TRENTON Systems, Inc.
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Application Note: **Performance Benchmarks for the Trenton HEP8225 HDEC Series® System Host Board Utilizing Intel® Xeon® E5-2600 v4 Series (Broadwell-EP) Processors**

Date: **February 23, 2016**

The Trenton HDEC Series® HEP8225 Single Board Computer is undergoing final validation testing in anticipation of availability of Intel's new Xeon E5-2600 v4 series of processors, developed under the name Broadwell-EP-EP. The goal of this document is to define anticipated performance of these new processors relative to each other. Additionally, Trenton's engineering team has conducted an updated benchmark suite of the E5-2680 v3 (Haswell-EP-EP) processor in order to demonstrate the anticipated performance differences between the two generations of processors, utilizing the SiSoft Sandra 2016 benchmarking suite.

About Broadwell-EP

The Xeon E5-2600 v4 series of processors comprise a tick in Intel's Tick-Tock approach to processor evolution. This tick takes the form of a process shrink, in this case, from 22 nanometers in the E5-2600 v3 (Haswell-EP) family to 14 nanometers in the E5-2600 v4 (Broadwell-EP) family. A process shrink allows for less power leakage in the chip, making the processor more efficient per watt of power consumed.

Preliminary observations of note are large benefits in memory bandwidth and arithmetic performance over the E5-2600 v3 series and a significant advantage in several arenas for the E5-2695 v4 processor over the remainder of the E5-2600 v4 range.

Below is a table of currently tested Broadwell-EP chips:

Intel Part Number	Base Clock Speed	Cores	Cache	Maximum Thermal Design Power (TDP)
E5-2695v4	2.15GHz	16	45MB	120W
E5-2680v4	2.4GHz	14	35MB	120W
E5-2658v4	2.3GHz	14	35MB	105W
E5-2648Lv4	1.8GHz	14	25MB	75W
E5-2628Lv4	1.8GHz	14	25MB	75W
E5-2620v4	2.1GHz	8	20MB	85W
E5-2618Lv4	2.2GHz	10	10MB	75W

NOTE: What follows are synthetic laboratory tests, designed to approximate real-world performance scenarios. Environmental variables, the type of application code executed and ancillary system device speeds may impact final configured system performance. For more information about the performance you can expect from a HEP8225 equipped with Intel's new Xeon E5-2600 v4 series in your application, contact Trenton Systems.

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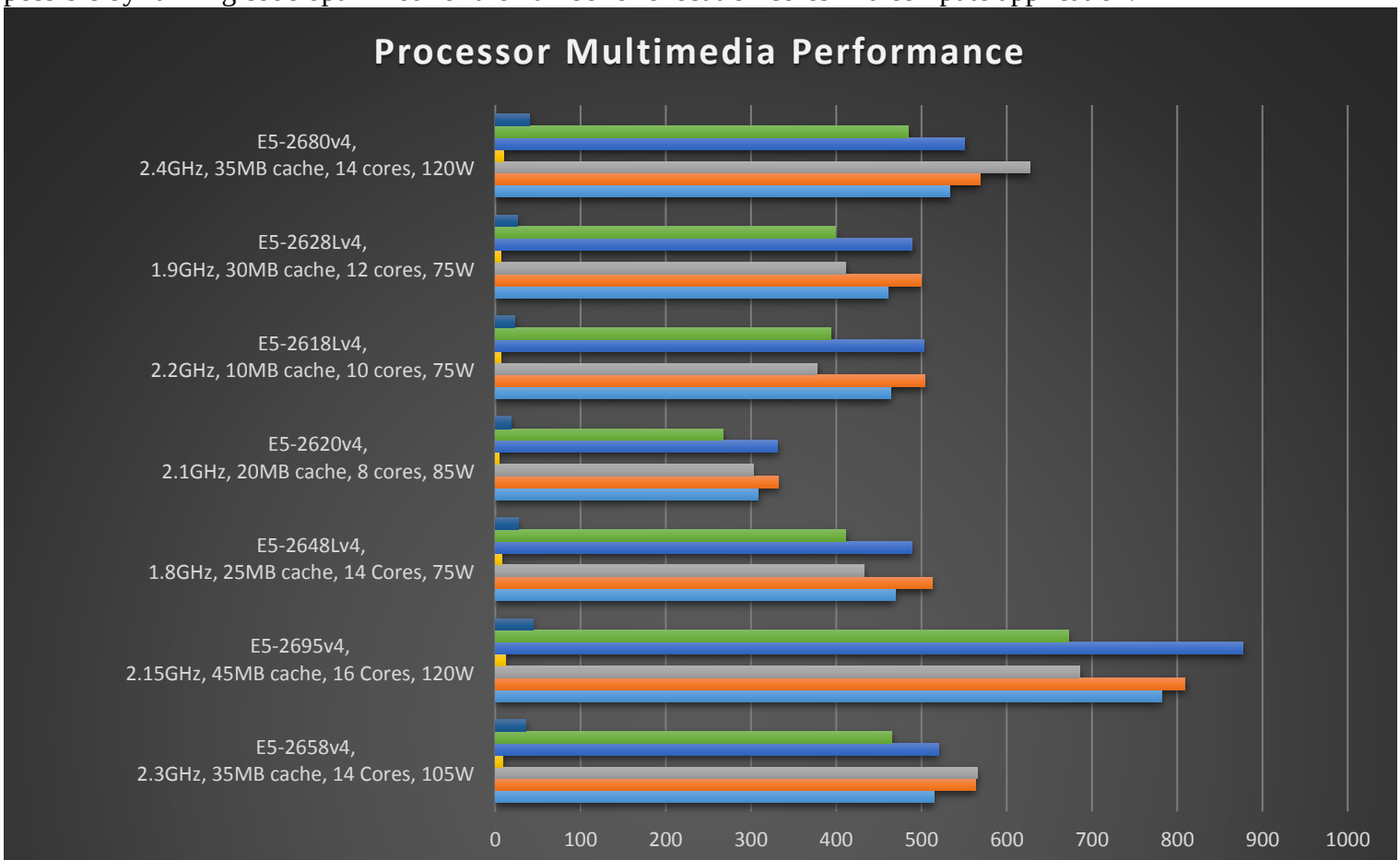
E5-26XX v4 Multimedia Benchmarks

The processor multimedia benchmark test focuses on the board's ability to process video and audio information. These benchmark test results illustrate how performance scales with increased processor frequency and additional processing cores. The obvious winner, here, is the E5-2695 v4, especially in the x16 Multi Media Long Native test, as it fully utilizes all 16 of the cores onboard that processor. This test demonstrates the large performance gains possible by running code optimized for the number of execution cores in a compute application.



HDECSeries®	E5-2658v4, 2.3GHz, 35MB cache, 14 Cores, 105W	E5-2695v4, 2.15GHz, 45MB cache, 16 Cores, 120W	E5-2648Lv4, 1.8GHz, 25MB cache, 14 Cores, 75W	E5-2620v4, 2.1GHz, 20MB cache, 8 cores, 85W	E5-2618Lv4, 2.2GHz, 10MB cache, 10 cores, 75W	E5-2628Lv4, 1.9GHz, 30MB cache, 12 cores, 75W	E5-2680v4, 2.4GHz, 35MB cache, 14 cores, 120W
Multi-Media Quad-float Native x2 FMA (Mpixel/s)	35.6	44.00	27.13	18.80	23.43	25.74	40.00
Multi-Media Double-float Native x8 FMA (Mpixel/s)	465.08	672.33	411.29	267.22	394.20	399.10	484.60
Multi-Media Single-float Native x16 FMA (Mpixel/s)	520	877.19	489.00	331.55	502.51	489.38	550.81
Multi-Media Quad-int Native x1 ALU (Mpixel/s)	9	11.78	7.56	4.75	6.19	6.17	10.10
Multi-Media Long-int Native x16 AVX2 (Mpixel/s)	565.46	685.39	432.52	302.79	377.40	411.08	626.85
Multi-Media Integer Native x32 AVX2 (Mpixel/s)	563.13	809.43	512.00	331.77	503.45	499.14	568.47
Aggregate MultiMedia Native Performance (Mpixel/s)	514.55	781.54	468.72	308.62	463.73	460.24	533.37

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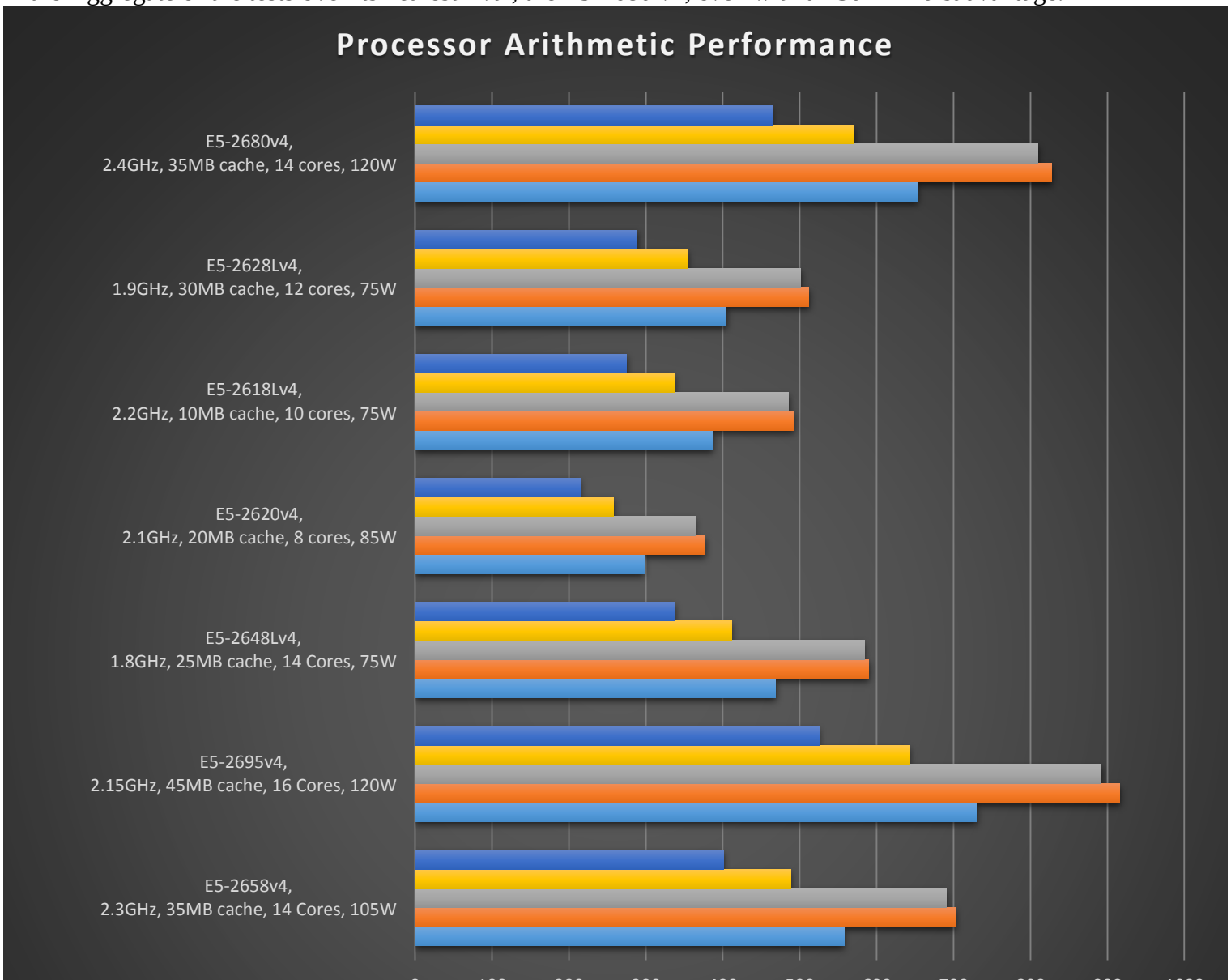
E5-26XX v4 Arithmetic Benchmarks

The Arithmetic Benchmark represents pure computational power of a particular system configuration. Additional cores and cache do provide an appreciable benefit but the real driver of performance is processor clock speed. Of particular note is the impressive performance of the E5-2695 v4 which presents a performance gain of more than 10% in the Aggregate of the tests over its nearest rival, the E5-2680 v4, even with a 250MHz disadvantage.



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	E5-2658v4, 2.3GHz, 35MB cache, 14 Cores, 105W	E5-2695v4, 2.15GHz, 45MB cache, 16 Cores, 120W	E5-2648Lv4, 1.8GHz, 25MB cache, 14 Cores, 75W	E5-2620v4, 2.1GHz, 20MB cache, 8 cores, 85W	E5-2618Lv4, 2.2GHz, 10MB cache, 10 cores, 75W	E5-2628Lv4, 1.9GHz, 30MB cache, 12 cores, 75W	E5-2680v4, 2.4GHz, 35MB cache, 14 cores, 120W
Whetstone Double-float AVX (GFLOPS)	401	525.24	337.20	214.60	274.75	288.65	464.33
Whetstone Single-float Native AVX (GFLOPS)	488.31	642.87	411.28	258.22	337.53	354.41	570.55
Dhrystone Long Native AVX2 (GIPs)	690.62	892.09	584.08	363.65	485.71	501.70	809.85
Dhrystone Integer Native AVX2 (GIPs)	702.55	916.00	590.00	376.92	491.88	511.84	827.85
Aggregate Native Performance (GOPs)	557.59	729.60	468.72	297.87	387.00	404.61	652.76

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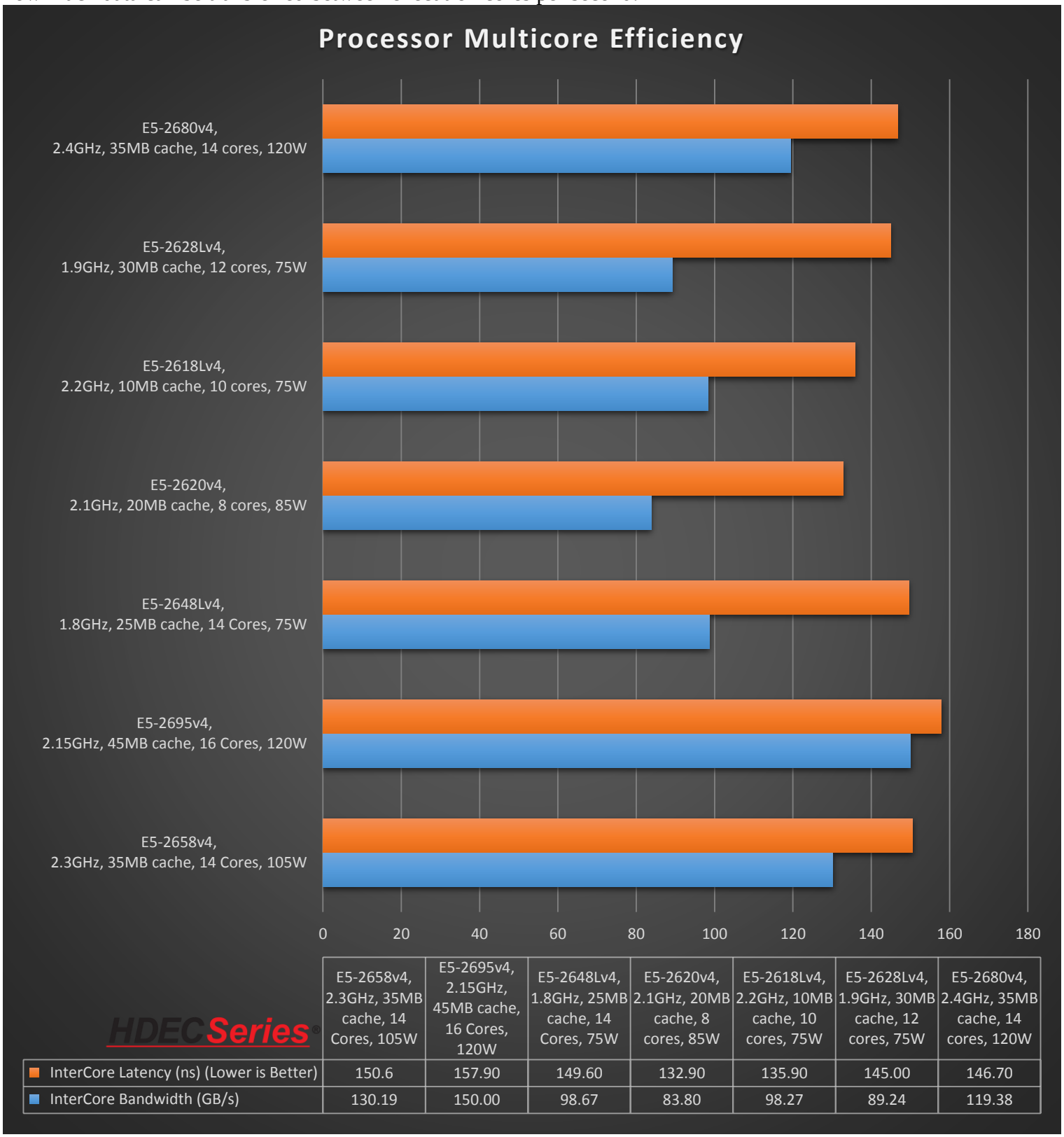
E5-26XX v4 Multicore Efficiency Benchmarks

With the InterCore Latency performance measure, a smaller number indicates a better performance score, i.e. a reduction in inter-core latency delays. While one might assume the dies with fewer cores would always have less latency, it is important to remember that the latency is also clock speed dependent. InterCore bandwidth assesses how much data can be transferred between execution cores per second.



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	E5-2658v4, 2.3GHz, 35MB cache, 14 Cores, 105W	E5-2695v4, 2.15GHz, 45MB cache, 16 Cores, 120W	E5-2648Lv4, 1.8GHz, 25MB cache, 14 Cores, 75W	E5-2620v4, 2.1GHz, 20MB cache, 8 cores, 85W	E5-2618Lv4, 2.2GHz, 10MB cache, 10 cores, 75W	E5-2628Lv4, 1.9GHz, 30MB cache, 12 cores, 75W	E5-2680v4, 2.4GHz, 35MB cache, 14 cores, 120W
InterCore Latency (ns) (Lower is Better)	150.6	157.90	149.60	132.90	135.90	145.00	146.70
InterCore Bandwidth (GB/s)	130.19	150.00	98.67	83.80	98.27	89.24	119.38

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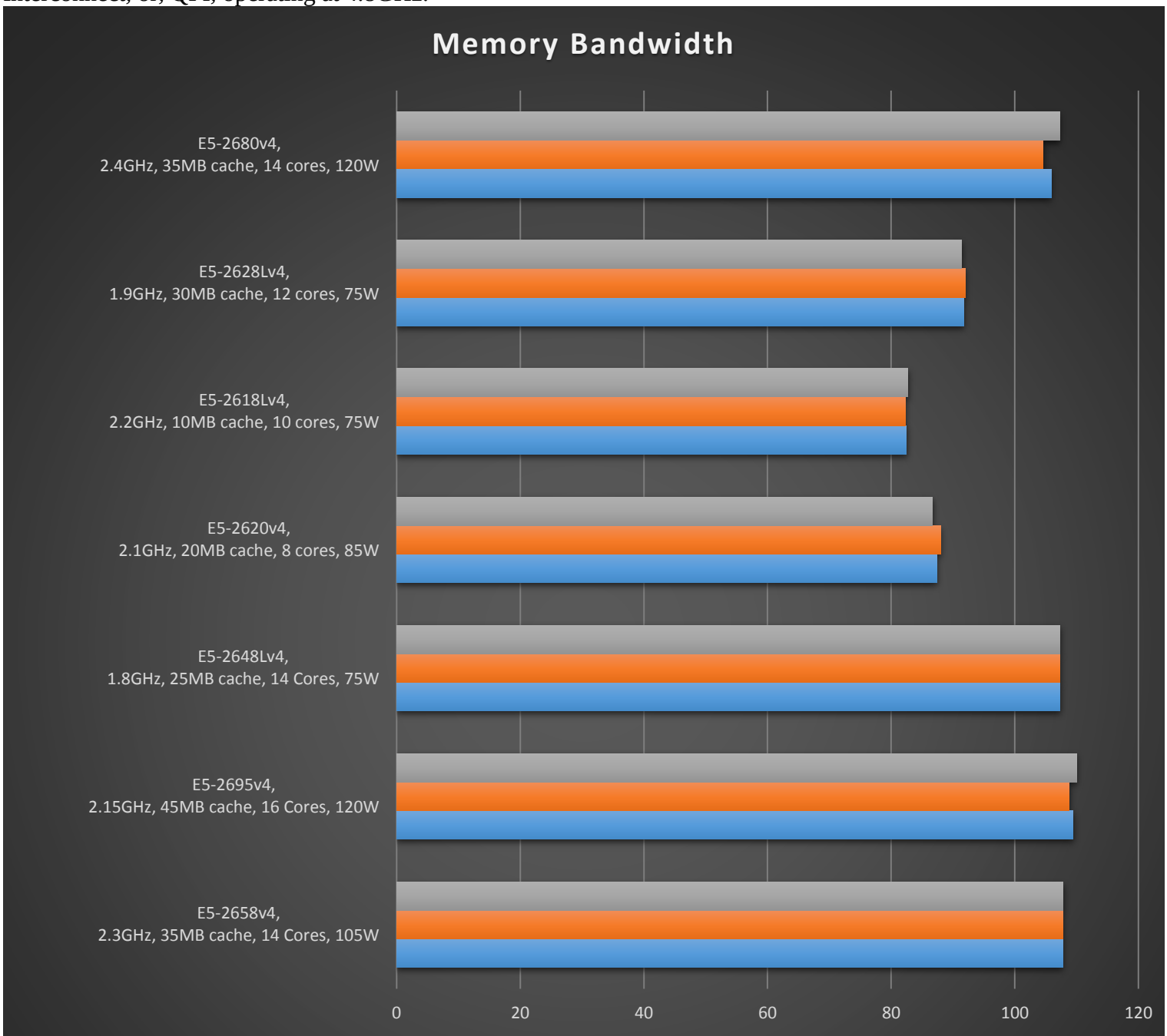
E5-26XX v4 Memory Bandwidth Benchmarks

The Memory Bandwidth Benchmark tests how much data can be transferred between the processor and system random access memory. In the Xeon® E5-2600 v4 series, this is performed over a special bus called the Quick Path Interconnect, or, QPI, operating at 4.8GHz.



HDEC Series®	E5-2658v4, 2.3GHz, 35MB cache, 14 Cores, 105W	E5-2695v4, 2.15GHz, 45MB cache, 16 Cores, 120W	E5-2648Lv4, 1.8GHz, 25MB cache, 14 Cores, 75W	E5-2620v4, 2.1GHz, 20MB cache, 8 cores, 85W	E5-2618Lv4, 2.2GHz, 10MB cache, 10 cores, 75W	E5-2628Lv4, 1.9GHz, 30MB cache, 12 cores, 75W	E5-2680v4, 2.4GHz, 35MB cache, 14 cores, 120W
Float Memory Bandwidth B/F FMA/256 (GB/s)	107.79	110.00	107.37	86.68	82.72	91.42	107.26
Integer Memory Bandwidth B/F AVX2 /256 (GB/s)	107.74	108.84	107.32	88.00	82.28	92.00	104.59
Aggregate Memory Performance (GB/s)	107.77	109.43	107.34	87.37	82.50	91.74	105.92

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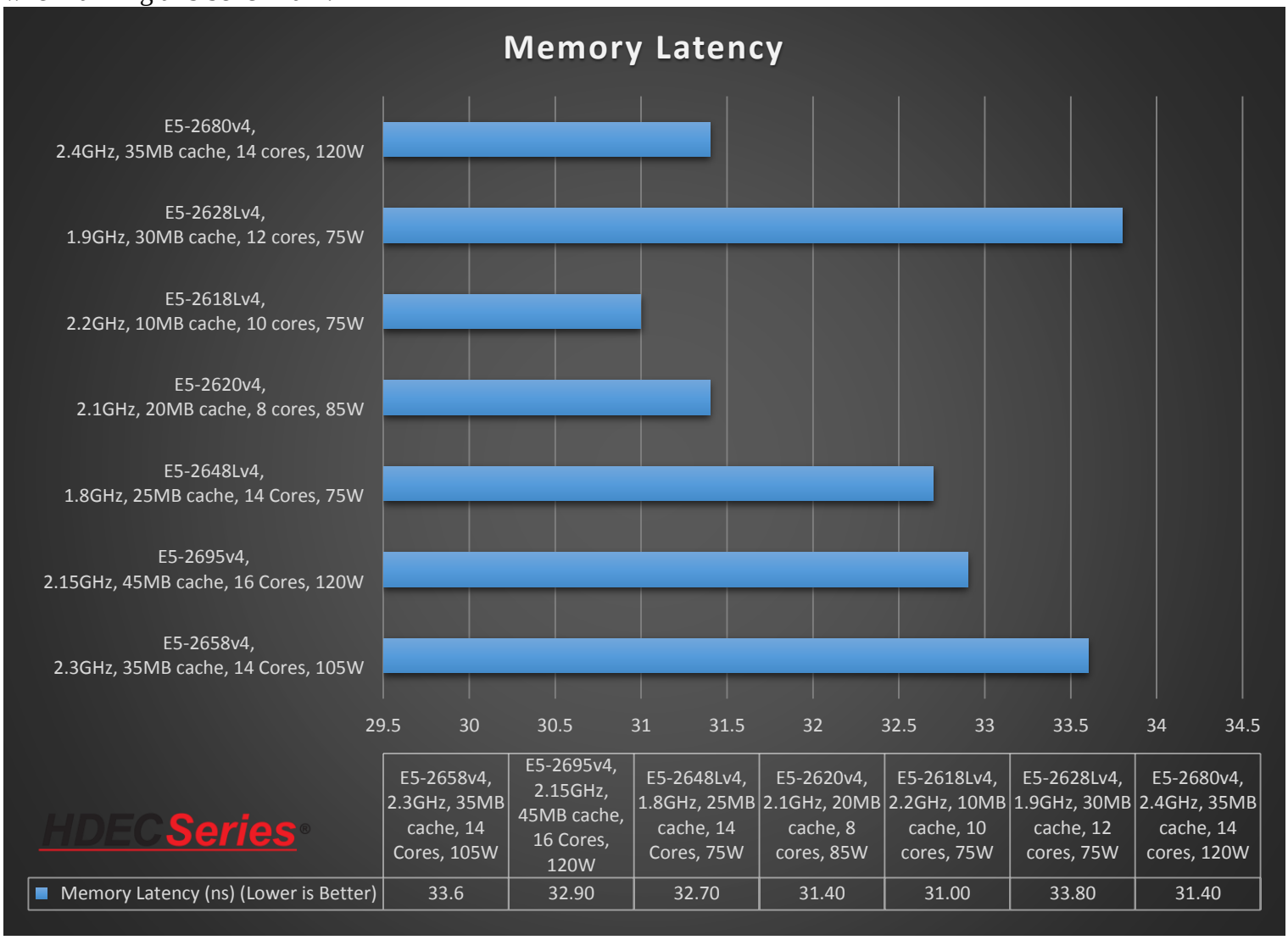
E5-26XX v4 Memory Latency Benchmarks

Again, a smaller number indicates a better performance score (i.e. a reduction in memory interface latency delays) when running this benchmark.



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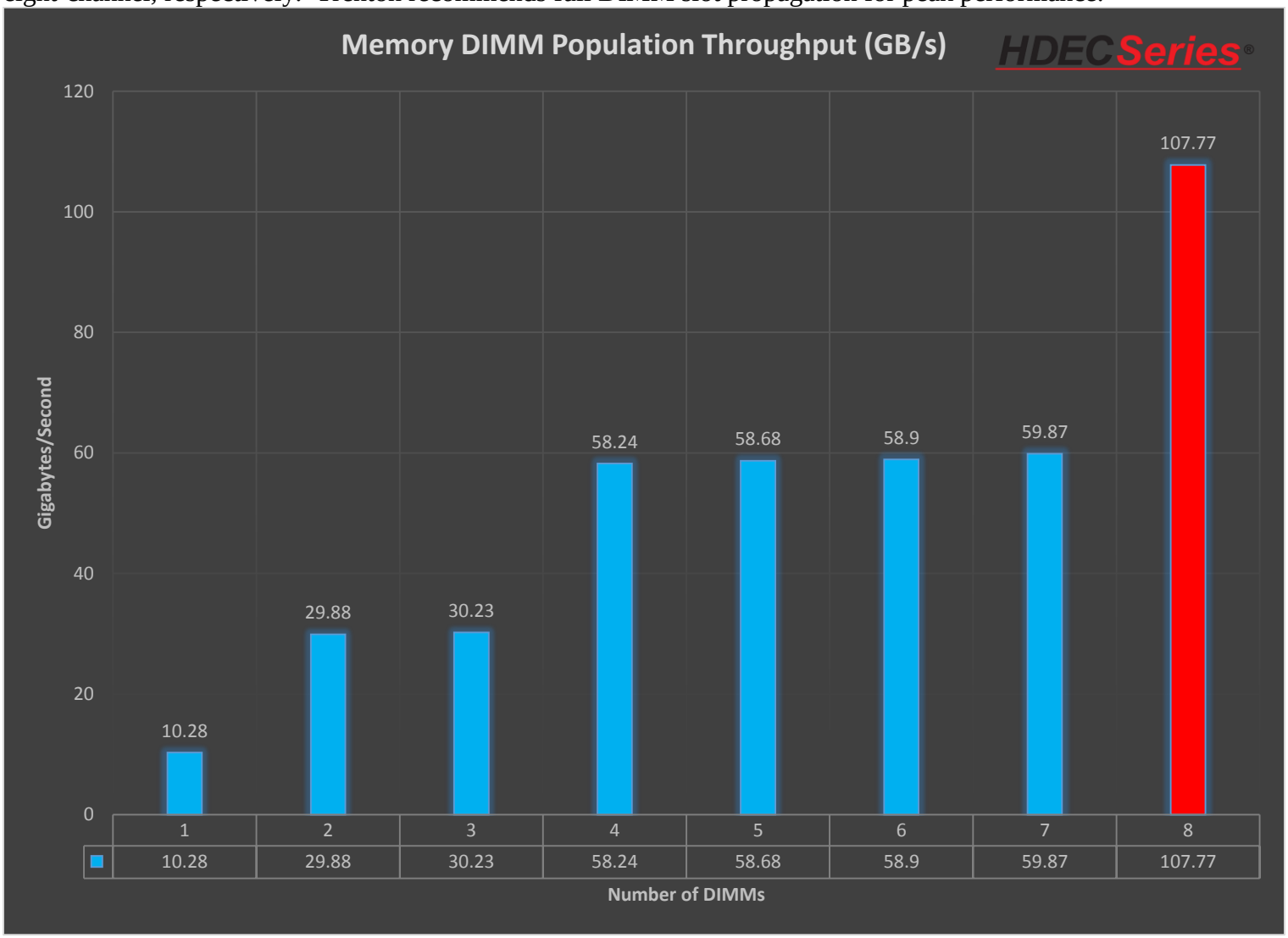
Memory DIMM Population Throughput

This chart depicts the advantages of fully utilizing all 8 memory channels provided by the dual Xeon E5-2600 v4 Series (4 per processor). Obvious performance increases occur when the SHB is able to operate at dual, quad and eight-channel, respectively. Trenton recommends full DIMM slot propagation for peak performance.



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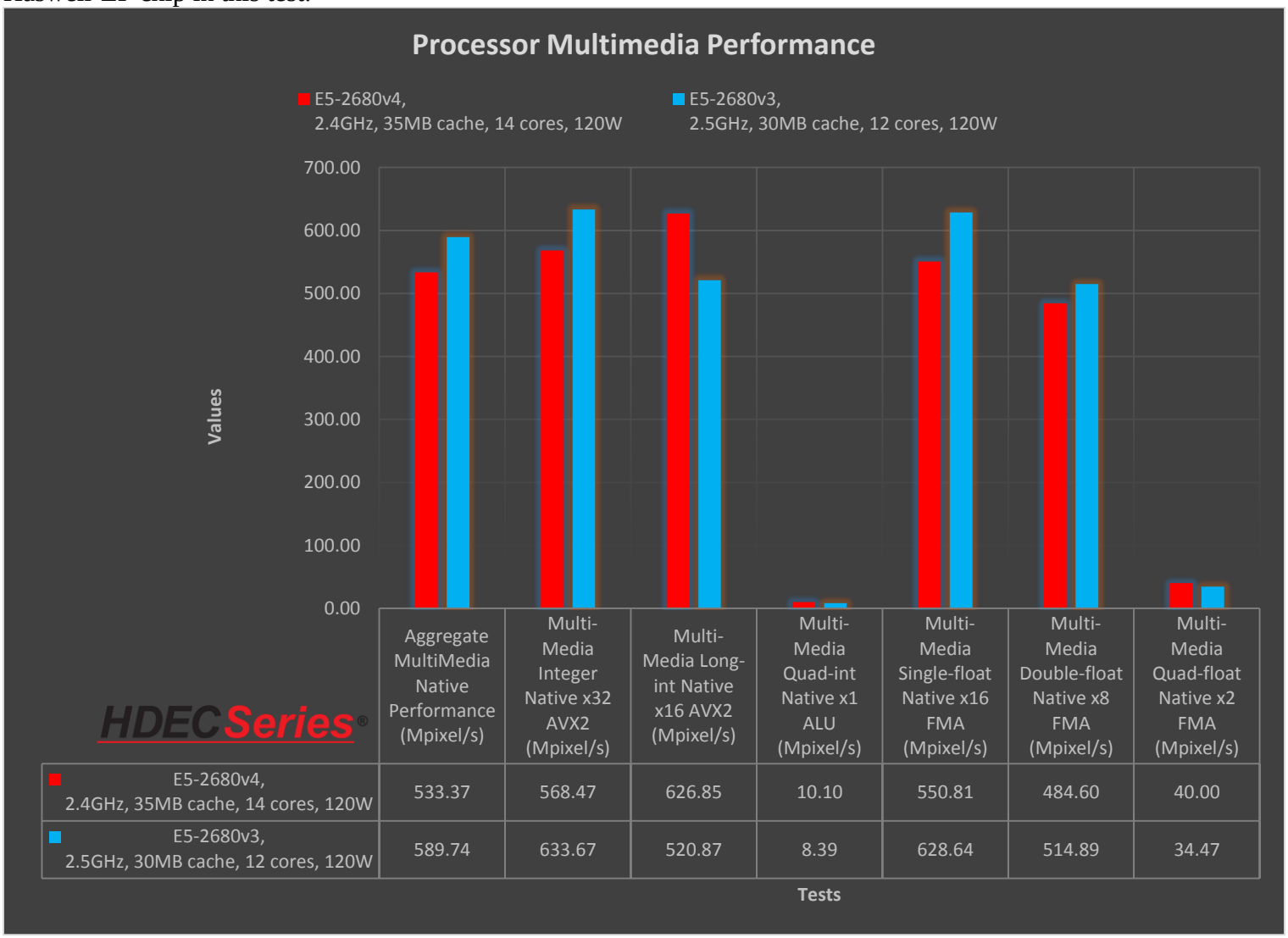
E5-2680 v3 Versus E5-2680 v4

Additionally, Trenton has conducted updated benchmarks on the E5-2680 v3, in order to provide an apples-to-apples comparison of the two '2680' parts. Again, it is important to remember that these are synthetic laboratory tests and are meant to be a guide to potential real-world performance. Additional performance gains or losses may be realized due to execution code optimization or additional external factors.

Haswell-EP versus Broadwell-EP E5-2680 Multimedia Performance

Despite an additional two execution cores and 5MB of cache, the Broadwell-EP cannot outperform the older Haswell-EP chip in this test.



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	Aggregate MultiMedia Native Performance (Mpixel/s)	Multi-Media Integer Native x32 AVX2 (Mpixel/s)	Multi-Media Long-int Native x16 AVX2 (Mpixel/s)	Multi-Media Quad-int Native x1 ALU (Mpixel/s)	Multi-Media Single-float Native x16 FMA (Mpixel/s)	Multi-Media Double-float Native x8 FMA (Mpixel/s)	Multi-Media Quad-float Native x2 FMA (Mpixel/s)
E5-2680v4, 2.4GHz, 35MB cache, 14 cores, 120W	533.37	568.47	626.85	10.10	550.81	484.60	40.00
E5-2680v3, 2.5GHz, 30MB cache, 12 cores, 120W	589.74	633.67	520.87	8.39	628.64	514.89	34.47

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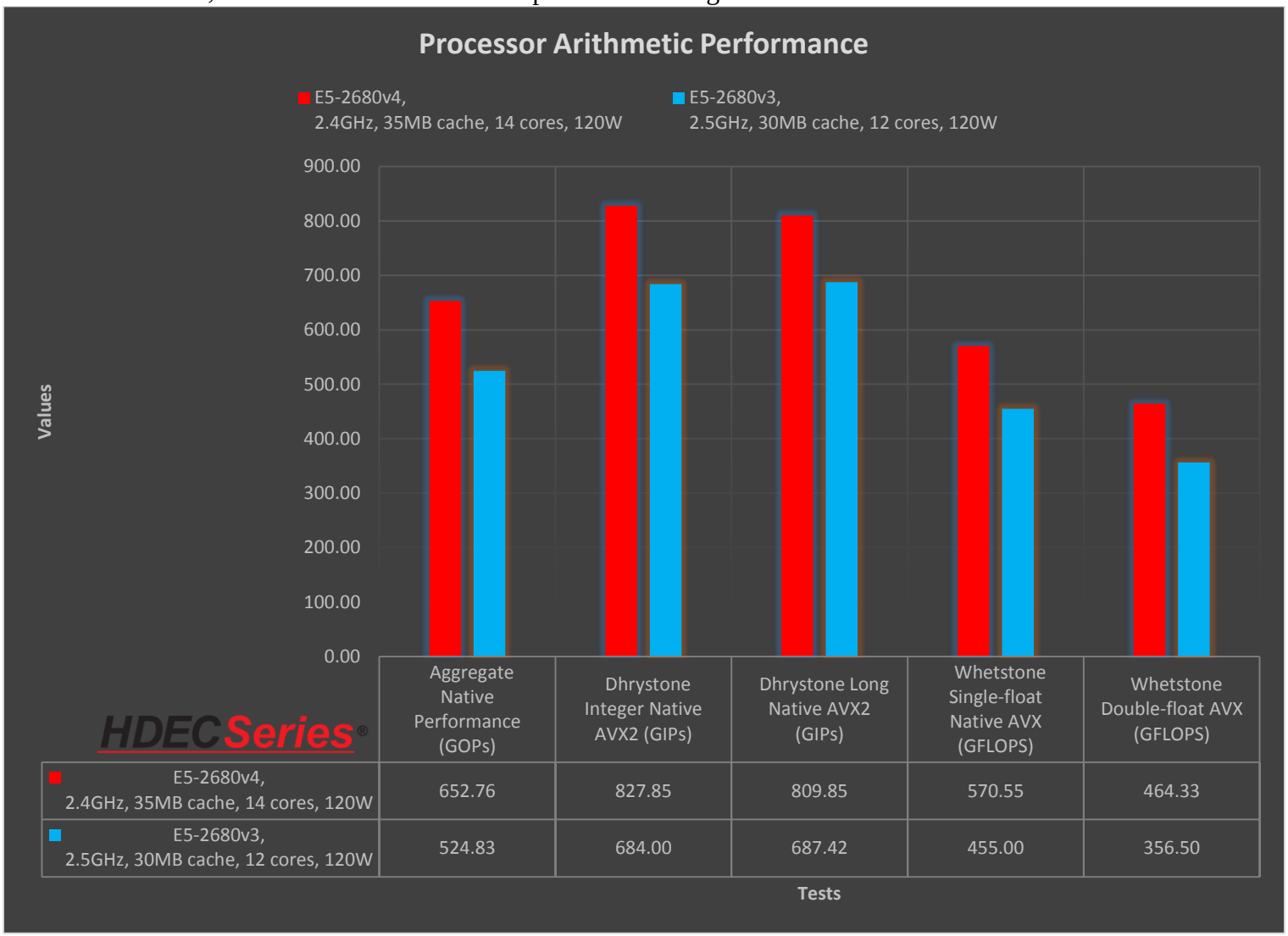
Haswell-EP versus Broadwell-EP E5-2680 Arithmetic Performance

The Broadwell-EP chip demonstrates its increase in efficiency by besting the Haswell-EP by an average of 24% in the arithmetic tests, even with a 100MHz clock speed disadvantage.



	Aggregate Native Performance (GOPs)	Dhrystone Integer Native AVX2 (GIPs)	Dhrystone Long Native AVX2 (GIPs)	Whetstone Single-float Native AVX (GFLOPS)	Whetstone Double-float AVX (GFLOPS)
E5-2680v4, 2.4GHz, 35MB cache, 14 cores, 120W	652.76	827.85	809.85	570.55	464.33
E5-2680v3, 2.5GHz, 30MB cache, 12 cores, 120W	524.83	684.00	687.42	455.00	356.50

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Haswell-EP versus Broadwell-EP E5-2680 Multicore Performance

Haswell-EP's additional clock speed and reduced core count allow it to outperform the Broadwell-EP, here. The mean of the difference in results is 9.65%.

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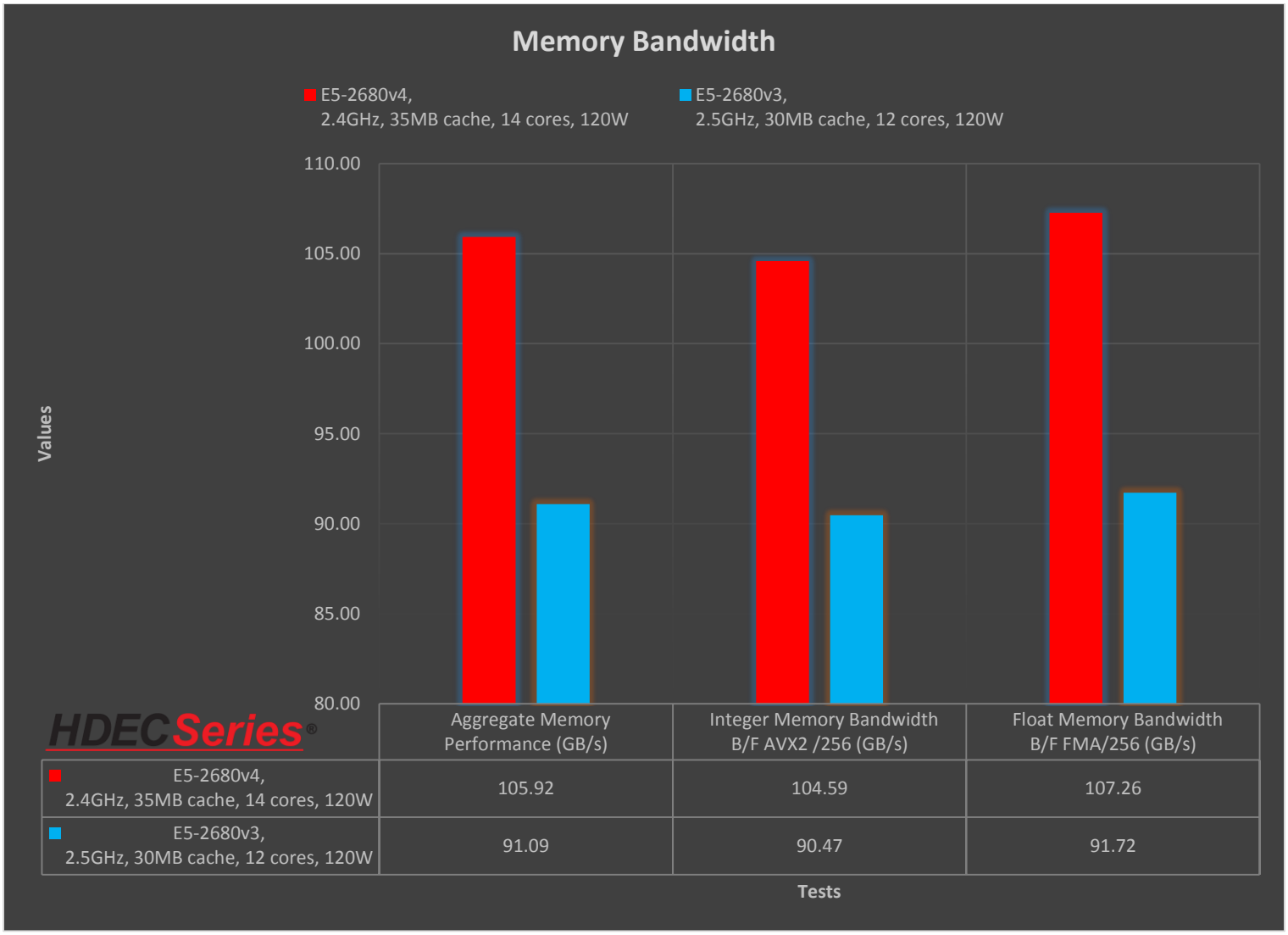
Haswell-EP versus Broadwell-EP E5-2680 Memory Bandwidth

Broadwell-EP demonstrates the benefits of the of the 14nm process, here: average increase in Bandwidth over Haswell-EP is 14%.



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Haswell-EP versus Broadwell-EP E5-2680 Memory Latency

Broadwell-EP edges out a win, here, as well, though a very small one: a 3.7% decrease in Memory Latency. (Lower is better.)

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Broadwell-EP Current Requirements

Required voltage rail current and thermal design power (TDP) are somewhat related processor specs. The following are observed values for both idle and 100% utilization of the available Broadwell-EP SKUs.

Typical Values - Idle Desktop (Values in Amperes unless otherwise specified)

Processor	Frequency (GHz)	TDP (Watts)	3.3V	5V	12V
Intel® Xeon® E5-2695v4	2.15	120W	2.63	3.92	6.59
Intel® Xeon® E5-2680v4	2.4	120W	2.43	4.69	5.84
Intel® Xeon® E5-2658v4	2.3	105W	2.59	3.73	4.63
Intel® Xeon® E5-2648Lv4	1.8	75W	2.42	3.55	4.58
Intel® Xeon® E5-2628Lv4	1.9	75W	2.45	4.65	3.14
Intel® Xeon® E5-2620v4	2.1	85W	2.48	2.69	4.45
Intel® Xeon® E5-2618Lv4	2.2	75W	2.2	3.43	3.19

Typical Values - 100% Utilization (Values in Amperes unless otherwise specified)

Processor	Frequency (GHz)	TDP (Watts)	3.3V	5V	12V
Intel® Xeon® E5-2695v4	2.15	120W	2.46	4.16	28.75
Intel® Xeon® E5-2680v4	2.4	120W	2.92	5.2	27.56
Intel® Xeon® E5-2658v4	2.3	105W	2.68	4.14	24.32
Intel® Xeon® E5-2648Lv4	1.8	75W	2.59	4.01	17.95
Intel® Xeon® E5-2628Lv4	1.9	75W	2.93	5.07	17.32
Intel® Xeon® E5-2620v4	2.1	85W	2.49	3.94	16.44
Intel® Xeon® E5-2618Lv4	2.2	75W	2.78	4.06	17.39

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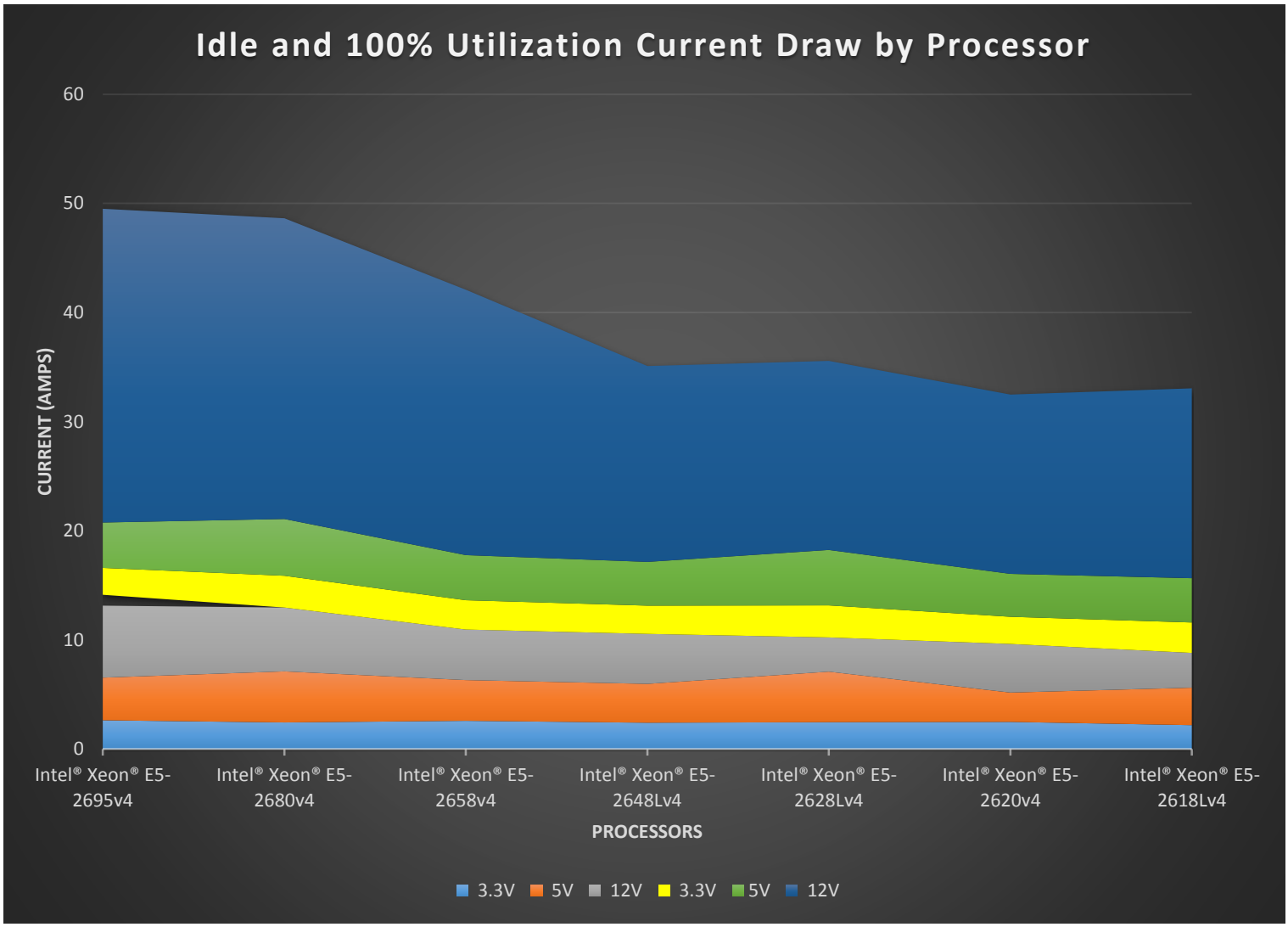

Hopefully, you find this information helpful as you assess the performance benefits of the HDEC Series architecture and requisite Haswell-EP or Broadwell-EP (E5-2600 v3, E5-2600 v4) Intel Xeon processors in your particular system application. For additional information contact Trenton toll-free in the U.S. at 1-800-875-6031 or worldwide at +1-770-287-3100. Please visit our website at www.TrentonSystems.com or follow us on: