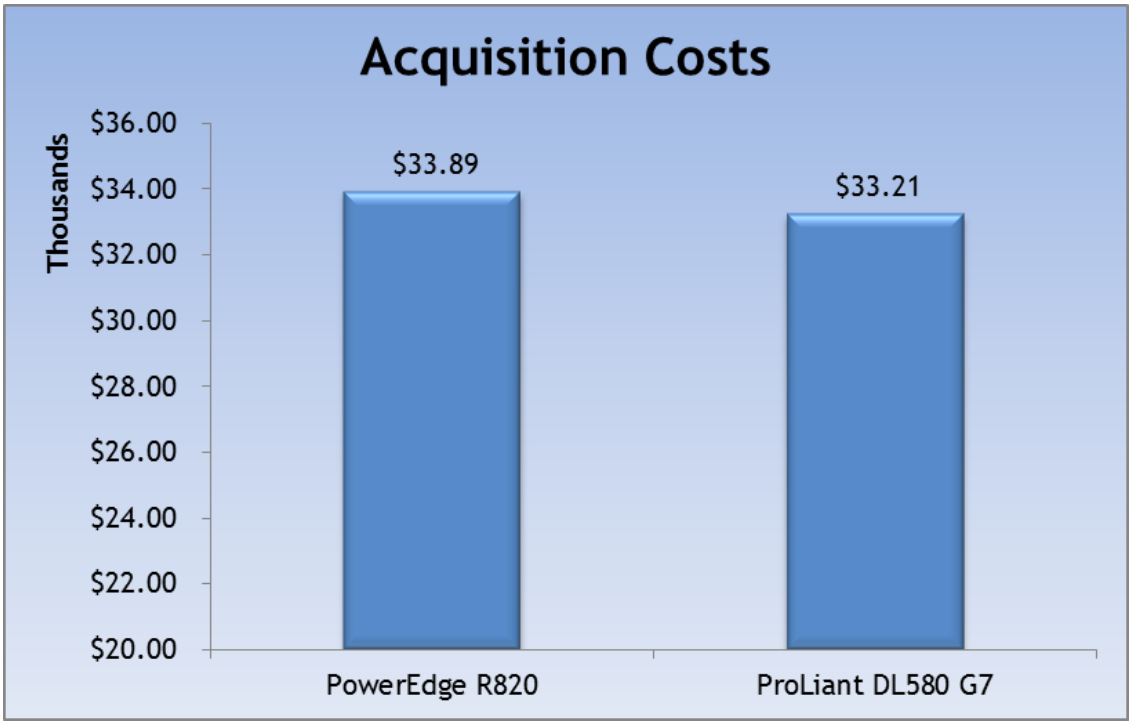
Server acquisition cost

The configurations used in this study are virtually the same when comparing the acquisition costs. In fact, at MSRP, the HP ProLiant DL580 G7 hardware is $675.88 less expensive than the Dell PowerEdge R820. If we calculate that savings over a large data center of 1000 servers, that small difference very rapidly turns into a significant savings. Table 8 and Figure 8 identify the base hardware acquisition cost per single server for each model and its respective configuration.

Table 8. Server acquisition cost

Server model	PowerEdge R820	ProLiant DL580 G7
Acquisition Cost per Server	$33,890	$33,214

Figure 8. Server acquisition costs



While hardware acquisition is the most obvious cost to consider when purchasing a server, there are several other factors that need to be addressed. The cost of software licenses, support, administration, power, cooling, and rack space are all important considerations in purchasing decisions as well.

Software acquisition

For the purposes of this study we calculated the per socket licensing cost of Windows SQL Server 2008 and VMware 4.1 and also added 1300.00 annually for warranty support. None of which provide either configuration an advantage for annual costs of software or support.

However, it is worth mentioning that if we had used software that required a per core license cost, like Microsoft SQL Server 2012, the ProLiant DL580 G7 with a 10 core processor would have immediately driven software acquisition costs much higher than the 8core processors used in the PowerEdge R820 configuration.

Administrative costs

We calculated the cost of a server administrator salary at $116,377 per year and based on their ability to administrate up to 50 servers that brings the costs to $2327.54 per server. In this case neither server has an advantage as these costs are fixed.

Dell PowerEdge R820 advantages

Where the rubber meets the road is the cost of power, cooling, and rack space. Our testing revealed that the Dell PowerEdge R820 not only provided better performance per U of rack space occupied but it was also much more energy efficient and would require less energy for power and cooling as well.

The increased density of the Dell PowerEdge R820 decreases the cost of rack space needed. These two wins add up to a significant savings over the life of the products.

Power and cooling costs

We calculated the costs of power at .12 cents per KWh based on the latest available estimates. Typically for every dollar spent on powering a server there is another dollar spent on cooling the server, so the server power cost was doubled to estimate including the data center cooling costs. We used three power levels to analyze power usage: system idle, 50%, and 100%. The 50% value was derived from averaging the system idle and 100% power levels. These three power usage levels were then used to calculate the average power and cooling costs for each server.

- The Dell PowerEdge R820 provides up to 279% lower cost at idle
- The Dell PowerEdge R820 provides up to 130% lower cost at average performance per watt
- The Dell PowerEdge R820 provides up to 162% lower cost at 50% utilization

Table 9. Power and cooling costs per server

Power Cost Breakdown	PowerEdge R820	ProLiant DL580 G7	R820 Advantage
Cost per year at idle	$204.90	$572.52	279%
Cost per year at 100% utilization	$739.31	$961.65	130%
Cost per year at 50% utilization	$472.48	$765.42	162%

Cost of rack space

The cost per server rack is $4142.90 and since up to 21 2U Dell PowerEdge R820 servers could fit into a 42U rack enclosure that brings the rack space cost of the Dell PowerEdge to $197.28 per server. Only ten of the 4U HP DL580 servers can fit into a 42U server rack enclosure at a cost of $414.21 per server.

The Dell PowerEdge R820 provides a significant savings due to its greater density and it requires much less space to provide a significant gain in performance compared the HP DL580.

The Dell PowerEdge R820 provides up to 216% lower cost per U of rack space

Table 10. Rack space cost per server

	PowerEdge R820	ProLiant DL580 G7	R820 Advantage
Cost per Rack Unit (U)	$192.28	$414.49	216%

Cost of OPM per rack unit and VMs per rack unit

Once we calculated the total cost of both the Dell PowerEdge R820 and the HP DL580 it is necessary to demonstrate the significant value that much greater density provides when comparing the two solutions. To do this, we divided those costs by the OPM per U and the VMs per U in order to get the cost for performance per unit of rack space.

- The Dell PowerEdge R820 provides a 184% lower cost per OPM per U
- The Dell PowerEdge R820 provides a 162% lower cost per VM per U

Table 11. Cost of OPM and VM per rack unit

	PowerEdge R820	ProLiant DL580 G7	R820 Advantage
Cost per OPM per U	$0.38	$0.7	184%
Cost per VM per U	$7714.27	$12,516.20	162%

TCO and ROI final metrics

Combining all of the preceding costs into one metric gives a true representation of how much it will cost to operate each of the systems in this study. The cost per year of the additional power, cooling, and rack space required for the ProLiant DL580 G7 make it a more expensive option when compared to the PowerEdge R820. The ProLiant DL580 G7 costs 3% more per year to operate because of these recurring costs. When combining acquisition costs with annual cost, the total payback period to get a full return on investment (ROI) for the PowerEdge R820 is 11 months. Extending this out to a typical lifespan of a server, the three-year total cost of ownership (TCO) for the PowerEdge R820 is 3% lower compared to the ProLiant DL580 G7, and this savings only gets larger the longer you own the system.

Table 12. Annual operating costs per server

	PowerEdge R820	ProLiant DL580 G7	R820 Advantage
Annual Operating Cost	$29,840	$30,650	3%

Figure 9. Annual operating costs per server

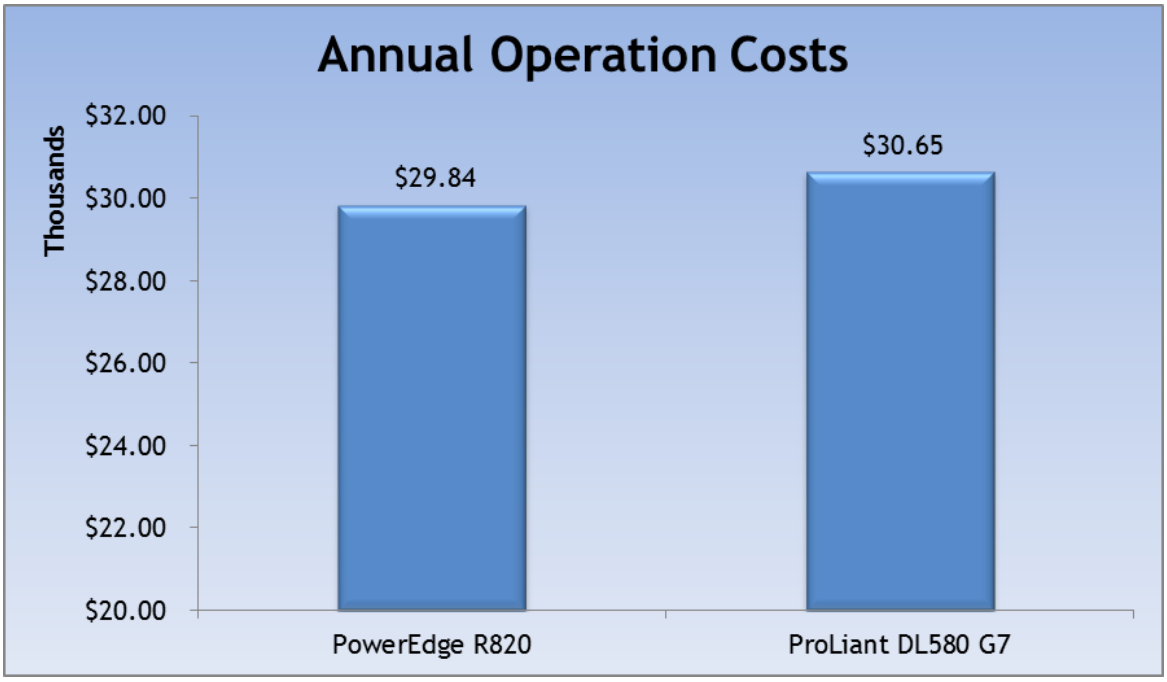


Table 13. Three-year total cost of ownership

	PowerEdge R820	ProLiant DL580 G7	R820 Advantage
3-Year Total Cost of Ownership	$89,520	$91,950	3%

Figure 10. Three-year total cost of ownership

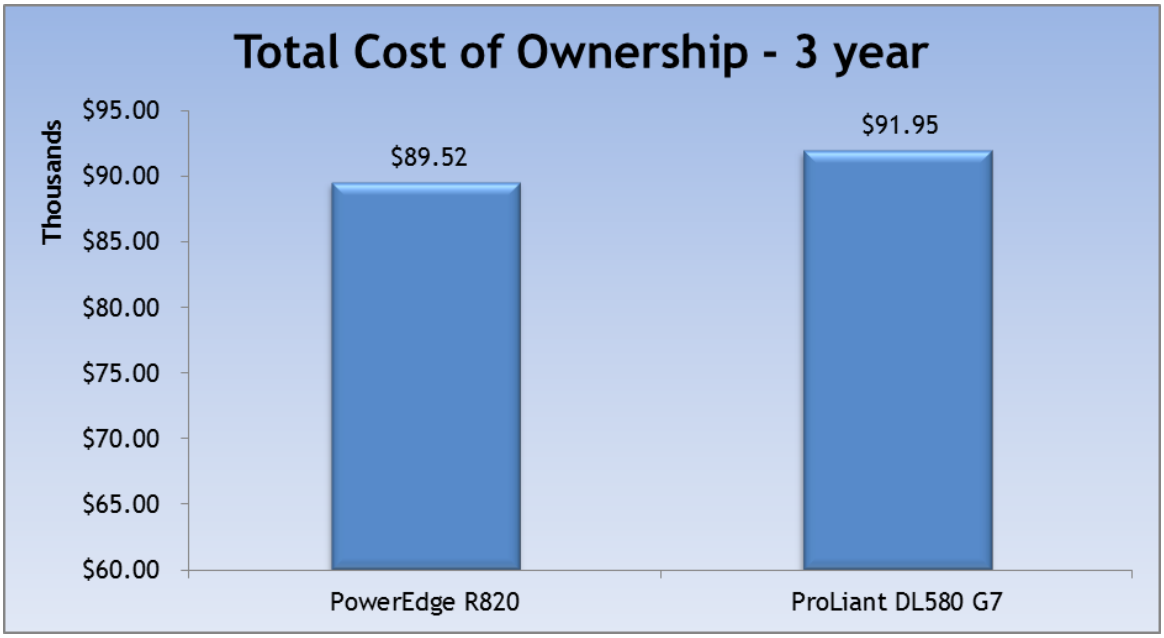


Table 14. Payback period for full return on investment

Month	PowerEdge R820	ProLiant DL580 G7
1	$36,376.76	$35,768.50
2	$38,863.52	$38,322.57
3	$41,350.28	$40,876.65
4	$43,837.04	$43,430.73
5	$46,323.80	$45,984.80
6	$48,810.56	$48,538.88
7	$51,297.31	$51,092.96
8	$53,784.07	$53,647.03
9	$56,270.83	$56,201.11
10	$58,757.59	$58,755.19
11 month total payback period	***$61,244.35***	***$61,309.26***

The Big Picture

Our testing revealed that the Dell PowerEdge R820 is the clear winner when analyzing the total cost of ownership and cost per performance of each platform. Dell PowerEdge R820 provides a significant advantage when compared to the HP ProLiant DL580 across multiple categories.

- The Dell PowerEdge R820 provides up to 184% lower cost per OPM per U
- The Dell PowerEdge R820 provides up to 162% lower cost per VM per U
- The Dell PowerEdge R820 provides up to 279% lower cost of power and cooling at idle
- The Dell PowerEdge R820 provides up to 130% lower cost of power and cooling at 100% utilization

- The Dell PowerEdge R820 provides up to 162% lower cost of power and cooling at 50% utilization
- The Dell PowerEdge R820 provides up to a 1% lower cost of acquisition
- The Dell PowerEdge R820 provides up to a 3% lower total cost of ownership

Taking the results and multiplying them over a 100-, 500-, and a 1000-server deployment representing a small, medium and large data center, the Dell advantage becomes even more significant for both acquisition and 3-year operational costs.

Table 15. Savings for small, medium, and large data centers

Data center type	Total savings
3-year TCO Savings per 100 Servers	$174,785
3-year TCO Savings per 500 Servers	$873,925
3-year TCO Savings per 1000 Servers	$1,747,850
3-Year Operations Savings 100 Servers	$242,343
3-Year Operations Savings 500 Servers	$1,211,715
3-Year Operations Savings 1000 Servers	$2,423,430

Conclusion

The goal of this study was to characterize the performance and power impacts of the new Dell PowerEdge R820 server featuring the Intel Xeon processor E5-4600 product family when compared to the HP ProLiant DL580 G7 with Xeon processor E7-8800/4800 product family using a virtualized database workload. Actual customer environments are unlikely to be running continuously at 100% processor utilization levels, but the relative scaling achieved with the transition to the PowerEdge R820 should still be indicative of the merits of the Intel Xeon processor E5-4600 product family and the overall design of the Dell PowerEdge R820.

Based on the data contained in this study, the PowerEdge R820 with E5-4650 processors provides considerable overall performance, performance per watt, and density advantages while reducing the overall system power at idle and under load over the HP ProLiant DL580 G7. The PowerEdge R820, with the Intel Xeon processor E5-4600 product family, is the quad-socket platform of choice for maximum performance and scalability with additional processing cores and higher capacity memory support, as well as reduced overall power usage through improved processor efficiency. For customers that desire a smaller data center footprint and a lower TCO, the Dell PowerEdge R820 is clearly the better alternative compared to the HP ProLiant DL580 G7.

Appendix A: References

The DVD Store Virtualized SQL test methodology and overall structure of this white paper are due in large part to previous studies, as well as technical manuals and documents. The following list contains the key sources of information this study drew upon.

- "Dell PowerEdge R910 SQL OLTP Virtualization Study: Measuring Performance and Power Improvements of New Intel Xeon E7 Processors and Low-Voltage Memory" by Waseem Raja and John Beckett, attachments.wetpaintserv.us/jD7st0SRn16bZhoLImoZoQ505396

- "Configuring VMware vSphere Software iSCSI With Dell EqualLogic PS Series Storage," en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19861454.aspx

- "How do I configure the optimal switch settings for IP based SAN?" by Naveen Iyengar, en.community.dell.com/techcenter/enterprise-solutions/w/oracle_solutions/1422.aspx

- "Dell EqualLogic Configuration Guide: A guide to building an iSCSI based SAN solution with Dell EqualLogic PS Series Arrays," en.community.dell.com/techcenter/storage/w/wiki/equallogic-configuration-guide.aspx

- "Dell PowerEdge R720 SQL OLTP Virtualization Study: Measuring performance and power improvements of the new Intel Xeon E5-2600 Series Processors" by Don Hoffman, http://i.dell.com/sites/content/shared-content/data-sheets/en/Documents/Dell-PowerEdge-R720-SQL-OLTP-Virtualization-Study.pdf

- "Dell PowerEdge R820 Virtualization Consolidation Study: Measuring performance and power improvements of the new Intel Xeon E5-4600 and E5-2600 product family" by Don Hoffman, Louis Barton, and John Barnhart, http://en.community.dell.com/techcenter/extras/m/white_papers/20106856.aspx

Appendix B: Additional configuration details

Table 16. Detailed system test configurations

Platform	PowerEdge R820	ProLiant DL580 G7
Processor model	4 x Intel Xeon E5-4650	4 x Intel Xeon E7-8837 and E7-4870
Processor frequency	2700 MHz	2667 MHz and 2400 MHz
Processor L3 cache	20 MB	20 MB and 30MB
Physical cores	32	32 and 40
Logical processors	64	64 and 80
Memory frequency	1333 MT/s	1333 MT/s
Memory details	32 x 8 GB 2Rx4 LV RDIMMs	32 x 8 GB 2Rx4 LV RDIMMs
Internal storage	2 x 2.5-inch 300 GB 10K rpm SAS (RAID 1)	
HBA	PERC H710p mini	P410i (512 MB)
BIOS power management	Maximum Performance and System DBPM were tested	Maximum Performance and Balanced Power and Performance were tested
BIOS version	1.0.0	2011.11.04A
iDRAC version	iDRAC7 Enterprise 1.05.05	iLO3 v1.2 - 3.14.2011
Total NIC ports used	1 x 10Gb PCIe, 1 x 1Gb LOM	1 x 10Gb PCIe, 1 x 1Gb LOM
10Gb Ethernet NIC	10Gb Intel XF PCI-E FC single port	10Gb Intel XF PCI-E FC single port
1Gb Ethernet onboard NIC	Intel Gigabit 4P I350-t rNDC	NC375i Integrated Quad Port Gigabit Adapter
Network firmware version	6.4.5	4.0.580
Power supply quantity and rating	1 x 1100W	2 x 1200W (min 2 PSU required for DL580 G7)
Line voltage used for testing	208V	208V

Table 17. Additional infrastructure and BIOS configurations

Virtual environment details		
Platform	**PowerEdge R820**	**ProLiant DL580 G7**
VMware ESXi version	4.1.2	4.1.2
OS version installed per VM	Windows 2008 Enterprise R2 x64	Windows 2008 Enterprise R2 x64
SQL version installed per VM	Microsoft SQL 2008 R2	Microsoft SQL 2008 R2
Number of VMs (optimal configuration)	32	20 and 40
Logical processors per VM	2	2
EqualLogic configuration		
EqualLogic systems in use	4	4
EqualLogic system type	EqualLogic PS6010 (RAID-10)	EqualLogic PS6010 (RAID-10)
Total storage per PS6010	3.66 TB	3.66 TB
Size and # of HDDs/PS6010	16 x 600 GB	16 x 600 GB
BIOS settings		
Turbo boost	Enabled	Enabled
Processor prefetchers	All enabled	All enabled
C-states	Enabled	Enabled
C1E	Enabled	Enabled
Logical processors	Enabled	Enabled
Node interleaving	Disabled	Disabled
Power management	Maximum Performance and System DBPM both tested	Maximum Performance and Balanced Power and Performance both tested