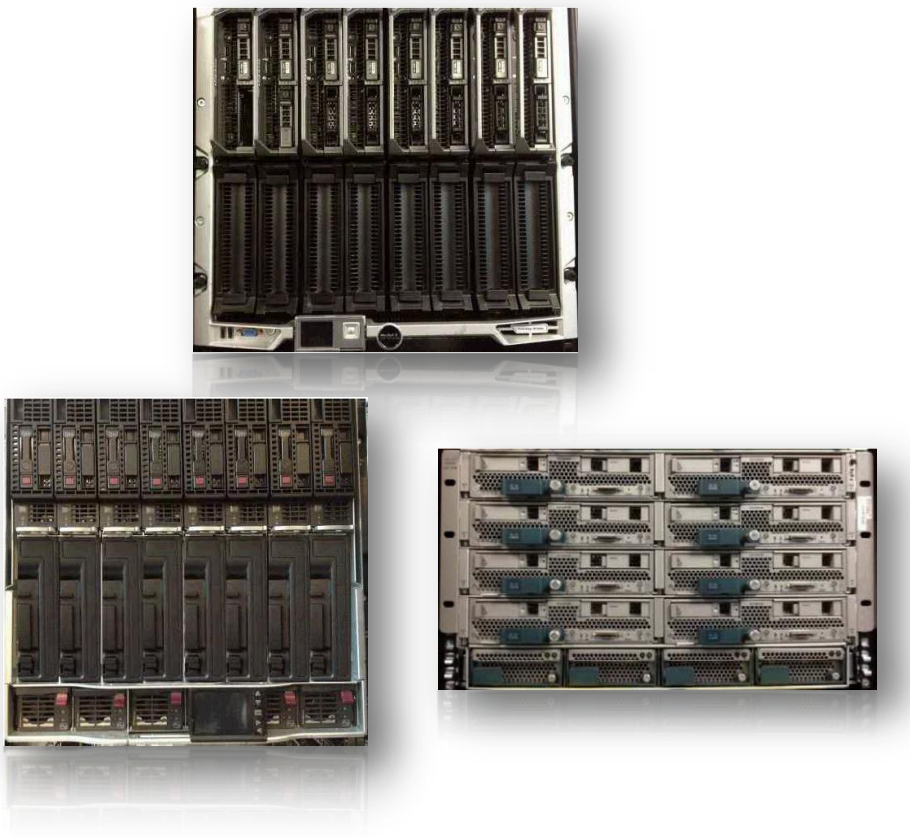
Comparing the Power Efficiency of Intel Xeon E5-2600 Based Blade Servers

This white paper compares the power efficiency of blade server solutions based on the Dell PowerEdge M620, the HP ProLiant BL460c Gen8, and the Cisco B200 M3 blade servers.



Brian Bassett

Solutions Performance Analysis

Dell | Enterprise Solutions Group

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Introduction

With power and cooling costs accounting for increasingly large portions of IT budgets, IT departments looking to minimize total cost of ownership (TCO) are making power efficiency a priority when choosing server hardware. On top of their density and management advantages, blade servers can be extremely power-efficient, and are an increasingly popular choice in the data centers. In this white paper, we examine the power efficiency of two-socket blade servers using the Intel® Xeon® processor E5-2600 product family.

The Dell™ Solutions Performance Analysis (SPA) team compared a blade server solution based on the Dell PowerEdge™ M620 to the HP® ProLiant™ BL460c Gen8 and the Cisco® UCS™ B200 M3; all of which use the Intel® Xeon® processor E5-2600 product family. Using the industry standard SPECpower_ssj2008® benchmark, the solution from each vendor was tested for performance, power draw, and performance per watt. The hardware for each solution was configured as similarly as possible to ensure an apples-to-apples comparison.

The results showed the **Dell PowerEdge™ M1000e blade chassis and M620 blades** delivered **better power efficiency** and **drew less power** than the **Cisco UCS and HP ProLiant blade solutions.**

Key findings

Performance per watt

- Overall, the **Dell PowerEdge M620 blade solution** achieved a **19% higher performance-to-power ratio** overall **than the Cisco** UCS B200 M3 blade solution in the base configuration, and **32% higher performance-to-power ratio than the HP** ProLiant BL460c Gen8 blade solution.
- At 70% target load, the **Dell blade solution** achieved a **23% higher performance-to-power ratio than the Cisco** blade solution in the tested configuration, and **48% higher performance-to-power ratio than the HP** blade solution.
- When each solution's power measurements included that vendor's external network switch, the **Dell blade solution** achieved a **45% higher performance-to-power ratio than the Cisco** blade solution in the tested configuration, and **26% higher performance-to-power ratio than the HP** blade solution.

Power

- When comparing power efficiency of the blades and enclosure, the **Dell blade solution drew 39% less power at idle than the Cisco solution**, and **32% less power at idle than the HP solution**.
- When external network components were measured for power, the **Dell** blade solution's external network switch **drew just 159 watts**, compared to **190 watts for the HP switch** and **690 watts for the Cisco switch** and external fabric interconnect.

Test methodology and detailed results are documented in this paper.

Methodology

SPECpower_ssj2008 is an industry standard benchmark created by the Standard Performance Evaluation Corporation (SPEC®) to measure a server's power and performance across multiple utilization levels. Appendix A — Test methodology details the test methodology used by Dell; Appendix B — Blade enclosure hardware configuration information; Appendix C — Blade server firmware and drivers; and Appendix D — SPECpower_ssj2008 results provide detailed report data that supports the results in this paper.

Configuration 1

Blades, chassis, and internal chassis components

Each blade solution measured for power efficiency was configured with eight blades, the blade enclosure, a 10GbE internal blade switch, and the maximum number of supported platinum-rated power supplies.

Table 1: Blade solution configurations

	Dell blade solution	HP blade solution	Cisco blade solution
Enclosure	PowerEdge M1000e	BladeSystem c7000	UCS 5108
Blade slots occupied / total	8 / 16	8 / 16	8 / 8
Blades	8 x PowerEdge M620	8 x ProLiant BL460c Gen8	8 x UCS B200 M3
Internal I/O Module	1 x Force10 MXL 10/40GbE blade switch	1 x Virtual Connect Flex-10 10Gb Ethernet Module	1 x UCS 2104XP Fabric Extender
Management	1 x Dell CMC Module	1 x HP Onboard Administrator Module	Cisco UCS Manager
Power supply quantity/rating	6 x 2700W platinum rated (Dell P/N 0G803N)	6 x 2450W platinum rated (HP P/N 570493-301)	4 x 2500W platinum rated (Cisco P/N N20-PAC5-2500W)

The blades in the three solutions were configured as similarly as possible, with comparable hard drives and memory. Storage controllers were matched as closely as possible between the three vendors.

The configurations of the blade servers used are summarized in Table 2.

Table 2: Detailed configuration for blades used in the power efficiency comparisons

Per blade	Dell PowerEdge M620	HP Proliant BL460c Gen8	Cisco UCS B200 M3
Sockets/form factor	2 / half height	2 / half height	2 / half width
Processors	2 x Intel Xeon E5-2670	2 x Intel Xeon E5-2670	2 x Intel Xeon E5-2670
Physical/logical cores	16/32	16/32	16/32
Memory	4 x 8GB Dual Ranked PC3L-10600R, LV RDIMMs	4 x 8GB Dual Ranked PC3L-10600R, LV RDIMMs	4 x 8GB Dual Ranked PC3L-10600R, LV RDIMMs
Hard drives	1 x 146GB 15k 6Gb, RAID 0	1 x 146GB 15k 6Gb, RAID 0	1 x 146GB 15k 6Gb, RAID 0
Network	Onboard 2 port Intel X520-k 10GbE	Onboard 2 port FlexFabric 10gb 554FLB FlexibleLOM	Integrated 4 port Cisco UCS VIC 1240
Storage controller	Dell PERC H310P	HP Smart Array P220i Controller	LSI SAS2004 Integrated RAID controller

As noted in Table 2, all blades were equipped with low voltage registered DIMMs (LV RDIMMs) purchased with their respective systems and running at the default 1.35 volts. Rather than employing power efficiency-specific BIOS tunings, the blade servers were set to their BIOS default settings for all tests, thus simulating a typical initial deployment. All blade servers ran Microsoft® Windows Server® 2008 R2 with Service Pack 1, with all Windows settings left at their defaults except for enabling the "Lock pages in memory" setting for the Administrator user, which is recommended in order for the SPECpower_ssj2008 benchmark to run optimally.

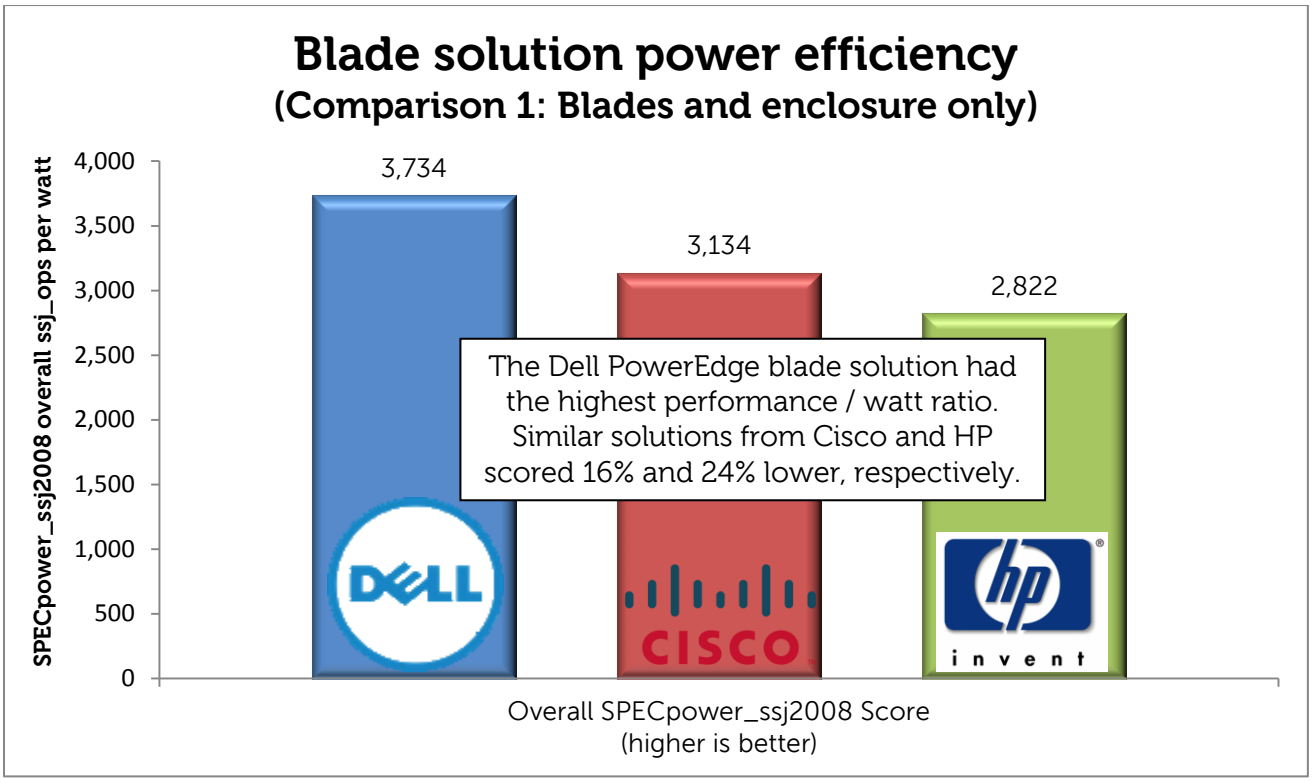
Results – Comparison 1

In Comparison 1, each vendor's blade solution was tested with only its blades, enclosure, and internal enclosure components measured for power; external network components were not included in the measurements.

At full load, the Dell blade solution's power draw was similar to that of the Cisco blade solution, but the HP blade solution drew 9% more power. At idle, however, the Cisco solution drew 64% more power than the Dell solution, and the HP solution drew 48% more power than the Dell solution.

Since the three solutions each provided equivalent performance at 100% load, with scores approximately 1% apart, the lower power draw of the Dell solution led to it scoring the highest in overall power efficiency score, with the scores by Cisco and HP being 16% and 24% lower, respectively.

Figure 1: Comparison 1 SPECpower_ssj2008 results for Dell, Cisco, and HP solutions



SPECpower_ssj2008 includes a measurement of power while the servers are at varying levels of target utilization. The performance-to-watt ratio at each target load level is total operations (ssj_ops) divided by average power consumption of the server at that load level. Figure 2 shows power efficiency at each interval.

Figure 2: Performance per watt ratios for all target loads (Comparison 1)[1]

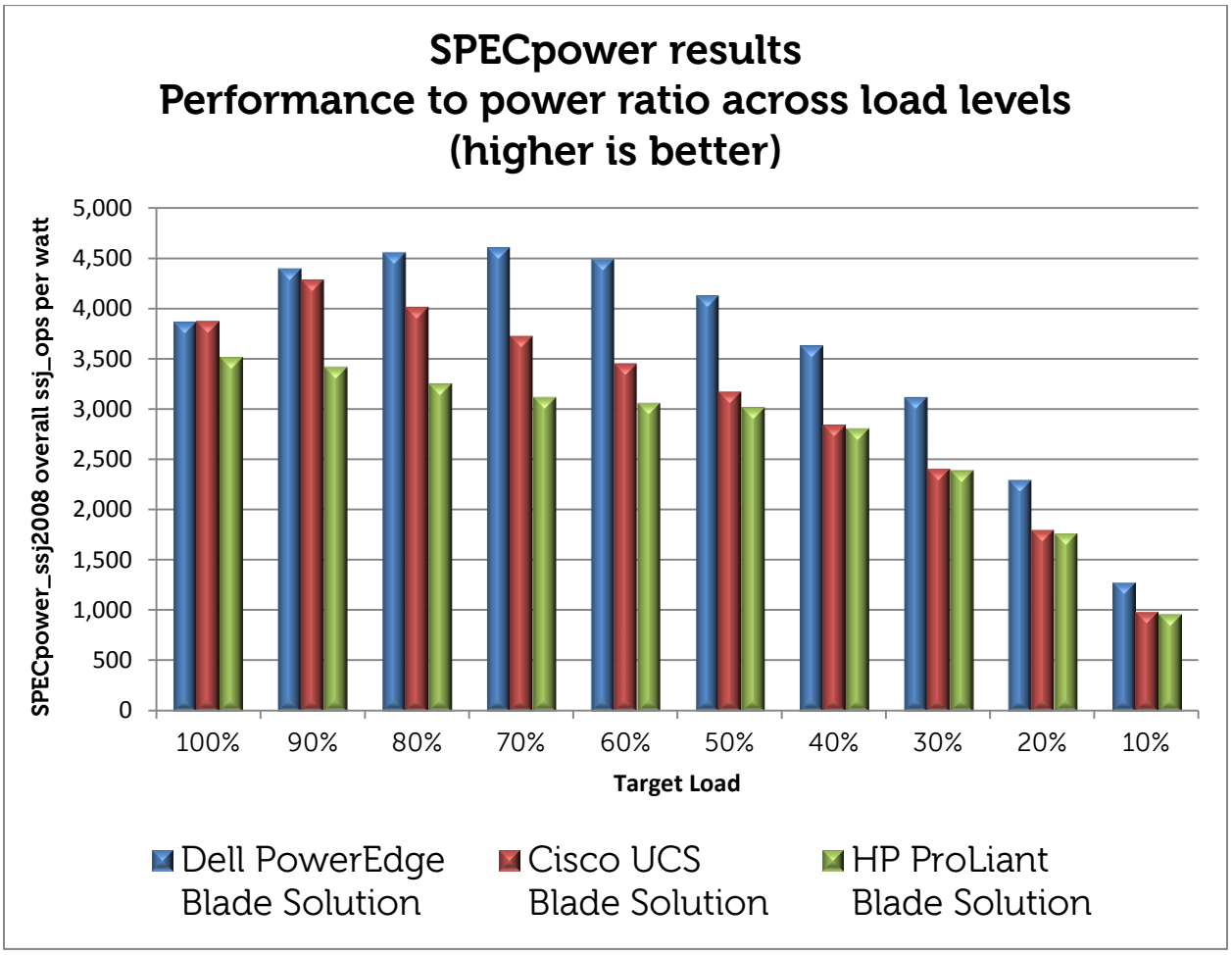


Figure 2 shows that the Dell PowerEdge blade solution has a significant power efficiency advantage over the HP ProLiant blade solution at all target loads, from a 10% percent advantage at 100% target load up to a 48% advantage at 70% load.

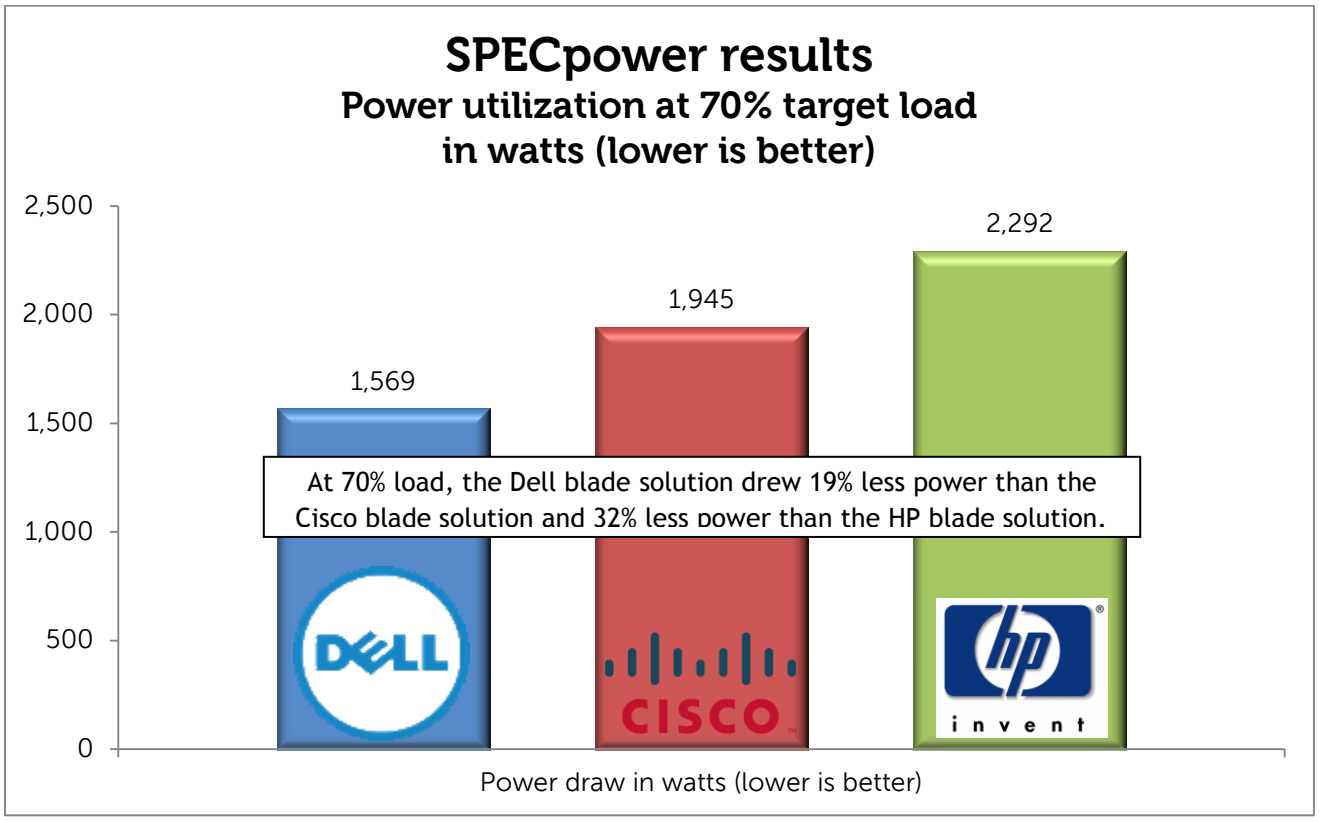
The Dell PowerEdge blade solution also shows significantly greater power efficiency than the Cisco UCS blade solution at most load levels, with as much as a 30% higher overall ratio at the 50% load level compared to the Cisco solution.

[1] Required SPEC disclosure information: PowerEdge M620 blade solution scores: (10,253,850 ssj_ops and 2,652 W) @ 100% target load and 3,734 overall ssj_ops/watt vs. UCS B200 M3 blade solution scores: (10,376,719 ssj_ops and 2,677 W) @ 100% target load and 3,134 overall ssj_ops/watt vs. ProLiant BL460c Gen8 blade solution scores: (10,209,104 ssj_ops and 2,903 W) @ 100% and 2,822 overall ssj_ops/watt. Comparison based on results by Dell Labs October 2012. SPEC® and the benchmark name SPECpower_ssj® are registered trademarks of the Standard Performance Evaluation Corporation. For more information about SPECpower, see www.spec.org/power_ssj2008/.

When IT professionals are calculating their data center needs, a target CPU utilization per server of 70% is often used to allow extra capacity for load peaks. This makes that interval particularly relevant for evaluating power efficiency. At the 70% target load interval, the Dell PowerEdge blade solution's ratio of 4,607 overall ssj_ops per watt gives it a 23% power efficiency advantage over the Cisco UCS blade solution (3,751 overall ssj_ops per watt) and a 48% advantage over the HP ProLiant blade solution (3,118 overall ssj_ops per watt).

Figure 3 shows the power draw of the three solutions at the 70% load level.

Figure 3: Power utilization at 70% target load (Comparison 1)[2]

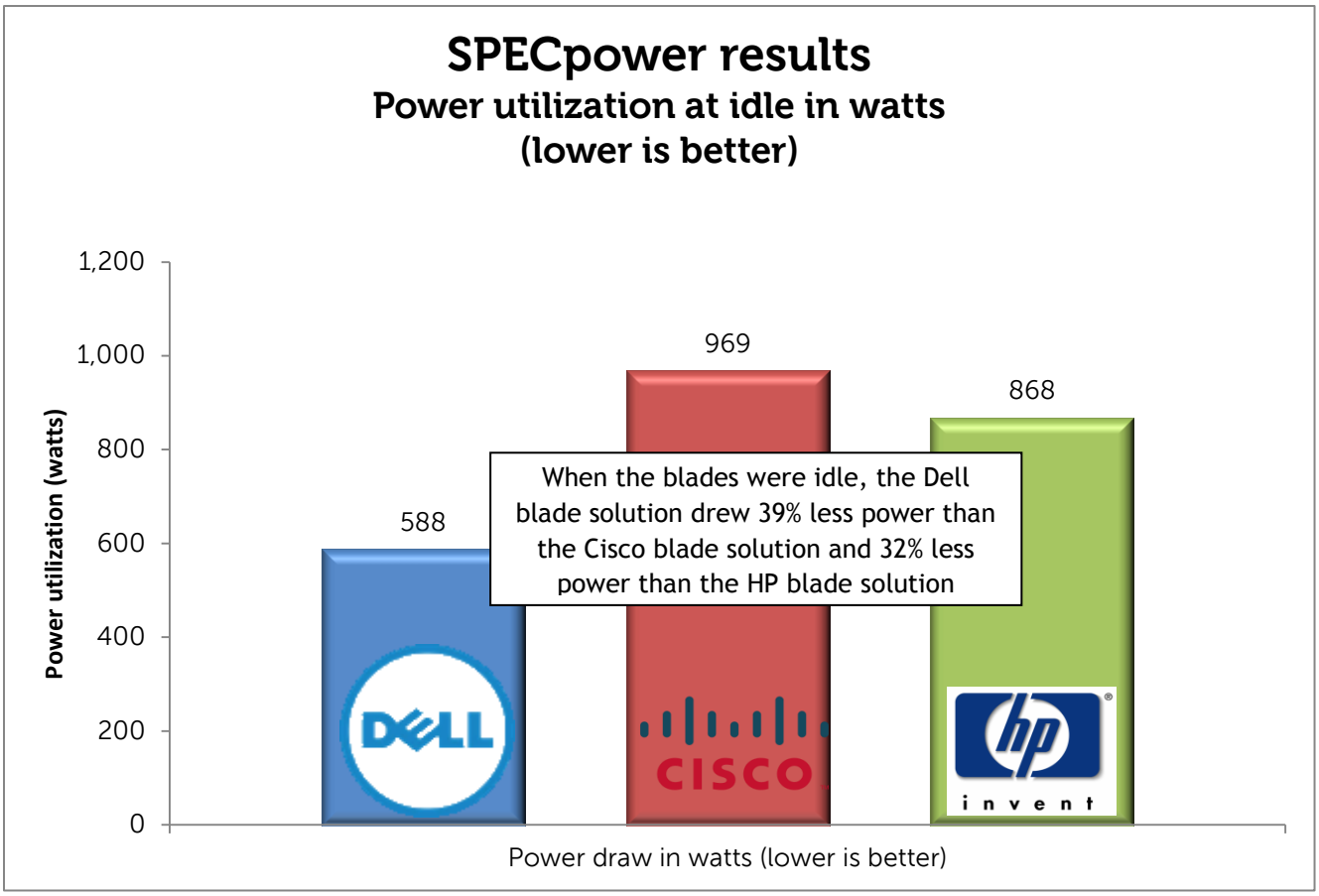


At this interval, the Cisco UCS blade solution consumed an average of 376 more watts than the Dell PowerEdge blade solution, and the HP ProLiant blade solution consumed an average of 723 more watts than the Dell PowerEdge solution.

[2] Required SPEC disclosure information: PowerEdge M620 blade solution scores: (7,230,008 ssj_ops and 1,569 W) @ 70% target load and 3,734 overall ssj_ops/watt vs. UCS B200 M3 blade solution scores: (7,261,416 ssj_ops and 1,945 W) @ 70% target load and 3,134 overall ssj_ops/watt vs. ProLiant BL460c Gen8 blade solution scores: (7,144,097 ssj_ops and 2,292 W) @ 70% and 2,822 overall ssj_ops/watt. Comparison based on results by Dell Labs October 2012. SPEC® and the benchmark name SPECpower_ssj® are registered trademarks of the Standard Performance Evaluation Corporation. For more information about SPECpower, see www.spec.org/power_ssj2008/.

SPECpower_ssj2008 also includes a measurement of power while the servers are at 0% target utilization (Active Idle). Average power utilization of the three blade solutions is shown in Figure 4. Compared to the Dell PowerEdge blade solution, at idle the Cisco UCS blade solution consumed 381 watts more (65% higher) on average, and the HP ProLiant blade solution consumed 280 watts more (48% higher) on average.

Figure 4: Power utilization at active idle (Comparison 1)[3]



[3] Required SPEC disclosure information: PowerEdge M620 blade solution scores: (10,253,850 ssj_ops and 2,652 W) @ 100% target load and 3,734 overall ssj_ops/watt vs. UCS B200 M3 blade solution scores: (10,376,719 ssj_ops and 2,677 W) @ 100% target load and 3,134 overall ssj_ops/watt vs. ProLiant BL460c Gen8 blade solution scores: (10,209,104 ssj_ops and 2,903 W) @ 100% and 2,822 overall ssj_ops/watt. Comparison based on results by Dell Labs October 2012. SPEC® and the benchmark name SPECpower_ssj® are registered trademarks of the Standard Performance Evaluation Corporation. For more information about SPECpower, see www.spec.org/power_ssj2008/.

Configuration 2

Blades, chassis, internal chassis components, and external networking

In Comparison 1, power measurements for each solution included the blades, blade enclosure, and internal enclosure components only. For Comparison 2, in order to provide a more detailed picture of the power efficiency of the complete solutions provided by the vendors, an additional power meter was used to measure the power draw of each vendor's enterprise-class external networking components, and that power draw was included in the power measurements of each solution. Other than including the external network components in the power measurements, no changes were made to the configuration of each solution between Configuration 1 and Configuration 2.

Table 3 lists the external network switch used in each blade solution and measured for power efficiency in Comparison 2.

Table 3: External networking components included in power measurements (Comparison 2)

	Dell blade solution	HP blade solution	Cisco blade solution
10GbE external switch	Dell Force10 S4810 (Dell P/N: W9C6F)	HP ProCurve 5900 (HP P/N: JC772A)	Cisco Nexus 5020 (Cisco Model Number/s: N5K-C5020P-BF, N5K-C5020P-BFS)
External Blade Management Module	N/A	N/A	Cisco UCS 6120XP 20 1RU Fabric Interconnect (Cisco P/N: N10-S100)

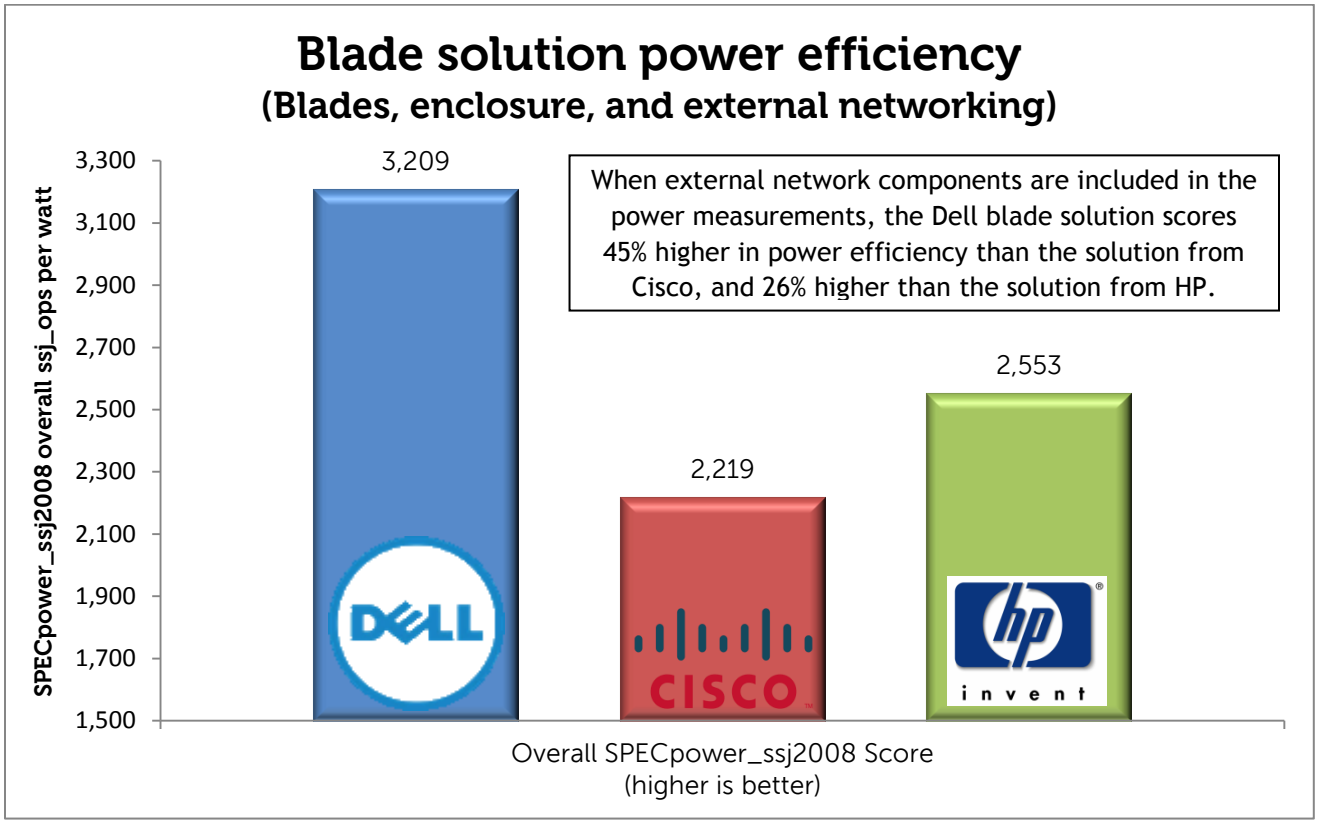
For external top-of-rack networking, similar solutions were chosen from each vendor, with each external switch providing at least 40 ports of 10Gb Ethernet.

The Cisco UCS blade solution's management is provided by the external UCS 6120XP Fabric Interconnect module. Since this is a required piece for the UCS solution, its power draw was included in the measurements for Comparison 2. The management for the Dell and HP blade solutions is provided by internal modules, and their power measurements were included in the measurements in Comparison 1, so they are also included in Comparison 2.

Results – Comparison 2

When the external network components are included in the power measurements, the power efficiency score of each vendor's solution goes down, as expected. Figure 5 shows that the Dell blade solution still leads in power efficiency, followed by the HP blade solution. The Cisco blade solution ranks the lowest for power efficiency in this comparison.

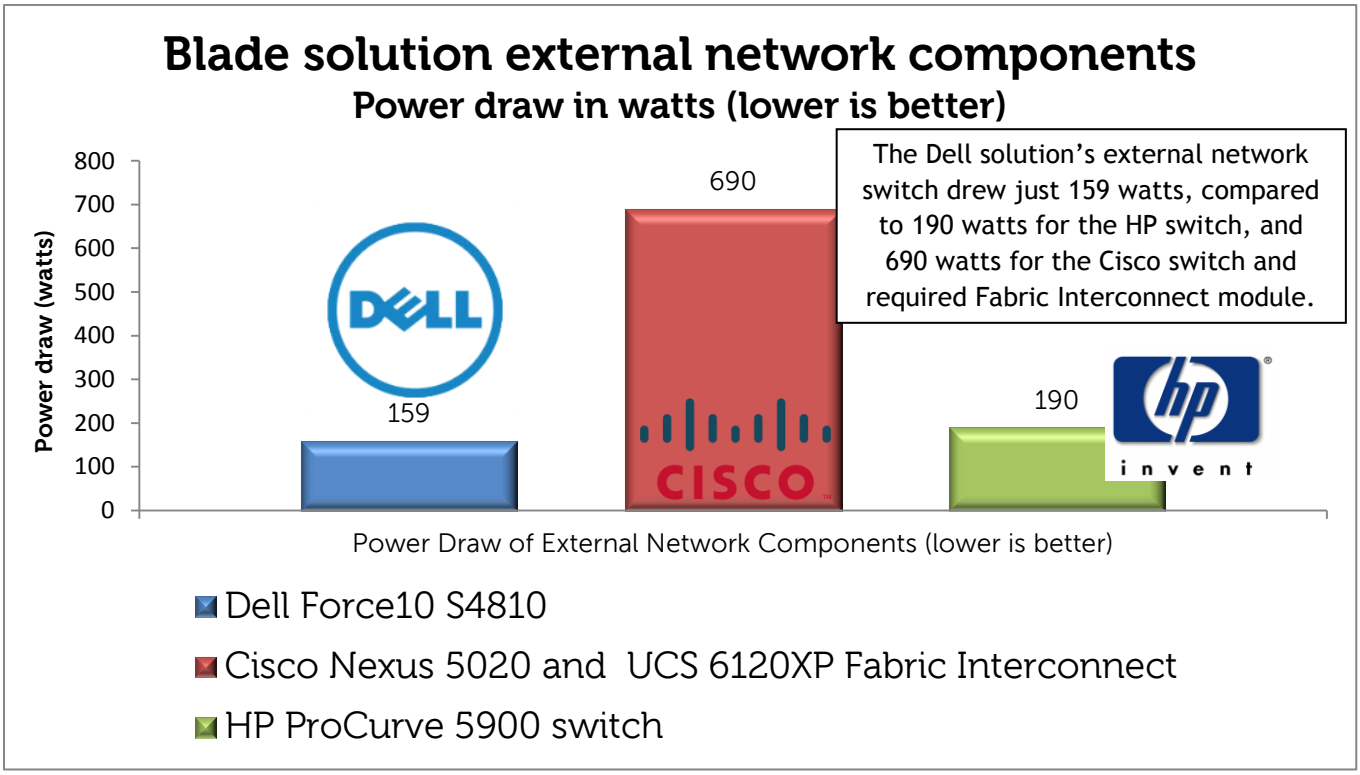
Figure 5: Blade solution power efficiency with external network components included[4]



[4] Comparison based on results by Dell Labs October 2012. SPEC® and the benchmark name SPECpower_ssj® are registered trademarks of the Standard Performance Evaluation Corporation. For more information about SPECpower, see www.spec.org/power_ssj2008/.

The Cisco blade solution scored second in overall power efficiency in Comparison 1 with external network components not included in the power measurements, but scores last in Comparison 2 when external network components are included in the power measurements. The reason for this can be seen in Figure 6, which shows the power draw of each solution's external network components. The combination of the Cisco Nexus 5020 top-of-rack switch, combined with the UCS solution's required 6120XP Fabric Interconnect, add 690W to the Cisco solution's power draw.

Figure 6: Power draw of external network components (Comparison 2)[5]



So, when external components of each solution are included in power measurements, the Dell Force10 S4810 switch adds just 159 watts to the Dell solution. The HP ProCurve 5900 switch, at 190 watts, consumes 19% more power.

Since the management modules for the blade solutions from Dell (CMC module) and HP (Onboard Administrator module) reside inside their blade enclosures, these blade solutions do not require an external management module like the UCS blade solution. When the power draw of the required Cisco UCS 6120XP Fabric Interconnect and the Cisco Nexus 5020 top-of-rack switch are included in power measurements, their combined power draw adds 690 watts to the total power draw of the Cisco blade solution, 334% percent more than the Dell Force10 S4810 switch.

[5] Required SPEC disclosure information: Comparison based on results by Dell Labs October 2012. SPEC® and the benchmark name SPECpower_ssj® are registered trademarks of the Standard Performance Evaluation Corporation. For more information about SPECpower, see www.spec.org/power_ssj2008/.

Summary

The blade server form factor has a reputation for superior power efficiency compared to similarly configured 1U rack servers. The results of the SPECpower_ssj2008 testing show similar performance between the three blade solutions. However, they can vary widely in power efficiency, even when the blades in each solution are configured as similarly as possible.

In Comparison 1, which measured power efficiency of the blades, blade enclosures, and internal chassis components, the Dell blade solution based on PowerEdge M620 blades had 19% higher power efficiency than the Cisco blade solution based on B200 M3 blades, and 32% higher power efficiency than the HP blade solution based on BL460c Gen8 blades. At the key 70% target load level, the Dell blade solution had 23% higher power efficiency than the Cisco blade solution, and 48% higher power efficiency than the HP blade solution. At idle, the Dell solution also drew 39% less power than the Cisco solution, and 32% less power than the HP solution.

In Comparison 2, when an additional power meter was used to measure the power draw of each solution's external network components, the Dell blade solution maintained its power efficiency advantage, with a 45% performance per watt advantage over the Cisco blade solution and a 26% performance per watt advantage over the HP blade solution. Measurements of the external network components showed the Dell Force10 S4810 switch drawing just 159 watts, compared to 190 watts for the HP ProCurve 5900, and 690 watts for the combination of the Cisco Nexus 5020 and UCS 6120XP Fabric Interconnect.

As energy costs rise, power efficiency becomes an increasingly important factor in the decision to purchase these important data center components. The higher performance per watt ratio of the blade solution based on Dell PowerEdge M620 blades makes it a compelling addition to the datacenter compared to the solutions from Cisco and HP.

Appendix A — Test methodology

SPECpower_ssj2008 standard

SPECpower_ssj2008 is an industry standard benchmark created by the Standard Performance Evaluation Corporation (SPEC) to measure a server's power and performance across multiple utilization levels. SPECpower_ssj2008 consists of a Server Side Java (SSJ) workload along with data collection and control services. SPECpower_ssj2008 results portray the server's performance in ssj_ops (server side Java operations per second) divided by the power used in watts (ssj_ops per watt). SPEC created SPEcpower_ssj2008 for those who want to accurately measure the power consumption of their server in relation to the performance that the server is capable of achieving with ssj2008 workload.

SPECpower_ssj2008 consists of three main software components:

- **Server Side Java (SSJ) Workload**—Java database that stresses the processors, caches and memory of the system, as well as software elements, such as operating system elements and the Java implementation chosen to run the benchmark.
- **Power and Temperature Daemon (PTDaemon)**—Program that controls and reports the power analyzer and temperature sensor data.
- **Control and Collect System (CCS)**—Java program that coordinates the collection of all the data.

For more information on how SPECpower_ssj008 works, see http://www.spec.org/power_ssj2008/.

All results discussed in this whitepaper are from *compliant runs* in SPEC terminology, which means that although they have not been submitted to SPEC for review, Dell can disclose them for the purpose of this study. All configuration details required to reproduce these results are listed in Appendices A, B, and C; all result files from the runs compared are included in Appendix D — SPECpower_ssj2008 results.

All servers were configured by installing a fresh copy of Microsoft Windows Server 2008 Enterprise R2 (Service Pack 1) and the operating system install with a single drive RAID 0, choosing the *full installation* option for each.

The latest driver and firmware update packages available were installed to all servers at the beginning of this study. Refer to Appendix B — Blade enclosure hardware configuration information for details.

BIOS settings

Available BIOS settings differed between the two manufacturers. Rather than experiment with each setting to evaluate its effect on performance per watt, each blade was tested as it was shipped from the factory, with default settings. This configuration more closely mimics a typical customer deployment in most situations.

For both servers, Intel Turbo Boost was enabled by default, and memory speed was left at the default value of 1333 MHz. Prefetchers built into the Intel Xeon E5-2660 processors were left on for all three blade models. Both systems defaulted to handling their own power management rather than leaving that function to the operating system.

For the Dell PowerEdge M620 blades, the following default settings were used:

- Adjacent Cache Line Prefetch enabled
- Hardware Prefetcher enabled
- DCU Streamer Prefetcher enabled
- DCU IP Prefetcher enabled

- System Profile set to Performance Per Watt (DAPC)
- Turbo Boost enabled
- C1E Enabled
- C States enabled
- Memory Patrol Scrub set to Enabled
- Memory Refresh Rate set to 1x
- Memory Operating Voltage set to Auto

For the HP ProLiant BL460c Gen8 blades, the following default settings were used:

- HP Power Regulator set to HP Dynamic Power Savings Mode
- Energy/Performance Bias set to Balanced Performance
- Minimum Processor Idle Power Core State set to C6 State
- Minimum Processor Idle Power Package State set to Package C6 (non-retention) State
- HW Prefetch Enabled in BIOS
- Adjacent Sector Prefetch Enabled in BIOS
- DCU Prefetcher Enabled in BIOS
- Dynamic Power Savings Mode Response set to Fast in BIOS
- Collaborative Power Control Enabled in BIOS
- Intel Turbo Boost enabled
- DIMM Voltage Preference set to Optimized for Power in BIOS

Some BIOS settings on the Cisco UCS B200 M3 blades are configured by the UCS Manager software installed on the UCS 6120XP Fabric Interconnect, and some settings are controlled locally on each blade. To ensure the B200 M3 blades were configured as factory installed, all blades were reset to BIOS defaults through the local setup program accessed during blade bootup, and all settings in the BIOS profiles for blades in the UCS Manager were set to Platform Defaults.

For the Cisco UCS B200 M3 blades, the following default settings were used:

- Adjacent Sector Prefetcher Enabled
- Hardware Prefetcher Enabled
- Disabled DCU Streamer Prefetcher Enabled
- DCU IP Prefetcher Enabled
- Workload configuration set to Balanced
- Enhanced SpeedStep® Technology Enabled
- Intel Turbo Boost Technology Enabled
- Processor Power State C1 Enhanced Disabled
- Processor Power State C6 Disabled
- Energy Performance Policy set to OS Controlled
- Low Voltage DDR Mode set to Power Saving Mode

Operating system tuning

To improve Java performance, large pages were enabled by entering **Control Panel>Administrative Tools>Local Security Policy>Local Policies>User Rights Assignment>Lock Pages in Memory**. An option was changed to add Administrator. Operating System Power Management mode for all blades was left at the default **Balanced Mode.**

All servers were configured with separate IP addresses on the same subnet as the SPECpower_ssj2008 controller system where the Director, CCS, and PTDaemon components were located, and connected all servers at 10GbE network speed through their onboard I/O module and into their external top-of-rack switch.

SPECpower_ssj2008 configuration

The IBM® J9 Java Virtual Machine (JVM)[6] was used for all solutions.

The following JVM options were used on all blade servers.

```
-Xaggressive -Xcompressedrefs -Xmn1100m -Xms1500m -Xmx1500m -XlockReservation -
Xnoloa -Xlp -Xconcurrentlevel0
```

The following bindings were used to ensure that each of the 16 JVMs ran on four logical processors:

```
start /affinity [F, F0, F00, F000, F0000, F00000, F000000, F0000000]
```

Power and temperature configuration

Yokogawa WT210 Digital Power Meters were used for the actual power measurements of the servers, as this is the most commonly used analyzer for SPECpower_ssj2008 publications at the time that this study was conducted. The WT210 units used were each calibrated less than a year prior to the test date to ensure accurate power consumption measurements.

To ensure a fair comparison, the systems were mounted near each other in the test racks, and inlet temperature was measured at the front of each system during their runs using a Digi International Watchport/H temperature probe. As the attached Power Temperature Details reports show, the three solutions were run in environments with a temperature difference of less than 1 degree Celsius.

[6] IBM J9 VM (build 2.6, JRE 1.7.0 Windows Server 2008 R2 amd64-64 20120322_106209 (JIT enabled, AOT enabled)

Appendix B — Blade enclosure hardware configuration information

Table 4: Blade enclosure hardware configuration information

	Dell blade solution	HP blade solution	Cisco blade solution
Enclosure	PowerEdge M1000e	BladeSystem c7000	UCS 5108
Enclosure management module	1 x Dell CMC Module	1 x HP Onboard Administrator module	Cisco UCS Manager
Enclosure management firmware	CMC 4.11	Onboard Administrator 3.60	UCS 5.0(3)N2(2.04a)
Internal I/O module	1 x Force10 MXL 10/40GbE blade switch	1 x Virtual Connect Flex-10 10Gb Ethernet module	1 x UCS 2104XP Fabric Extender
Internal IOM firmware	8.3.16.2	Virtual Connect Firmware 3.70	2.0(4a)
Power supply quantity/rating	6 x 2700W platinum rated (Dell P/N 0G803N)	6 x 2450W platinum-rated (HP P/N 570493-301)	4 x 2500W platinum-rated (Cisco P/N N20-PAC5-2500W)

Appendix C — Blade server firmware and drivers

Table 5: Blade server firmware and drivers

Driver/firmware versions	PowerEdge M620	Proliant BL460c Gen8	UCS B200 M3
System BIOS	1.3.6	I31 07/15/2012	B200M3.2.0.4a.0.080920121557
Network drivers	13.5.0	4.1.450.5	2.1.0.10
Network firmware	13.5.6	4.1.402.20	2.0(4a)
HBA firmware	20.10.1-0084	13.10.83.00	2.120.184-141
HBA drivers	5.1.118.64	6.24.0.64 (B)	5.1.112.64
Video driver	2.4.1.0	6.12.1.1030	OS Native
Integrated management controller firmware	iDRAC7 1.23.23 (Build 1)	1.10	2.0(4a)
Management controller driver	N/A	3.6.0.0	N/A

Appendix D — SPECpower_ssj2008 results

Figure 7: SPECpower_ssj2008 results for Dell PowerEdge M620 blade solution (Comparison 1: Blades, blade enclosure, and internal modules)

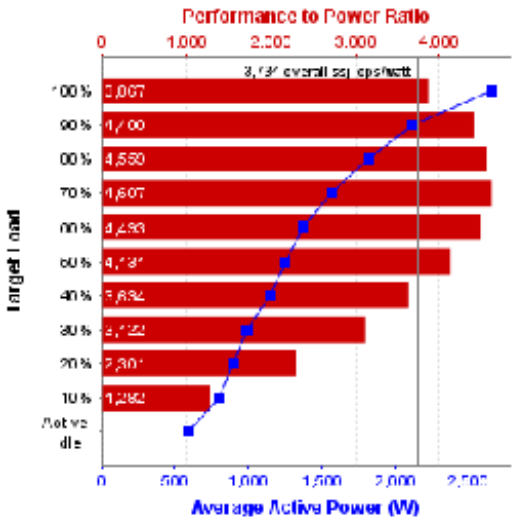
SPECpower_ssj2008

Dell Inc. PowerEdge M620 (Intel Xeon E5-2670, 2.60 GHz)				SPECpower_ssj2008 = 3,734 overall ssj_ops/watt	
Test Sponsor:	Dell Inc.	SPEC License #:	55	Test Method:	Multi Node
Tested By:	Dell Inc.	Test Location:	Round Rock, TX, USA	Test Date:	Oct 6, 2012
Hardware Availability:	Sep-2012	Software Availability:	Jun-2012	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set sut WARNING: For point 0, elapsed nanoTime=241219979118 ns, elapsed currentTimeMillis=240054 ms

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	99.2%	10,253,850	2,652	3,867
90%	90.0%	9,308,825	2,116	4,400
80%	80.0%	8,270,340	1,814	4,559
70%	69.9%	7,230,008	1,569	4,607
60%	60.0%	6,204,926	1,381	4,493
50%	50.0%	5,173,099	1,252	4,131
40%	40.1%	4,145,299	1,141	3,634
30%	30.0%	3,100,540	993	3,122
20%	20.0%	2,066,806	898	2,301
10%	10.0%	1,031,267	805	1,282
Active Idle		0	588	0
?ssj_ops / ?power =				3,734



Aggregate SUT Data

# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
8	16	128	256	256	8	64

System Under Test

Shared Hardware

Shared Hardware	
Enclosure:	Dell PowerEdge M1000e
Form Factor:	10U
Power Supply Quantity and Rating (W):	6 x 2700
Power Supply Details:	Dell P/N: G803N
Network Switch:	Dell Force10 S4810, Dell P/N: W9C6F
Network	

Figure 8: SPECpower_ssj2008 results for HP ProLiant BL460c Gen8 blade solution (Comparison 1: Blades, blade enclosure, and internal modules)

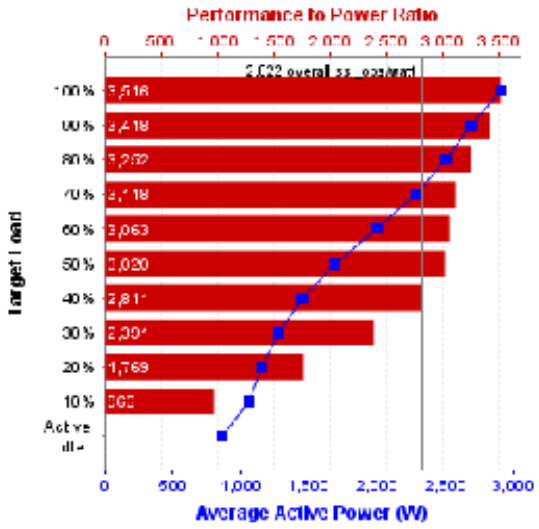
SPECpower_ssj2008

Hewlett Packard Company ProLiant BL460c Gen8			SPECpower_ssj2008 = 2,822 overall ssj_ops/watt		
Test Sponsor:	Dell Inc.	SPEC License #:	55	Test Method:	Multi Node
Tested By:	Dell Inc.	Test Location:	Round Rock, TX, USA	Test Date:	Oct 8, 2012
Hardware Availability:	Sep-2012	Software Availability:	Jun-2012	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set sut WARNING: For point 0, elapsed nanoTime=241217315105 ns, elapsed currentTimeMillis=240038 ms
Set sut WARNING: For point 0, elapsed nanoTime=242093422297 ns, elapsed currentTimeMillis=240272 ms

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	100.1%	10,209,104	2,903	3,516
90%	90.1%	9,185,908	2,688	3,418
80%	80.0%	8,155,632	2,508	3,252
70%	70.0%	7,144,097	2,292	3,118
60%	59.9%	6,111,574	1,995	3,063
50%	50.0%	5,097,307	1,688	3,020
40%	40.0%	4,080,302	1,452	2,811
30%	30.0%	3,060,415	1,280	2,391
20%	20.1%	2,046,020	1,157	1,769
10%	10.0%	1,020,853	1,057	966
Active Idle		0	868	0
		?ssj_ops / ?power =		2,822



Aggregate SUT Data

# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
8	16	128	256	256	8	64

System Under Test

Shared Hardware

Shared Hardware	
Enclosure:	HP BladeSystem C7000 Enclosure, HP P/N: 507019-B21
Form Factor:	10U
Power Supply Quantity and Rating (W):	6 x 2450
Power Supply	HP 2450W Platinum PSU, HP P/N: 588603-B21

Figure 9: SPECpower_ssj2008 results for Cisco UCS B200 M3 blade solution
(Comparison 1: Blades, blade enclosure, and internal modules)

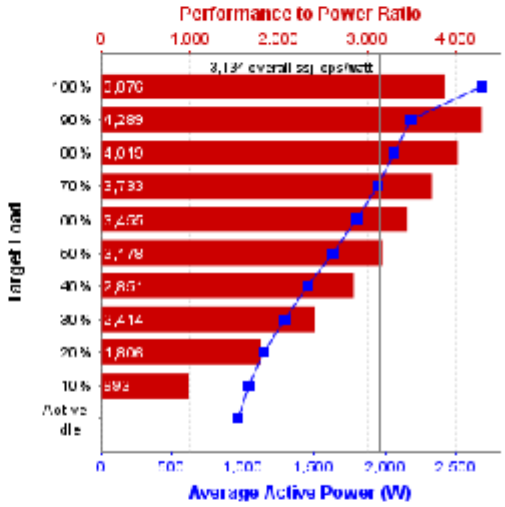
SPECpower_ssj2008

Cisco Inc. UCS B200 M3			SPECpower_ssj2008 = 3,134 overall ssj_ops/watt		
Test Sponsor:	Dell Inc.	SPEC License #:	55	Test Method:	Multi Node
Tested By:	Dell Inc.	Test Location:	Round Rock, TX, USA	Test Date:	Oct 10, 2012
Hardware Availability:	Sep-2012	Software Availability:	Jun-2012	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set sut WARNING: For point 0, elapsed nanoTime=241285722725 ns, elapsed currentTimeMillis=240116 ms

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	100.0%	10,376,719	2,677	3,876
90%	90.1%	9,344,480	2,179	4,289
80%	80.0%	8,299,677	2,065	4,019
70%	70.0%	7,261,416	1,945	3,733
60%	59.9%	6,216,659	1,799	3,455
50%	50.0%	5,189,339	1,633	3,178
40%	40.1%	4,155,856	1,458	2,851
30%	30.0%	3,113,994	1,290	2,414
20%	20.0%	2,074,369	1,149	1,806
10%	10.0%	1,037,673	1,045	993
Active Idle		0	969	0
?ssj_ops / ?power =				3,134



Aggregate SUT Data

# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
8	16	128	256	256	8	64

System Under Test

Shared Hardware

Shared Hardware	
Enclosure:	Cisco UCS 5108
Form Factor:	6U
Power Supply Quantity and Rating (W):	4 x 2500
Power Supply Details:	Platinum rated, Cisco P/N: N20-PAC5-2500W
Network	Cisco Nexus 5020, Cisco Model Number/s N5K-

Figure 10: SPECpower_ssj2008 results for Dell PowerEdge M620 blade solution
(Comparison 2: Blades, blade enclosure, internal modules, and external network components)

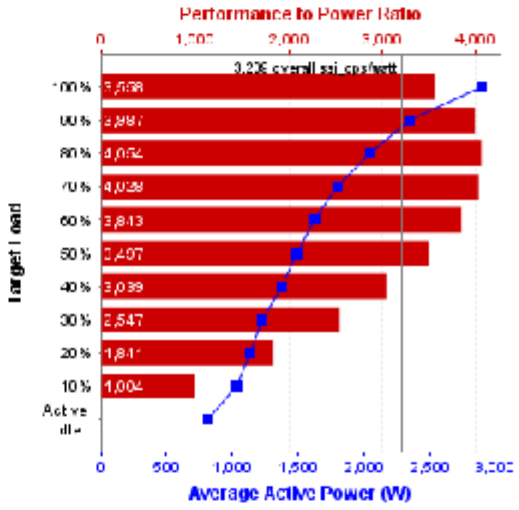
SPECpower_ssj2008

Dell Inc. PowerEdge M620 (Intel Xeon E5-2670, 2.60 GHz)				SPECpower_ssj2008 = 3,209 overall ssj_ops/watt	
Test Sponsor:	Dell Inc.	SPEC License #:	55	Test Method:	Multi Node
Tested By:	Dell Inc.	Test Location:	Round Rock, TX, USA	Test Date:	Oct 7, 2012
Hardware Availability:	Sep-2012	Software Availability:	Jun-2012	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set sut WARNING: For point 0, elapsed nanoTime=241767096571 ns, elapsed currentTimeMillis=240366 ms
Set sut WARNING: For point 0, elapsed nanoTime=241514631811 ns, elapsed currentTimeMillis=240100 ms

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	99.0%	10,284,262	2,890	3,558
90%	89.9%	9,338,858	2,343	3,987
80%	80.0%	8,310,093	2,050	4,054
70%	69.9%	7,257,298	1,802	4,028
60%	60.0%	6,232,186	1,622	3,843
50%	50.0%	5,195,599	1,486	3,497
40%	40.1%	4,160,378	1,369	3,039
30%	30.0%	3,117,875	1,224	2,547
20%	20.0%	2,078,580	1,129	1,841
10%	10.0%	1,038,731	1,035	1,004
Active Idle		0	816	0
		?ssj_ops / ?power =		3,209



Aggregate SUT Data

# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
8	16	128	256	256	8	64

System Under Test

Shared Hardware

Shared Hardware	
Enclosure:	Dell PowerEdge M1000e
Form Factor:	10U
Power Supply Quantity and Rating (W):	6 x 2700
Power Supply Details:	Dell P/N: G803N
Network Switch:	Dell Force10 S4810, Dell P/N: W9C6F

Figure 11: SPECpower_ssj2008 results for HP ProLiant BL460c Gen8 blade solution
(Comparison 2: Blades, blade enclosure, internal modules, and external network components)

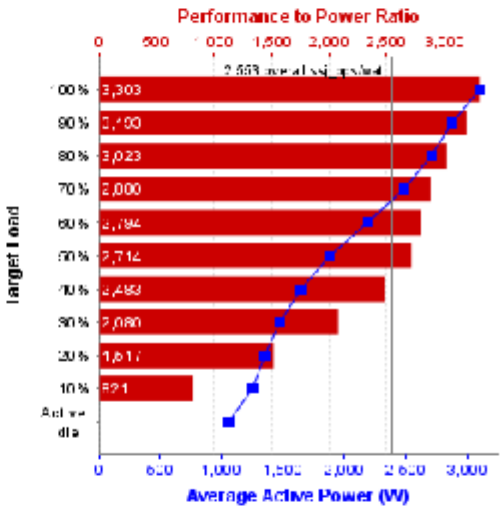
SPECpower_ssj2008

Hewlett Packard Company ProLiant BL460c Gen8			SPECpower_ssj2008 = 2,553 overall ssj_ops/watt		
Test Sponsor:	Dell Inc.	SPEC License #:	55	Test Method:	Multi Node
Tested By:	Dell Inc.	Test Location:	Round Rock, TX, USA	Test Date:	Oct 8, 2012
Hardware Availability:	Sep-2012	Software Availability:	Jun-2012	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set sut WARNING: For point 0, elapsed nanoTime=241245379932 ns, elapsed currentTimeMillis=240210 ms
Set sut WARNING: For point 0, elapsed nanoTime=241319687558 ns, elapsed currentTimeMillis=240162 ms
Set sut WARNING: For point 0, elapsed nanoTime=241336604321 ns, elapsed currentTimeMillis=240178 ms

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	100.1%	10,225,597	3,096	3,303
90%	90.0%	9,195,261	2,880	3,193
80%	80.0%	8,169,365	2,703	3,023
70%	70.0%	7,146,475	2,481	2,880
60%	60.0%	6,133,518	2,196	2,794
50%	49.9%	5,098,098	1,878	2,714
40%	39.9%	4,077,968	1,642	2,483
30%	29.9%	3,058,983	1,470	2,080
20%	20.0%	2,040,615	1,346	1,517
10%	10.0%	1,023,697	1,247	821
Active Idle		0	1,058	0
			?ssj_ops / ?power =	2,553



Aggregate SUT Data

# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
8	16	128	256	256	8	64

System Under Test

Shared Hardware

Shared Hardware	
Enclosure:	HP BladeSystem C7000 Enclosure, HP P/N: 507019-B21
Form Factor:	10U
Power Supply Quantity and Rating (W):	6 x 2450
Power	

Figure 12: SPECpower_ssj2008 results for Cisco UCS B200 M3 blade solution
(Comparison 2: Blades, blade enclosure, internal modules, and external network components)

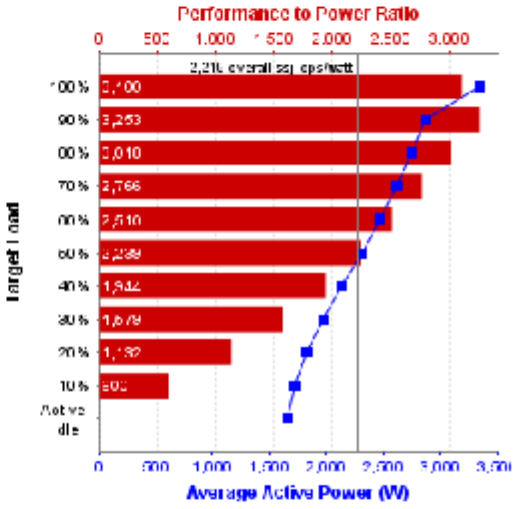
SPECpower_ssj2008

Cisco Inc. UCS B200 M3			SPECpower_ssj2008 = 2,219 overall ssj_ops/watt		
Test Sponsor:	Dell Inc.	SPEC License #:	55	Test Method:	Multi Node
Tested By:	Dell Inc.	Test Location:	Round Rock, TX, USA	Test Date:	Oct 7, 2012
Hardware Availability:	Sep-2012	Software Availability:	Jun-2012	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set sut WARNING: For point 0, elapsed nanoTime=241578401877 ns, elapsed currentTimeMillis=240069 ms

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	100.0%	10,354,520	3,340	3,100
90%	90.0%	9,320,170	2,865	3,253
80%	79.9%	8,277,060	2,743	3,018
70%	70.0%	7,253,813	2,622	2,766
60%	60.0%	6,217,103	2,477	2,510
50%	50.0%	5,174,242	2,311	2,239
40%	40.0%	4,142,716	2,131	1,944
30%	30.0%	3,105,440	1,967	1,579
20%	20.0%	2,067,279	1,826	1,132
10%	10.0%	1,035,522	1,725	600
Active Idle		0	1,652	0
?ssj_ops / ?power =				2,219



Aggregate SUT Data

# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
8	16	128	256	256	8	64

System Under Test

Shared Hardware

Shared Hardware	
Enclosure:	Cisco UCS 5108
Form Factor:	6U
Power Supply Quantity and Rating (W):	4 x 2500
Power Supply Details:	Platinum rated, Cisco P/N: N20-PAC5-2500W
Network	Cisco Nexus 5020, Cisco Model Number/s N5K-