Power Efficiency Comparison of Enterprise-Class Blade Servers and Enclosures

A Dell Technical White Paper

John Beckett, Robert Bradfield, and the

Dell Server Performance Analysis Team

August 2010

Contents

Tables

Figures

Executive Summary

Introduction

With rising energy costs continuing to demand larger portions of organizational budgets, Dell Inc. (Dell) commissioned its Server Performance Analysis team to use the industry standard SPECpower_ssj2008 benchmark to compare the power draw and performance per watt of blade solutions from Dell, HP, and IBM. The purpose of the testing was to examine on a level playing field the true power efficiency of the top three global blades server providers and compare and contrast the results. Each blade configuration included an enclosure configured as similarly as possible and was fully populated with each company's best-selling blade servers[1] using identical processor, RAM and hard drive selections.

The results were clear. In like-for-like comparisons, a Dell M1000e enclosure fully populated with 16 M610 blade servers consistently demonstrated significant advantages over both the IBM BladeCenter H enclosure fully populated with 14 HS22 blade servers and the Hewlett-Packard C7000 enclosure fully populated with 16 BL460C G6 blade servers in both power draw and performance-per-watt, regardless of utilization levels. While the actual monetary impact of these savings may vary for a variety of reasons, such as the regional disparity in cost of electricity and overall data center power and cooling design efficiency, there is no doubt that the performance and power efficiency of Dell M-series blades can result in significant operational cost savings.

Key Findings

Key findings from the study for power and performance are summarized below.

Power

- The Dell M1000e enclosure fully populated with 16 M610 blade servers used **less power across all load levels** than either the HP C7000 enclosure fully populated with 16 BL460C G6 blade servers or the IBM BladeCenter H enclosure fully populated with 14 HS22 blade servers (Figure 4).
- In the CPU utilization midrange (40–60%), the HP C7000 enclosure fully populated with 16 BL460C G6 blade servers **used 13–17% more power per server** than Dell M1000e enclosure fully populated with 16 M610 blade servers and the IBM BladeCenter H enclosure fully populated with 14 HS22 blade servers **used 19-20% more power per server** (Figure 4).
- The IBM BladeCenter H enclosure fully populated with 14 HS22 blade servers **used 63.6% more power at idle** than the Dell M1000e enclosure fully populated with 16 M610 blade servers**, despite having two fewer blade servers** (Figure 2).
- A HP C7000 enclosure fully populated with 16 BL460C G6 blade servers **used 24% more power** than the Dell M1000e enclosure fully populated with 16 M610 blade servers **at idle and 13% more at 100% CPU utilization** (Figure 2 and Figure 3).
- In head-to-head testing with fully populated chassis, **IBM HS22 blades used 87% more power per blade at idle than Dell** PowerEdge M610 blade servers (Figure 7).
- In head-to-head testing with fully populated chassis, **IBM HS22 blades used an average of 16.1% more power per blade at 100% CPU utilization than Dell** PowerEdge M610 blade servers (Figure 7)**.**

[1] IDC Worldwide Quarterly Server Tracker Q1 CY2010 results

Performance

- The Dell M1000e enclosure fully populated with 16 M610 blade servers achieved a **higher performance to power ratio across all load levels** than the HP C7000 enclosure fully populated with 16 BL460C G6 blade servers or **the** IBM BladeCenter H enclosure fully populated with 14 HS22 blade servers (Figure 5).
- Despite drawing less power, the Dell M1000e enclosure fully populated with 16 M610 blade servers **provided 13.9% greater performance than the** IBM BladeCenter H enclosure fully populated with 14 HS22 blade servers **at 100% utilization** (Figure 6).
- The Dell M1000e enclosure fully populated with 16 M610 blade servers achieved up to **15% higher performance/watt** than the HP C7000 enclosure fully populated with 16 BL460C G6 blade servers and up to **22% higher performance/watt** than **the** IBM BladeCenter H enclosure fully populated with 14 HS22 blade servers (Figure 8).

Test methodology and detailed results are documented in this paper.

Testing Details

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 details the test methodology used by Dell, Appendices B–D detail configuration for the tests, and Appendix E provides detailed report data that supports the Results in this paper.

Results

The Dell blade solution delivered the best SPECpower_ssj2008 result (see Figure 1), coming in at 2,530 overall ssj_ops/watt compared to the HP blade solution, which came in with 2,197 overall ssj_ops/watt (Dell 15% higher). The IBM blade solution came in last with 2,068 overall ssj_ops/watt (Dell 22% higher). This result is even more notable due to the fact that IBM is only capable of providing 14 blade servers per chassis, and thus is providing a solution that, despite drawing significantly more power, is not capable of the same raw performance per chassis that HP or Dell can provide using identical processor and memory architectures.

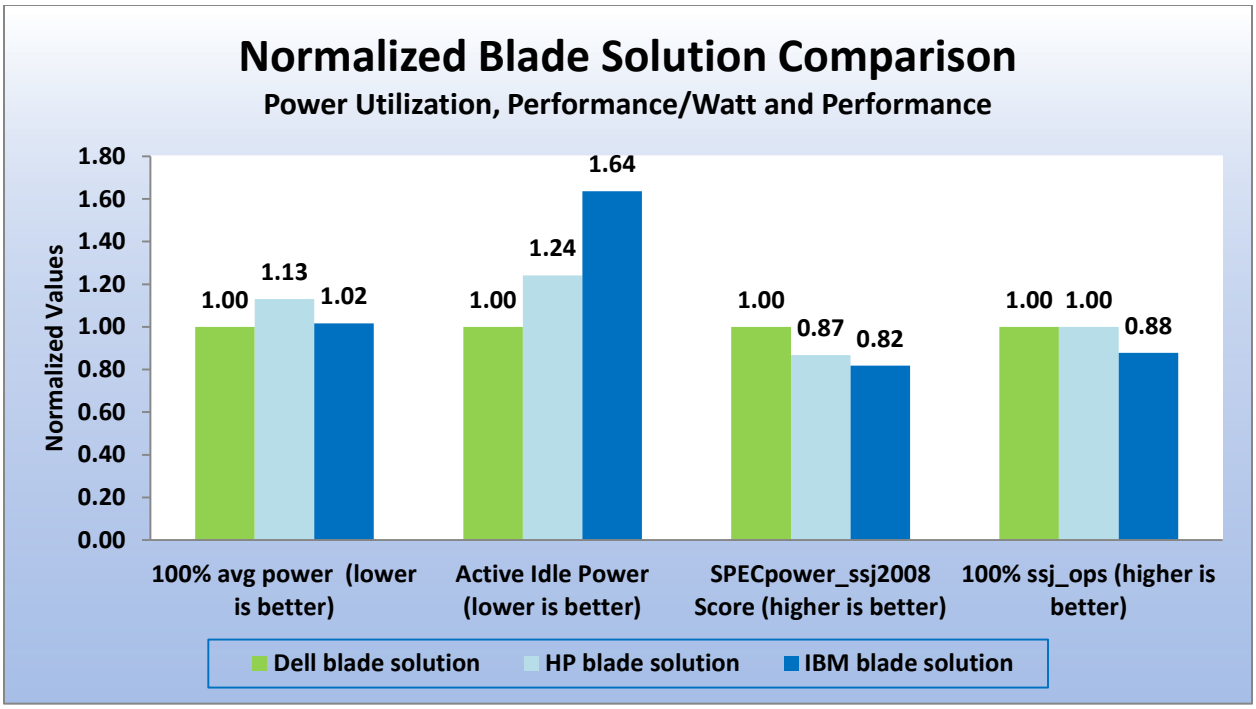


Figure 1. Blade Solution Comparison Chart

SPECpower_ssj2008 includes a measurement of power while the blades are idle at the final phase of the benchmark. As Figure 2 shows, the full enclosure of 16 Dell PowerEdge M610 blade servers used 24.1 percent less overall power while idle than the HP blade solution. In addition, the 16 Dell PowerEdge M610 blade servers used 63.6 percent less overall power while idle than the 14 IBM HS22 blade servers. The 16-blade Dell PowerEdge M610 solution used 1,288 watts at idle, while the 16-blade HP ProLiant BL460c solution used 1,598 watts at idle. The 14-blade IBM HS22 solution used 2,107 watts at idle.

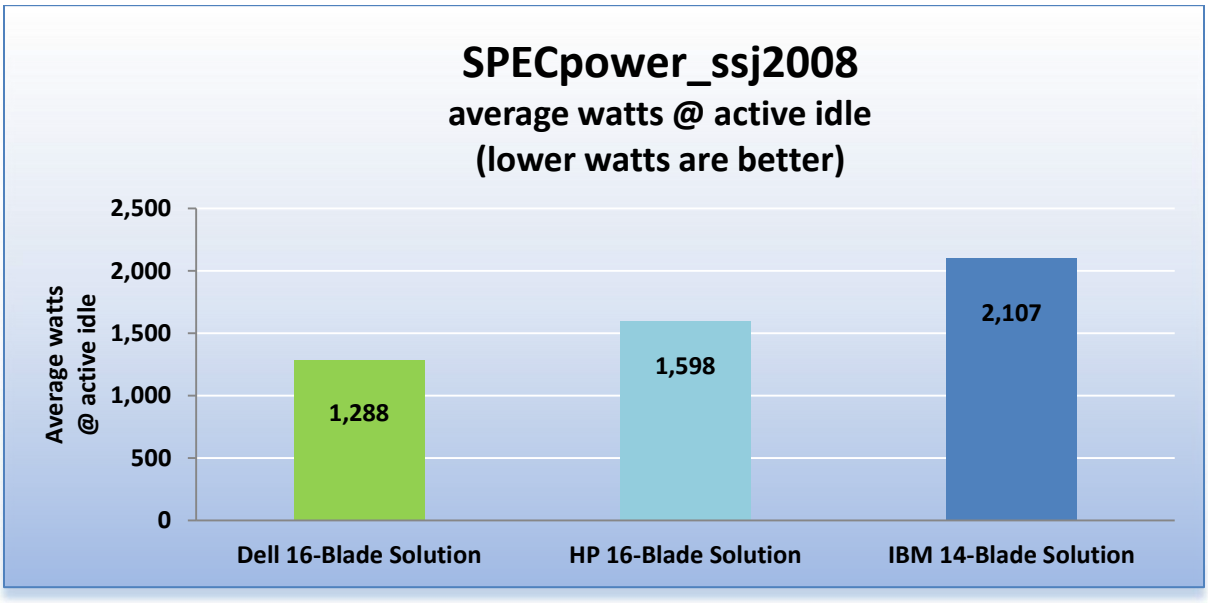


Figure 2. Comparison of the Blade Solutions at the Active Idle Power Measurement

SPECpower_ssj2008 includes a measurement of power while the blades are at 100% utilization. As Figure 3 shows, the full enclosure of 16 Dell PowerEdge M610 blade servers used 11.5 percent less overall power at 100% utilization than the HP blade solution and 1.6% percent less than the IBM BladeCenter H enclosure with 14 HS22 blade servers. The 16-blade Dell PowerEdge M610 solution used 4,372 watts at 100% utilization, while the 16-blade HP ProLiant BL460c solution used 4,940 and the 14-blade IBM HS22 solution used 4,444 watts (despite the fact that the IBM blade solution has 2 less blades than the Dell & HP blade solutions).

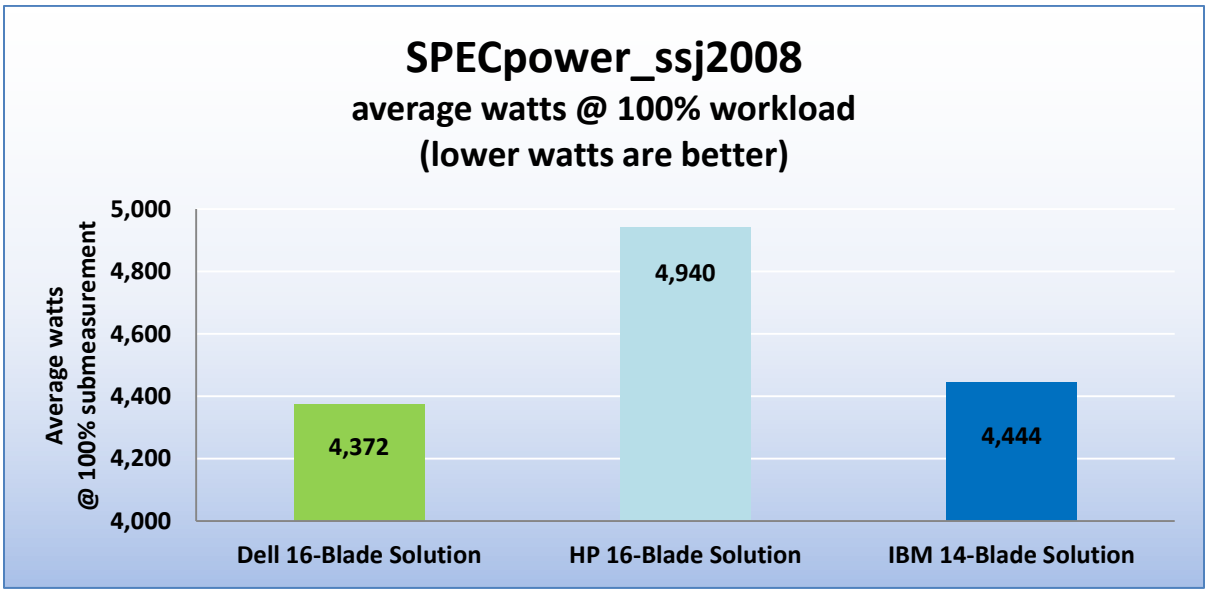


Figure 3. Power Usage Comparison of Blade Solutions at 100% Utilization

Figure 4 shows the average interval power in watts while running the workload at 100% target load down to 10 percent in stepped 10 percent utilization increments as reported by the SPECpower_ssj2008 benchmark. A full enclosure of 16 Dell PowerEdge M610 blade servers used less power than both the 16 HP ProLiant BL460c G6 blade servers and the 14 IBM HS22 blade servers across all of the SPECpower_ssj2008 target load levels. The power deltas were greater between the Dell blade solution and the HP blade solution, where at higher utilization levels (60%-100%) we saw a difference of between 13 and 18.9% in favor of the Dell blade solution. At the same utilization levels, the delta between the Dell blade solution and the IBM blade solution was between 1.6 and 5.4%. At lower utilization ranges of the SPECpower_ssj2008 benchmark (50%-10%) we saw a delta between the Dell blade solution and the HP blade solution of between 11.8 and 14.2%, and a delta of between 4.2 and 11.6% between the Dell blade solution and the IBM blade solution.

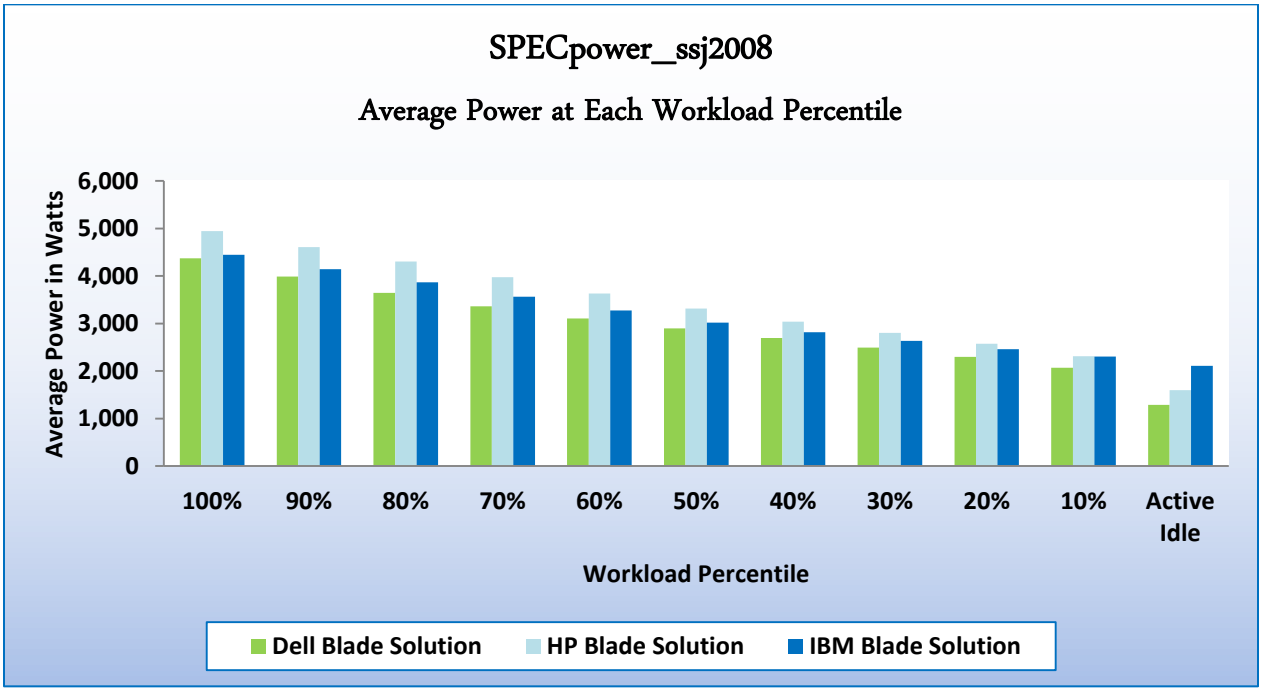


Figure 4. Average Power Utilization Across Workload Intervals

Figure 5 shows the performance-to-watt ratio results for the target load percentages. Results are the measured throughput (performance) divided by the average power consumption for each of the workload intervals. The 16 HP ProLiant BL460c G6 blade servers achieved almost identical 100% throughput to the16 Dell PowerEdge M610 blade servers , but used more power at this and every other workload interval. As a result, the Dell blade solution achieved a higher performance-to-watt ratio than the HP blade solution across all load levels. The 16 Dell PowerEdge M610 blade servers achieved 14% higher throughput than the 14 IBM BladeCenter HS22 Blade servers, and used less power across all workload intervals. As a result, the Dell blade solution also achieved a higher performance-to-watt ratio than the IBM blade solution across all load levels.

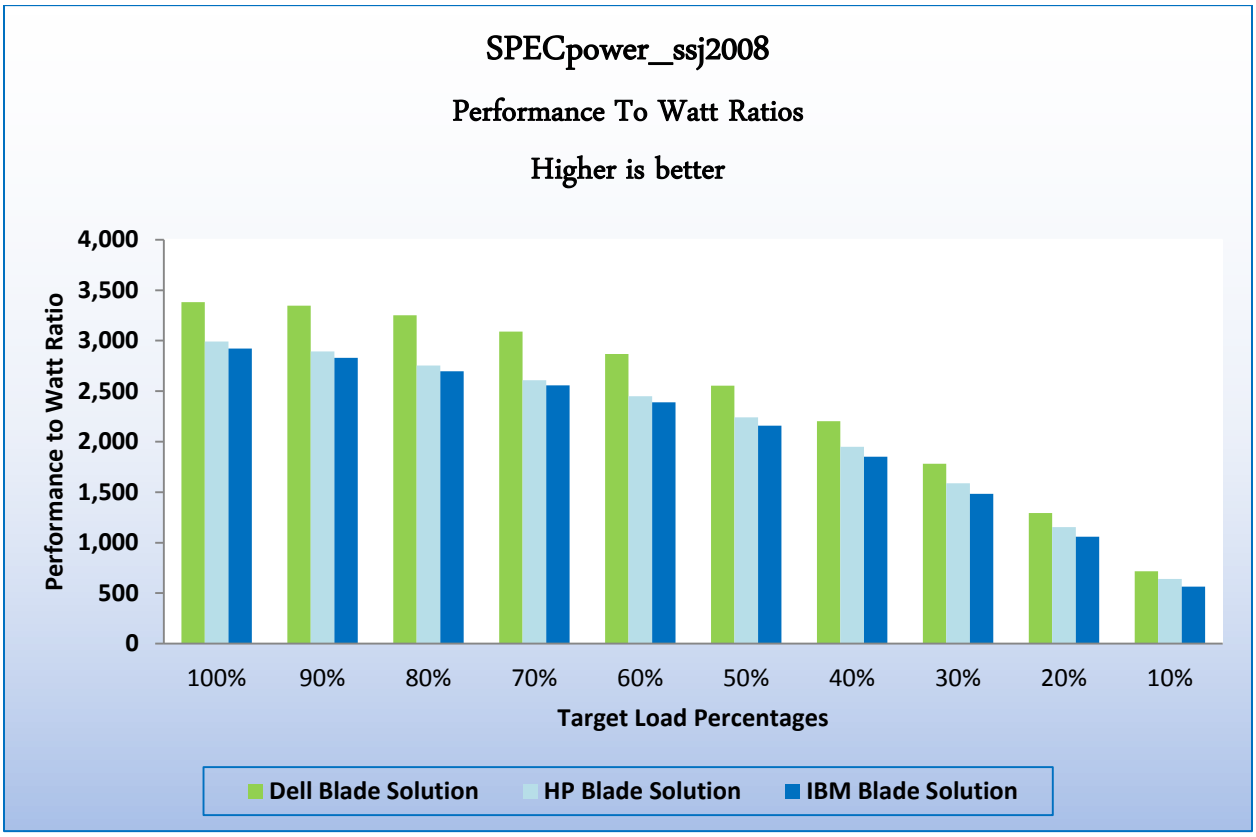


Figure 5. Performance Comparison of Watt Ratios Across Workload Intervals

SPECpower_ssj2008 includes a measurement of performance at 100% utilization. As Figure 6 shows, the full enclosure of 16 Hewlett-Packard BL460c blades was almost equivalent in performance to the Dell PowerEdge M-Series blade solution. However, the 16 Dell PowerEdge M610 blade servers achieved 13.9% higher performance at 100% utilization than the 14 IBM HS22 blade servers. The 16-blade Dell PowerEdge M610 solution achieved 14,785,342 ssj_ops at 100% utilization, while the 16-blade HP ProLiant BL460c solution achieved 14,774,218 and the 14-blade IBM HS22 solution was able to reach 12,979,356 ssj_ops.

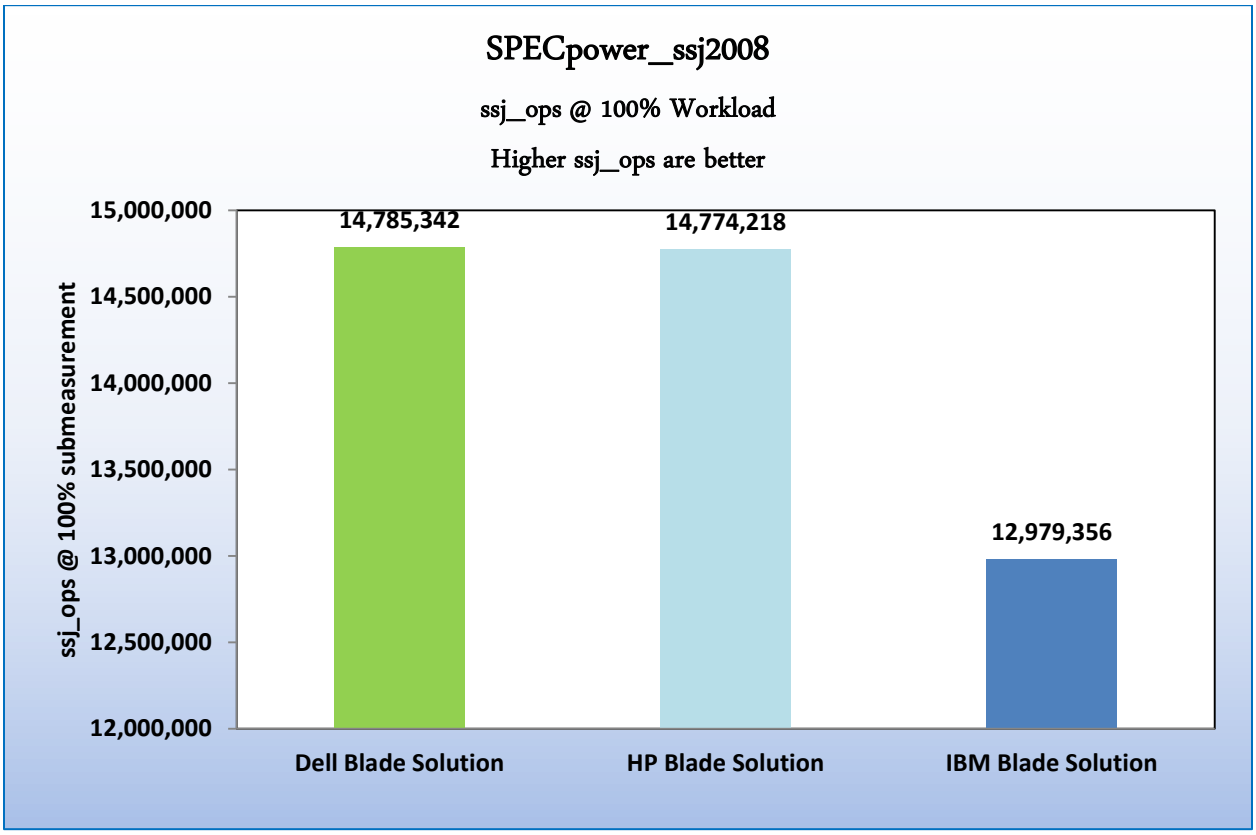


Figure 6. Performance Comparison at 100% Utilization

Power Draw on a Per Blade Basis

Due to the inequities in the number of blades per chassis between the 14 Blade IBM solution and the 16 Blade Dell and HP solutions, we also looked at the power draw on a per blade basis by dividing the average power for each SPECpower load level by the number of blades in each chassis. We saw that the Dell blade solution was more power efficient on a per blade basis at every load level than either the HP blade solution or the IBM blade solution. The efficiency differences are especially striking when comparing the Dell blade solution against the IBM blade solution at the active idle workload level, where the IBM solution draws 87% more power at idle on a per blade basis as the Dell blade solution. The Dell blade solution calculated on a per blade basis drew 81W versus 151W for the IBM blade solution. The HP blade solution used 24.1% more power on a per blade basis than the Dell blade

solution, where the per blade power utilization was calculated to be 100W for the HP solution, and 81W for the Dell solution.

In addition, when comparing the Dell blade solution against the IBM blade solution at the 100% load level on a per blade basis, the IBM blade solution drew 16.2% more power than the Dell blade solution. The Dell solution on a per blade basis was calculated to draw 273W versus 317W for the IBM solution. The HP blade solution drew up to 13% more power at the 100% load level than the Dell blade solution on a per blade basis, where the per blade power utilization was calculated to be 273W for the Dell blade solution versus 309W for the HP blade solution. See Figure 7.

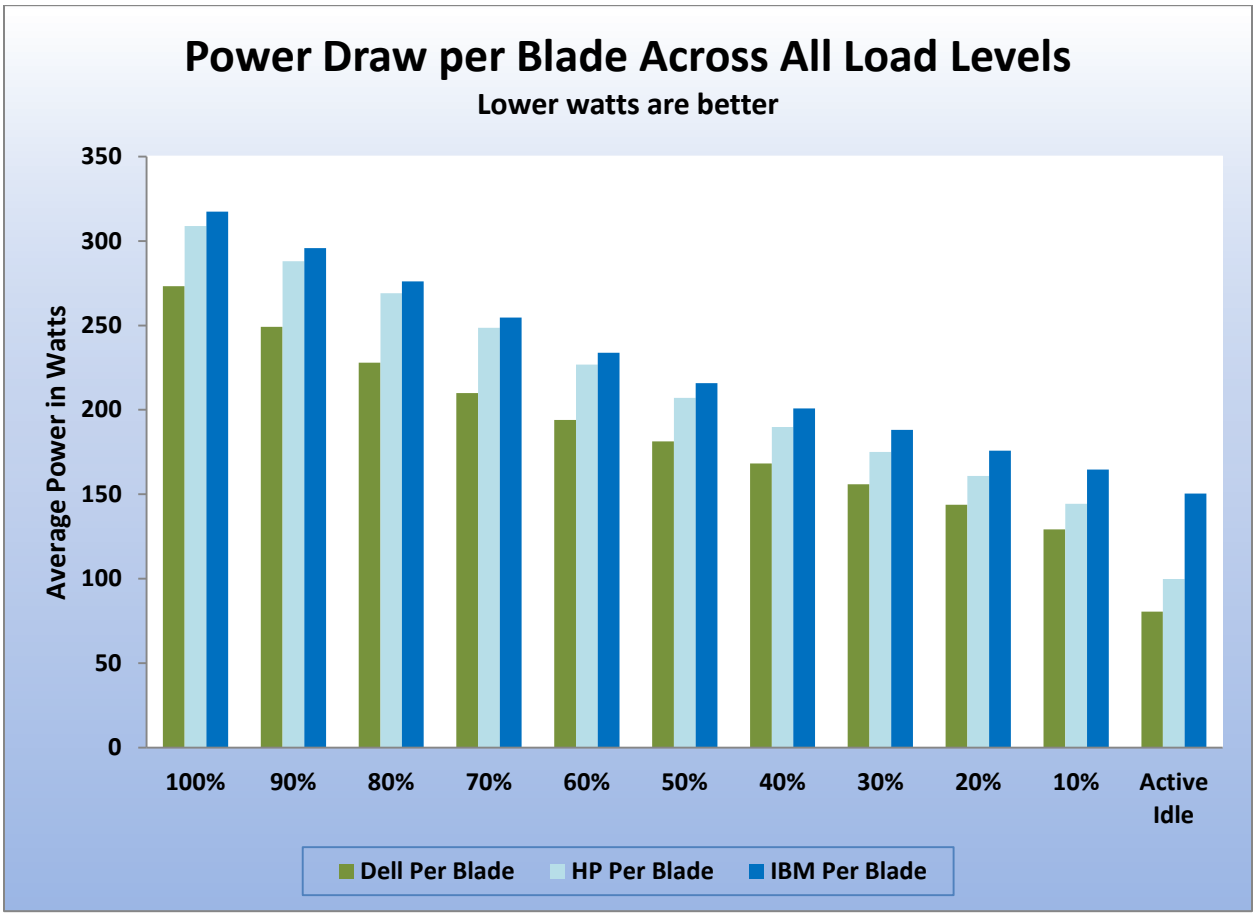


Figure 7. Comparison of the Power Utilization on a per Blade Basis

Workload

During a SPECpower_ssj2008 run, the system under test runs three calibration phases to determine the 100% workload target ssj_ops. Once this value is determined, then the benchmark runs the 100% workload interval, collecting performance and power data, and then scales the workload back in 10% increments until reaching the active idle measurement interval. The active idle interval runs no workload on the server(s) under test, but the power is collected for 5 minutes and averaged.

The final SPEcpower_ssj2008 score is the server's performance (in ssj_ops) summed across all workload intervals, divided by the average power summed across all workload intervals. A higher SPECpower_ssj2008 ssj_ops/watt score is better.

Overall ssj_ops/watt

Figure 8 shows the SPECpower_ssj2008 results for the Dell blade solution, the HP blade solution, and the IBM blade solution in overall ssj_ops/watt.

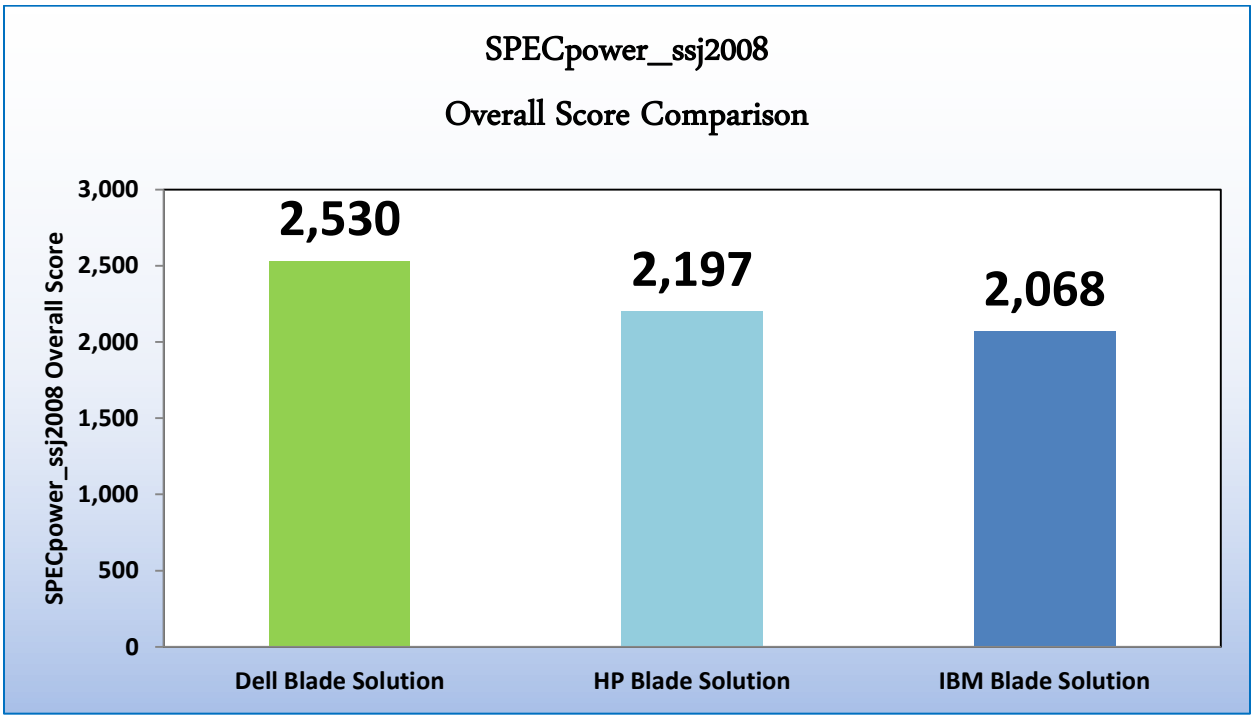


Figure 8. Comparison of the Overall ssj_ops/watt Score

Table 1 shows the SPECpower_ssj2008 results for the Dell PowerEdge solution for each target load.

Table 1. SPECpower_ssj2008 Results for the 16-Blade Dell Solution

Dell PowerEdge M610 (16 total blades)				
Performance			Power	Performance to Power Ratio
Target Load	Actual Load	ssj_ops	Average Active Power (W)	
100%	99.70%	14,785,342	4,372	3,382
90%	90.00%	13,344,934	3,987	3,347
80%	79.90%	11,853,404	3,646	3,251
70%	70.00%	10,380,753	3,359	3,090
60%	60.00%	8,903,133	3,104	2,868
50%	50.00%	7,412,879	2,900	2,556
40%	40.00%	5,928,182	2,692	2,203
30%	30.00%	4,444,109	2,496	1,781
20%	20.00%	2,971,405	2,301	1,292
10%	10.00%	1,481,894	2,067	717
Active Idle		0	1,288	0
Σssj_ops / Σpower =				2,530

Table 2 shows the SPECpower_ssj2008 results for the HP blade solution for each target load. (Lower Watts are better. Higher ssj_ops are better.)

Table 2. SPECpower_ssj2008 Results for the 16-Blade HP Solution

HP Solution (16 total blades)				
Performance			Power	Performance to Power Ratio
Target Load	Actual Load	ssj_ops	Average Active Power (W)	
100%	99.60%	14,774,218	4,940	2,991
90%	90.00%	13,338,325	4,608	2,895
80%	80.00%	11,858,862	4,306	2,754
70%	70.00%	10,377,087	3,977	2,609
60%	60.00%	8,895,651	3,630	2,451
50%	50.00%	7,420,425	3,313	2,240
40%	39.90%	5,922,357	3,038	1,949
30%	30.00%	4,452,479	2,801	1,589
20%	20.00%	2,971,369	2,574	1,154
10%	10.00%	1,479,418	2,310	641
Active Idle		0	1,598	0
∑ssj_ops / ∑power =				2,197

Table 3 shows the SPECpower_ssj2008 results for the IBM blade solution for each target load.

Table 3. SPECpower_ssj2008 Results for the 14-Blade IBM Solution

IBM HS22 (14 total blades)				
Performance			Power	Performance to Power Ratio
Target Load	Actual Load	ssj_ops	Average Active Power (W)	
100%	99.60%	12,979,356	4,444	2,921
90%	89.90%	11,716,988	4,141	2,829
80%	80.10%	10,429,739	3,865	2,698
70%	70.10%	9,128,012	3,566	2,559
60%	60.00%	7,820,687	3,273	2,390
50%	50.00%	6,516,261	3,021	2,157
40%	39.90%	5,202,062	2,813	1,850
30%	30.00%	3,905,546	2,634	1,483
20%	20.00%	2,604,026	2,462	1,058
10%	10.00%	1,302,857	2,306	565
Active Idle		0	2,107	0
Σssj_ops / Σpower =				2,068

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/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 OS 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 is allowed to disclose them for the purpose of this study. All configuration details required to reproduce these results are listed in Appendices A, B, and C, and all result files from the runs compared are included in Appendix D.

Each blade solution was configured by installing a fresh copy of Microsoft® Windows Server® 2008 Enterprise R2 on each blade with the operating system installed on a two-hard drive RAID 1 (or RAID 1 + 0 in the case of the HP blade solution) choosing the "full installation" option for each.

The latest driver and firmware update packages available to all three blade solutions were installed at the beginning of this study. Refer to Appendix B for details.

The Dell Server Performance Analysis Team ran SPECpower_ssj2008 three times per configuration across all three blade solutions and chose the highest overall ssj_ops/watt score for each configuration to compare for this study.

Configuration

Table 4 details the configuration used for testing.

Table 4. Configuration for Testing

Configuration	Dell Blade Solution	HP Blade Solution	IBM Blade Solution
Blade Chassis	PowerEdge M1000e	BladeSystem c7000	BladeCenter H-series
Blade Type	M610	BL460c	HS22
# Blades	16	16	14 (maximum possible)
CPU Type per blade	2 x X5670 2.93GHz	2 x X5670 2.93GHz	2 x X5670 2.93GHz
Memory per blade	6 x 4GB 1333MHz DDR3	6 x 4GB 1333MHz DDR3	6 x 4GB 1333MHz DDR3
HDD per blade	2 x 73GB 15K SAS	2 x 73GB 15K SAS	2 x 73GB 15K SAS
Operating System	Microsoft® Windows Server® 2008 Enterprise R2	Microsoft® Windows Server® 2008 Enterprise R2	Microsoft® Windows Server® 2008 Enterprise R2
Java Version Used	IBM J9 052192009	IBM J9 052192009	IBM J9 052192009

Chassis Configuration

The team configured the three blade solution chassis for AC Redundancy where applicable, and left any Dynamic Power Supply Engagement options to the default settings. For the Dell PowerEdge M1000e chassis, the Power Redundancy mode defaulted to AC Redundancy, and the Dynamic Power Supply Engagement Mode defaulted to Disabled. For the HP c7000 Blade Enclosure, we selected AC Redundancy, and left the "Dynamic Power" option at the default of Enabled[2]. For the IBM BladeCenter H-Chassis configuration, we changed the Power Management mode from Basic to Redundant Power Management, which best matched our Redundancy choices for the HP and Dell blade solutions.

BIOS Settings

BIOS settings differed between manufacturers, so we tuned for best-known SPECpower_ssj2008 performance results, following a similar strategy between the three systems. We disabled Turbo Mode on all blades which had it enabled by default and left Turbo off for blades that already had it disabled by default, and disabled all Processor Prefetcher Options exposed in BIOS, which generally improves java-oriented benchmarks such as SPECpower_ssj2008.

For the Dell PowerEdge M610, we disabled Turbo Mode, and disabled the following Prefetcher options: Hardware Prefetcher, Adjacent Cache Line Prefetcher, DCU Prefetcher, and Data Reuse. We left the default Power Management mode (Dell Active Power Controller) intact.

For the HP ProLiant BL460c G6, we changed the Dynamic Power Regulator speed on the HP blade to Slow (a common HP tuning to enhance performance/watt). We disabled Hardware Prefetcher and Adjacent Cache Line Prefetcher in BIOS. In addition, because two Intel® Xeon® processor 5600 series BIOS prefetcher settings (DCU Prefetch and Data Reuse) were not exposed as tunable options in the

[2] From our testing, we determined that the Dynamic Power option in either position offered no real enhancement to SPECpower_ssj2008 results in the configuration as tested, so we left it at the default.

version of BIOS available at the time of our test, so we referred to the following HP site to disable these options to enhance performance using the conrep utility as described by *HP Support Communication—Customer Advisory Document ID: c02207408 version 2*[3].

For the IBM BladeCenter HS22, we disabled both exposed Processor Prefetcher options in BIOS: Cache Data Prefetch and Data Reuse. In addition, we enabled Processor C-States (disabled by default) to make the system more comparable to the HP and Dell blade solutions which have this option enabled by default. Enabling C-States enhances SPECpower_ssj2008 competitiveness by allowing the processor to reduce power to the cores to save energy at lower utilization levels, especially at idle.

OS 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 solutions was changed from Balanced (the default) to Power Saver and Power Saver mode was edited to turn off the Hard Drive after 1 minute. Since the IBM BladeCenter HS22 does not have a BIOS Power Management algorithm similar to Dell Active Power Controller or HP Dynamic Power Saver, we changed the minimum processor state of the Power Saver plan from 5% to 0% and the maximum processor state from 75% to 100%. This tuning mimics other Intel® Xeon® processor 5600 series based IBM SPECpower disclosures.

We configured each blade with a separate IP address on the same subnet as our SPECpower_ssj2008 controller system where the Director, CCS, and PTDaemon components were located, and connected each blade to a Dell 24-port Gigabit switch external to the blade enclosure to ensure network connectivity to the controller system.

SPECpower_ssj2008 Configuration

IBM J9 Java Virtual Machine (JVM)[4] was used for all three blade solutions, as this JVM provided the best performance for SPECpower_ssj2008 of any of the available choices at the time that this study was undertaken.

The following JVM options were used on all three blade solutions, as they are the best-known JVM tunings for SPECpower_ssj2008 for the IBM J9 JVM when running with larger memory configurations:

-Xmn1400m -Xms1875m -Xmx1875m -Xaggressive -Xcompressedrefs -Xgcpolicy:gencon -XlockReservation -Xnoloa –Xlp

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

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

[3] http://bizsupport1.austin.hp.com/bizsupport/TechSupport/Document.jsp?objectID=c02207408&lang=en&cc=us&taskId=101&prodSeriesId=3948598&prodTypeId=15351

[4] JVM build 2.4, J2RE 1.6.0 IBM J9 2.4 Windows Server® 2008 amd64-64 jvmwa64 60sr5-20090519_35743

Power Meter Configuration

We used the Yokogawa WT210 Digital Power Meter for the actual power measurement of the blade enclosures, as this is the most commonly used analyzer for SPECpower_ssj2008 publications at the time that this study was undertaken.

For the Dell blade solution, we used two Yokogawa WT210 Power Meters to measure the enclosure power by attaching the first three power supplies to one Power Distribution Unit (PDU) that was connected to a single WT210, and the next three power supplies to a second PDU connected to a second WT210. Each WT210/PDU combination was connected to a separate 208v floor outlet. See Figure 9.

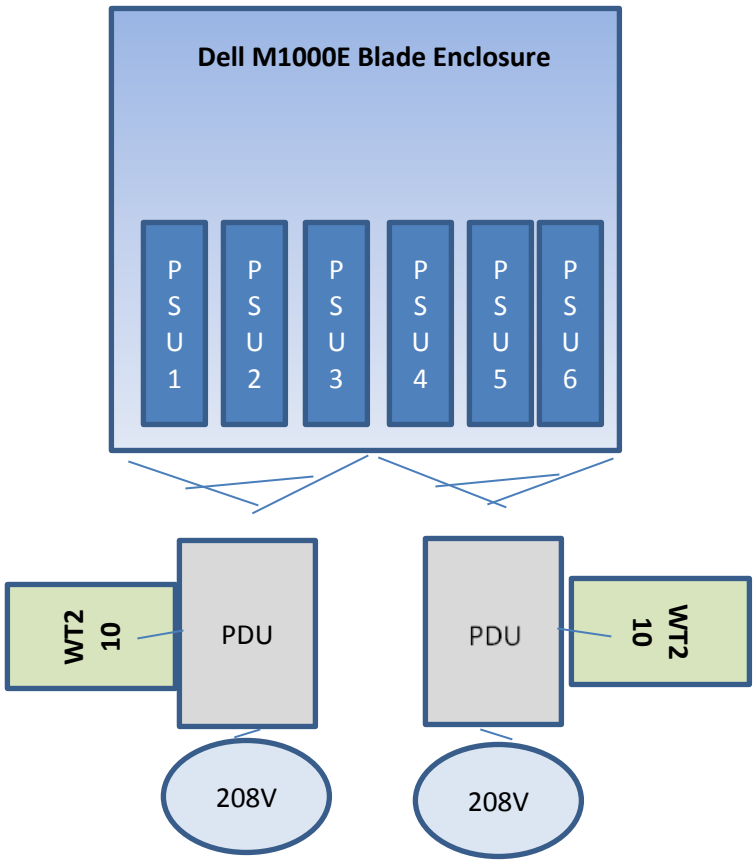


Figure 9. Power Measurement Diagram for the Dell Blade Solution

For the HP blade solution, we used two Yokogawa WT210 Digital Power Meters to measure the enclosure power by attaching the first three power supplies to one Power Distribution Unit (PDU) that was connected to a single WT210, and the next three power supplies to a second PDU connected to a second WT210. Each WT210/PDU combination was connected to a separate 208v floor outlet. See Figure 10.

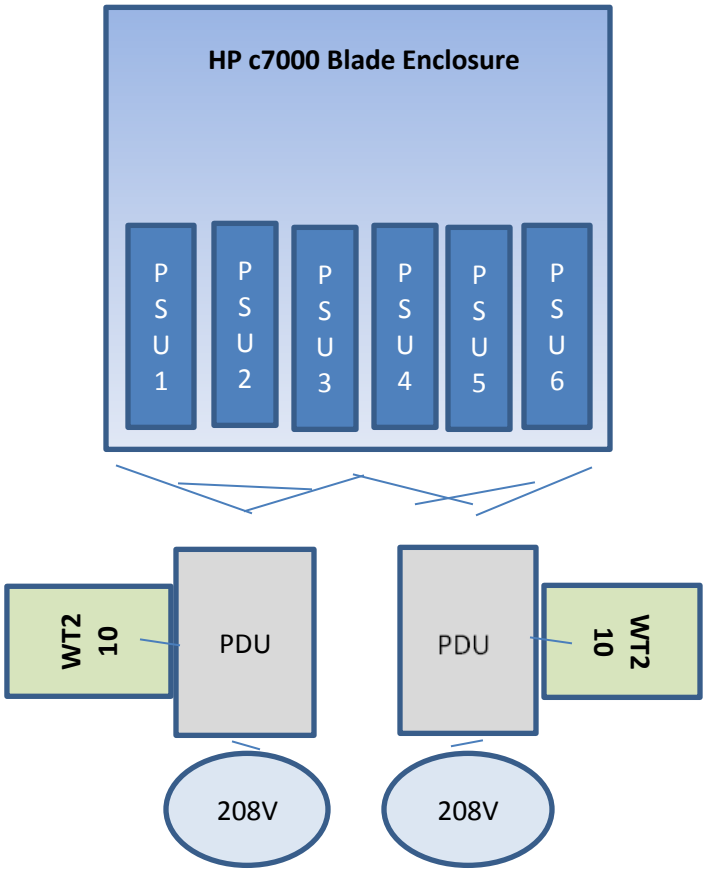


Figure 10. Power Measurement Diagram for the HP Blade Solution

The IBM blade solution presented a challenge. The IBM Blade Enclosure has two sets of three power cables coming from the rear of the unit. Because the power cable connector was different than the Dell and HP Blade Enclosures, we were forced to use a different PDU that would accept the NEMA C20 plug from the IBM enclosure. Each PDU only had two power receptacles to connect power cables, so we used three Yokogawa WT210 Digital Power Meters and three PDUs to measure power from this enclosure. Both of the cable bundles from the rear of the IBM enclosure contained three power cables. The first cable was marked “PSU 1,2”, the next marked “PSU 3,4”, and the last marked “Blower.” We attached the “PSU 1,2” from the first cable bundle and “PSU 1,2” cable from the second cable bundle to one Yokogawa WT210/PDU combination. The Blower power cables from both bundles were attached to a second Yokogawa WT210/PDU combination. Finally, the “PSU 3,4” power cable from the first cable bundle and the ”PSU 3,4” power cable from the second cable bundle were attached to a third

Yokogawa WT210/PDU combination. Each WT210/PDU combination was connected to a separate 208v floor outlet.[5] See Figure 11.

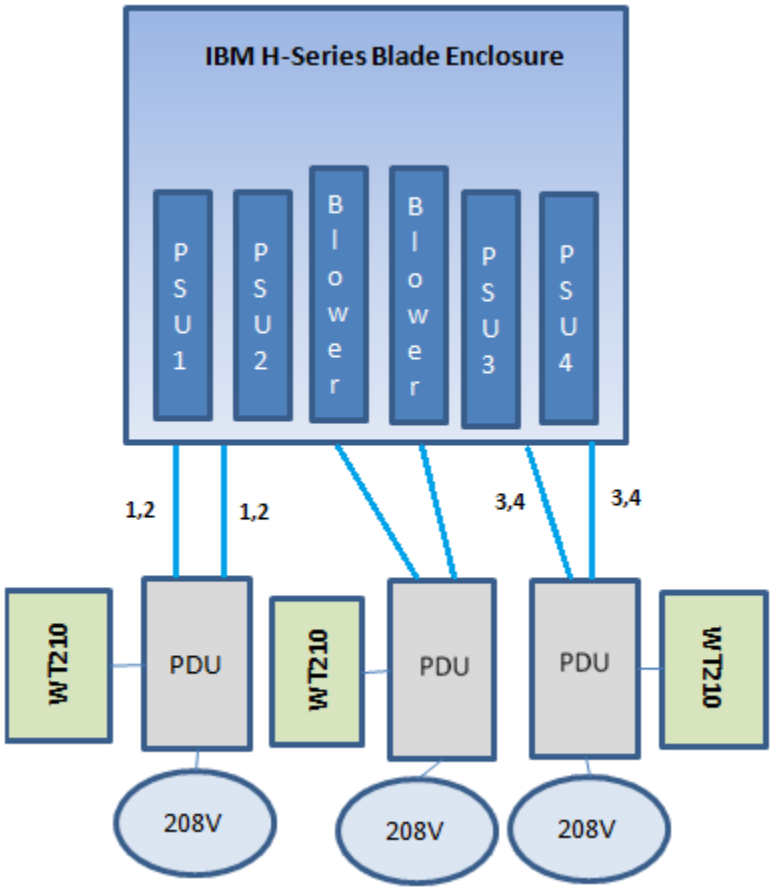


Figure 11. Power Measurement Diagram for the IBM Blade Solution

[5] We also tried connecting power cable "1,2" and "3,4" from the first cable bundle to the first Yokogawa WT210/PDU combination, the blower cables to the second WT210/PDU combination, and power cables "1,2" and "3,4" from the second cable bundle to the third Yokogawa WT210/PDU combination, but got slightly lower SPECpower results using this cabling configuration, so we reverted to the above described cabling methodology (pairing similarly marked cables to PDUs).

Appendix B—Enclosure Configuration Information

Table 5. Enclosure Configuration Information

	Dell PowerEdge M1000e	HP BladeSystem c7000	IBM BladeCenter H-Chassis 8852
Dimensions and Specifications			
Height (inches)	17.3	17.5	15.75
Width (inches)	17.6	17.5	17.5
Depth (inches)	29.7	32	29
U size in server rack	10	10	9
Number of blades	16	16	14
Chassis Management Firmware	CMC 3.0.0 (build 32)	Onboard Administrator 3.00	Advanced Module Management 3.54G
Power Supplies			
Total number	6	6	4
Wattage of each	2700	2450	2900
Power Supply Part Number	G803N	499243-B21	88524SU
Cooling Fans			
Total number	9	10	2 Blower Modules
I/O Modules in Chassis			
Gigabit Pass Through Modules	2 x Dell 16-port Gigabit Pass-Through	2 x HP 16-port Gigabit Pass-Through	2 x IBM 14-Port Gigabit Pass-Through

Appendix C—Blade System Configuration Information

Table 6. Blade System Configuration Information

Servers	Dell PowerEdge M610	HP ProLiant BL460c G6	IBM HS22 7870 4HU
Memory Modules			
Total RAM in system (GB)	24	24	24
Vendor and model number	Samsung M393B5170FHD-CH9	Micron MT36JSZF51272PY-1G4D1AB	Samsung M392B5170EM1-CH9
Type	PC3-10600R	PC3-10600R	PC3-10600R
Speed (MHz)	1333	1333	1333
Speed in system as tested	1333	1333	1333
Timing/latency	CAS 9	CAS 9	CAS 9
Number of RAM modules	6 x 4 GB	6 x 4 GB	6 x 4 GB
Rank organization	Dual Rank	Dual Rank	Dual Rank
Hard Disk			
Vendor and model number	Hitachi HUC151473CSS600	Seagate ST973452SS	Seagate ST973452SS
Number of disks in system	2	2	2
Size (GB)	73	73	73
Buffer size (MB)	16	16	16
RPM	15,000	15,000	15,000
Type	SAS 6 Gbps	SAS	SAS 6 Gbps
RAID Type	RAID 1	RAID 1 + 0	RAID 1
Controller	PERC H200 Modular	SmartArray P410i	LSI SAS StorPort 1064E
Operating System			
Name	Microsoft® Windows Server® 2008 R2 Enterprise	Microsoft® Windows Server® 2008 R2 Enterprise	Microsoft® Windows Server® 2008 R2 Enterprise
Build number	7600	7600	7600
File system	NTFS	NTFS	NTFS
Language	English	English	English
Network Adapter			
Vendor and model number	Broadcom® BCM5709S NetXtreme® II	Broadcom® 57711 10GbE	Broadcom® BCM5709S NetXtreme® II
Type	Integrated	Integrated	Integrated

Appendix D—Blade System Firmware and Drivers

Table 7. Detailed Configuration Information for Blade Server Solutions

Servers	Dell PowerEdge M610	HP ProLiant BL460c G6	IBM HS22 7870 4HU
Driver/Firmware Updates			
Network Firmware	5.0.13	2.1.5.7	2.1.3c
Network Drivers	14.2.0 A00	5.2.20.0	5.2.17.0
HBA Firmware	A01	2.74.0.0	2.70
HBA Drivers	A01	6.20.0.64	1.30.04.00
HDD FW	N/A	N/A	1.0.6
Video Driver	A02	6.14.10.6748	1.01.003
Power Management Controller Package	N/A	3.4.0.0	N/A
Management Controller Driver	N/A	1.13.0.0	N/A
Power Management Driver	N/A	1.15.0.0	N/A

Appendix E—SPECpower_ssj2008 Results

This appendix provides actual detailed reports and results from Dell testing using tools from the Standard Performance Evaluation Corporation. Benchmark results stated above reflect results run as of July 6, 2010. For the latest SPECpower_ssj2008 benchmark results, visit http://www.spec.org/power_ssj2008/results/power_ssj2008.html.

Dell M1000e Blade Enclosure/16 x PowerEdge M610

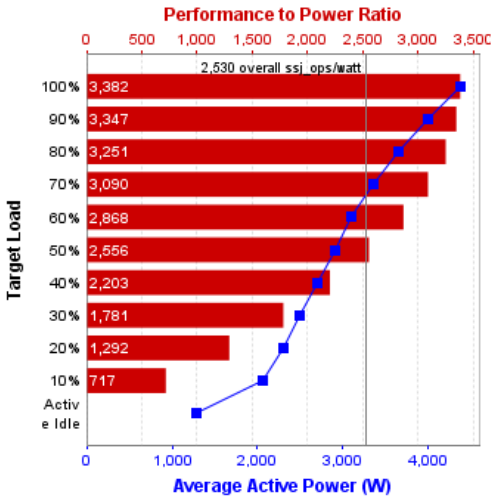
SPECpower_ssj2008

Dell Inc. PowerEdge M610				SPECpower_ssj2008 = 2,530 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:	Jun 24, 2010
Hardware Availability:	Sep-2010	Software Availability:	Sep-2009	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set M610 WARNING: For point 1, elapsed nanoTime=240021561031 ms, elapsed currentTimeMillis=240225 ms
Set M610 WARNING: For point 1, elapsed nanoTime=240006227165 ms, elapsed currentTimeMillis=240194 ms
Set M610 WARNING: For point 2, elapsed nanoTime=240003208410 ms, elapsed currentTimeMillis=240209 ms
Set M610 WARNING: For point 2, elapsed nanoTime=240009759367 ms, elapsed currentTimeMillis=240147 ms
Set M610 WARNING: For point 5, elapsed nanoTime=240024666403 ms, elapsed currentTimeMillis=240225 ms
Set M610 WARNING: For point 0, elapsed nanoTime=240003932149 ms, elapsed currentTimeMillis=240116 ms
Set M610 WARNING: For point 1, elapsed nanoTime=240170814042 ms, elapsed currentTimeMillis=240006 ms

Benchmark Results Summary

Performance			Power	Performance to Power Ratio
Target Load	Actual Load	ssj_ops	Average Active Power (W)	
100%	99.7%	14,785,342	4,372	3,382
90%	90.0%	13,344,934	3,987	3,347
80%	79.9%	11,853,404	3,646	3,251
70%	70.0%	10,380,753	3,359	3,090
60%	60.0%	8,903,133	3,104	2,868
50%	50.0%	7,412,879	2,900	2,556
40%	40.0%	5,928,182	2,692	2,203
30%	30.0%	4,444,109	2,496	1,781
20%	20.0%	2,971,405	2,301	1,292
10%	10.0%	1,481,894	2,067	717
Active Idle		0	1,288	0
			∑ssj_ops / ∑power =	2,530



Aggregate SUT Data						
# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
16	32	192	384	384	16	96

System Under Test

Shared Hardware

Shared Hardware	
Enclosure:	Dell M1000e Blade Enclosure
Form Factor:	10U
Power Supply Quantity and Rating (W):	6 x 2700
Power Supply Details:	Dell PN G803N
Network Switch:	1
Network Switch Details:	24 port Dell Gigabit Switch
KVM Switch:	None
KVM Switch Details:	N/A
Other Hardware:	2 x Dell 16-port Gigabit Ethernet Pass-Through Modules
Comment:	Network Switch not measured for Power

Set: 'M610'

Set Identifier:	M610
Set Description:	M610
# of Identical Nodes:	16
Comment:	None

Hardware per Node	
Hardware Vendor:	Dell Inc.
Model:	PowerEdge M610
Form Factor:	Blade
CPU Name:	Intel Xeon 5670 (2.93 GHz)
CPU Characteristics:	Six Core, 2.93 GHz, 12 MB L3 Cache
CPU Frequency (MHz):	2933
CPU(s) Enabled:	12 cores, 2 chips, 6 cores/chip
Hardware Threads:	24 (2 / core)
CPU(s) Orderable:	1,2 chip
Primary Cache:	32 KB I + 32 KB D on chip per core
Secondary Cache:	256 KB I+D on chip per core

Software per Node	
Power Management:	Power Saver Mode in OS (See Notes)
Operating System (OS):	Windows 2008 Server Enterprise x64 Edition
OS Version:	R2
Filesystem:	NTFS
JVM Vendor:	IBM Corporation
JVM Version:	IBM J9 VM (build 2.4, J2RE 1.6.0 IBM J9 2.4 Windows Server 2008 amd64-64 jvmwa64 60sr5-20090519_35743 (JIT enabled, AOT enabled)
JVM Command -line Options:	-Xmn1400m -Xms1875m -Xmx1875m -Xaggressive -Xcompressedrefs -Xgcpolicy:gencon -XlockReservation -Xnoloa -Xlp

Tertiary Cache:	12 MB I+D on chip per chip
Other Cache:	None
Memory Amount (GB):	24
# and size of DIMM:	6 x 4096 MB
Memory Details:	4GB 2Rx4 PC3-10600R ECC, Slots A1-A3, B1-B3 populated
Power Supply Quantity and Rating (W):	None
Power Supply Details:	N/A
Disk Drive:	2 x 73GB 2.5" 15k RPM SAS (RAID 1)
Disk Controller:	PERC H200 Modular
# and type of Network Interface Cards (NICs) Installed:	1 x onboard dual-port Gigabit Ethernet
NICs Enabled in Firmware / OS / Connected:	2/1/1
Network Speed (Mbit):	1000
Keyboard:	None
Mouse:	None
Monitor:	None
Optical Drives:	None
Other Hardware:	None

JVM Affinity:	start /affinity [F,F0,F00,F000,F0000,F00000]
JVM Instances:	96
JVM Initial Heap (MB):	1875
JVM Maximum Heap (MB):	1875
JVM Address Bits:	64
Boot Firmware Version:	2.1.11
Boot Firmware Settings:	See SUT Notes
Management Firmware Version:	3.0.0 Build 32
Management Firmware Settings:	none
Benchmark Version:	SPECpower_ssj2008 1.2.6
Director Location:	Controller
Other Software:	None

System Under Test Notes

- AC Redundancy Mode on Chassis
- Disable Dynamic Power Supply Engagement on Chassis(default)
- Each JVM instance was affinitized to four logical processors.
- Using the local security settings console, "lock pages in memory" was enabled for the user running the benchmark.
- Turn Off Hard Disk After 1 minute
- BIOS Settings
  - Turbo Disabled in BIOS
  - Hardware and Adjacent Cache Line Prefetchers disabled in BIOS
  - DCU Prefetch Disabled in BIOS
  - Data Reuse Disabled in BIOS

Controller System

Hardware	
Hardware Vendor:	Dell Inc.
Model:	PowerEdge 1950
CPU Description:	Intel Xeon 5160
Memory amount (GB):	4

Software	
Operating System (OS):	Microsoft Windows 2003 Server Enterprise Edition
JVM Vendor:	Oracle Corporation
JVM Version:	Jrockit(R) 1.6.0_02 build R26.4.0-63 (32-bit)
CCS Version:	1.2.4

Measurement Devices

Power Analyzer pwr1	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91H648897
Connectivity:	RS-232
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91H648897
Date of Calibration:	22-Sep-2009
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 1,2,3

Power Analyzer pwr2	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91G643889
Connectivity:	RS-232 to USB-to-Serial Adapter
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91G643889
Date of Calibration:	23-Apr-2010
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 4,5,6

Temperature Sensor temp1	
Hardware Vendor:	Digi International Inc.
Model:	Watchport/H
Driver Version:	Watchport Virtual Port 4.20.0.0
Connectivity:	USB
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
Setup Description:	Unknown

Notes

None

Aggregate Electrical and Environmental Data

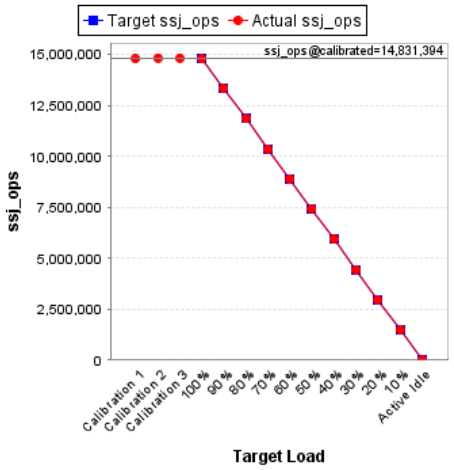
Target Load	Average Active Power (W)	Minimum Ambient Temperature (°C)
100%	4,372	22.8
90%	3,987	22.8
80%	3,646	22.9
70%	3,359	22.9
60%	3,104	22.9
50%	2,900	22.9
40%	2,692	22.9
30%	2,496	22.9
20%	2,301	22.9
10%	2,067	22.9
Active Idle	1,288	23.0

Line Standard	Minimum Temperature (°C)	Elevation (m)
208V / 60 Hz / 1 phase / 2 wires	22.8	255

See the Power/Temperature Details Report for additional details.

Aggregate Performance Data

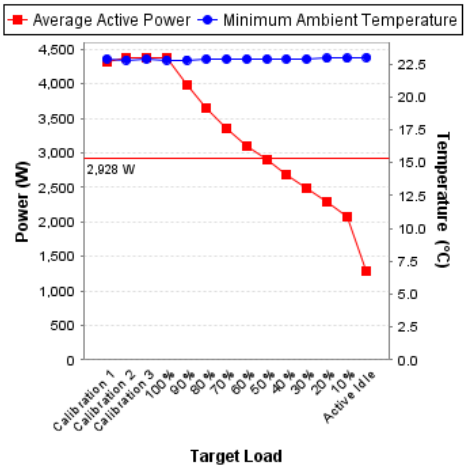
Target Load	Actual Load	ssj_ops	
		Target	Actual
Calibration 1			14,790,732
Calibration 2			14,833,556
Calibration 3			14,829,232
ssj_ops@calibrated=14,831,394			
100%	99.7%	14,831,394	14,785,342
90%	90.0%	13,348,254	13,344,934
80%	79.9%	11,865,115	11,853,404
70%	70.0%	10,381,976	10,380,753
60%	60.0%	8,898,836	8,903,133
50%	50.0%	7,415,697	7,412,879
40%	40.0%	5,932,557	5,928,182
30%	30.0%	4,449,418	4,444,109
20%	20.0%	2,966,279	2,971,405
10%	10.0%	1,483,139	1,481,894
Active Idle		0	0



See the Aggregate Performance Report for additional details.

Benchmark Results Summary

Target Load	Average Active Power (W)	Minimum Ambient Temperature (°C)
Calibration 1	4,325	22.9
Calibration 2	4,375	22.8
Calibration 3	4,383	22.9
100%	4,372	22.8
90%	3,987	22.8
80%	3,646	22.9
70%	3,359	22.9
60%	3,104	22.9
50%	2,900	22.9
40%	2,692	22.9
30%	2,496	22.9
20%	2,301	22.9
10%	2,067	22.9
Active Idle	1,288	23.0
Averages	**2,928**	**22.9**



Measurement Devices

Power Analyzer pwr1	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91H648897
Connectivity:	RS-232
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91H648897
Date of Calibration:	22-Sep-2009
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 1,2,3

Power Analyzer pwr2	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91G643889
Connectivity:	RS-232 to USB-to-Serial Adapter
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91G643889
Date of Calibration:	23-Apr-2010
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 4,5,6

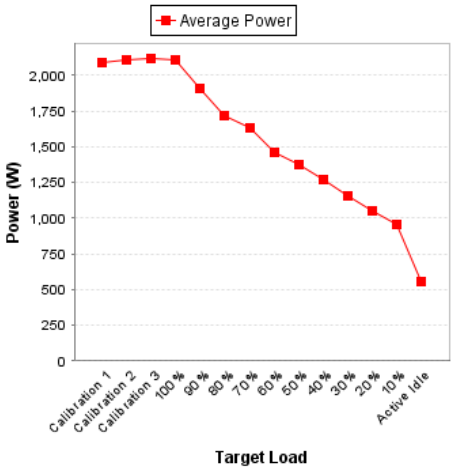
Temperature Sensor temp1	
Hardware Vendor:	Digi International Inc.
Model:	Watchport/H
Driver Version:	Watchport Virtual Port 4.20.0.0
Connectivity:	USB
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
Setup Description:	Unknown

Notes

None

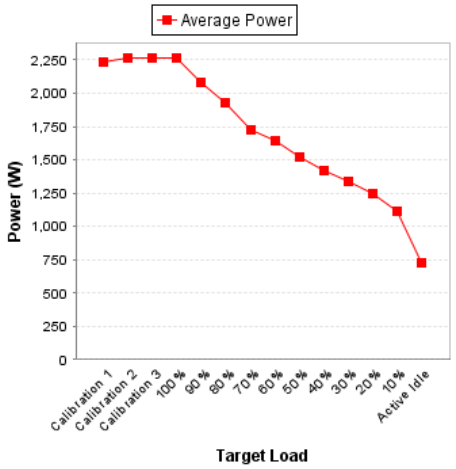
Power Details for Device pwr1

Target Load	Voltage (V)		Current (A)		Avg Power Factor	Avg Active Power (W)	Power Measurement Uncertainty (%)
	Avg	Range	Avg	Range			
Calibration 1	206	300.0	10.3	20.0	0.987	2,091	0.4%
Calibration 2	206	300.0	10.4	20.0	0.987	2,107	0.4%
Calibration 3	206	300.0	10.4	20.0	0.987	2,120	0.4%
100%	206	300.0	10.4	20.0	0.987	2,108	0.4%
90%	206	300.0	9.40	20.0	0.985	1,910	0.4%
80%	206	300.0	8.47	10.0	0.984	1,721	0.3%
70%	207	300.0	8.02	10.0	0.983	1,630	0.3%
60%	207	300.0	7.17	10.0	0.982	1,458	0.3%
50%	207	300.0	6.76	10.0	0.981	1,376	0.4%
40%	208	300.0	6.22	10.0	0.984	1,270	0.4%
30%	208	300.0	5.66	10.0	0.981	1,155	0.4%
20%	208	300.0	5.15	10.0	0.979	1,050	0.4%
10%	208	300.0	4.69	10.0	0.973	952	0.5%
Active Idle	209	300.0	2.88	5.0	0.928	558	0.4%
Averages	**207**		**6.80**		**0.977**	**1,381**	



Power Details for Device pwr2

Target Load	Voltage (V)		Current (A)		Avg Power Factor	Avg Active Power (W)	Power Measurement Uncertainty (%)
	Avg	Range	Avg	Range			
Calibration 1	204	300.0	11.1	20.0	0.988	2,234	0.4%
Calibration 2	204	300.0	11.3	20.0	0.988	2,268	0.4%
Calibration 3	204	300.0	11.2	20.0	0.988	2,263	0.4%
100%	204	300.0	11.2	20.0	0.988	2,263	0.4%
90%	205	300.0	10.3	20.0	0.987	2,077	0.4%
80%	205	300.0	9.54	10.0	0.986	1,925	0.3%
70%	205	300.0	8.56	10.0	0.984	1,729	0.3%
60%	206	300.0	8.14	10.0	0.984	1,645	0.3%
50%	206	300.0	7.53	10.0	0.983	1,524	0.3%
40%	206	300.0	7.03	10.0	0.982	1,422	0.3%
30%	206	300.0	6.60	10.0	0.983	1,340	0.4%
20%	207	300.0	6.16	10.0	0.981	1,250	0.4%
10%	207	300.0	5.49	10.0	0.982	1,115	0.4%
Active Idle	207	300.0	3.68	5.0	0.957	730	0.4%
Averages	**206**		**7.66**		**0.981**	**1,547**	



HP BladeSystem c7000/16 x ProLiant BL460c G6

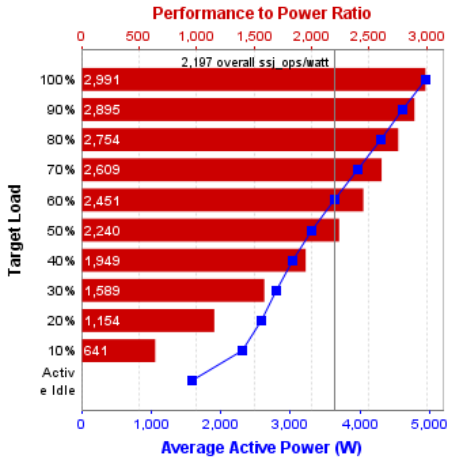
SPECpower_ssj2008

HP Inc. ProLiant BL460c G6			SPECpower_ssj2008 = 2,197 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:**	Jun 23, 2010
Hardware Availability:	May-2010	**Software Availability:**	Sep-2009	**Publication:**	Unpublished
System Source:	Single Supplier	**System Designation:**	Server	**Power Provisioning:**	Line-powered

Set BL460c WARNING: For point 0, elapsed nanoTime=240026818085 ms, elapsed currentTimeMillis=240194 ms
Set BL460c WARNING: For point 2, elapsed nanoTime=240123679028 ms, elapsed currentTimeMillis=240319 ms
Set BL460c WARNING: For point 3, elapsed nanoTime=240160486569 ms, elapsed currentTimeMillis=240366 ms
Set BL460c WARNING: For point 1, elapsed nanoTime=240030755713 ms, elapsed currentTimeMillis=240147 ms
Set BL460c WARNING: For point 3, elapsed nanoTime=240018820714 ms, elapsed currentTimeMillis=240132 ms
Set BL460c WARNING: For point 2, elapsed nanoTime=240020239213 ms, elapsed currentTimeMillis=240178 ms

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	99.6%	14,774,218	4,940	2,991
90%	90.0%	13,338,325	4,608	2,895
80%	80.0%	11,858,862	4,306	2,754
70%	70.0%	10,377,087	3,977	2,609
60%	60.0%	8,895,651	3,630	2,451
50%	50.0%	7,420,425	3,313	2,240
40%	39.9%	5,922,357	3,038	1,949
30%	30.0%	4,452,479	2,801	1,589
20%	20.0%	2,971,369	2,574	1,154
10%	10.0%	1,479,418	2,310	641
Active Idle		0	1,598	0
		∑ssj_ops / ∑power =		**2,197**



Aggregate SUT Data

# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
16	32	192	384	384	16	96

System Under Test

Shared Hardware

Shared Hardware	
Enclosure:	HP C7000 Blade Enclosure
Form Factor:	10U
Power Supply Quantity and Rating (W):	6 x 2400
Power Supply Details:	HP 2400W HE PSU
Network Switch:	1
Network Switch Details:	24 port Dell Gigabit Switch
KVM Switch:	None
KVM Switch Details:	N/A
Other Hardware:	2 x HP 16-port Gigabit Ethernet Pass-Through Modules
Comment:	Network Switch not measured for Power

Set: 'BL460c'

Set Identifier:	BL460c
Set Description:	BL460c
# of Identical Nodes:	16
Comment:	None

Hardware per Node	
Hardware Vendor:	HP Inc.
Model:	ProLiant BL460c G6
Form Factor:	Blade
CPU Name:	Intel Xeon 5670 (2.93 GHz)
CPU Characteristics:	Six Core, 2.93 GHz, 12 MB L3 Cache
CPU Frequency (MHz):	2933
CPU(s) Enabled:	12 cores, 2 chips, 6 cores/chip
Hardware Threads:	24 (2 / core)
CPU(s) Orderable:	1,2 chip
Primary Cache:	32 KB I + 32 KB D on chip per core
Secondary Cache:	256 KB I+D on chip per core

Software per Node	
Power Management:	Power Saver Mode in OS (See Notes)
Operating System (OS):	Windows 2008 Server Enterprise x64 Edition
OS Version:	R2
Filesystem:	NTFS
JVM Vendor:	IBM Corporation
JVM Version:	IBM J9 VM (build 2.4, J2RE 1.6.0 IBM J9 2.4 Windows Server 2008 amd64-64 jvmwa64 60sr5-20090519_35743 (JIT enabled, AOT enabled)
JVM Command -line Options:	-Xmn1400m -Xms1875m -Xmx1875m -Xaggressive -Xcompressedrefs -Xgcpolicy:gencon -XlockReservation -Xnoloa -Xlp

Tertiary Cache:	12 MB I+D on chip per chip
Other Cache:	None
Memory Amount (GB):	24
# and size of DIMM:	6 x 4096 MB
Memory Details:	4GB 2Rx4 PC3-10600R ECC, Slots A1-A3, B1-B3 populated
Power Supply Quantity and Rating (W):	None
Power Supply Details:	N/A
Disk Drive:	2 x 73GB 2.5" 15k RPM SAS (RAID 1 + 0)
Disk Controller:	HP SmartArray P410i
# and type of Network Interface Cards (NICs) Installed:	2 x onboard Broadcom 10Gb
NICs Enabled in Firmware / OS / Connected:	2/1/1
Network Speed (Mbit):	1000
Keyboard:	None
Mouse:	None
Monitor:	None
Optical Drives:	None
Other Hardware:	None

JVM Affinity:	start /affinity [F,F0,F00,F000,F0000,F00000]
JVM Instances:	96
JVM Initial Heap (MB):	1875
JVM Maximum Heap (MB):	1875
JVM Address Bits:	64
Boot Firmware Version:	I24 3/30/2010
Boot Firmware Settings:	See SUT Notes
Management Firmware Version:	1.82 ILOM2
Management Firmware Settings:	none
Benchmark Version:	SPECpower_ssj2008 1.2.6
Director Location:	Controller
Other Software:	None

System Under Test Notes

- AC Redundant Mode
- Dynamic Power Mode: Enabled
- Each JVM instance was affinitized to four logical processors.
- Using the local security settings console, "lock pages in memory" was enabled for the user running the benchmark.
- Turn Off Hard Disk After 1 minute
-
- BIOS Settings
  - Turbo Disabled in BIOS
  - Hardware and Adjacent Cache Line Prefetchers disabled in BIOS
  - Dynamic Power Regulator: Slow
  - DCU Prefetch and Data Reuse Prefetch Disabled via conrep

Controller System

Hardware	
Hardware Vendor:	Dell Inc.
Model:	PowerEdge 1950
CPU Description:	Intel Xeon 5160
Memory amount (GB):	4

Software	
Operating System (OS):	Microsoft Windows 2003 Server Enterprise Edition
JVM Vendor:	Oracle Corporation
JVM Version:	Jrockit(R) 1.6.0_02 build R26.4.0-63 (32-bit)
CCS Version:	1.2.4

Measurement Devices

Power Analyzer pwr1	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91H648897
Connectivity:	RS-232
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91H648897
Date of Calibration:	22-Sep-2009
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 1,2,3

Power Analyzer pwr2	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91G643889
Connectivity:	RS-232 to USB-to-Serial adapter
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91G643889
Date of Calibration:	23-Apr-2010
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 4,5,6

Temperature Sensor temp1	
Hardware Vendor:	Digi International Inc.
Model:	Watchport/H
Driver Version:	Watchport Virtual Port 4.20.0.0
Connectivity:	USB
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
Setup Description:	Unknown

Notes

None

Aggregate Electrical and Environmental Data

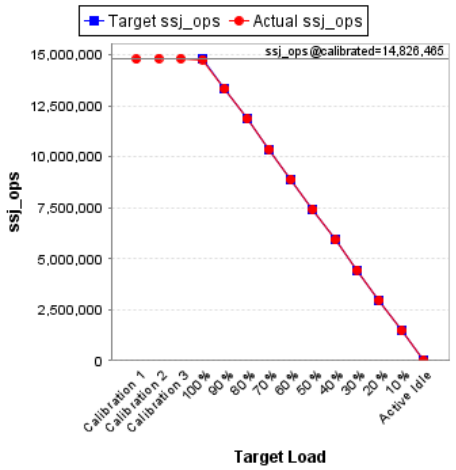
Target Load	Average Active Power (W)	Minimum Ambient Temperature (°C)
100%	4,940	23.6
90%	4,608	23.6
80%	4,306	23.6
70%	3,977	23.6
60%	3,630	23.7
50%	3,313	23.7
40%	3,038	23.6
30%	2,801	23.5
20%	2,574	23.5
10%	2,310	23.4
Active Idle	1,598	23.4

Line Standard	Minimum Temperature (°C)	Elevation (m)
208V / 60 Hz / 1 phase / 2 wires	23.4	255

See the Power/Temperature Details Report for additional details.

Aggregate Performance Data

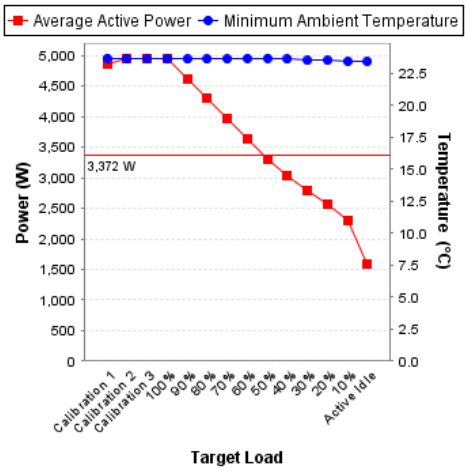
Target Load	Actual Load	ssj_ops	
		Target	Actual
Calibration 1			14,789,991
Calibration 2			14,827,697
Calibration 3			14,825,232
ssj_ops@calibrated=14,826,465			
100%	99.6%	14,826,465	14,774,218
90%	90.0%	13,343,818	13,338,325
80%	80.0%	11,861,172	11,858,862
70%	70.0%	10,378,525	10,377,087
60%	60.0%	8,895,879	8,895,651
50%	50.0%	7,413,232	7,420,425
40%	39.9%	5,930,586	5,922,357
30%	30.0%	4,447,939	4,452,479
20%	20.0%	2,965,293	2,971,369
10%	10.0%	1,482,646	1,479,418
Active Idle		0	0



See the Aggregate Performance Report for additional details.

Benchmark Results Summary

Target Load	Average Active Power (W)	Minimum Ambient Temperature (°C)
Calibration 1	4,851	23.7
Calibration 2	4,943	23.6
Calibration 3	4,956	23.6
100%	4,940	23.6
90%	4,608	23.6
80%	4,306	23.6
70%	3,977	23.6
60%	3,630	23.7
50%	3,313	23.7
40%	3,038	23.6
30%	2,801	23.5
20%	2,574	23.5
10%	2,310	23.4
Active Idle	1,598	23.4
Averages	**3,372**	**23.6**



Measurement Devices

Power Analyzer pwr1	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91H648897
Connectivity:	RS-232
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91H648897
Date of Calibration:	22-Sep-2009
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 1,2,3

Power Analyzer pwr2	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91G643889
Connectivity:	RS-232 to USB-to-Serial adapter
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91G643889
Date of Calibration:	23-Apr-2010
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 4,5,6

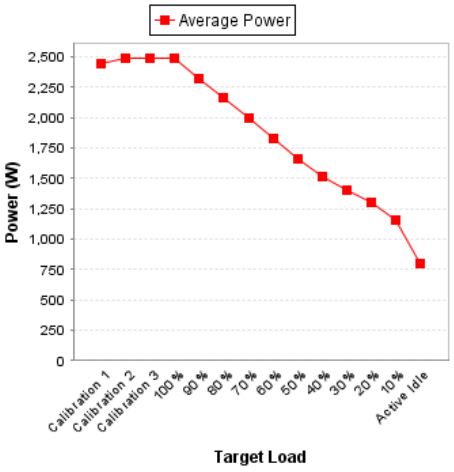
Temperature Sensor temp1	
Hardware Vendor:	Digi International Inc.
Model:	Watchport/H
Driver Version:	Watchport Virtual Port 4.20.0.0
Connectivity:	USB
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
Setup Description:	Unknown

Notes

None

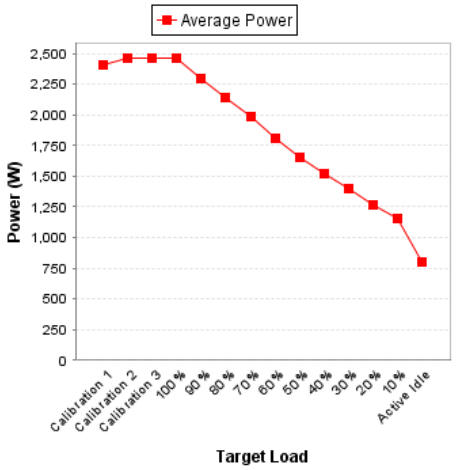
Power Details for Device pwr1

Target Load	Voltage (V)		Current (A)		Avg Power Factor	Avg Active Power (W)	Power Measurement Uncertainty (%)
	Avg	Range	Avg	Range			
Calibration 1	206	300.0	11.9	20.0	0.989	2,438	0.4%
Calibration 2	206	300.0	12.2	20.0	0.990	2,484	0.4%
Calibration 3	206	300.0	12.2	20.0	0.990	2,491	0.4%
100%	206	300.0	12.2	20.0	0.990	2,483	0.4%
90%	206	300.0	11.3	20.0	0.988	2,315	0.4%
80%	207	300.0	10.6	20.0	0.987	2,161	0.4%
70%	207	300.0	9.78	10.0	0.986	1,992	0.3%
60%	207	300.0	8.95	10.0	0.984	1,823	0.3%
50%	207	300.0	8.15	10.0	0.983	1,661	0.3%
40%	208	300.0	7.46	10.0	0.981	1,517	0.3%
30%	208	300.0	6.89	10.0	0.978	1,402	0.4%
20%	208	300.0	6.44	10.0	0.977	1,306	0.4%
10%	208	300.0	5.69	10.0	0.974	1,152	0.4%
Active Idle	208	300.0	3.98	5.0	0.963	798	0.3%
Averages	**207**		**8.31**		**0.981**	**1,692**	



Power Details for Device pwr2

Target Load	Voltage (V)		Current (A)		Avg Power Factor	Avg Active Power (W)	Power Measurement Uncertainty (%)
	Avg	Range	Avg	Range			
Calibration 1	205	300.0	11.9	20.0	0.990	2,412	0.4%
Calibration 2	205	300.0	12.1	20.0	0.990	2,459	0.4%
Calibration 3	205	300.0	12.1	20.0	0.990	2,466	0.4%
100%	205	300.0	12.1	20.0	0.990	2,457	0.4%
90%	205	300.0	11.3	20.0	0.989	2,293	0.4%
80%	206	300.0	10.6	20.0	0.988	2,146	0.4%
70%	205	300.0	9.79	10.0	0.986	1,984	0.3%
60%	206	300.0	8.92	10.0	0.985	1,807	0.3%
50%	206	300.0	8.16	10.0	0.983	1,652	0.3%
40%	206	300.0	7.51	10.0	0.981	1,521	0.3%
30%	207	300.0	6.92	10.0	0.979	1,400	0.4%
20%	206	300.0	6.29	10.0	0.976	1,268	0.4%
10%	207	300.0	5.74	10.0	0.975	1,158	0.4%
Active Idle	207	300.0	4.00	5.0	0.964	800	0.3%
Averages	**206**		**8.30**		**0.981**	**1,681**	



IBM BladeCenter 8852 H-Series/14 x BladeCenter HS22 7870

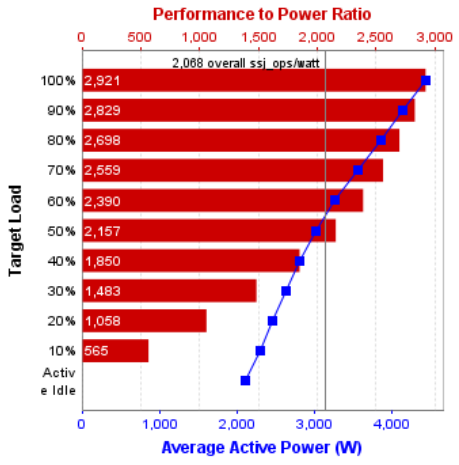
SPECpower_ssj2008

IBM Corporation HS22 Blade			SPECpower_ssj2008 = 2,068 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:	Jun 29, 2010
Hardware Availability:	Jun-2010	Software Availability:	Sep-2009	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set HS22 WARNING: For point 0, elapsed nanoTime=240058743079 ms, elapsed currentTimeMillis=240194 ms
Set HS22 WARNING: For point 0, elapsed nanoTime=240054075489 ms, elapsed currentTimeMillis=240209 ms
Set HS22 WARNING: For point 0, elapsed nanoTime=240058743079 ms, elapsed currentTimeMillis=240194 ms
Set HS22 WARNING: For point 0, elapsed nanoTime=240019512027 ms, elapsed currentTimeMillis=240193 ms
Set HS22 WARNING: For point 0, elapsed nanoTime=240072997397 ms, elapsed currentTimeMillis=240288 ms

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	99.6%	12,979,356	4,444	2,921
90%	89.9%	11,716,988	4,141	2,829
80%	80.1%	10,429,739	3,865	2,698
70%	70.1%	9,128,012	3,566	2,559
60%	60.0%	7,820,687	3,273	2,390
50%	50.0%	6,516,261	3,021	2,157
40%	39.9%	5,202,062	2,813	1,850
30%	30.0%	3,905,546	2,634	1,483
20%	20.0%	2,604,026	2,462	1,058
10%	10.0%	1,302,857	2,306	565
Active Idle		0	2,107	0
			∑ssj_ops / ∑power =	2,068



Aggregate SUT Data

# of Nodes	# of Chips	# of Cores	# of Threads	Total RAM (GB)	# of OS Images	# of JVM Instances
14	28	168	336	336	14	84

Shared Hardware

Shared Hardware	
Enclosure:	IBM BladeCenter H-Series 8852 Enclosure
Form Factor:	9U
Power Supply Quantity and Rating (W):	4 x 2900
Power Supply Details:	88524SU
Network Switch:	1
Network Switch Details:	24 port Dell Gigabit Switch
KVM Switch:	None
KVM Switch Details:	N/A
Other Hardware:	2 x IBM 14-port Gigabit Ethernet Pass-Through Modules
Comment:	Network Switch not measured for Power

Set: 'HS22'

Set Identifier:	HS22
Set Description:	HS22
# of Identical Nodes:	14
Comment:	None

Hardware per Node	
Hardware Vendor:	IBM Corporation
Model:	HS22 Blade
Form Factor:	Blade
CPU Name:	Intel Xeon 5670 (2.93 GHz)
CPU Characteristics:	Six Core, 2.93 GHz, 12 MB L3 Cache
CPU Frequency (MHz):	2933
CPU(s) Enabled:	12 cores, 2 chips, 6 cores/chip
Hardware Threads:	24 (2 / core)
CPU(s) Orderable:	1,2 chip
Primary Cache:	32 KB I + 32 KB D on chip per core
Secondary Cache:	256 KB I+D on chip per core

Software per Node	
Power Management:	Power Saver Mode in OS (See Notes)
Operating System (OS):	Windows 2008 Server Enterprise x64 Edition
OS Version:	R2
Filesystem:	NTFS
JVM Vendor:	IBM Corporation
JVM Version:	IBM J9 VM (build 2.4, J2RE 1.6.0 IBM J9 2.4 Windows Server 2008 amd64-64 jvmwa64 60sr5-20090519_35743 (JIT enabled, AOT enabled)
JVM Command -line Options:	-Xmn1400m -Xms1875m -Xmx1875m -Xaggressive -Xcompressedrefs -Xgcpolicy:gencon -XlockReservation -Xnoloa -Xlp

Tertiary Cache:	12 MB I+D on chip per chip
Other Cache:	None
Memory Amount (GB):	24
# and size of DIMM:	6 x 4096 MB
Memory Details:	4GB 2Rx4 PC3-10600R ECC, Slots A1-A3, B1-B3 populated
Power Supply Quantity and Rating (W):	None
Power Supply Details:	N/A
Disk Drive:	2 x 73GB 2.5" 6Gbps 15k RPM SAS (RAID 1)
Disk Controller:	LSI SAS StorPort 1064E
# and type of Network Interface Cards (NICs) Installed:	1 x onboard dual-port Gigabit Ethernet
NICs Enabled in Firmware / OS / Connected:	2/1/1
Network Speed (Mbit):	1000
Keyboard:	None
Mouse:	None
Monitor:	None
Optical Drives:	None
Other Hardware:	None

JVM Affinity:	start /affinity [F,F0,F00,F000,F0000,F00000]
JVM Instances:	84
JVM Initial Heap (MB):	1875
JVM Maximum Heap (MB):	1875
JVM Address Bits:	64
Boot Firmware Version:	1.0.8
Boot Firmware Settings:	See SUT Notes
Management Firmware Version:	3.0.1
Management Firmware Settings:	none
Benchmark Version:	SPECpower_ssj2008 1.2.6
Director Location:	Controller
Other Software:	None

System Under Test Notes

- Redundant Power Management Mode on Chassis
- Each JVM instance was affinitized to four logical processors.
- Using the local security settings console, "lock pages in memory" was enabled for the user running the benchmark.
- Turn Off Hard Disk After 1 minute
- Minimum Processor State:0%
- Maximum Processor State:100%
- BIOS Settings
  - Turbo Disabled in BIOS(default)
  - C-states Enabled in BIOS
  - Cache Data Prefetch Disabled in BIOS
  - Data Reuse Disabled in BIOS

Controller System

Hardware	
Hardware Vendor:	Dell Inc.
Model:	PowerEdge 1950
CPU Description:	Intel Xeon 5160
Memory amount (GB):	4

Software	
Operating System (OS):	Microsoft Windows 2003 Server Enterprise Edition
JVM Vendor:	Oracle Corporation
JVM Version:	Jrockit(R) 1.6.0_02 build R26.4.0-63 (32-bit)
CCS Version:	1.2.4

Measurement Devices

Power Analyzer pwr1	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91H648897
Connectivity:	RS-232
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91H648897
Date of Calibration:	22-Sep-2009
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 1,2 and 1,2

Power Analyzer pwr2	
Hardware Vendor:	Yokogawa Electric International Pte. Ltd.
Model:	WT210
Serial Number:	91G643889
Connectivity:	RS-232 to USB-to-Serial Adapter
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Davis Calibration
Calibration Label:	91G643889
Date of Calibration:	23-Apr-2010
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supply Blower 1,2

Power Analyzer pwr3	
Hardware Vendor:	Unknown
Model:	WT210
Serial Number:	91J936842
Connectivity:	RS-232 to USB-to-Serial Adapter
Input Connection:	Default
Calibration Institute:	NIST
Accredited by:	Yokogawa Corporation of America
Calibration Label:	09-2371
Date of Calibration:	10-Nov-2009
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
PTDaemon Version:	1.3.10-511c8daa
Setup Description:	SUT Power Supplies 3,4 and 3,4

Temperature Sensor temp1	
Hardware Vendor:	Digi International Inc.
Model:	Watchport/H
Driver Version:	Watchport Virtual Port 4.20.0.0
Connectivity:	USB
PTDaemon Host System:	same as CCS
PTDaemon Host OS:	same as CCS
Setup Description:	Unknown

Notes

None

Aggregate Electrical and Environmental Data

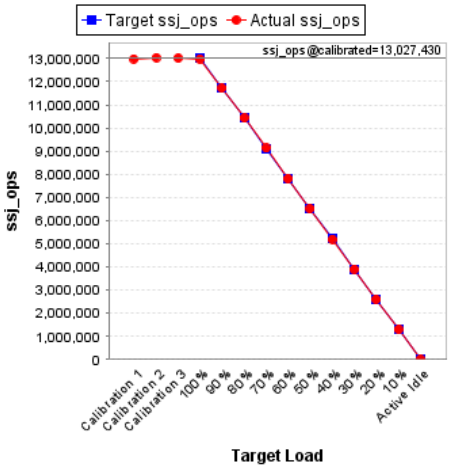
Target Load	Average Active Power (W)	Minimum Ambient Temperature (°C)
100%	4,444	25.0
90%	4,141	25.0
80%	3,865	25.0
70%	3,566	25.0
60%	3,273	25.0
50%	3,021	25.0
40%	2,813	24.9
30%	2,634	24.9
20%	2,462	24.9
10%	2,306	24.9
Active Idle	2,107	24.9

Line Standard	Minimum Temperature (°C)	Elevation (m)
208V / 60 Hz / 1 phase / 2 wires	24.9	255

See the Power/Temperature Details Report for additional details.

Aggregate Performance Data

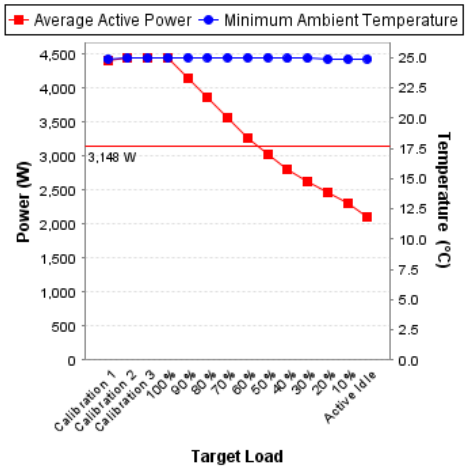
Target Load	Actual Load	ssj_ops	
		Target	Actual
Calibration 1			12,982,281
Calibration 2			13,037,293
Calibration 3			13,017,567
ssj_ops@calibrated=13,027,430			
100%	99.6%	13,027,430	12,979,356
90%	89.9%	11,724,687	11,716,988
80%	80.1%	10,421,944	10,429,739
70%	70.1%	9,119,201	9,128,012
60%	60.0%	7,816,458	7,820,687
50%	50.0%	6,513,715	6,516,261
40%	39.9%	5,210,972	5,202,062
30%	30.0%	3,908,229	3,905,546
20%	20.0%	2,605,486	2,604,026
10%	10.0%	1,302,743	1,302,857
Active Idle		0	0



See the Aggregate Performance Report for additional details.

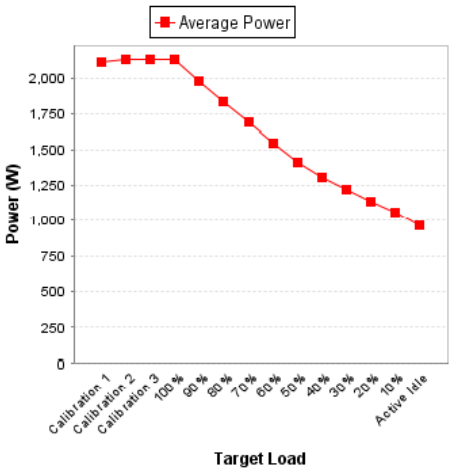
Benchmark Results Summary

Target Load	Average Active Power (W)	Minimum Ambient Temperature (°C)
Calibration 1	4,409	24.9
Calibration 2	4,446	24.9
Calibration 3	4,452	24.9
100%	4,444	25.0
90%	4,141	25.0
80%	3,865	25.0
70%	3,566	25.0
60%	3,273	25.0
50%	3,021	25.0
40%	2,813	24.9
30%	2,634	24.9
20%	2,462	24.9
10%	2,306	24.9
Active Idle	2,107	24.9
Averages	**3,148**	**25.0**



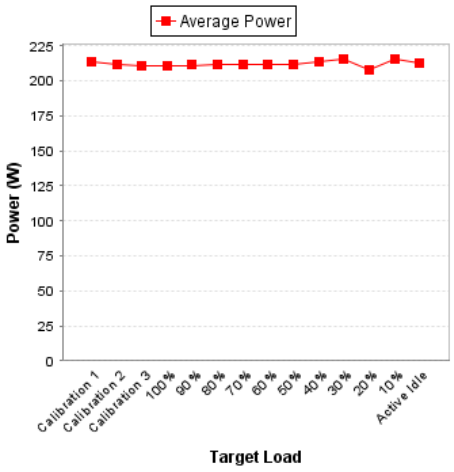
Power Details for Device pwr1

Target Load	Voltage (V)		Current (A)		Avg Power Factor	Avg Active Power (W)	Power Measurement Uncertainty (%)
	Avg	Range	Avg	Range			
Calibration 1	206	300.0	10.4	20.0	0.987	2,109	0.4%
Calibration 2	206	300.0	10.5	20.0	0.987	2,129	0.4%
Calibration 3	206	300.0	10.5	20.0	0.987	2,133	0.4%
100%	206	300.0	10.5	20.0	0.987	2,128	0.4%
90%	206	300.0	9.75	20.0	0.985	1,976	0.4%
80%	206	300.0	9.07	10.0	0.983	1,836	0.3%
70%	206	300.0	8.37	10.0	0.980	1,689	0.3%
60%	206	300.0	7.66	10.0	0.976	1,542	0.3%
50%	206	300.0	7.06	10.0	0.973	1,416	0.4%
40%	206	300.0	6.54	10.0	0.971	1,310	0.4%
30%	206	300.0	6.10	10.0	0.970	1,220	0.4%
20%	206	300.0	5.69	10.0	0.968	1,136	0.4%
10%	206	300.0	5.30	10.0	0.966	1,055	0.4%
Active Idle	206	300.0	4.83	10.0	0.961	957	0.5%
Averages	**206**		**7.35**		**0.975**	**1,479**	



Power Details for Device pwr2

Target Load	Voltage (V)		Current (A)		Avg Power Factor	Avg Active Power (W)	Power Measurement Uncertainty (%)
	Avg	Range	Avg	Range			
Calibration 1	209	300.0	1.19	2.0	0.861	214	0.5%
Calibration 2	209	300.0	1.18	2.0	0.859	212	0.5%
Calibration 3	209	300.0	1.18	2.0	0.858	211	0.5%
100%	208	300.0	1.18	2.0	0.859	211	0.5%
90%	208	300.0	1.18	2.0	0.860	211	0.5%
80%	208	300.0	1.18	2.0	0.860	211	0.5%
70%	208	300.0	1.18	2.0	0.860	211	0.5%
60%	208	300.0	1.18	2.0	0.861	212	0.5%
50%	208	300.0	1.18	2.0	0.861	211	0.5%
40%	208	300.0	1.19	2.0	0.864	214	0.5%
30%	208	300.0	1.20	2.0	0.866	216	0.5%
20%	207	300.0	1.17	2.0	0.859	208	0.5%
10%	207	300.0	1.20	2.0	0.867	216	0.5%
Active Idle	207	300.0	1.19	2.0	0.863	213	0.5%
Averages	**208**		**1.19**		**0.862**	**212**	



Power Details for Device pwr3

Target Load	Voltage (V)		Current (A)		Avg Power Factor	Avg Active Power (W)	Power Measurement Uncertainty (%)
	Avg	Range	Avg	Range			
Calibration 1	207	300.0	10.2	10.0	0.987	2,087	0.3%
Calibration 2	207	300.0	10.3	10.0	0.987	2,105	0.3%
Calibration 3	206	300.0	10.4	10.0	0.987	2,108	0.3%
100%	206	300.0	10.3	10.0	0.987	2,105	0.3%
90%	206	300.0	9.62	10.0	0.985	1,954	0.3%
80%	206	300.0	8.96	10.0	0.983	1,818	0.3%
70%	206	300.0	8.24	10.0	0.980	1,666	0.3%
60%	206	300.0	7.53	10.0	0.977	1,519	0.3%
50%	207	300.0	6.92	10.0	0.975	1,394	0.4%
40%	207	300.0	6.41	10.0	0.972	1,289	0.4%
30%	207	300.0	5.98	10.0	0.970	1,199	0.4%
20%	207	300.0	5.59	10.0	0.967	1,117	0.4%
10%	207	300.0	5.19	5.0	0.964	1,035	0.3%
Active Idle	207	300.0	4.72	5.0	0.960	937	0.3%
Averages	**207**		**7.23**		**0.975**	**1,457**