Performance and Energy Efficiency of Dell PowerEdge Servers with E5-2600 v4

This white paper details the performance and energy efficiency improvements of Dell™ PowerEdge™ servers with the Intel® Xeon® processor E5-2600 v4 product family.
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Executive summary

Introduction

Dell’s 13th generation PowerEdge servers are now available with the Intel Xeon processor E5-2600 v4 product family, code named “Broadwell-EP”. These new Xeon processors feature up to 22 cores and are built upon a 14-nanometer process for improved energy efficiency.

In order to show customers the performance and power efficiency improvements that E5-2600 v4 processors bring to PowerEdge 13G servers, Dell’s Solutions Performance Analysis team performed a series of benchmarks and compared the results to those obtained using the existing PowerEdge 13G servers with the Intel Xeon processor E5-2600 v3 product family, code named “Haswell-EP”.

Based on the results of performed testing, PowerEdge 13G refresh servers with new E5-2600 v4 processors perform up to 32% better, compared to those running the previous release E5-2600 v3 processors.

Key findings

Performance with E5-2600 v4

- **PowerEdge 13G servers with two E5-2699 v4 processors achieved up to 31% higher throughput using the comprehensive SPECcpu2006 integer suite.**
- **PowerEdge 13G servers with two E5-2699 v4 processors produced up to 32% higher floating-point operations per second using the popular Linpack high performance computing metric.**
- **PowerEdge 13G servers with two E5-2699 v4 processors achieved up to a 27% higher score on the SAP-SD two-tier business transaction benchmark.**
- **PowerEdge 13G servers with two E5-2699 v4 processors demonstrated up to 26% higher energy efficiency.**
Methodology

To highlight the performance improvements gained by PowerEdge servers running E5-2600 v4 processors, few configuration changes were made between those runs and the runs with E5-2600 v3 processors that were used for comparison. However, as PowerEdge servers with E5-2600 v4 processors support up to 16 DDR4 RDIMMs running at 2400 MT/s, that speed memory was used in most benchmarks, except as noted in Appendix A.
**Integer performance**

**SPEC CPU2006 integer tests**

The industry standard SPEC CPU2006 benchmark is described on SPEC.org as:

CPU2006 is SPEC’s next-generation, industry-standardized, CPU-intensive benchmark suite, stressing a system’s processor, memory subsystem and compiler. SPEC designed CPU2006 to provide a comparative measure of compute-intensive performance across the widest practical range of hardware using 31 different workloads developed from real user applications.

The integer portion of the benchmark is particularly good at measuring a server’s ability to run general business applications. In figure 1, we see a 31% improvement\(^1\) in the SPECint_rate benchmark with E5-2600 v4 processors.

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See the Appendix E for comparative SPECint_base2006 results across the full Broadwell and Haswell CPU stacks.

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\(^1\) SPEC and SPECcpu are registered trademarks of Standard Performance Evaluation Corporation. The performance described is based upon results posted at http://www.spec.org as of March 31, 2016.
Floating point performance

SPEC CPU2006 floating point tests

Floating point performance is important to those running science, simulations and HPC workloads. SPEC CPU2006 contains a suite of floating point tests which when in “rate” (multithreaded) mode, show a 22% performance improvement\(^2\) with E5-2699 v4, as seen in figure 2.

Figure 2 Performance improvement running SPECfp_rate_base2006

![SPECfp_rate_base2006 graph](image)

See the Appendix F for comparative SPECfp_base2006 results across the full Broadwell and Haswell CPU stacks.

---

\(^2\) SPEC and SPECcpu are registered trademarks of Standard Performance Evaluation Corporation. The performance described is based upon E5-2699 v4 results posted at [http://www.spec.org](http://www.spec.org) as of March 31, 2016.
HPC performance tests

The Linpack benchmark is used to measure a system’s floating point processing power by solving linear equations. We ran the widely-available Intel Optimized Linpack benchmark against a single node using both generations of processors.

Thanks to Broadwell EP’s higher core count, improvements in IPC (instructions per clock cycle) and 2400 MT/s DDR4 memory support, the E5-2699 v4 shows a 32% performance improvement over E5-2699 v3, as seen in the following figure.

Figure 3  Performance improvement running Linpack

See the Appendix B for Linpack results across the full Broadwell E5-2600 v4 CPU family
Memory subsystem performance

Many workloads benefit from greater memory bandwidth. Dell PowerEdge servers with select E5-2600 v4 processor models support up to 16 DDR4 RDIMMs running at a speed of 2400 MT/s. The E5-2600 v3 line was limited to 2133 MT/s. In figure 4, the server industry-standard STREAM benchmark shows a 13% improvement in system memory bandwidth performance over the best Haswell-based result thanks to not only Broadwell’s faster memory interface, but further optimized cache coherency snoop modes.

Figure 4  Performance improvement running STREAM

See the Appendix C for STREAM results across the full Broadwell E5-2600 v4 CPU family
Energy Efficiency

SPECpower_ssj2008 is an industry standard benchmark created by the Standard Performance Evaluation Corporation (SPEC®) to measure a server’s power and performance across its full range of utilization levels from 100% to idle.

As figure 5 shows, a Dell PowerEdge R730 with a pair of the new Xeon Broadwell family E5-2699 v4 processors with their new power management features built on a more efficient manufacturing process demonstrated a 26% higher performance per watt than ever before3.

3 Required SPEC disclosure information: R730/E5-2699v4 scores: (3,341,589 ssj_ops and 269W) @ 100% target load and 10,802 overall ssj_ops/watt vs. R730/2699v3: (2,541,354 ssj_ops and 257W) @ 100% and 8,592 overall ssj_ops/watt. Comparison based on results by Dell Labs March 2016. SPEC® and the benchmark name SPECpower_ssj® are registered trademarks.
Business Functions

SPECjbb2015

This benchmark models a Java-based business application for a worldwide supermarket company with an IT infrastructure that handles a mix of point-of-sale requests, online purchases and data-mining operations. It exercises the latest data formats (XML), communication using compression and messaging with security in a virtualized cloud computing environment.

As figure 6 shows, a Dell PowerEdge R730 with a pair of the new Xeon Broadwell family E5-2699 v4 processors and accompanying 2400M memory provides 23% more Java operations per second than the R730 originally introduced back in Sept 2015.4

4 SPEC and SPECjbb are registered trademarks of Standard Performance Evaluation Corporation. The performance described is based upon results posted at http://www.spec.org as of March 31, 2016.
SAP-SD 2-Tier, Linux / Sybase

The (Sales and Distribution) benchmark is described on the SAP web site as:

The Sales and Distribution (SD) Benchmark covers a sell-from-stock scenario, which includes the creation of a customer order with five line items and the corresponding delivery with subsequent goods movement and invoicing.

Figure 7  Performance improvement running SAP SD 2-Tier, Linux / Sybase

The SAP-SD Two-Tier benchmark’s primary metric is the Number of Benchmark Users. As figure 7 shows, the published result for PowerEdge R730 with E5-2699 v4 in this benchmark is 28% higher\(^5\) than the previous highest score on E5-2699 v3\(^6\), which was achieved on Dell’s R730 platform.


\(^6\) Results of the Dell PowerEdge R730 on the two-tier SAP SD standard application benchmark: 16,500 SAP SD benchmark users with the SAP enhancement package 5 for SAP ERP 6.0, Red Hat Enterprise Linux 7, and Sybase ASE 16, 2 x Intel Xeon E5-2699 v3 processors (36 cores, 72 threads), 256 GB main memory. Certification number 2014033.
Performance and energy efficiency of Dell PowerEdge servers with E5-2600 v4

SAP-SD 2-Tier, Windows / SQL

Figure 8  Performance improvement running SAP SD 2-Tier, Windows / SQL Server

Using the Microsoft Windows 2012 SQL Server OS environment, the SAP-SD Two-Tier benchmark published result for PowerEdge R730 with E5-2699 v4 is 41% higher\(^7\) than the previous highest score on R730 with E5-2699 v3\(^8\)

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\(^8\) Results of the Dell PowerEdge R730 on the two-tier SAP SD standard application benchmark: 13,680 SAP SD benchmark users with the SAP enhancement package 5 for SAP ERP 6.0, Windows Server 2012 R2 Datacenter Edition, and SQL Server 2012, 2 x Intel Xeon E5-2699 v3 processors (36 cores, 72 threads), 256 GB main memory. Certification number 2015003.
Summary

PowerEdge 13G servers with the new E5-2600 v4 processor models, provide even more performance from common scientific and business transaction workloads. Thanks to both the CPU family’s improved design and Dell’s Energy Smart implementation; this additional performance comes with the same or even less electricity required or waste heat generated making possible capacity growth, infrastructure reduction and lower total cost of ownership over the life of the product.

The E5-2600 v4 product family is available for purchase on all PowerEdge 13G servers. The enhanced performance of the 13G server lineup continues the PowerEdge tradition of delivering the maximum performance today’s datacenter administrators demand.
## Appendix A — Test configurations

Table 1 Benchmark configurations

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Processor quantity</th>
<th>E5-2600 v4 family processor</th>
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<th>DIMM specifications</th>
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<td>16</td>
<td>32GB 2R 2400 MT/s RDIMMs</td>
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</table>
Appendix B — 13G PowerEdge Floating Point Operations per Second

Figure 9 Linpack results for the E5-2600 v4 family
Appendix C — 13G PowerEdge System Memory Bandwidth

Figure 10  Stream results for the E5-2600 v4 family
Appendix D — Intel Xeon E5-2600 v4 Architectural Advantage

To illustrate the CPU design improvements of the Broadwell family over legacy Haswell, consider these two figures where Broadwell E5-2667 v4 CPUs of identical core count, base clock rate and TDP rating was substituted in for the Haswell E5-2600 v3 ones.

Figure 11  Broadwell Performance Advantage over Haswell running Linpack

Feb 2016 SPA lab measurements of an R630 configured with 8x32GB DIMM. BIOS 2.0.1 default settings other than Logical Processor disabled and Performance System Profile. iDRAC8 version 2.30.30.30. Intel MKL MP Linpack binary version 11.2.3.008 with run parameters: N=170K, NB=192, P=1, Q=1
Figure 12  Broadwell Energy Efficiency Advantage over Haswell Running SPECpower_ssj2008

Xeon E5v4 Energy Efficiency Advantage over E5v3
(100% CPU utilization ssj_ops per watt, higher is better)

Feb 2016 SPA lab measurements of an R630 configured with 8x16GB DIMM. BIOS 2.0.1 default settings other than Performance System Profile. iDRAC8 version 2.30.30.30
Appendix E - SPECCPU2006 base (SPEED) across E5-2600 v4/v3 families

Figure 13 Integer, Single-threaded Workloads

SPEC and SPECCPU are registered trademarks of Standard Performance Evaluation Corporation. The performance described is based upon results posted at http://www.spec.org as of March 31, 2016.
Figure 14  Floating Point, Single-threaded Workloads
# Performance and energy efficiency of Dell PowerEdge servers with E5-2600 v4

## Appendix F — Intel Xeon E5-2600 v4 Server CPU Product Family

**Figure 15** Broadwell-EP SKU line-up

<table>
<thead>
<tr>
<th>Broadwell-EP E5-26xx v4 SKU</th>
<th>Description</th>
<th>Dell PN</th>
<th>Stepping/QDF</th>
<th>TDP base frequency (MHz)</th>
<th>AVX base frequency (MHz)</th>
<th># Cores</th>
<th>TDP Wattage</th>
<th>HT (2=Yes, 1=No)</th>
<th>L3 Cache (MB)</th>
<th>Max Memory Freq (MT/sec)</th>
<th>QPI (GT/sec)</th>
<th>All Cores non-AVX Turbo Freq (MHz)</th>
<th>Max Cores AVX Freq (MHz)</th>
<th>Max non-AVX Turbo Freq (MHz)</th>
<th>Max AVX Turbo Freq (MHz)</th>
<th>Max Uncore Frequency (MHz)</th>
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<td>YW9NG</td>
<td>R-0/QK9F</td>
<td>2600</td>
<td>2200</td>
<td>4</td>
<td>85</td>
<td>2</td>
<td>10</td>
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<td>2800</td>
<td>2800</td>
<td>3200</td>
<td>3200</td>
<td>2800</td>
<td>2800</td>
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<td>9Ke5V</td>
<td>R-0/QK9S</td>
<td>2100</td>
<td>1800</td>
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<td>85</td>
<td>2</td>
<td>20</td>
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<td>R-0/QKEW</td>
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<td>1700</td>
<td>8</td>
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<td>1</td>
<td>20</td>
<td>1866</td>
<td>6.4</td>
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<td>N/A</td>
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<td>2800</td>
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<tr>
<td>ES-2603 v4</td>
<td>PE69R</td>
<td>R-0/QKEV</td>
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<td>1700</td>
<td>6</td>
<td>85</td>
<td>1</td>
<td>15</td>
<td>1866</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>2800</td>
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</tbody>
</table>
# Appendix G — 13G PowerEdge System Memory Speed Limits

## Table 2: Broadwell E5-2600 v4 memory configuration speeds

<table>
<thead>
<tr>
<th>DIMM Type</th>
<th>DIMM Ranking</th>
<th>Capacity</th>
<th>DIMM Rated Voltage, Speed</th>
<th>13G MLK Broadwell -EP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDIMM</td>
<td>1R / 2R</td>
<td>4GB, 8GB, 16GB, 32GB</td>
<td>DDR4 (1.2V), 2400</td>
<td>2400 2400 1866</td>
</tr>
<tr>
<td>LRDIMM</td>
<td>4R</td>
<td>64GB</td>
<td>DDR4 (1.2V), 2400</td>
<td>2400 2400 2133</td>
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## Table 3: Haswell E5-2600 v3 memory configuration speeds

<table>
<thead>
<tr>
<th>DIMM Type</th>
<th>DIMM Ranking</th>
<th>Capacity</th>
<th>DIMM Rated Voltage, Speed</th>
<th>13G Haswell -EP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDIMM</td>
<td>1R / 2R</td>
<td>4GB, 8GB, 16GB, 32GB</td>
<td>DDR4 (1.2V), 2133</td>
<td>2133 2133 1866</td>
</tr>
<tr>
<td>LRDIMM</td>
<td>4R</td>
<td>32GB, 64GB</td>
<td>DDR4 (1.2V), 2133</td>
<td>2133 2133 1866</td>
</tr>
</tbody>
</table>