Intergenerational Energy Efficiency of Dell PowerEdge Servers

This white paper compares the energy efficiency of the refreshed 13th generation PowerEdge 1U rack server, based on the Intel Xeon processor E5-2600 v4 product family, to that of its direct predecessors.

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Introduction

With power and cooling costs accounting for an increasingly large portion of IT budgets, IT departments looking to minimize total cost of ownership (TCO) are finding it advisable to make energy efficiency a priority when choosing server hardware. In this white paper, we examine the intergenerational energy efficiency improvements in the latest Dell PowerEdge server family focusing on the popular two-processor, 1U rack form factor platform, configured just as it is typically specified by large data center customers.

The Dell Solutions Performance Analysis (SPA) team compared the Dell PowerEdge R630+ configured with the latest Broadwell-EP microarchitecture Xeon E5-2600 v4 product family CPUs versus one configured with the preceding Haswell-EP microarchitecture Xeon E5-2600 v3 ones. Using the industry-standard SPECpower_ssj2008® benchmark, the two servers were tested for outright performance, performance/watt and input power consumption.

The results showed **the refreshed Dell PowerEdge R630+ delivered substantially better performance and greater energy efficiency than its two-year old predecessor.**

Key findings

Performance/watt

The PowerEdge R630+ achieved a **16% higher overall performance-to-power ratio** than the R630 in this typical configuration.

Performance

The **PowerEdge R630+ provided 13% better raw performance** than the R630 at every workload level.

Power

The PowerEdge R630+ consumed 7% less power when running at the 100% utilization level **saving 123KWh of electricity annually**.

Test methodology and detailed result reports are documented in this paper.

Methodology

SPECpower_ssj2008 is an industry-standard benchmark created by Standard Performance Evaluation Corporation (SPEC) to measure a server's power and performance across multiple utilization levels. Appendix A—Test details the test methodology used by Dell and Appendix B SPECpower_ssj2008 provides the detailed report data that supports the results in this paper.

Typical configuration

The two systems were configured according to enterprise data center customer requirement feedback and Dell's new product marketing projections. The differences between the two configurations being due to the natural advancement in technology, commodity component price/availability and industry performance agency accepted benchmarking environment standards that occur over time.

The configurations used are summarized in Table 1.

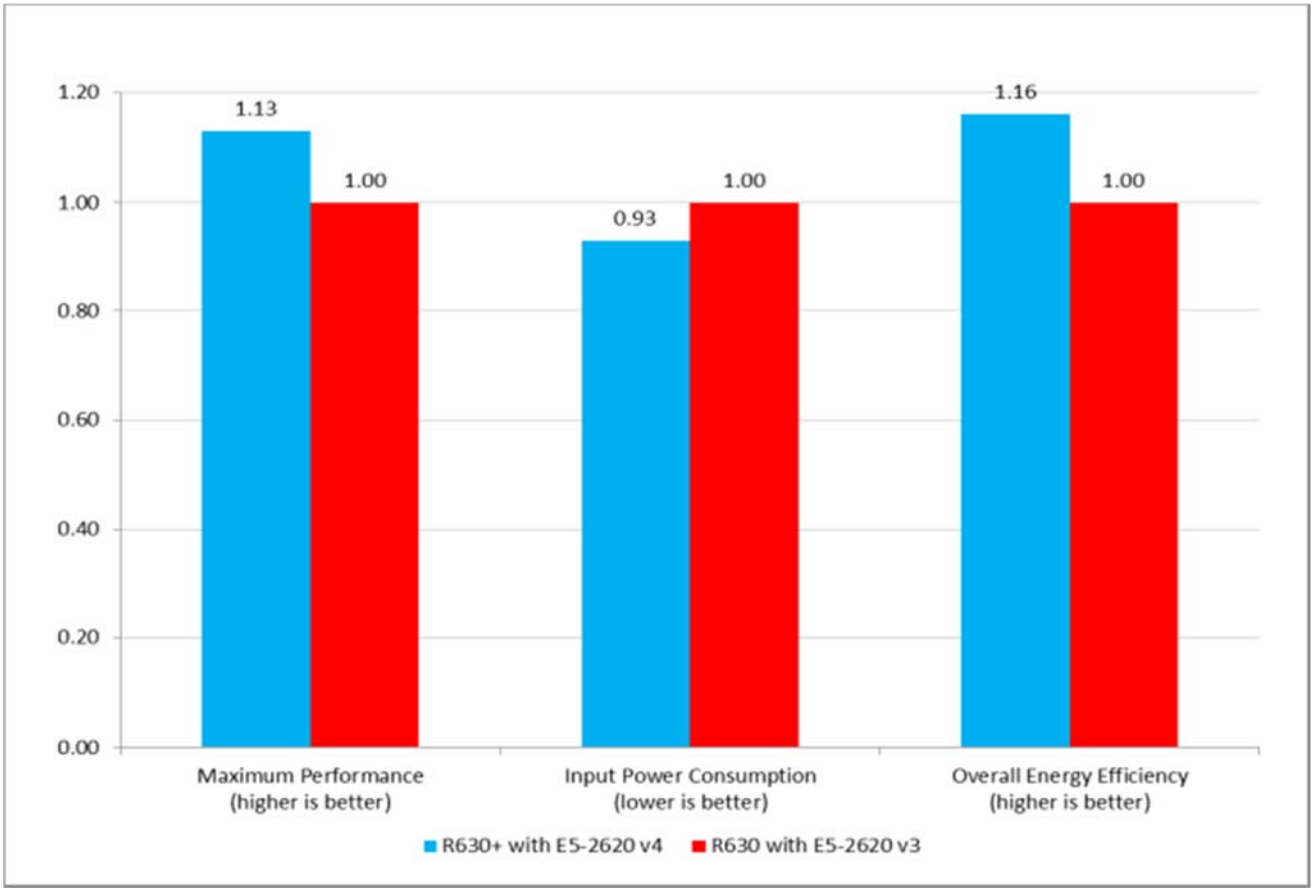
Table 1. Detailed configuration for energy efficiency comparison

Configuration	PowerEdge R630+	PowerEdge R630
Sockets/form factor	2S/1U	2S/1U
Processors	2 x Intel® Xeon® E5-2620 v4, 8 physical/16 logical cores, 2.10GHz	2 x Intel Xeon E5-2620 v3, 6 physical/12 logical cores, 2.40GHz
Memory	64GB, 8 x 8GB dual-ranked PC4-2133P RDIMMs (Dell P/N H8PGN)	64GB, 8 x 8GB dual-ranked PC4-2133P RDIMMs (Dell P/N H8PGN)
Hard drives	2 x 300GB 10K RPM 6Gb SAS RAID 1 (Dell P/N PGHJG)	2 x 300GB 10K RPM 6Gb SAS RAID 1 (Dell P/N MTV7G)
Storage controller	Dell PERC H730 1GB cache (Dell P/N KMCCD)	Dell PERC H730 1GB cache (Dell P/N KMCCD)
Power supply quantity/rating	2 χ 495W (Dell P/N 2FR04)	2 χ 495W (Dell P/N 2FR04)
Network adapter	1 x quad-port Broadcom® 5720 1GBase-T (Dell P/N FM487)	1 x quad-port Broadcom® 5720 1GBase-T (Dell P/N FM487)
Operating system	Microsoft® Windows Server® 2012 R2 Datacenter, Build 9600	Microsoft Windows Server 2012 R2 Datacenter, Build 9600
System BIOS FW	2.1.7	1.0.2
Board management FW	2.30.30.30	2.00.00.00

Results

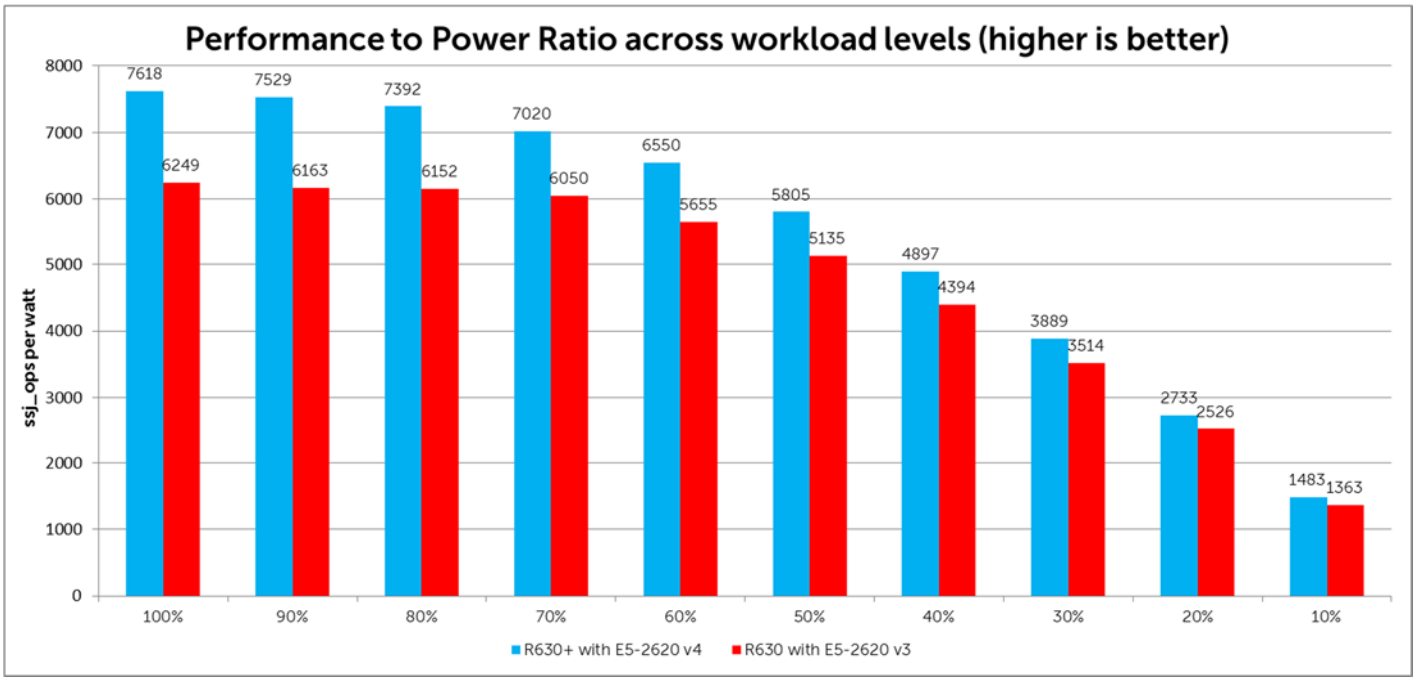
In the like-for-like configurations detailed in table 1, the PowerEdge R630+ delivered 13% more work while at the same time using 7% less power. Overall energy efficiency across all workload levels was improved 16%

Figure 1. Normalized SPECpower_ssj2008 results for PowerEdge R630+ and PowerEdge R630



SPECpower_ssj2008 reports the server's performance to watt ratio at workload levels from 10% to 100% CPU utilization. These are calculated by dividing total computational output for the given workload level by the measured average input power consumption (ssj_ops/watts). Figure 2 shows the PowerEdge R630+ has a higher performance to power ratio than the R630 at every CPU utilization level.

Figure 2. Performance per watt ratios for all target loads[1]



[1] Required SPEC disclosure information: R630+ scores: (1,432,168 ssj_ops and 188W) at 100% target load and 5597 overall ssj_ops/watt vs. R630: (1,262,314 ssj_ops and 202W) at 100% and 4825 overall ssj_ops/watt. Comparison based on Dell lab results from August 2016 and August 2014. For more information about SPECpower, see spec.org/power_ssj2008/.

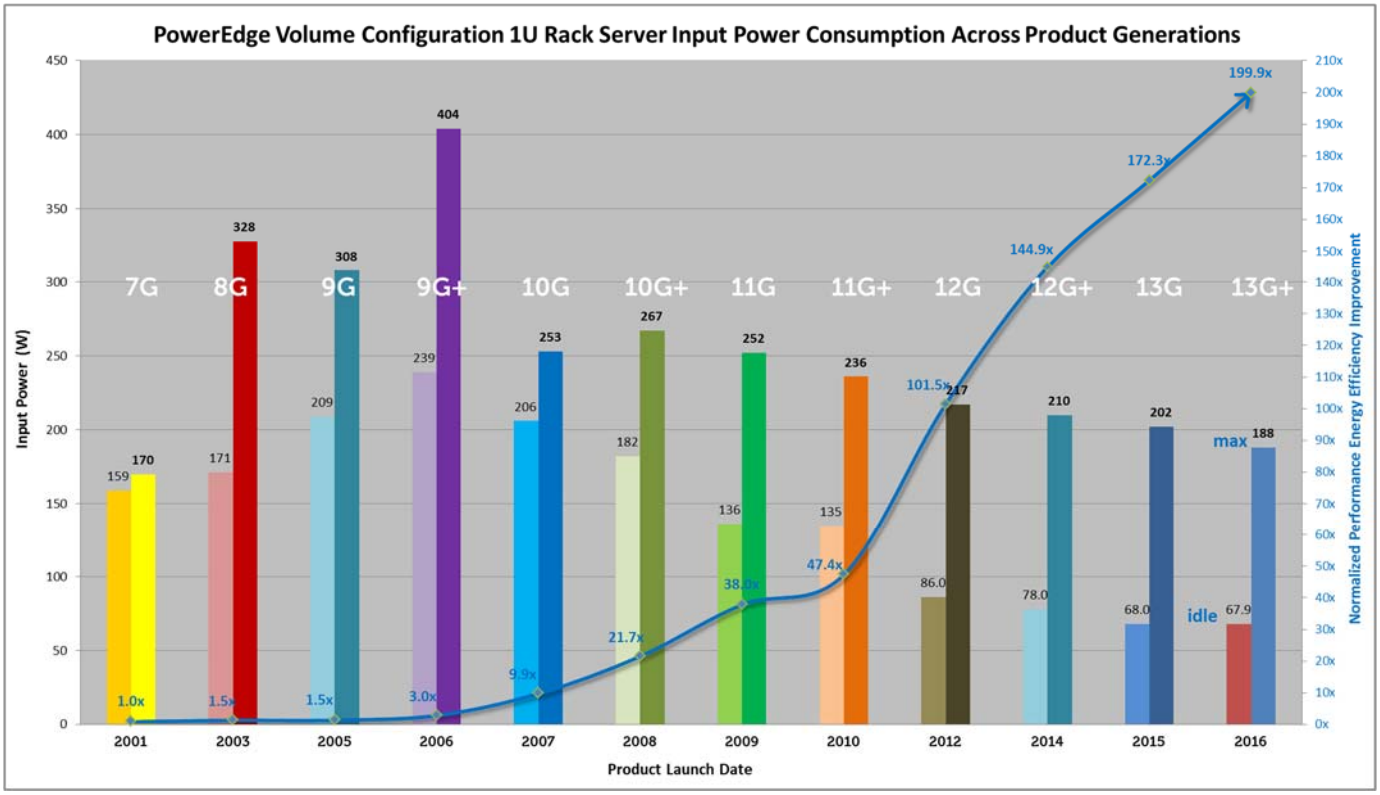
Summary

The PowerEdge R630 1U rack server orderable now with E5-2620 v4 CPUs produces 13% more work and with 16% better overall energy efficiency than that same platform from two years ago with Xeon E5-2620 v3 CPUs.

Outlook

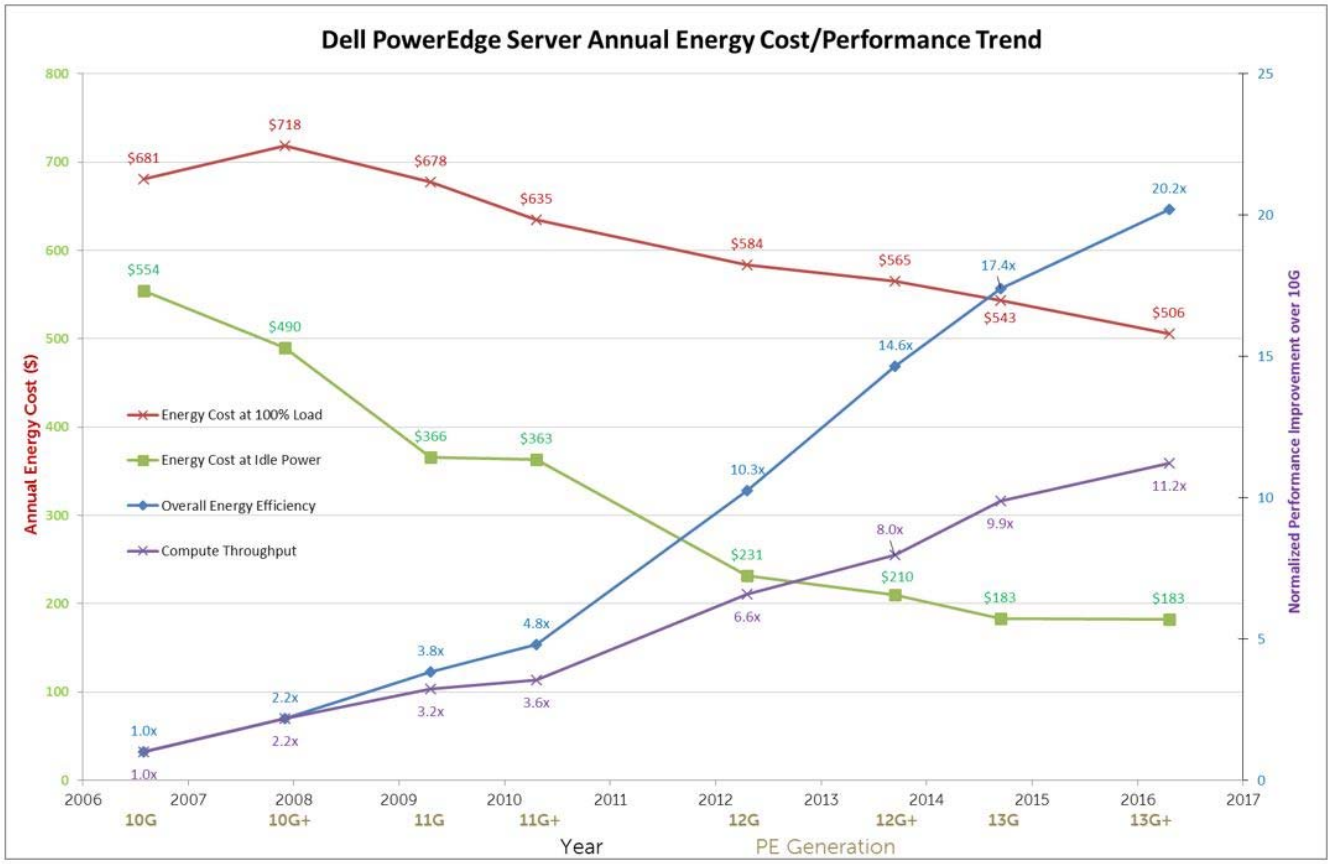
As charted in Figures 3 and 4, the energy efficiency of Dell's typically-configured PowerEdge servers has improved a whopping 200-fold over the past ten years. Given IT customers' demand for servers that can perform more work while also reducing the data center's physical, electrical, cooling and TCO requirement; Dell continues to supply those solutions.

Figure 3. PowerEdge energy efficiency progress[2]



[2] Based upon Dell internal lab recurring evaluation of typically-configured product performance.

Figure 4. PowerEdge energy cost and performance improvement trend[3]



[3] Based upon:

1) Enterprise server industry prediction of the fully-burdened cost of a watt (annualized) of **$2.69**
http://perspectives.mvdirona.com/2008/12/06/AnnualFullyBurdenedCostOfPower.aspx

2) US EIA 2014, 2016 average retail price of electricity for commercial sector in ($ per KWh) of $**0.11**
http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

Appendix A—Test methodology

SPECpower_ssj2008 standard

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 to accurately measure the power consumption of servers 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 spec.org/power_ssj2008/

All results discussed in this white paper 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 the appendices and all result files from the runs compared are included in Appendix B SPECpower_ssj2008 results.

Both servers were configured by installing a fresh copy of Microsoft Windows Server 2012 Enterprise R2 (Service Pack 1) with the operating system installed on a two-drive RAID 1 configuration, choosing the "full installation" option for each.

BIOS settings

The BIOS menu settings were those that the SPA team identified as being the best efficiency practices for the select PowerEdge server model.

Table 2. BIOS settings

PowerEdge R630+	PowerEdge R630
Memory Snoop mode set to Home Snoop	Memory Snoop mode set to Early Snoop
QPI speed set to 6.4GT/s Data Rate	QPI speed set to 6.4GT/s Data Rate
Adjacent Cache Line Prefetch disabled	Adjacent Cache Line Prefetch disabled
Hardware Prefetcher disabled	Hardware Prefetcher disabled
DCU Streamer Prefetcher disabled	DCU Streamer Prefetcher disabled
DCU IP Prefetcher enabled	DCU IP Prefetcher enabled
CPU Power Management set to System DBPM (DAPC/PowerSaver)	CPU Power Management set to System DBPM (DAPC)
Turbo Boost enabled	Turbo Boost enabled
Energy Efficiency Turbo enabled	Energy Efficiency Turbo enabled
Memory DDR Freq Limit set to Maximum Performance	Memory DDR Freq Limit set to 1866 MHz
C States set to Autonomous	C states enabled
Memory Patrol Scrub disabled	Memory Patrol Scrub disabled
Collaborative CPU Performance Control disabled	Collaborative CPU Performance Control enabled
Uncore Frequency set to Dynamic	Uncore Frequency set to Dynamic
Energy Efficiency Policy set to Energy Efficient	Energy Efficiency Policy set to Balanced Performance

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.

The Operating System Power Plan was set to Power Saver for the R630+ configuration testing and Balanced for the R630 configuration testing.

Both servers were configured with a separate IP address on the same subnet as the SPECpower_ssj2008 controller system where the Director, CCS, and PTDaemon components were located. Both servers were connected directly to the controller system through an available network interface port.

SPECpower_ssj2008 configuration

For the R630+ E5-2600 v4 configuration, the Oracle® HotSpot 64-bit server Java Virtual Machine (JVM)[4] was used for the with the following run options:

```
-server -Xmx13g -Xms13g -Xmn11g -XX:SurvivorRatio=1 -XX:TargetSurvivorRatio=99
-XX:ParallelGCThreads=16 -XX:AllocatePrefetchDistance=256 -XX:AllocatePrefetchLines=4
-XX:LoopUnrollLimit=45 -XX:InitialTenuringThreshold=12 -XX:MaxTenuringThreshold=15
-XX:InlineSmallCode=9000 -XX:MaxInlineSize=270 -XX:FreqInlineSize=6000 -XX:+UseLargePages
-XX:+UseParallelOldGC -XX:+AggressiveOpts -XX:+OptimizeStringConcat -XX:+UseStringCache
```

And these logical processor to JVM application thread bindings: **start /NODE[0,1] /AFFINITY [0xFFFF]**

For the R630 E5-2600 v3 configuration, the IBM® J9 Java Virtual Machine (JVM)[5] was used with the following run options:

```
-Xaggressive -Xcompressedrefs -Xmn1400m -Xms1875m -Xmx1875m -XlockReservation -Xnoloa
-XtlhPrefetch -Xlp -Xconcurrentlevel0 -Xthr:minimizeusercpu -Xgcthreads4
-Xgc:preferredHeapBase=0x80000000
```

And these logical processor to JVM application thread bindings:

start /AFFINITY [0x3,0xC,0x30,0xC0,0x300,0xC00,0x3000,0xC000,0x30000,0xC0000,0x300000,0xC00000]

Power and temperature configuration

A Yokogawa WT210 Digital Power Meter was used for the actual power measurement of the servers, as this was the most commonly used analyzer for SPECpower_ssj2008 publications at the time that this study was conducted. The WT210 unit used was within its one-year calibration certification period to ensure accurate power consumption measurements. Input line voltage supplying both systems varied by less than 1V.

To ensure a fair comparison, the systems were run within a temperature controlled chamber with inlet temperatures measured at the front chassis bezel of both systems using a Digi® International Watchport®/H temperature probe. As the attached reports show, temperatures over each run were held constant to within 0.4 °C.

[4] Build 24.80-b11, mixed mode, version 1.7.0_80

[5] Build 2.6, JRE 1.7.0 Windows Server 2008 R2 amd64-64 20120322_106209 (JIT enabled, AOT enabled)

Appendix B—SPECpower_ssj2008 results

Figure 5.SPECpower_ssj2008 results for Dell PowerEdge R630+

SPECpower_ssj2008

Dell Inc. PowerEdge R630 (Intel Xeon E5-2620 v4 2.10 GHz)			SPECpower_ssj2008 = 5,597 overall ssj_ops/watt		
Test Sponsor:	Dell Inc.	SPEC License #:	55	Test Method:	Single Node
Tested By:	Dell Inc.	Test Location:	Round Rock, TX, USA	Test Date:	Jul 12, 2016
Hardware Availability:	Mar-2016	Software Availability:	Apr-2015	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Benchmark Results Summary

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	100.1%	1,432,168	188	7,604
90%	91.6%	1,310,033	174	7,539
80%	80.1%	1,145,739	155	7,397
70%	69.7%	996,778	142	7,012
60%	60.0%	858,096	131	6,536
50%	49.9%	713,972	123	5,802
40%	40.1%	572,927	117	4,903
30%	29.9%	427,761	110	3,878
20%	19.9%	284,274	104	2,741
10%	10.0%	142,919	96.4	1,482
Active Idle		0	67.9	0
			∑ssj_ops / ∑power =	5,597

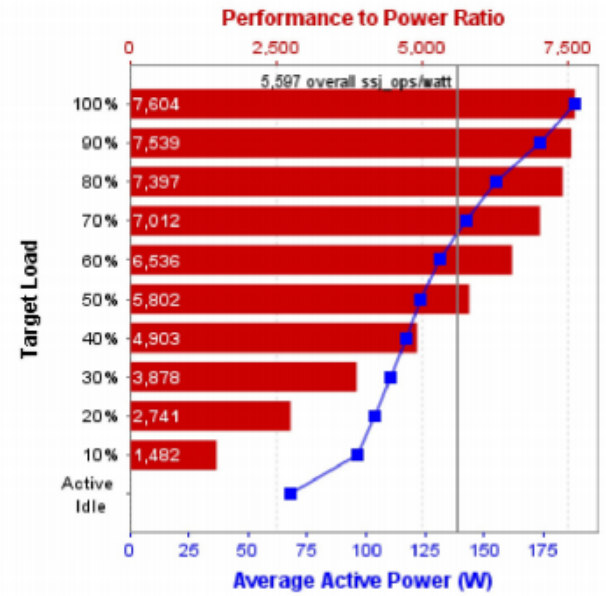


Figure 6.SPECpower_ssj2008 results for the Dell PowerEdge R630

SPECpower_ssj2008

Dell Inc. PowerEdge R630 (Intel Xeon E5-2620 v3 2.40 GHz)			SPECpower_ssj2008 = 4,825 overall ssj_ops/watt		
Test Sponsor:	Dell Inc.	SPEC License #:	55	Test Method:	Single Node
Tested By:	Dell Inc.	Test Location:	Round Rock, TX, USA	Test Date:	Aug 8, 2014
Hardware Availability:	Sep-2014	Software Availability:	Sep-2012	Publication:	Unpublished
System Source:	Single Supplier	System Designation:	Server	Power Provisioning:	Line-powered

Set sut WARNING: For point 0, elapsed nanoTime=242138988492 ns, elapsed currentTimeMillis=240188 ms

Benchmark Results Summary

Performance			Power	Performance to Power Ratio
Target Load	Actual Load	ssj_ops	Average Active Power (W)	
100%	99.7%	1,262,314	202	6,241
90%	90.0%	1,140,152	185	6,165
80%	80.2%	1,015,066	165	6,164
70%	70.2%	889,334	147	6,030
60%	59.8%	757,764	134	5,659
50%	49.9%	631,587	123	5,124
40%	39.9%	505,336	115	4,389
30%	30.0%	379,512	108	3,510
20%	20.2%	255,138	101	2,517
10%	10.1%	127,321	93.4	1,363
Active Idle		0	68.5	0
			∑ssj_ops / ∑power =	4,825