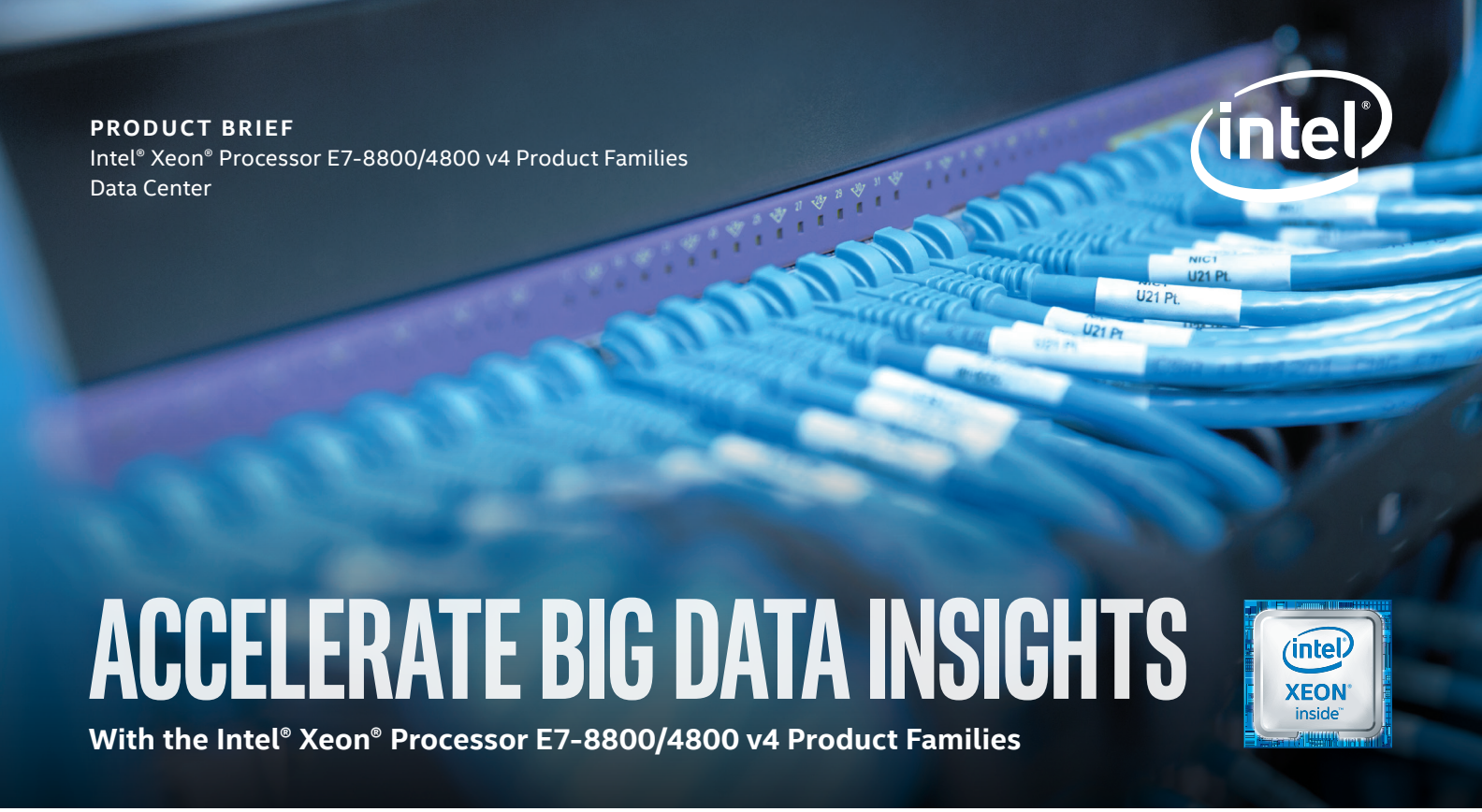


PRODUCT BRIEF
Intel® Xeon® Processor E7-8800/4800 v4 Product Families
Data Center

ACCELERATE BIG DATA INSIGHTS

With the Intel® Xeon® Processor E7-8800/4800 v4 Product Families

High-speed analytics operating on large, fast-moving data sets is changing the way businesses compete. From core business transactions to social media posts, all relevant data can now be analyzed almost instantly and the insights can be integrated into real-time processes. The benefits are potentially transformative. From front-line sales teams to customer-facing applications, businesses can respond faster and more intelligently to drive better results, deliver new services and experiences, and implement new revenue-generating business models.

Four-socket, eight-socket, and larger servers based on the Intel® Xeon® processor E7-8800/4400 v4 product families provide exceptional performance and scalability for real-time business. With their massive execution resources, large memory capacity, and advanced reliability features, these servers are ideal for high-speed analytics operating on multi-terabyte datasets. They also provide a robust foundation for enterprise applications, such as enterprise resource planning (ERP), data warehousing, and online transaction processing (OLTP).

Servers based on this new processor family can help you virtualize demanding workloads and move them into private or hybrid clouds to bring higher agility, efficiency, and resilience into your mission-critical environments. Intel® Resource Director Technology provides deep insight and control over shared platform resources, such as cache and system memory, so you can balance workloads more efficiently and prioritize performance and uptime for your most critical applications.

Up to 1.28x Higher Performance[1] for Key Workloads

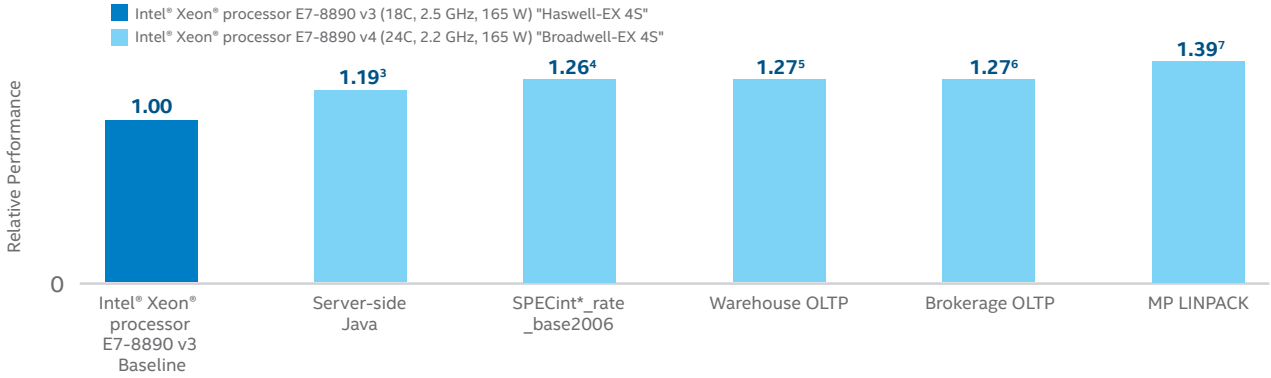
With up to 33 percent more cores, threads, and last-level cache than previous generation processors,[2] the Intel Xeon processor E7-8800/4400 v4 product families make fast work of complex, high-volume transactions and queries. These processors support up to 24 terabytes of DDR4 3DS LRDIMM memory per eight-socket server, so they provide exceptional headroom for advanced analytics, in-memory computing, and other data-demanding workloads.

These and many additional enhancements enable up to 1.28x[1] faster performance for traditional OLTP workloads versus previous-generation processors.

A number of integrated technologies provide opportunities for even greater, and often dramatic, performance gains.

- **Acceleration for multi-threaded workloads.** Intel® Transactional Synchronization Extensions (Intel® TSX) exposes hidden parallelism to help boost performance for online transaction processing (OLTP) and other multi-threaded workloads slowed down by memory locking.
- **Acceleration for mixed workloads.** Intel® Advanced Vector Extensions 2.0 doubles the number of floating point operations per clock cycle versus

Current Generational Gains up to 1.28x on average on "Broadwell-EX" using the 4-Socket Intel® Xeon® Processor E7 v4 Product Family-based Servers



Results have been estimated or measured based on internal Intel analysis and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance. Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. Configurations: Baseline 4x Intel® Xeon® processor E7-8890 v3 compared to E7-8890 v4 both with 64x (Oracle* 12c OLTP) DDR4-1600 16GB DIMMs. For more information go to http://www.intel.com/performance/datacenter.

first generation Intel® AVX. It also doubles the maximum width of vector integer instructions (to 256 bits). New optimizations for this performance-enhancing technology provide better support for mixed workloads, by enabling higher core frequencies for concurrent applications that don't use Intel® AVX2.

World-Class Reliability, Availability, and Security

Servers based on the Intel Xeon processor E7 product family have been delivering uptime levels comparable to high-end RISC-based systems for several years.[8] These systems include Intel® Run Sure Technology which provides Resilient System and Resilient Memory technologies to support mission-critical uptime and advanced data integrity.

The Intel Xeon processor E7 product family also includes hardware-enhanced security features to help organizations protect their data, software, and hardware more effectively. Accelerated encryption, trusted platform launches, and advanced runtime protections support and extend software-based protections to help reduce risk and simplify compliance.

The Intel Xeon processor E7 v4 product family adds a number of new reliability and security technologies.

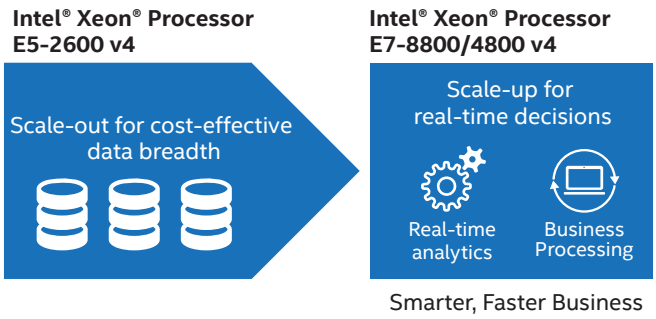
- **Intelligent orchestration.** New features of Intel® Resource Director Technology support cache monitoring and allocation and memory bandwidth monitoring to help IT provide more reliable service levels. "Noisy neighbor" issues can be identified and dynamically resolved, and resource guarantees can be implemented to help ensure that critical applications have the resources they need.
- **Fast, high-quality encryption.** New instructions (such as ADCX/ADOX and PCLMULQDQ micro-architecture) enable up to 70 percent faster per-core performance[9] on key encryption algorithms. A new random bit generator provides high-quality seeding for software-based key generation. These technologies extend previous-generation capabilities to harden and accelerate more use cases. Protecting data both at rest and during transmission is now practically transparent for many workloads.
- **Enhanced protection against platform attacks.** A number of technologies have been added to help protect against stealthy malware and zero day attacks. These technologies work by restricting access to privileged platform resources and by providing hardware support for a new class of security applications that employ deep memory monitoring.

Scalability for Any Workload

With up to 24 cores, 48 threads, and 60 MB of last-level cache per socket, the Intel Xeon processor E7 v4 product family provides a powerful engine for both in-memory and traditional workloads. The platform supports up to 24 TB of memory per 8-socket system. Scale-up systems with up to 32-sockets (built using third party node-controllers) are available from select server vendors.

Optimizing platform scalability requires a balanced platform to avoid performance-limiting bottlenecks. Intel offers high-performance storage and networking solutions for the most demanding workloads.

- **Intel® Solid-State Drive Data Center Family for PCIe*.** Built on the NVMe* specification, this comprehensive product family delivers breakthrough storage performance optimized for real-world applications. For more information, visit Intel® SSD.[10]



A Real-Time Front-End for Your Distributed Big Data Lake

- **Intel® Ethernet Controller XL710 Series.** These high-performance network adapters provide proven 10 and 40 Gigabit Ethernet connectivity for Intel Xeon processor-based platforms. They also extend Intel® Virtualization technologies to support next-generation network virtualization.
- **Intel® QuickAssist Technology** offloads cryptography and data compression to dedicated accelerators for higher performance and improved scalability.

Powerful Virtualization for Data Center Modernization

Servers based on the Intel Xeon processor E7 v4 product family provide the performance, large memory, scalability, and reliability needed to virtualize enterprise workloads and move them into private or hybrid cloud environments. Platform-wide hardware assists for virtualization enable near-native performance in virtual machines.

A number of new features help to support faster, more efficient, and more resilient virtualization:

- Posted Interrupts enable fewer and faster transitions to the VMM, so more compute cycles can be devoted to virtual machine performance.
- Page Modification Logging enables high availability for virtual machines with reduced performance overhead.
- Advanced telemetry, including new features in Intel Resource Director, enable smarter orchestration of shared resources.

Servers based on these processors provide a solid foundation for large-scale workload consolidation. A single eight-socket server can provide as many as 192 cores, 384 threads, and 24 TB of memory to support large numbers of applications running concurrently.

Features at a Glance

Up to 1.28x higher performance[1] for more responsive applications

- Up to 33 percent more cores, threads, and cache compared with the previous generation[2] delivers balanced resources for accelerating performance and improving scalability.
- Intel® Transactional Synchronization Extensions (Intel® TSX) accelerate queries and database transactions by dynamically optimizing the execution of critical, lock- protected data sections.
- Intel® Advanced Vector Extensions 2.0 (Intel® AVX 2.0) improves performance for many applications, through wider vector units, instructions that perform more work per clock cycle, and improved support for mixed workloads.

Scalable memory capacity for real-time analytics across large data sets

- Up to 24 TB per 8-socket server, with larger configurations—up to 32 sockets—available from select server vendors.
- Support for both DDR4 or DDR3 memory provides flexibility and headroom for future growth.
- Memory performance mode provides higher I/O and bandwidth; lockstep mode provides higher data reliability.
- An integrated I/O controller and support for direct storage-to-cache data transfers help to increase performance for data-demanding applications.

The most advanced reliability features of any Intel Xeon processor family

- Intel® Run Sure Technology extends the reliability, availability, and serviceability (RAS) capabilities of the platform to support mission-critical environments. Altogether, more than 70 advanced RAS features help to reduce the frequency and cost of unplanned downtime.
  - Advanced error detection, correction, and recovery features extend all the way from memory and communication pathways to the execution core.
  - Address range memory mirroring supports extreme data reliability for targeted needs without driving up system-wide memory requirements.
- New features of Intel Resource Director Technology include Cache Monitoring and Allocation Technologies (CMT, CAT) and Memory Bandwidth Monitoring Technology (MBM) to enable smarter scheduling and load balancing, enhanced utilization, and guaranteed resources for high priority applications.

Hardware-enhanced security to reduce risk

- Intel® AES-NI and new crypto acceleration for RSA, ECC, and SHA help to accelerate bulk data encryption and secure session initiation protocols, enabling encryption to be used more pervasively without slowing applications.
- Intel® Secure Key provides an integrated random number generator for producing high-quality security keys. New RDSEED technology provides random bits for software-based key generation solutions.
- Intel® Trusted Execution Technology enables IT to establish trusted pools of virtualized resources for stronger security and compliance in multi-tenant virtual and cloud environments.
- Intel® OS Guard now includes Supervisor Mode Access Prevention (SMAP) in addition to existing Supervisor Mode Execution Prevention (SMEP) to provide even more protection against escalation of privilege attacks.
- New #VE (Virtualization Exception) provides hardware assists to reduce overhead for today's advanced hypervisor-based anti-malware applications that employ deep memory monitoring (below the OS).

INTEL® XEON® PROCESSOR E7 v4 FAMILY SPECIFICATIONS

Intel® Xeon® processor SKU	Frequency (GHz)	Cache	Power	Cores	Intel® Turbo Boost Technology	Intel® HT Technology	Intel® QPI Link Speed
E7-8893 v4	3.2	60M	140 W	4	●	●	9.6 GT/s
E7-8891 v4	2.8	60M	165 W	10	●	●	9.6 GT/s
E7-8867 v4	2.4	45M	165 W	18	●	●	9.6 GT/s
E7-8890 v4	2.2	60M	165 W	24	●	●	9.6 GT/s
E7-8880 v4	2.2	55M	150 W	22	●	●	9.6 GT/s
E7-8870 v4	2.1	50M	140 W	20	●	●	9.6 GT/s
E7-8860 v4	2.2	45M	140 W	18	●	●	9.6 GT/s
E7-4850 v4	2.1	40M	115 W	16	●	●	8.0 GT/s
E7-4830 v4	2.0	35M	115 W	14	●	●	8.0 GT/s
E7-4820 v4	2.0	25M	115 W	10	No Turbo	●	6.4 GT/s
E7-4809 v4	2.1	20M	115 W	8	No Turbo	●	6.4 GT/s

For more information visit intel.com

[1] Average generational performance gains of up to 1.26x for "Broadwell-EX" using 4-socket servers based on the Intel® Xeon® Processor E7 product family. Results have been estimated based on internal Intel analysis and are provided for informational purposes only. Configurations: 4x Intel® Xeon® processor E7-8890 v4 compared with 4x Intel® Xeon® processor E7-8890 v3, both with 32x (Intel C++/Fortran Compiler 14.1 STREAM and SPECint) or 64x (Oracle* 12c OLTP) DDR4-1600 16GB DIMMs. Intel Performance Projections as of December 2015." For more information, go to http://www.intel.com/performance/datacenter.

[2] The Intel® Xeon® processor E7 v4 product family supports up to 24 cores, 48 threads, and 60 MB of last level cache, versus up to 18 cores, 36 threads, and 45 MB of last level cache for the Intel® Xeon® processor E7 v3 family.

[3] Up to 1.19x performance increase claim based on Server-side Java workload measuring MultiJVM Max-jOPS – internal technical report (TR) #2153. Configurations: 1) Baseline: 1-Node, 4S Intel® Xeon® processor E7-8890 v3, with 1TB DDR4, running SUSU Linux Enterprise Server 12, Oracle Java* SE8u60, Java HotSpot v1.8.0_60, Score: 171642 Max-jOPS; 2) 1-Node, 4S Intel® Xeon® processor E7-8890 v4, with 1TB DDR4, running Red Hat Enterprise Linux* 7.2, Oracle JDK 1.8u74, Score: 204770.

[4] Up to 1.26x claim based on SPECint*_rate_base internal throughput benchmark workloads – internal technical reports (TR) #184, 2063. Configurations: 1) Baseline: 1-Node, 4S Intel® Xeon® processor E7-8890 v3, 1 TB DDR4, Red Hat Enterprise Linux* 7.0, Intel Compiler v15.0. Score: 2670. 2) 1-Node, 4S Intel® Xeon® processor E7-8890 v4, 512 GB DDR4, using Red Hat Enterprise Linux 7.2, Intel Compiler 14. Score: 3410.

[5] Up to 1.27x performance increase claim based on warehouse OLTP workload measuring transactions per minute (tpm) using Oracle* 11g R2 on Red Hat Enterprise Linux 6.5 – internal technical report (TR) #2272. Configurations: 1) Baseline 4S Intel Xeon processor E7-8890 v3 using 2 TB DDR4-1600 memory, 84x 800GB Intel DC S3700 SSDs. Score: 6602K. 2) 4S Intel Xeon processor E7-8890 v4 using 2 TB DDR4-1600 memory, 84x 800GB Intel DC S3700 SSDs, 48x 320GB SSDs. Score: 7463K

[6] Up to 1.27x performance increase claim based on brokerage OLTP workload measuring transactions per second (tps) using Windows Server* 2012 R2 Standard with SQL Server 2014 – internal technical reports (TR) 2307, 2148. Configurations: 1) Baseline: 1-Node, 4S Intel® Xeon® Processor E7-8890 v3 2.5GHz (4 processors, 72 cores, 144 threads), with a total of 256 GB DDR4 memory, 70x 800GB Intel DC S3700 SSDs. 2) 1-Node, 4S Intel® Xeon® Processor E7-8890 v4 2.2GHz (4 processors, 96 cores, 192 threads), 1 TB DDR4, 84x 800GB Intel DC S3700 SSDs.

[7] Up to 1.39x additional floating point operations claim based on Intel Optimized MP LINPACK workload, running Red Hat Enterprise Linux* (RHEL). Internal technical reports (TR) 49, 2154. Configurations: 1) Baseline: 4S E7-8890 v3, RHEL 7.0, 1 TB DDR4-1600 memory, 220000 problem size; Score: 2188 GFLOP/sec. 2) 4S E7-8890 v4, RHEL 6.4, 128 GB DDR4-1600 memory, 120000 problem size, MP_LINPACK 11.3.2, MPI 4.1.0; Score: 3045 GFLOP/sec.

[8] TIC 2014-2015 Global Server Hardware, Server OS Reliability Report; Information Technology Intelligence Consulting (ITIC) Corp.

[9] Up to 70 percent per-core speed up claim based on tests performed by Intel using RSA 4096 bits (Sign) running on 2 x Intel® Xeon® Processor E5-2699 v4 at 12961765 cycles/op compared with the same workload running on 2 x Intel® Xeon® Processor E5-2697 v3 at 21465370 cycles/op.

[10] See https://www-ssl.intel.com/content/www/us/en/solid-state-drives/intel-ssd-dc-family-for-pcie.html.

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