White Paper
FUJITSU Server PRIMEQUEST
Performance Report PRIMEQUEST 2800E2

This document contains a summary of the benchmarks executed for the FUJITSU Server PRIMEQUEST 2800E2.

The PRIMEQUEST 2800E2 performance data are compared with the data of other PRIMEQUEST models and discussed. In addition to the benchmark results, an explanation has been included for each benchmark and for the benchmark environment.

Version
1.3
2015-11-18

Contents

Document history

Version 1.0 (2015-05-22)

New:

- Technical data
- SPECcpu2006
  Measurements with Intel® Xeon® Processor E7-8800 v3 Product Family
- SAP SD
  Certification number 2015013
- VMmark V2
  "Performance Only" Measurements with Xeon E7-8890 v3
  „Performance with Server Power" Measurement with Xeon E7-8890 v3
- STREAM
  Measurements with Intel® Xeon® Processor E7-8800 v3 Product Family

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- Disk I/O: Performance of RAID controllers
  Measurements with "PRAID EP420i" controller

Version 1.2 (2015-09-15)

New:

- vServCon
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Version 1.3 (2015-11-18)

New:

- OLTP-2
  Results for Intel® Xeon® Processor E7 v3 Family
- TPC-E
  Measurement with Xeon E7-8890 v3

Technical data

PRIMEQUEST 2800E2


Decimal prefixes according to the SI standard are used for measurement units in this white paper (e.g. 1 GB = 10^9 bytes). In contrast, these prefixes should be interpreted as binary prefixes (e.g. 1 GB = 2^{30} bytes) for the capacities of caches and memory modules. Separate reference will be made to any further exceptions where applicable.

Model	PRIMEQUEST 2800E2
Form factor	Rack server
Number of system boards orderable	1 – 4
Number of I/O units orderable	1 – 4
Number of disk units orderable	0 – 2
Per system board:	
Chipset	Intel® C602 Chipset
Number of sockets	2
Number of processors orderable	1 – 2
Processor type	Intel® Xeon® Processor E7-8800 v3 Product Family
Number of memory slots	48 (24 per processor)
Maximum memory configuration	3 TB
Max. number of internal hard disks	4
Per I/O unit:	
Onboard LAN controller	I/O Unit L (1GbE, 2xbaseTports) PQ2800E: 2 × 1 Gbit/s I/O Unit F (10GbE, 2xbaseTports) PQ2800E: 2 × 10 Gbit/s
PCI slots	I/O Unit L (1GbE, 2xbaseTports) PQ2800E: 4 × PCI-Express 3.0 x8 I/O Unit F (10GbE, 2xbaseTports) PQ2800E: 1 × PCI-Express 3.0 x8 2 × PCI-Express 3.0 x16
Per disk unit:	
Max. number of internal hard disks	4

Processors (since system release)								
Processor	**Cores**	**Threads**	**Cache** [MB]	**QPI Speed** [GT/s]	**Rated Frequency** [Ghz]	**Max. Turbo Frequency** [Ghz]	**Max. Memory Frequency** 1) [MHz]	**TDP** [Watt]
Xeon E7-8893 v3	4	8	45	9.60	3.20	3.50	1600	140
Xeon E7-8891 v3	10	20	45	9.60	2.80	3.50	1600	165
Xeon E7-8860 v3	16	32	40	9.60	2.20	3.20	1600	140
Xeon E7-8867 v3	16	32	45	9.60	2.50	3.30	1600	165
Xeon E7-8870 v3	18	36	45	9.60	2.10	2.90	1600	140
Xeon E7-8880 v3	18	36	45	9.60	2.30	3.10	1600	150
Xeon E7-8890 v3	18	36	45	9.60	2.50	3.30	1600	165

1) BIOS setting: *Memory Operation Mode = Performance Mode*

All the processors that can be ordered with the PRIMEQUEST 2800E2 support Intel® Turbo Boost Technology 2.0. This technology allows you to operate the processor with higher frequencies than the nominal frequency. Listed in the processor table is "Max. Turbo Frequency" for the theoretical frequency maximum with only one active core per processor. The maximum frequency that can actually be achieved depends on the number of active cores, the current consumption, electrical power consumption and the temperature of the processor.

As a matter of principle Intel does not guarantee that the maximum turbo frequency will be reached. This is related to manufacturing tolerances, which result in a variance regarding the performance of various examples of a processor model. The range of the variance covers the entire scope between the nominal frequency and the maximum turbo frequency.

The turbo functionality can be set via BIOS option. Fujitsu generally recommends leaving the "Turbo Mode" option set at the standard setting "Enabled", as performance is substantially increased by the higher frequencies. However, since the higher frequencies depend on general conditions and are not always guaranteed, it can be advantageous to disable the "Turbo Mode" option for application scenarios with intensive use of AVX instructions and a high number of instructions per clock unit, as well as for those that require constant performance or lower electrical power consumption.

Memory modules (since system release)								
Memory module	**Capacity [GB]**	**Ranks**	**Bit width of the memory chips**	**Frequency [MHz]**	**Low voltage**	**Load reduced**	**Registered**	**ECC**
16GB (2x8GB) 1Rx4 DDR4-2133 R ECC	16	1	4	2133			✓	✓
32GB (2x16GB) 2Rx4 DDR4-2133 R ECC	32	2	4	2133			✓	✓
64GB (2x32GB) 4Rx4 DDR4-2133 LR ECC	64	4	4	2133		✓	✓	✓
128GB (2x64GB) 4Rx4 DDR4-2133 LR ECC	128	4	4	2133		✓	✓	✓

Power supplies (since system release)	Max. number
Power supply 2.880W silver	6
Power Supply 2.880W platinum hp	6

Some components may not be available in all countries or sales regions.

Detailed technical information is available in the data sheet PRIMEQUEST 2800E2.

SPECcpu2006

Benchmark description

SPECcpu2006 is a benchmark which measures the system efficiency with integer and floating-point operations. It consists of an integer test suite (SPECint2006) containing 12 applications and a floating-point test suite (SPECfp2006) containing 17 applications. Both test suites are extremely computing-intensive and concentrate on the CPU and the memory. Other components, such as Disk I/O and network, are not measured by this benchmark.

SPECcpu2006 is not tied to a special operating system. The benchmark is available as source code and is compiled before the actual measurement. The used compiler version and their optimization settings also affect the measurement result.

SPECcpu2006 contains two different performance measurement methods: the first method (SPECint2006 or SPECfp2006) determines the time which is required to process single task. The second method (SPECint_rate2006 or SPECfp_rate2006) determines the throughput, i.e. the number of tasks that can be handled in parallel. Both methods are also divided into two measurement runs, “base” and “peak” which differ in the use of compiler optimization. When publishing the results the base values are always used; the peak values are optional.

Benchmark	Arithmetics	Type	Compiler optimization	Measurement result	Application
SPECint2006	integer	peak	aggressive	Speed	single-threaded
SPECint_base2006	integer	base	conservative		
SPECint_rate2006	integer	peak	aggressive	Throughput	multi-threaded
SPECint_rate_base2006	integer	base	conservative		
SPECfp2006	floating point	peak	aggressive	Speed	single-threaded
SPECfp_base2006	floating point	base	conservative		
SPECfp_rate2006	floating point	peak	aggressive	Throughput	multi-threaded
SPECfp_rate_base2006	floating point	base	conservative		

The measurement results are the geometric average from normalized ratio values which have been determined for individual benchmarks. The geometric average - in contrast to the arithmetic average - means that there is a weighting in favour of the lower individual results. Normalized means that the measurement is how fast is the test system compared to a reference system. Value “1” was defined for the SPECint_base2006-, SPECint_rate_base2006, SPECfp_base2006 and SPECfp_rate_base2006 results of the reference system. For example, a SPECint_base2006 value of 2 means that the measuring system has handled this benchmark twice as fast as the reference system. A SPECfp_rate_base2006 value of 4 means that the measuring system has handled this benchmark some 4/[# base copies] times faster than the reference system. “# base copies” specify how many parallel instances of the benchmark have been executed.

Not every SPECcpu2006 measurement is submitted by us for publication at SPEC. This is why the SPEC web pages do not have every result. As we archive the log files for all measurements, we can prove the correct implementation of the measurements at any time.

Benchmark environment

System Under Test (SUT)	
Hardware	
Model	PRIMEQUEST 2800E2
Processor	Intel® Xeon® Processor E7-8800 v3 Product Family
Memory	2 Sockets: 16 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC 4 Sockets: 32 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC 8 Sockets: 64 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC
Software	
BIOS settings	Energy Performance = Performance
Operating system	SPECint_rate_base2006, SPECint_rate2006: Red Hat Enterprise Linux Server release 6.6 SPECfp_rate_base2006, SPECfp_rate2006: Red Hat Enterprise Linux Server release 7.1
Operating system settings	SPECint_rate_base2006, SPECint_rate2006: echo always > /sys/kernel/mm/redhat_transparent_hugepage/enabled
Compiler	SPECint_rate_base2006, SPECint_rate2006: Version 14.0.0.080 of Intel C++ Studio XE for Linux SPECfp_rate_base2006, SPECfp_rate2006: C/C++: Version 15.0.0.090 of Intel C++ Studio XE for Linux Fortran: Version 15.0.0.090 of Intel Fortran Studio XE for Linux

Some components may not be available in all countries or sales regions.

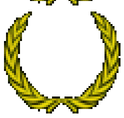
Benchmark results

In terms of processors the benchmark result depends primarily on the size of the processor cache, the support for Hyper-Threading, the number of processor cores and on the processor frequency. The number of cores, which are loaded by the benchmark, determines the maximum processor frequency that can be achieved.

Processor	Number of processors	SPECint_rate_base2006	SPECint_rate2006	Number of processors	SPECint_rate_base2006	SPECint_rate2006	Number of processors	SPECint_rate_base2006	SPECint_rate2006
Xeon E7-8893 v3	2			4			8	1700	1760
Xeon E7-8891 v3	2			4			8	3780	3900
Xeon E7-8860 v3	2			4			8	4740	4870
Xeon E7-8867 v3	2			4			8	4920	5070
Xeon E7-8870 v3	2			4			8	5070	5230
Xeon E7-8880 v3	2			4			8	5260	5420
Xeon E7-8890 v3	2	1380	1420	4	2760	2840	8	5470	5630

Processor	Number of processors	SPECfp_rate_base2006	SPECfp_rate2006	Number of processors	SPECfp_rate_base2006	SPECfp_rate2006	Number of processors	SPECfp_rate_base2006	SPECfp_rate2006
Xeon E7-8893 v3	2			4			8	1580	1600
Xeon E7-8891 v3	2			4			8	3040	3090
Xeon E7-8860 v3	2			4			8	3530	3630
Xeon E7-8867 v3	2			4			8	3680	3740
Xeon E7-8870 v3	2			4			8	3680	3750
Xeon E7-8880 v3	2			4			8	3700	3770
Xeon E7-8890 v3	2	999	1030	4	1980	2030	8	3850	3910

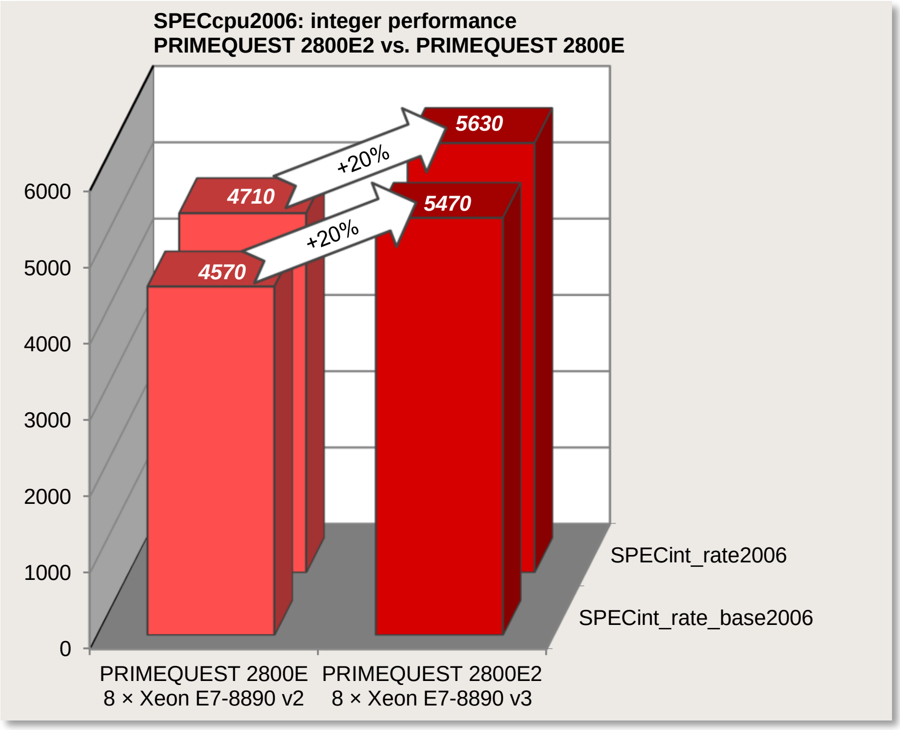
On 5th May 2015 the PRIMEQUEST 2800E2 with eight Xeon E7-8890 v3 processors was ranked first in the 8-socket systems category for the benchmark SPECint_rate_base2006.

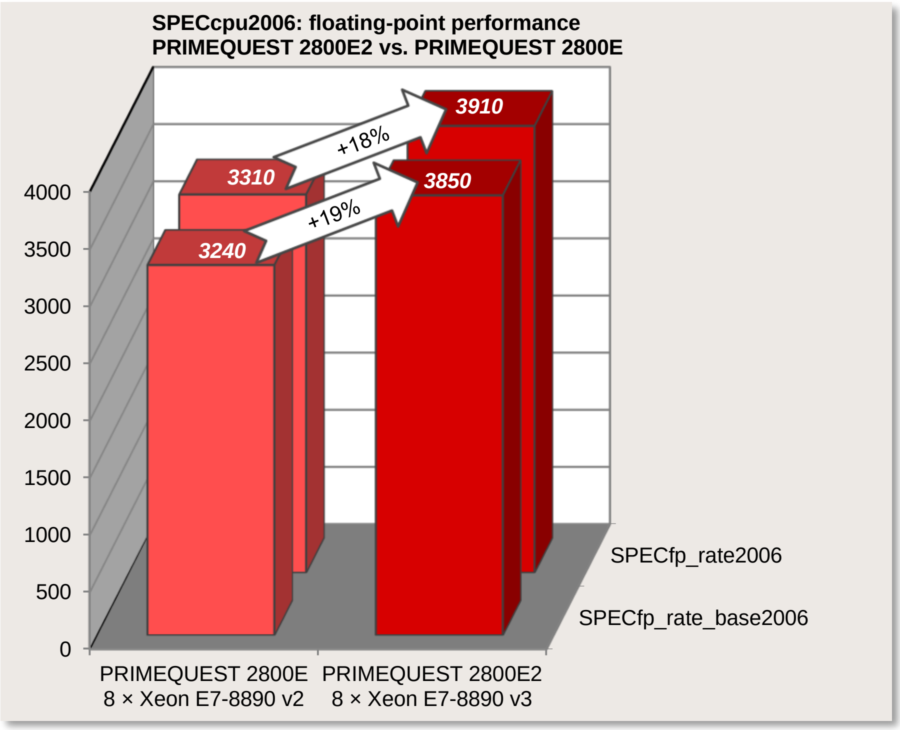


On 5th May 2015 the PRIMEQUEST 2800E2 with two Xeon E7-8890 v3 processors was ranked first in the 2-socket systems category for the benchmark SPECfp_rate_base2006.

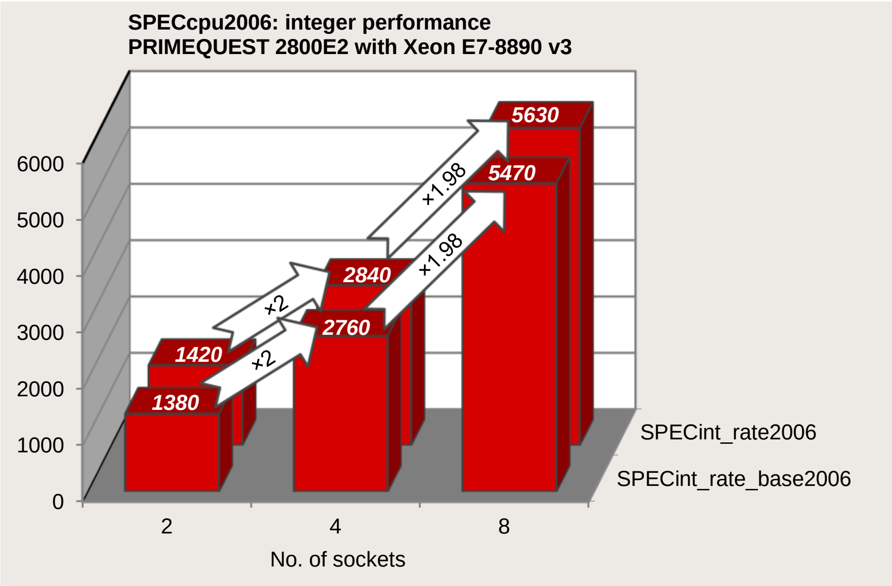
The results can be found at
http://www.fujitsu.com/fts/products/computing/servers/primergy/benchmarks/pq2800e2/.

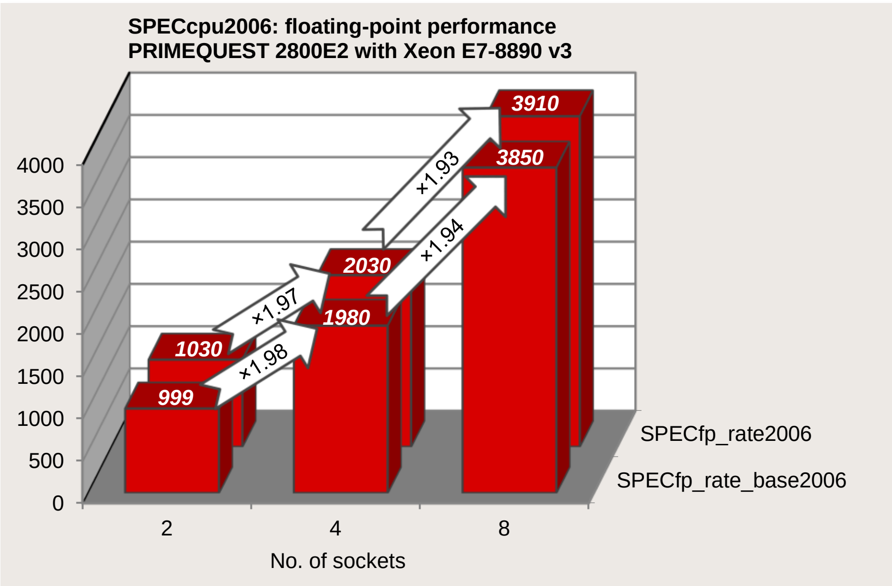
The following two diagrams illustrate the throughput of the PRIMEQUEST 2800E2 in comparison to its predecessor PRIMEQUEST 2800E, in their respective most performant configuration.





The two diagrams below reflect how the performance of the PRIMEQUEST 2800E2 scales from two to eight processors when using the Xeon E7-8890 v3.





Disk I/O: Performance of RAID controllers

Benchmark description

Performance measurements of disk subsystems for PRIMEQUEST servers are used to assess their performance and enable a comparison of the different storage connections for PRIMEQUEST servers. As standard, these performance measurements are carried out with a defined measurement method, which models the accesses of real application scenarios on the basis of specifications.

The essential specifications are:

- Share of random accesses / sequential accesses
- Share of read / write access types
- Block size (kB)
- Number of parallel accesses (# of outstanding I/Os)

A given value combination of these specifications is known as "load profile". The following five standard load profiles can be allocated to typical application scenarios:

Standard load profile	Access	Type of access		Block size [kB]	Application
		read	write		
File copy	random	50%	50%	64	Copying of files
File server	random	67%	33%	64	File server
Database	random	67%	33%	8	Database (data transfer) Mail server
Streaming	sequential	100%	0%	64	Database (log file), Data backup; Video streaming (partial)
Restore	sequential	0%	100%	64	Restoring of files

In order to model applications that access in parallel with a different load intensity, the "# of Outstanding I/Os" is increased, starting with 1, 3, 8 and going up to 512 (from 8 onwards in increments to the power of two).

The measurements of this document are based on these standard load profiles.

The main results of a measurement are:

- Throughput [MB/s] Throughput in megabytes per second
- Transactions [IO/s] Transaction rate in I/O operations per second
- Latency [ms] Average response time in ms

The data throughput has established itself as the normal measurement variable for sequential load profiles, whereas the measurement variable "transaction rate" is mostly used for random load profiles with their small block sizes. Data throughput and transaction rate are directly proportional to each other and can be transferred to each other according to the formula

Data throughput [MB/s]	*= Transaction rate [IO/s] × Block size [MB]*
Transaction rate [IO/s]	*= Data throughput [MB/s] / Block size [MB]*

This section specifies capacities of storage media on a basis of 10 (1 TB = 10^{12} bytes) while all other capacities, file sizes, block sizes and throughputs are specified on a basis of 2 (1 MB/s = 2^{20} bytes/s).

All the details of the measurement method and the basics of disk I/O performance are described in the white paper "Basics of Disk I/O Performance".

Benchmark environment

All the measurement results discussed in this chapter were determined using the hardware and software components listed below:

System Under Test (SUT)	
Hardware	
Controller	1 × "PRAID EP420i"
Drive	4 × 2.5" SAS SSD Toshiba PX02SMF040 4 × 2.5" SAS HDD HGST HUC156045CSS204
Software	
BIOS settings	Intel Virtualization Technology = Disabled VT-d = Disabled Energy Performance = Performance Utilization Profile = Unbalanced CPU C6 Report = Disabled
Operating system	Microsoft Windows Server 2012 Standard
Operating system settings	Choose or customize a power plan: High performance For the processes that create disk I/Os: set the AFFINITY to the CPU node to which the PCIe slot of the RAID controller is connected
Administration software	ServerView RAID Manager 6.1.4
Initialization of RAID arrays	RAID arrays are initialized before the measurement with an elementary block size of 64 kB ("stripe size")
File system	NTFS
Measuring tool	Iometer 2006.07.27
Measurement data	Measurement files of 32 GB with 1 – 8 hard disks; 64 GB with 9 – 16 hard disks; 128 GB with 17 or more hard disks

Some components may not be available in all countries / sales regions.

Benchmark results

The results presented here are designed to help you choose the right solution from the various configuration options of the PRIMEQUEST 2800E2 in the light of disk-I/O performance. Various combinations of RAID controllers and storage media will be analyzed below.

Hard disks

The hard disks are the first essential component. If there is a reference below to "hard disks", this is meant as the generic term for HDDs ("hard disk drives", in other words conventional hard disks) and SSDs ("solid state drives", i.e. non-volatile electronic storage media).

Model versions

The maximum number of hard disks in the system depends on the system configuration. The PRIMEQUEST 2800E2 permits up to four system boards (SB), which can be optionally configured with one RAID controller each for the connection to local hard disks. The system can be extended with up to two disk units (DU). The system boards and disk units are also referred to below with the generic term "subunit".

The following table lists the essential cases. The two configuration versions of the disk unit are abbreviated as follows: "Disk Unit (1C)" is a disk unit with one controller and "Disk Unit (2C)" is a disk unit with two controllers.

Only the highest supported version is named for all the interfaces we have dealt with in this section.

Subunit	Form factor	Interface	Number of PCIe controllers	Maximum number of hard disks
System Board	2.5"	SAS 12G	1	4
Disk Unit (1C)	2.5"	SAS 12G	1	4
Disk Unit (2C)	2.5"	SAS 12G	2	2 × 2

Thanks to the modular architecture of the system it is sufficient to consider the disk-I/O performance for each controller. The possible overall performance of the system is the result of the sum of the performance maximums of all the controllers contained in the system.

RAID controller

In addition to the hard disks the RAID controller is the second performance-determining key component.

The following table summarizes the most important features of the available RAID controllers of the PRIMEQUEST 2800E2. A short alias is specified here for each controller, which is used in the subsequent list of the performance values.

Controller name / mounting position	Alias	Cache	Supported interfaces		Max. # disks in the subunit	RAID levels in the subunit	BBU/ FBU
PRAID EP420i in System Board	PRAID EP420i (SB)	2 GB	SAS 12G	PCIe 3.0 x8	4 × 2.5"	0, 1, 1E, 5, 6, 10	-/✓
PRAID EP420i in Disk Unit (1C)	PRAID EP420i (DU-1C)	2 GB	SAS 12G	PCIe 3.0 x8	4 × 2.5"	0, 1, 1E, 5, 6, 10	-/✓
PRAID EP420i in Disk Unit (2C)	PRAID EP420i (DU-2C)	2 GB	SAS 12G	PCIe 3.0 x8	2 × 2.5"	0, 1	-/✓

System-specific interfaces

The interfaces of a controller to the system board (also applies for the disk unit / system board interface) and to the hard disks have in each case specific limits for data throughput. These limits are listed in the following table. The minimum of these two values is a definite limit, which cannot be exceeded. This value is highlighted in bold in the following table.

Controller alias	Effective in the configuration					Connection via expander
	# Disk channels	Limit for throughput of disk interface	PCIe-version	PCIe width	Limit for throughput of PCIe interface	
PRAID EP420i (SB)	4 × SAS 12G	4120 MB/s	2.0	x4	**1716 MB/s**	-
PRAID EP420i (DU-1C)	4 × SAS 12G	4120 MB/s	2.0	x4	**1716 MB/s**	-
PRAID EP420i (DU-2C)	2 × SAS 12G	2060 MB/s	2.0	x4	**1716 MB/s**	-

More details about these RAID controllers are available in the white paper “RAID Controller Performance”.

Settings

In most cases, the cache of HDDs has a great influence on disk-I/O performance. It is frequently regarded as a security problem in case of power failure and is thus switched off. On the other hand, it was integrated by hard disk manufacturers for the good reason of increasing the write performance. For performance reasons it is therefore advisable to enable the hard disk cache. To prevent data loss in case of power failure you are recommended to equip the system with a UPS.

In the case of controllers with a cache there are several parameters that can be set. The optimal settings can depend on the RAID level, the application scenario and the type of data medium. In the case of RAID levels 5 and 6 in particular (and the more complex RAID level combinations 50 and 60) it is obligatory to enable the controller cache for application scenarios with write share. If the controller cache is enabled, the data temporarily stored in the cache should be safeguarded against loss in case of power failure. Suitable accessories are available for this purpose (e.g. a BBU or FBU).

For the purpose of easy and reliable handling of the settings for RAID controllers and hard disks it is advisable to use the RAID-Manager software “ServerView RAID” that is supplied for the server. All the cache settings for controllers and hard disks can usually be made en bloc – specifically for the application – by using the pre-defined modi “Performance” or “Data Protection”. The “Performance” mode ensures the best possible performance settings for the majority of the application scenarios.

More information about the setting options of the controller cache is available in the white paper “RAID Controller Performance”.

Performance values

In general, disk-I/O performance of a RAID array depends on the type and number of hard disks, on the RAID level and on the RAID controller if the limits of the system-specific interfaces are not exceeded. This is why all the performance statements of the document “RAID Controller Performance” also apply for the PRIMEQUEST 2800E2 if the configurations measured there are also supported by this system.

The performance values of the PRIMEQUEST 2800E2 are listed in table form below, specifically for different RAID levels, access types and block sizes. Substantially different configuration versions are dealt with separately. The established measurement variables, as already mentioned in the subsection Benchmark description, are used here. Thus, transaction rate is specified for random accesses and data throughput for sequential accesses. To avoid any confusion among the measurement units the tables have been separated for the two access types.

The table cells contain the maximum achievable values. This has three implications: On the one hand hard disks with optimal performance were used (the components used are described in more detail in the subsection Benchmark environment). Furthermore, cache settings of controllers and hard disks, which are optimal for the respective access scenario and the RAID level, are used as a basis. And ultimately each value is the maximum value for the entire load intensity range (# of outstanding I/Os).

In order to also visualize the numerical values each table cell is highlighted with a horizontal bar, the length of which is proportional to the numerical value in the table cell. All bars shown in the same scale of length have the same color. In other words, a visual comparison only makes sense for table cells with the same colored bars.

Since the horizontal bars in the table cells depict the maximum achievable performance values, they are shown by the color getting lighter as you move from left to right. The light shade of color at the right end of the bar tells you that the value is a maximum value and can only be achieved under optimal prerequisites. The darker the shade becomes as you move to the left, the more frequently it will be possible to achieve the corresponding value in practice.

2.5" - Random accesses (maximum performance values in IO/s):

Base Unit PQ2800E2							
Configuration version			RAID level	HDDs random 8 kB blocks 67% read [IO/s]	HDDs random 64 kB blocks 67% read [IO/s]	SSDs random 8 kB blocks 67% read [IO/s]	SSDs random 64 kB blocks 67% read [IO/s]
RAID Controller	Hard disk type	#Disks					
PRAID EP420i (SB) / (DU-1C)	HUC156045CSS204 SAS HDD PX02SMF040 SAS SSD	2	1	1949	1085	77312	12141
		4	10	3479	1445	106524	20473
		4	0	3939	1871	128697	32507
		4	5	2151	936	36808	13110
PRAID EP420i (DU-2C)	HUC156045CSS204 SAS HDD PX02SMF040 SAS SSD	2	1	1949	1085	77312	12141
		2	0	1950	970	105105	15537

2.5" - Sequential accesses (maximum performance values in MB/s):

Base Unit PQ2800E2							
Configuration version			RAID level	HDDs sequential 64 kB blocks 100% read [MB/s]	HDDs sequential 64 kB blocks 100% write [MB/s]	SSDs sequential 64 kB blocks 100% read [MB/s]	SSDs sequential 64 kB blocks 100% write [MB/s]
RAID Controller	Hard disk type	#Disks					
PRAID EP420i (SB) / (DU-1C)	HUC156045CSS204 SAS HDD PX02SMF040 SAS SSD	2	1	424	272	1489	418
		4	10	586	467	1571	736
		4	0	968	901	1570	1469
		4	5	726	669	1556	1248
PRAID EP420i (DU-2C)	HUC156045CSS204 SAS HDD PX02SMF040 SAS SSD	2	1	424	272	1489	418
		2	0	504	492	1489	816

Conclusion

The use of one controller at its maximum configuration with powerful hard disks enables the PRIMEQUEST 2800E2 to achieve a throughput of up to 1571 MB/s for sequential load profiles and a transaction rate of up to 128697 IO/s for typical, random application scenarios.

In the maximum system configuration with four system boards and two disk units with two controllers each, i.e. a total of six controllers, a maximum of 24 hard disks could be run. If powerful hard disks are used in this maximum configuration, the system would mathematically achieve a total throughput of up to 12240 MB/s for sequential load profiles and a total transaction rate of up to 935208 IO/s for typical random application scenarios.

SAP SD

Benchmark description

The SAP application software consists of modules used to manage all standard business processes. These include modules for ERP (Enterprise Resource Planning), such as Assemble-to-Order (ATO), Financial Accounting (FI), Human Resources (HR), Materials Management (MM), Production Planning (PP) plus Sales and Distribution (SD), as well as modules for SCM (Supply Chain Management), Retail, Banking, Utilities, BI (Business Intelligence), CRM (Customer Relation Management) or PLM (Product Lifecycle Management).

The application software is always based on a database so that a SAP configuration consists of the hardware, the software components operating system, zhe database and the SAP software itself.

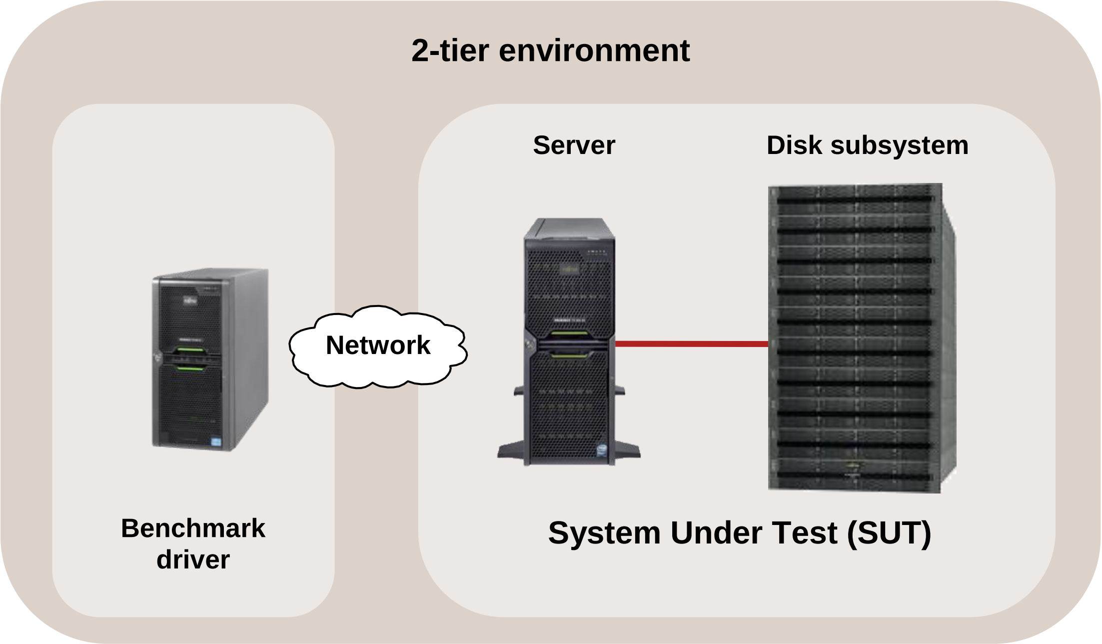
SAP AG has developed SAP Standard Application Benchmarks in order to verify the performance, stability and scaling of a SAP application system. The benchmarks, of which SD Benchmark is the most commonly used and most important, analyze the performance of the entire system and thus measure the quality of the integrated individual components.

The benchmark differentiates between a 2-tier and a 3-tier configuration. The 2-tier configuration has the SAP application and database installed on one server. With a 3-tier configuration the individual components of the SAP application can be distributed via several servers and an additional server handles the database.

The entire specification of the benchmark developed by SAP AG, Walldorf, Germany can be found at: http://www.sap.com/benchmark.

Benchmark environment

The measurement set-up is symbolically illustrated below:



System Under Test (SUT)	
Hardware	
Model	PRIMEQUEST 2800E2
Processor	8 × Xeon E7-8890 v3
Memory	64 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC
Network interface	1Gbit/s LAN
Disk subsystem	PRIMEQUEST 2800E2: 4 × HD SAS 6G 300GB 10K HOT PL 2.5" EP 1 × PRAID EP420i 1 × RAID Ctrl SAS 6G 8Port ex 1GB LP LSI V3 2 × Eternus JX40
Software	
BIOS settings	Energy Performance = Performance
Operating system	Microsoft Windows Server 2012 R2 Standard Edition
Database	Microsoft SQL Server 2012 (64-bit)
SAP Business Suite Software	SAP enhancement package 5 for SAP ERP 6.0

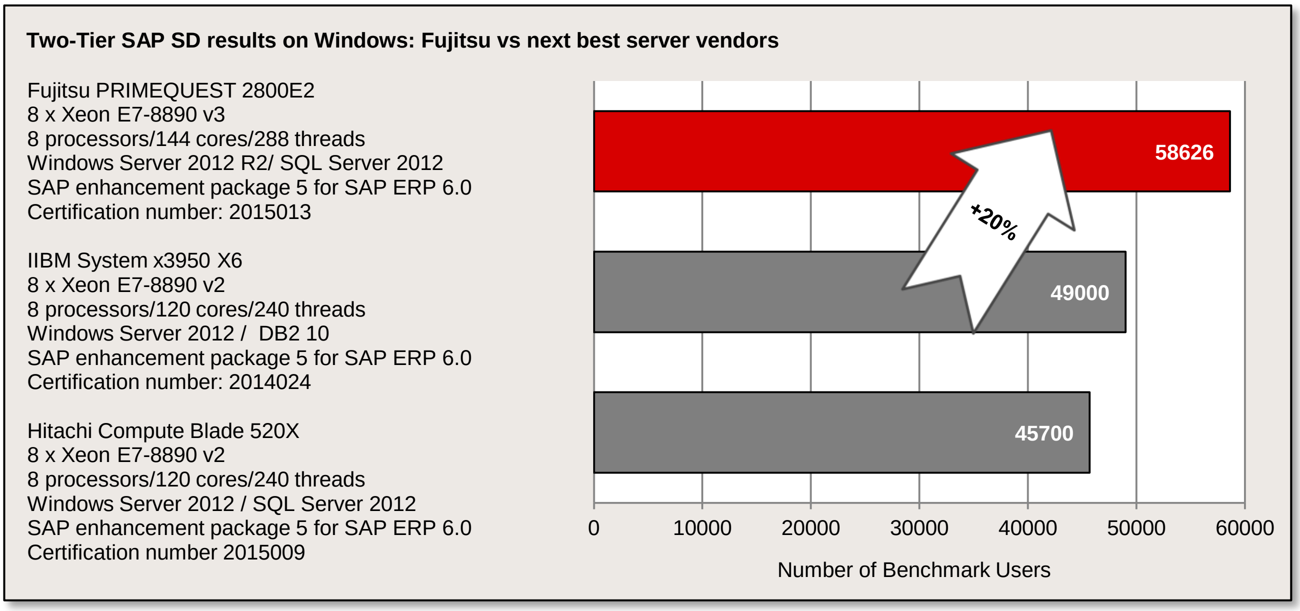
Benchmark driver	
Hardware	
Model	PRIMERGY RX300 S4
Processor	2 × Xeon X5460
Memory	32 GB
Network interface	1Gbit/s LAN
Software	
Operating system	SUSE Linux Enterprise Server 11 SP1

Some components may not be available in all countries or sales regions.

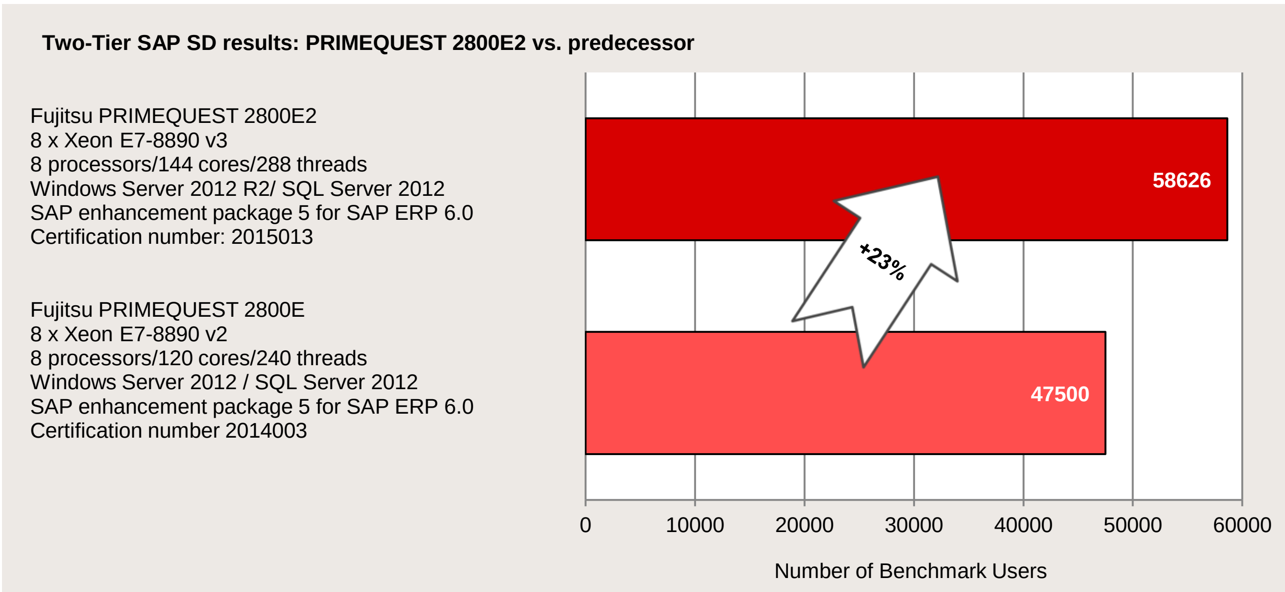
Benchmark results

Certification number 2015013	
Number of SAP SD benchmark users	58,626
Average dialog response time	0.96 seconds
Throughput Fully processed order line items/hour Dialog steps/hour SAPS	 6,417,670 19,253,000 320,880
Average database request time (dialog/update)	0.011 sec / 0.025 sec
CPU utilization of central server	99%
Operating system, central server	Windows Server 2012 R2 Standard Edition
RDBMS	SQL Server 2012
SAP Business Suite software	SAP enhancement package 5 for SAP ERP 6.0
Configuration Central Server	Fujitsu PRIMEQUEST 2800E2 8 processors / 144 cores / 288 threads Intel Xeon E7-8890 v3, 2.50 GHz, 64 KB L1 cache and 256KB L2 cache per core, 45 MB L3 cache per processor 2048 GB main memory

The PRIMEQUEST 2800E2 obtained the best two-tier SAP SD Standard Application Benchmark result on Windows (as of May 21, 2015). The latest SAP SD 2-tier results can be found at http://www.sap.com/solutions/benchmark/sd2tier.epx.



The following diagram illustrates the throughput of the PRIMEQUEST 2800E2 in comparison to its predecessor, the PRIMEQUEST 2800E, in the respective most performant configuration.



OLTP-2

Benchmark description

OLTP stands for Online Transaction Processing. The OLTP-2 benchmark is based on the typical application scenario of a database solution. In OLTP-2 database access is simulated and the number of transactions achieved per second (tps) determined as the unit of measurement for the system.

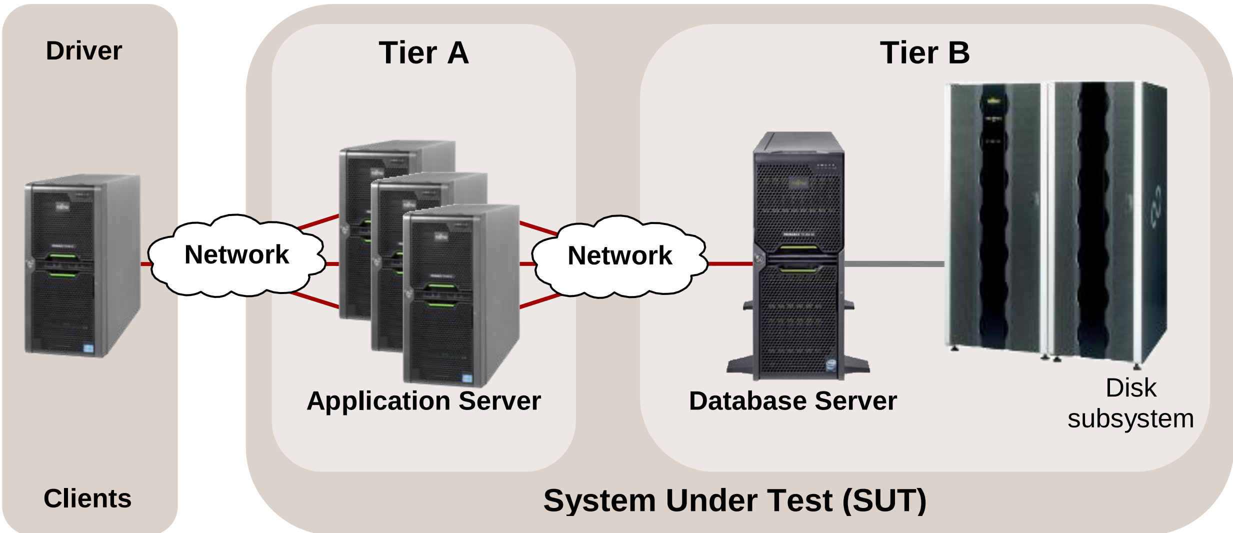
In contrast to benchmarks such as SPECint and TPC-E, which were standardized by independent bodies and for which adherence to the respective rules and regulations are monitored, OLTP-2 is an internal benchmark of Fujitsu. OLTP-2 is based on the well-known database benchmark TPC-E. OLTP-2 was designed in such a way that a wide range of configurations can be measured to present the scaling of a system with regard to the CPU and memory configuration.

Even if the two benchmarks OLTP-2 and TPC-E simulate similar application scenarios using the same load profiles, the results cannot be compared or even treated as equal, as the two benchmarks use different methods to simulate user load. OLTP-2 values are typically similar to TPC-E values. A direct comparison, or even referring to the OLTP-2 result as TPC-E, is not permitted, especially because there is no price-performance calculation.

Further information can be found in the document Benchmark Overview OLTP-2.

Benchmark environment

The measurement set-up is symbolically illustrated below:



All results were determined by way of example on a PRIMEQUEST 2800E2.

Database Server (Tier B)	
Hardware	
Model	PRIMEQUEST 2800E2
Processor	Intel® Xeon® Processor E7- v3 Family
Memory	4096 GB: 64 × 64GB (2x32GB) 4Rx4 DDR4-2133 LR ECC 2048 GB: 32 × 64GB (2x32GB) 4Rx4 DDR4-2133 LR ECC 1024 GB: 16 × 64GB (2x32GB) 4Rx4 DDR4-2133 LR ECC
Network interface	2 × onboard LAN 10 Gb/s

Disk subsystem	PRIMEQUEST 2800E2: 1 × PRAID EP420i 2 × 300 GB 10k rpm SAS Drives, RAID1 (OS) 15 × PRAID EP420e 14 × JX40: Je 15 × 400 GB SSD Drive, RAID5 (data) 1 × JX40: 10 × 900 GB 10k rpm SAS Drives, RAID10 (LOG)
Software	
BIOS	Version BB15068
Operating system	Microsoft Windows Server 2012 R2 Standard
Database	Microsoft SQL Server 2014 Enterprise

Application Server (Tier A)	
Hardware	
Model	2 × PRIMERGY RX2530 M1
Processor	2 × Xeon E5-2697 v3
Memory	64 GB, 2133 MHz registered ECC DDR4
Network interface	2 × onboard LAN 10 Gb/s
Disk subsystem	2 × 300 GB 15k rpm SAS Drive
Software	
Operating system	Microsoft Windows Server 2012 Standard

Client	
Hardware	
Model	1 × PRIMERGY RX300 S8
Processor	2 × Xeon E5-2667 v2
Memory	64 GB, 1600 MHz registered ECC DDR3
Network interface	2 × onboard LAN 1 Gb/s 1 × Dual Port LAN 1Gb/s
Disk subsystem	1 × 300 GB 10k rpm SAS Drive
Software	
Operating system	Microsoft Windows Server 2012 R2 Standard
Benchmark	OLTP-2 Software EGen version 1.14.0

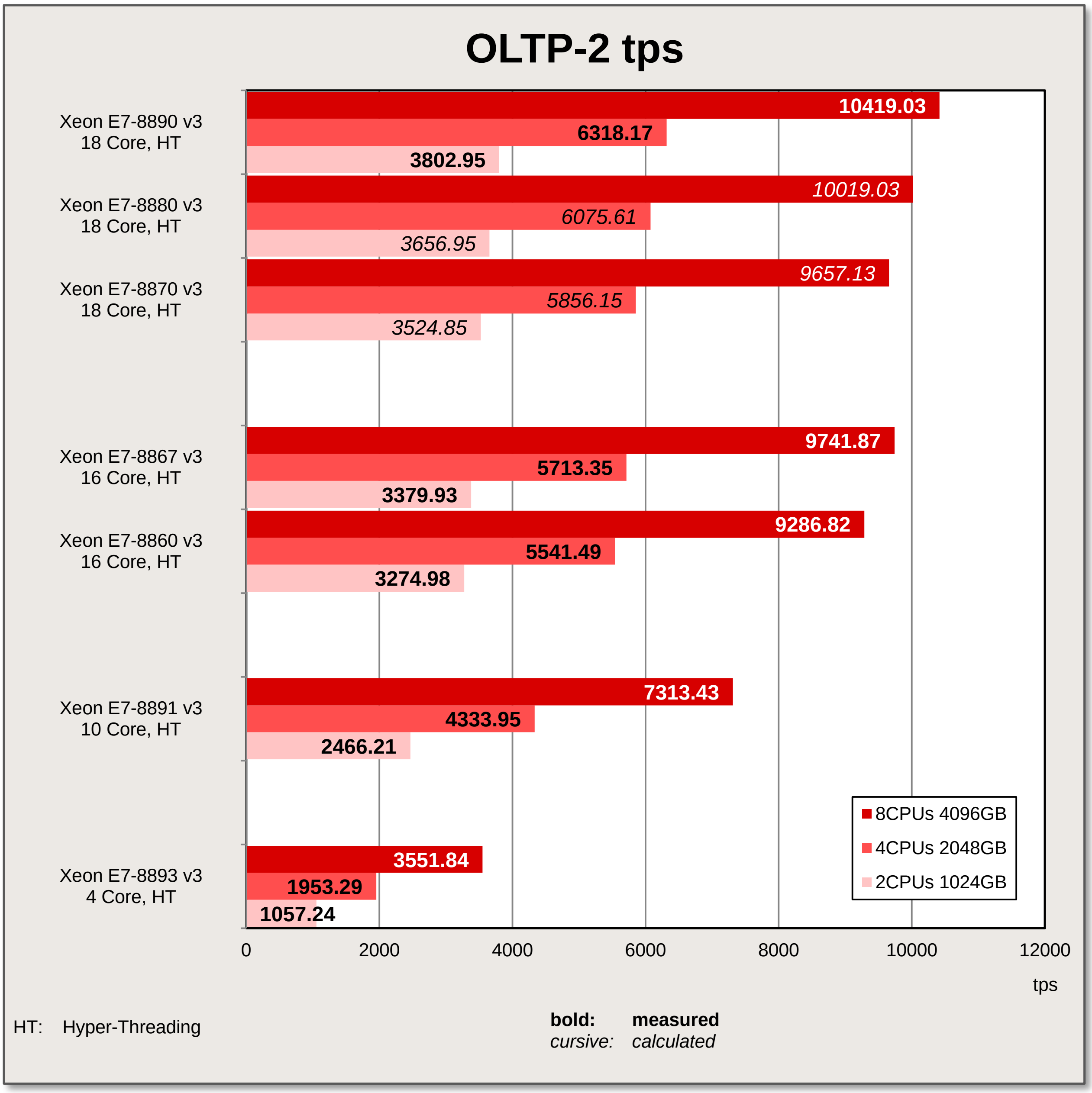
Some components may not be available in all countries / sales regions.

Benchmark results

Database performance greatly depends on the configuration options with CPU, memory and on the connectivity of an adequate disk subsystem for the database. In the following scaling considerations for the processors we assume that both the memory and the disk subsystem has been adequately chosen and is not a bottleneck.

A guideline in the database environment for selecting main memory is that sufficient quantity is more important than the speed of the memory accesses. This why a configuration with a total memory of 1024 GB was considered for the measurements with two processors, a configuration with a total memory of 2048 GB for the measurements with four processors and a configuration with a total memory of 4096 GB for the measurements with eight processors. The memory configurations had memory access of 1600 MHz. Further information about memory performance can be found in the White Paper Memory performance of Xeon E7 v3 (Haswell-EX)-based systems.

The following diagram shows the OLTP-2 transaction rates that can be achieved with two, four and eight processors of the Intel® Xeon® Processor E7 v3 Family.



It is evident that a wide performance range is covered by the variety of released processors. If you compare the OLTP-2 value of the processor with the lowest performance (Xeon E7-8893 v3) with the value of the processor with the highest performance (Xeon E7-8890 v3), the result is a 2.9-fold increase in performance.

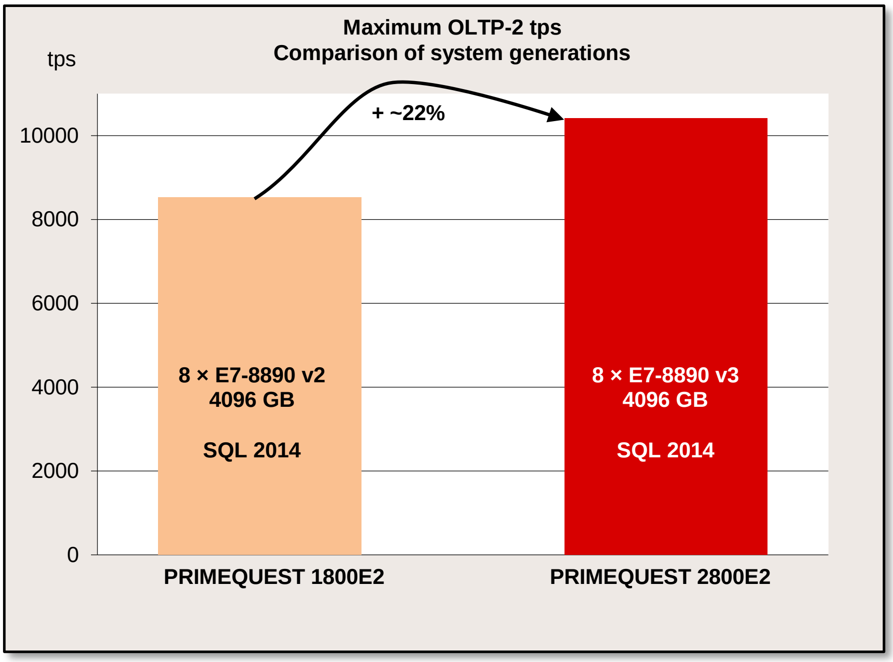
Based on the number of cores the processors can be divided into different performance groups:

The start is made with Xeon E7-8893 v3 as processor with four cores and Hyper-Threading.

The groups of 10- and 16-core processors offer in this processor series a medium-range OLTP-2 performance. Due to the various technical features of the processors in these groups (see. "Technical data") it is possible to choose the right CPU depending on the usage scenario.

The group of processors with 18 cores is to be found at the upper end of the performance scale. Due to the graduated CPU clock frequencies an OLTP performance of between 9657.13 tps (8 × Xeon E7-8870 v3) and 10419.03 tps (8 × Xeon E7-8890 v3) is achieved.

If you compare the maximum achievable OLTP-2 values of the current system generation with the values that were achieved on the predecessor systems, the result is an increase of about 22%.



TPC-E

Benchmark description

The TPC-E benchmark measures the performance of online transaction processing systems (OLTP) and is based on a complex database and a number of different transaction types that are carried out on it. TPC-E is not only a hardware-independent but also a software-independent benchmark and can thus be run on every test platform, i.e. proprietary or open. In addition to the results of the measurement, all the details of the systems measured and the measuring method must also be explained in a measurement report (Full Disclosure Report or FDR). Consequently, this ensures that the measurement meets all benchmark requirements and is reproducible. TPC-E does not just measure an individual server, but a rather extensive system configuration. Keys to performance in this respect are the database server, disk I/O and network communication.

The performance metric is tpsE, where tps means transactions per second. tpsE is the average number of Trade-Result-Transactions that are performed within a second. The TPC-E standard defines a result as the tpsE rate, the price per performance value (e.g. $/tpsE) and the availability date of the measured configuration.

Further information about TPC-E can be found in the overview document Benchmark Overview TPC-E.

Benchmark results

In November 2015 Fujitsu submitted a TPC-E benchmark result for the PRIMEQUEST 2800E2 with the processor Intel Xeon E7-8890 v3 and 4 TB memory.

The results show an enormous increase in performance compared with the PRIMEQUEST 2800E with a simultaneous reduction in costs.

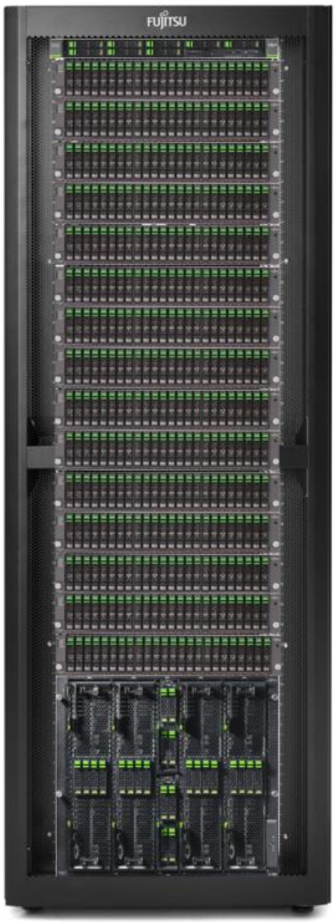
FUJITSU	**FUJITSU Server PRIMEQUEST 2800E2**	**TPC-E 1.14.0** **TPC Pricing 1.7.0** Report Date November 11, 2015

TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
10,058.28 tpsE	**$ 187.53 USD per tpsE**	**November 11, 2015**	**$ 1,886,164 USD**

Database Server Configuration

Operating System	Database Manager	Processors/Cores/Threads	Memory
Microsoft Windows Server 2012 R2 Standard Edition	**Microsoft SQL Server 2014 Enterprise Edition**	**8/128/256**	**4 TB**

SUT



Tier A
PRIMERGY RX2530 M1
2x Intel Xeon E5-2699 v3 2.30 GHz
64 GB Memory
2x onboard LAN 10 Gb/s
1x Dual Port LAN 1 Gb/s
1x SAS RAID controller

Tier B
PRIMEQUEST 2800E2
8x Intel Xeon E7-8890 v3 2.50 GHz
4 TB Memory
2x 300 GB 10k rpm SAS Drives
2x 400 GB SSD Drives
2x Onboard LAN 10 Gb/s
15x SAS RAID Controller

Storage
1x PRIMECENTER Rack
15x ETERNUS JX40
210x 400 GB SSD Drives
10x 900 GB 10k rpm SAS Drives

Initial Database Size	Redundancy Level 1	Storage
42,571 GB	**RAID-5 data and RAID-10 log**	**210 x 400 GB SSD** **10 x 900 GB 10k rpm HDD**

Some components may not be available in all countries / sales regions.

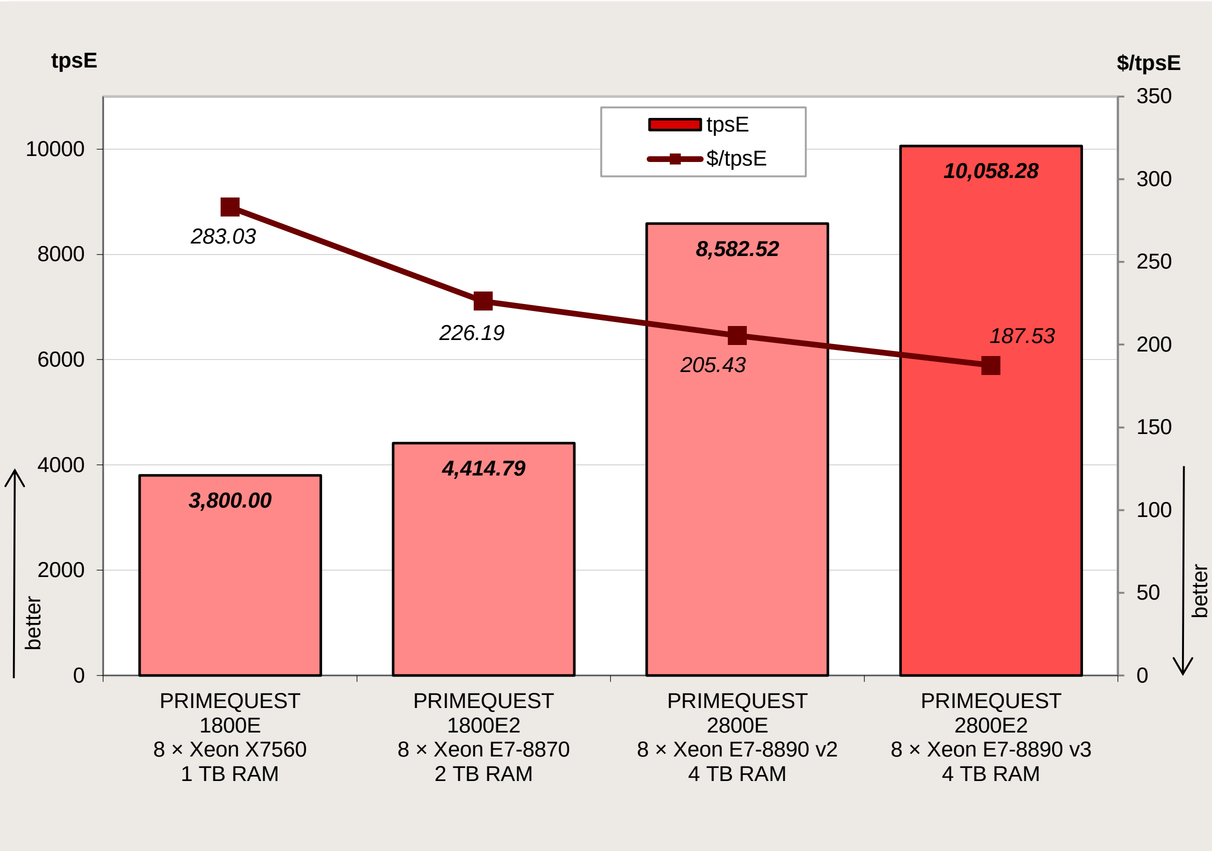
More details about this TPC-E result, in particular the Full Disclosure Report, can be found via the TPC web page http://www.tpc.org/tpce/results/tpce_result_detail.asp?id=115111101.

In November 2015, Fujitsu is represented with five results in the TPC-E list (without historical results).

System and Processors	Throughput	Price / Performance	Availability Date
PRIMERGY RX300 S8 with 2 × Xeon E5-2697 v2	2472.58 tpsE	$135.14 per tpsE	September 10, 2013
PRIMEQUEST 2800E with 2 × Xeon E7-8890 v2	8582.52 tpsE	$205.43 per tpsE	Mai 1, 2014
PRIMERGY RX2540 M1 with 2 × Xeon E5-2699 v3	3772.08 tpsE	$130.44 per tpsE	December 1, 2014
PRIMERGY RX4770 M2 with 4 × Xeon E7-8890 v3	6904.53 tpsE	$126.49 per tpsE	June 1, 2015
PRIMEQUEST 2800E2 with 8 × Xeon E7-8890 v3	10058.28 tpsE	$187.53 per tpsE	November 11, 2015

See the TPC web site for more information and all the TPC-E results (including historical results) (http://www.tpc.org/tpce).

The following diagram for 8-socket PRIMEQUEST systems with different processor types shows the good performance of the PRIMEQUEST 2800E2 system.



In comparison with the PRIMEQUEST 2800E the increase in performance is +17%, in comparison with the PRIMEQUEST 1800E2 +128% and in comparison with the PRIMEQUEST 1800E +165%. The price per performance is $187.53/tpsE. Compared with the PRIMEQUEST 2800E the costs are reduced to 91%, with the PRIMEQUEST 1800E2 to 83% and with the PRIMEQUEST 1800E to 66%.

The following overview shows the best TPC-E results (as of November 11th, 2015, without historical results) and the corresponding price per performance ratios. PRIMEQUEST 2800E2 with 10058.28 tpsE has the highest performance value of all TPC-E publications and the best price/performance value of $187.53/tpsE of all 8-socket systems.

System		Processor type processors/ cores/threads	tpsE (higher is better)	$/tpsE (lower is better)	availability date
Fujitsu	**PRIMEQUEST 2800E2**	8 × Intel Xeon E7-8890 v3	**10,058.28**	**187.53**	**2015-11-11**
Lenovo	System x3950 X6	8 × Intel Xeon E7-8890 v2	9,145.01	192.38	2014-11-25
Fujitsu	PRIMEQUEST 2800E	8 × Intel Xeon E7-8890 v2	8,582.52	205.43	2014-05-01
Lenovo	System x3850 X6	4 × Intel Xeon E7-8890 v3	6,964.75	245.98	2015-07-31
Fujitsu	PRIMERGY RX4770 M2	4 × Intel Xeon E7-8890 v3	6,904.53	126.49	2015-06-01
IBM	System x3850 X6	4 × Intel Xeon E7-4890 v2	5,576.27	188.69	2014-04-15
IBM	System x3850 X5	8 × Intel Xeon E7-8870	5,457.20	249.58	2013-03-08
NEC	Express5800/A2040b	4 × Intel Xeon E7-4890 v2	5,087.17	229.04	2014-04-15
Fujitsu	PRIMERGY RX2540 M1	2 × Intel Xeon E5-2699 v3	3,772.08	130.44	2014-12-01
IBM	System x3850 X5	4 × Intel Xeon E7-4870	3,218.46	225.30	2012-11-28

See the TPC web site for more information and all the TPC-E results (including historical results) (http://www.tpc.org/tpce).

vServCon

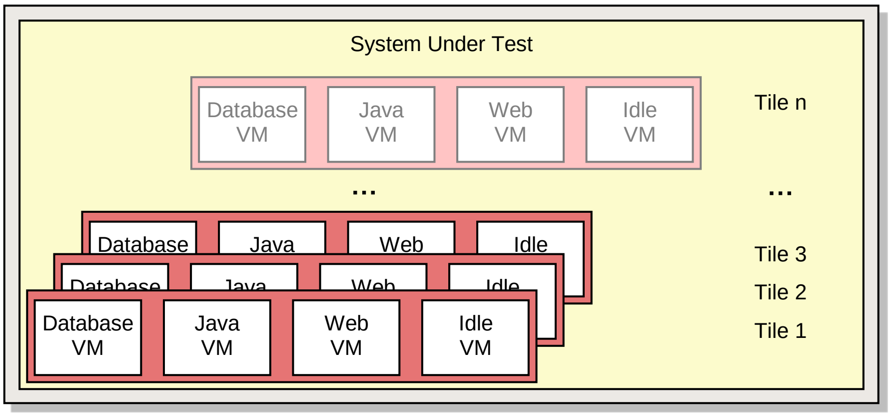
Benchmark description

vServCon is a benchmark used by Fujitsu to compare server configurations with hypervisor with regard to their suitability for server consolidation. This allows both the comparison of systems, processors and I/O technologies as well as the comparison of hypervisors, virtualization forms and additional drivers for virtual machines.

vServCon is not a new benchmark in the true sense of the word. It is more a framework that combines already established benchmarks (or in modified form) as workloads in order to reproduce the load of a consolidated and virtualized server environment. Three proven benchmarks are used which cover the application scenarios database, application server and web server.

Application scenario	Benchmark	No. of logical CPU cores	Memory
Database	Sysbench (adapted)	2	1.5 GB
Java application server	SPECjbb (adapted, with 50% - 60% load)	2	2 GB
Web server	WebBench	1	1.5 GB

Each of the three application scenarios is allocated to a dedicated virtual machine (VM). Add to these a fourth machine, the so-called idle VM. These four VMs make up a “tile”. Depending on the performance capability of the underlying server hardware, you may as part of a measurement also have to start several identical tiles in parallel in order to achieve a maximum performance score.



Each of the three vServCon application scenarios provides a specific benchmark result in the form of application-specific transaction rates for the respective VM. In order to derive a normalized score, the individual benchmark results for one tile are put in relation to the respective results of a reference system. The resulting relative performance values are then suitably weighted and finally added up for all VMs and tiles. The outcome is a score for this tile number.

Starting as a rule with one tile, this procedure is performed for an increasing number of tiles until no further significant increase in this vServCon score occurs. The final vServCon score is then the maximum of the vServCon scores for all tile numbers. This score thus reflects the maximum total throughput that can be achieved by running the mix defined in vServCon that consists of numerous VMs up to the possible full utilization of CPU resources. This is why the measurement environment for vServCon measurements is designed in such a way that only the CPU is the limiting factor and that no limitations occur as a result of other resources.

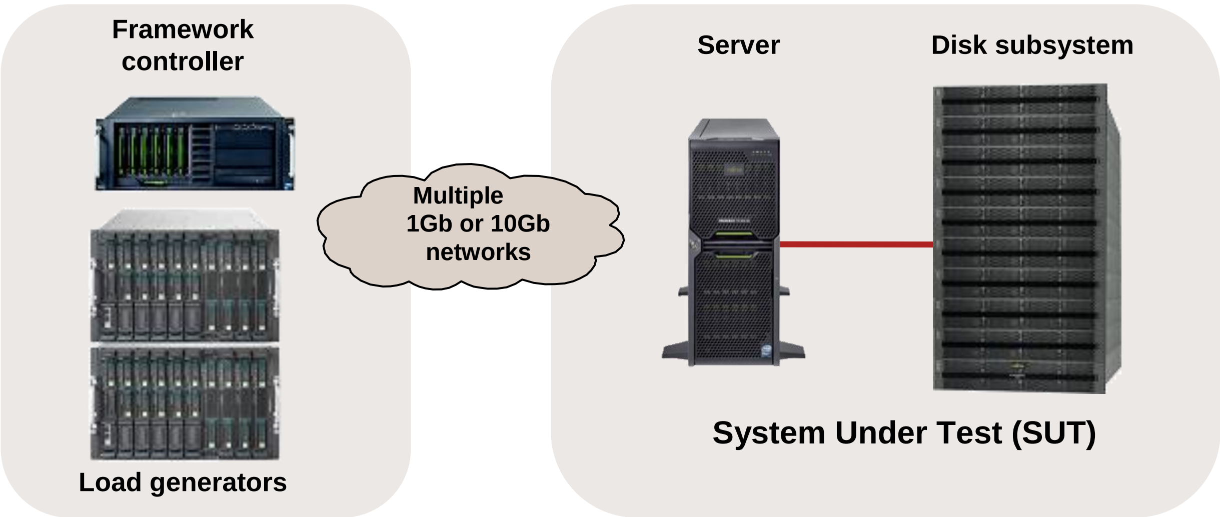
The progression of the vServCon scores for the tile numbers provides useful information about the scaling behavior of the “System under Test”.

Moreover, vServCon also documents the total CPU load of the host (VMs and all other CPU activities) and, if possible, electrical power consumption.

A detailed description of vServCon is in the document: Benchmark Overview vServCon.

Benchmark environment

The measurement set-up is symbolically illustrated below:



System Under Test (SUT)	
Hardware	
Processor	Intel® Xeon® Processor E7 v3 Family
Memory	2 TB: 64 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC
Network interface	1 × dual port 1GbE adapter 1 × dual port 10GbE server adapter
Disk subsystem	1 × dual-channel FC-Controller Emulex LPe16002 LINUX/LIO basiertes Flash Storage System
Software	
Operating system	VMware ESX 6.0.0 Build 2724185

Load generator (incl. Framework controller)	
Hardware (Shared)	
Enclosure	PRIMERGY BX900
Hardware	
Model	18 × PRIMERGY BX920 S1 server blades
Processor	2 × Xeon X5570
Memory	12 GB
Network interface	3 × 1 Gbit/s LAN
Software	
Operating system	Microsoft Windows Server 2003 R2 Enterprise with Hyper-V

Load generator VM (per tile 3 load generator VMs on various server blades)	
Hardware	
Processor	1 × logical CPU
Memory	512 MB
Network interface	2 × 1 Gbit/s LAN
Software	
Operating system	Microsoft Windows Server 2003 R2 Enterprise Edition

Some components may not be available in all countries or sales regions.

Benchmark results

The PRIMEQUEST eight-socket systems dealt with here are based on processors of the Intel® Xeon® Processor E7 v3 Family. The features of the processors are summarized in the section "Technical data".

The available processors of these systems with their results can be seen in the following table.

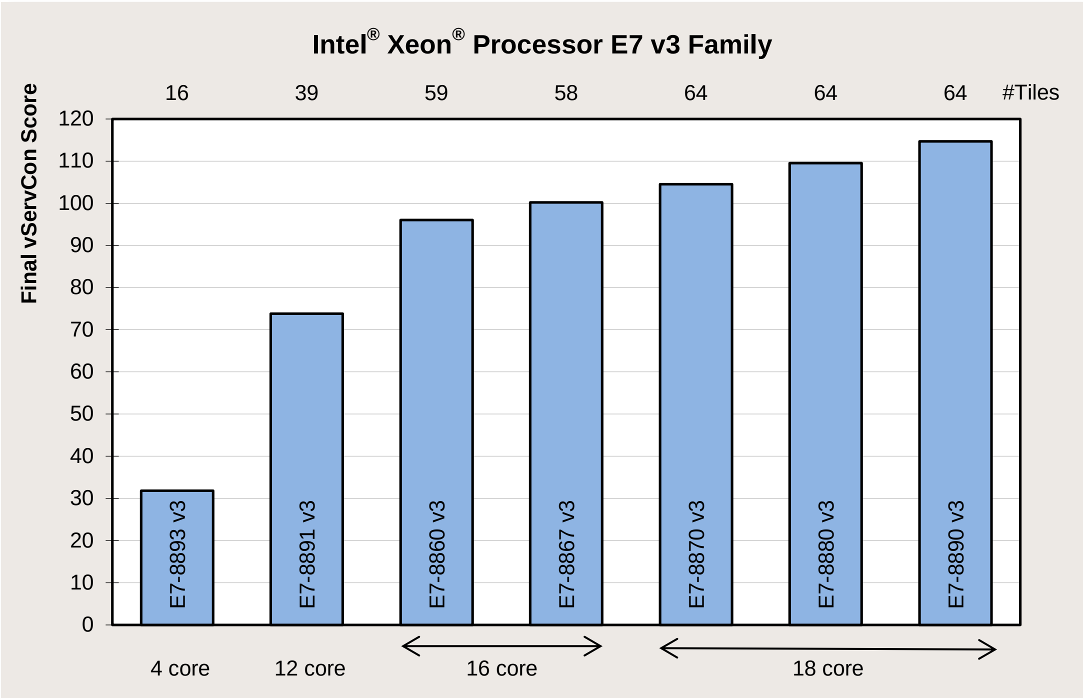
Processor			Score	#Tiles
Intel® Xeon® Processor E7 v3 Family	4 Cores Hyper-Threading, Turbo-Mode	E7-8893 v3	31.8	16
	10 Cores Hyper-Threading, Turbo-Mode	E7-8891 v3	73.8	39
	16 Cores Hyper-Threading, Turbo-Mode	E7-8860 v3	96.0	59
		E7-8867 v3	100.2	58
	18 Cores Hyper-Threading, Turbo-Mode	E7-8870 v3	104.5	64
		E7-8880 v3	109.5	64
		E7-8890 v3	114.7	64

These PRIMEQUEST eight-socket systems are very suitable for application virtualization thanks to the progress made in processor technology. Compared with a system based on the previous processor generation an approximate 40.5% higher virtualization performance can be achieved (measured in vServCon score in their maximum configuration).

The relatively large performance differences between the processors can be explained by their features. The values scale on the basis of the number of cores, the size of the L3 cache and the CPU clock frequency and as a result of the features of Hyper-Threading and turbo mode, which are available in most processor types. Furthermore, the data transfer rate between processors ("QPI Speed") also determines performance. As a matter of principle, the memory access speed also influences performance. A guideline in the virtualization environment for selecting main memory is that sufficient quantity is more important than the speed of the memory accesses.

More information about the topic "Memory Performance" can be found in the White Paper Memory performance of Xeon E7 v3 (Haswell-EX)-based systems.

The first diagram compares the virtualization performance values that can be achieved with the processors reviewed here.

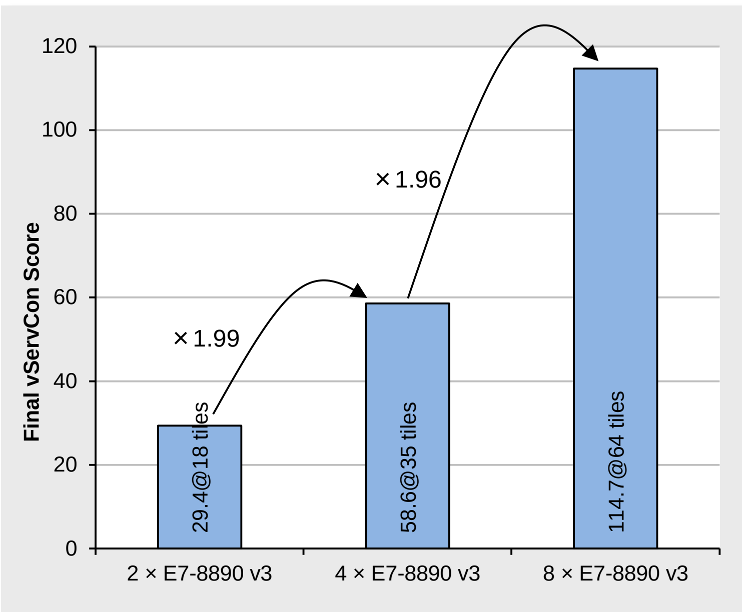


The Xeon E7-8893 v3 as the processor with four cores only makes the start.

An increase in performance is achieved by the processor with twelve cores (Xeon E7-8891 v3).

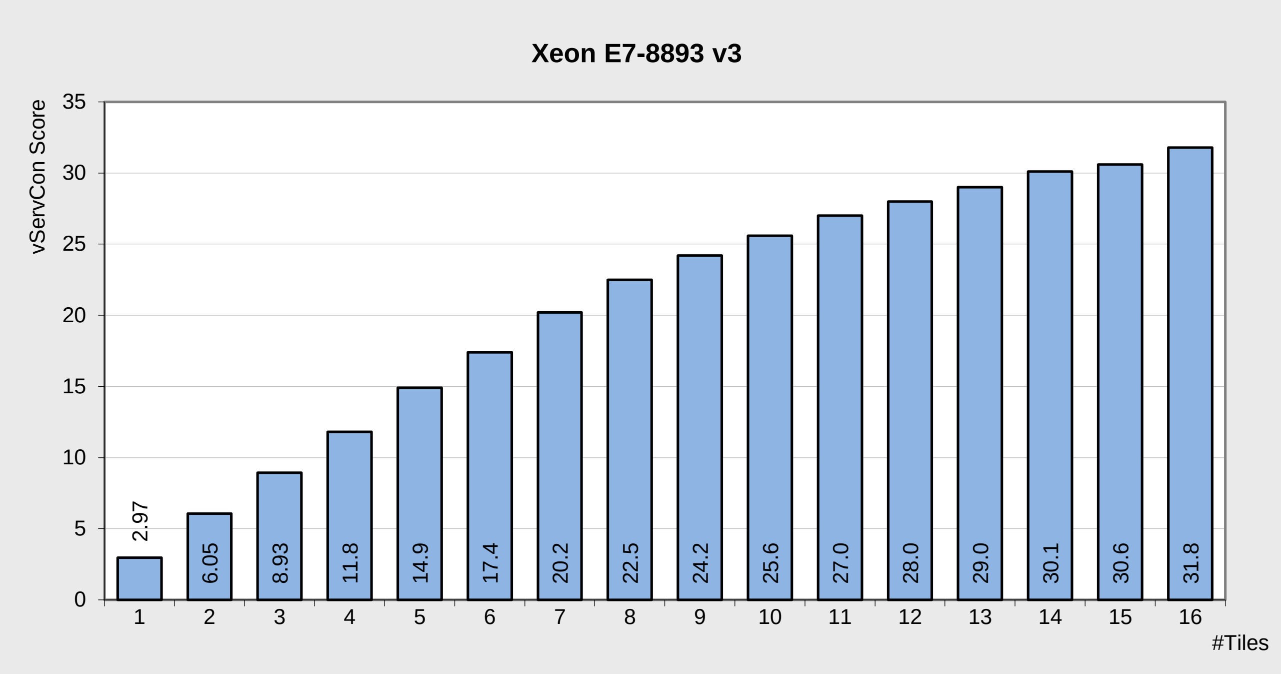
The group of processors with 18 cores, which achieves a higher performance than the 16-core processors, is to be found at the upper end of the performance scale.

Within a group of processors with the same number of cores scaling can be seen via the CPU clock frequency.



Until now we have looked at the virtualization performance of a fully configured system. However, with a server with eight sockets the question also arises as to how good performance scaling is from two to four or eight processors. The better the scaling, the lower the overhead usually caused by the shared use of resources within a server. The scaling factor also depends on the application. If the server is used as a virtualization platform for server consolidation, the system scales with a factor of 1.99 or 1.96. When operated with four or eight processors, the system thus achieves almost twice the performance as with two or four processors, as is illustrated in the diagram opposite using the processor version Xeon E7-8890 v3 as an example.

The next diagram illustrates the virtualization performance for increasing numbers of VMs based on the Xeon E7-8893 v3 (4-Core) processor.



In addition to the increased number of physical cores, Hyper-Threading, which is supported by all Xeon E7 processors, is an additional reason for the high number of VMs that can be operated. As is known, a physical processor core is consequently divided into two logical cores so that the number of cores available for the hypervisor is doubled. This standard feature thus generally increases the virtualization performance of a system.

The scaling curves for the number of tiles as seen in the previous diagram are specifically for systems with Hyper-Threading. 32 physical and thus 64 logical cores are available with the Xeon E7-8893 v3 processors; approximately four of them are used per tile (see Benchmark description). This means that a parallel use of the same physical cores by several VMs is avoided up to a maximum of about eight tiles. That is why the performance curve in this range scales almost ideal. For the quantities above the growth is flatter up to CPU full utilization.

The previous diagram examined the total performance of all application VMs of a host. However, studying the performance from an individual application VM viewpoint is also interesting. This information is in the previous diagram. For example, the total optimum is reached in the above Xeon E7-8893 v3 situation with 48 application VMs (16 tiles, not including the idle VMs); the low load case is represented by three application VMs (one tile, not including the idle VM). Remember: the vServCon score for one tile is an average value across the three application scenarios in vServCon. This average performance of one tile drops when changing from the low load case to the total optimum of the vServCon score - from 2.97 to 32.8/16=2.05, i.e. to 45%. The individual types of application VMs can react very differently in the high load situation. It is thus clear that in a specific situation the performance requirements of an individual application must be balanced against the overall requirements regarding the numbers of VMs on a virtualization host.

VMmark V2

Benchmark description

VMmark V2 is a benchmark developed by VMware to compare server configurations with hypervisor solutions from VMware regarding their suitability for server consolidation. In addition to the software for load generation, the benchmark consists of a defined load profile and binding regulations. The benchmark results can be submitted to VMware and are published on their Internet site after a successful review process. After the discontinuation of the proven benchmark “VMmark V1” in October 2010, it has been succeeded by “VMmark V2”, which requires a cluster of at least two servers and covers data center functions, like Cloning and Deployment of virtual machines (VMs), Load Balancing, as well as the moving of VMs with vMotion and also Storage vMotion.

In addition to the “Performance Only” result, it is also possible from version 2.5 of VMmark to alternatively measure the electrical power consumption and publish it as a “Performance with Server Power” result (power consumption of server systems only) and/or “Performance with Server and Storage Power” result (power consumption of server systems and all storage components).

VMmark V2 is not a new benchmark in the actual sense. It is in fact a framework that consolidates already established benchmarks, as workloads in order to simulate the load of a virtualized consolidated server environment. Three proven benchmarks, which cover the application scenarios mail server, Web 2.0, and e-commerce were integrated in VMmark V2.

Application scenario	Load tool	# VMs
Mail server	LoadGen	1
Web 2.0	Olio client	2
E-commerce	DVD Store 2 client	4
Standby server	(IdleVMTest)	1

Each of the three application scenarios is assigned to a total of seven dedicated virtual machines. Then add to these an eighth VM called the “standby server”. These eight VMs form a “tile”. Because of the performance capability of the underlying server hardware, it is usually necessary to have started several identical tiles in parallel as part of a measurement in order to achieve a maximum overall performance.

A new feature of VMmark V2 is an infrastructure component, which is present once for every two hosts. It measures the efficiency levels of data center consolidation through VM Cloning and Deployment, vMotion and Storage vMotion. The Load Balancing capacity of the data center is also used (DRS, Distributed Resource Scheduler).

The result of VMmark V2 for test type „Performance Only“ is a number, known as a “score”, which provides information about the performance of the measured virtualization solution. The score reflects the maximum total consolidation benefit of all VMs for a server configuration with hypervisor and is used as a comparison criterion of various hardware platforms.

This score is determined from the individual results of the VMs and an infrastructure result. Each of the five VMmark V2 application or front-end VMs provides a specific benchmark result in the form of application-specific transaction rates for each VM. In order to derive a normalized score the individual benchmark results for one tile are put in relation to the respective results of a reference system. The resulting dimensionless performance values are then averaged geometrically and finally added up for all VMs. This value is included in the overall score with a weighting of 80%. The infrastructure workload is only present in the benchmark once for every two hosts; it determines 20% of the result. The number of transactions per hour and the average duration in seconds respectively are determined for the score of the infrastructure workload components.

In addition to the actual score, the number of VMmark V2 tiles is always specified with each VMmark V2 score. The result is thus as follows: “Score@Number of Tiles”, for example “4.20@5 tiles”.

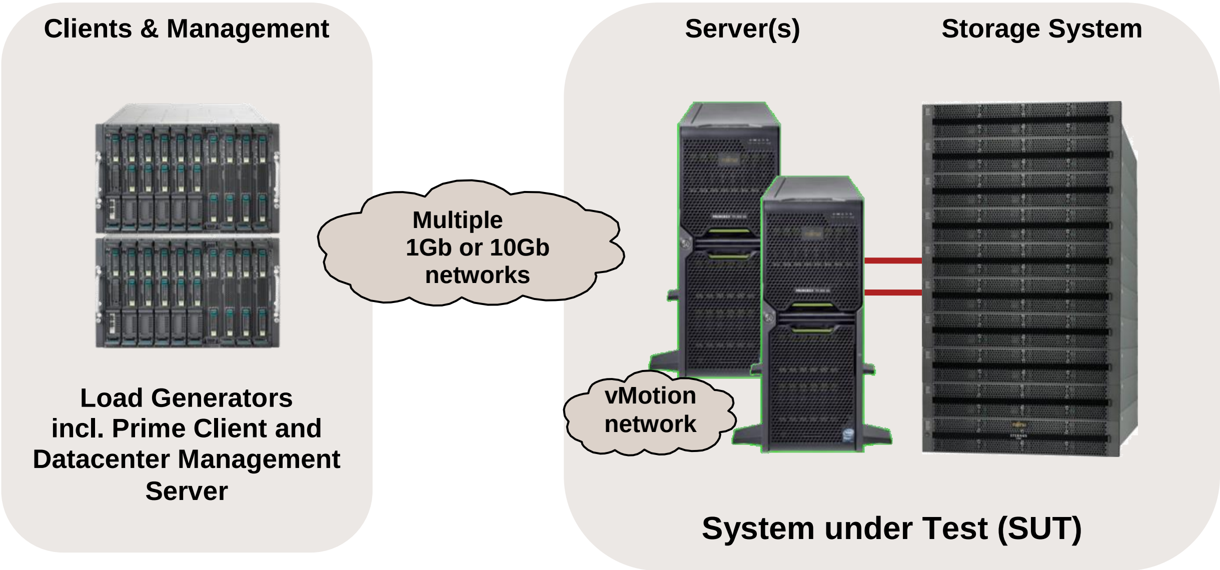
In the case of the two test types “Performance with Server Power” and “Performance with Server and Storage Power” a so-called “Server PPKW Score” and “Server and Storage PPKW Score” is determined, which is the performance score divided by the average power consumption in kilowatts (PPKW = performance per kilowatt (KW)).

The results of the three test types should not be compared with each other.

A detailed description of VMmark V2 is available in the document Benchmark Overview VMmark V2.

Benchmark environment

The measurement set-up is symbolically illustrated below:



System Under Test (SUT)	
Hardware	
Number of servers	1 / 2
Model	PRIMEQUEST 2800E2
Number of partitions / Number of ESXi hosts	2 / 4 / 8
Disk subsystem	2 / 4 × PRIMERGY RX300 S8 configured as Fibre Channel target Details see disclosures
Hardware per partition	
Processor	2 / 4 / 8 × Xeon E7-8890 v3
Memory	2-socket: 512 GB: 16 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC 4-socket: 1024 GB: 32 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC 8-socket: 2048 GB: 64 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC
Network interface	Intel 82579LM 1GbE Adapter Eth Ctrl 2x 1GbE Cu – PCIe x4 LP Fujitsu D2755 Dual Port 10GbE Adapter(s) / Dual port Emulex OCe14102 10GbE Adapter
Disk interface	Dual port PFC EP LPe16002 LP
Software	
BIOS	Version 1.09/1.13
BIOS settings	See details
Operating system	VMware ESXi 6.0.0 Build 2559268/2615704
Operating system settings	ESXi settings: see details

Datacenter Management Server (DMS)	
Hardware (Shared)	
Enclosure	PRIMERGY BX600
Network Switch	1 × PRIMERGY BX600 GbE Switch Blade 30/12

Hardware	
Model	1 × server blade PRIMERGY BX620 S5
Processor	2 × Xeon X5570
Memory	24 GB
Network interface	6 × 1 Gbit/s LAN
Software	
Operating system	VMware ESXi 5.1.0 Build 799733
Datacenter Management Server (DMS)VM	
Hardware	
Processor	4 × logical CPU
Memory	10 GB
Network interface	2 × 1 Gbit/s LAN
Software	
Operating system	Microsoft Windows Server 2008 R2 Enterprise x64 Edition

Prime Client	
Hardware (Shared)	
Enclosure	PRIMERGY BX600
Network Switch	1 × PRIMERGY BX600 GbE Switch Blade 30/12
Hardware	
Model	1 × server blade PRIMERGY BX620 S5
Processor	2 × Xeon X5570
Memory	12 GB
Network interface	6 × 1 Gbit/s LAN
Software	
Operating system	Microsoft Windows Server 2008 Enterprise x64 Edition SP2

Load generator	
Hardware	
Model	3 × PRIMERGY RX600 S6 1 – 2 × PRIMERGY RX500 S7
Processor	4 × Xeon E7-4870 (PRIMERGY RX600 S6) 4 × Xeon E5-4650 (PRIMERGY RX500 S7)
Memory	PRIMERGY RX600 S6: 512 GB PRIMERGY RX500 S7: 256 GB
Network interface	PRIMERGY RX600 S6: 6 × 1 Gbit/s LAN or 2 × 10 Gbit/s LAN PRIMERGY RX500 S7: 4 × 1 Gbit/s LAN or 2 × 10 Gbit/s LAN
Software	
Operating system	VMware ESX 4.1.0 U2 Build 502767
Load generator VM (per tile 1 load generator VM)	
Hardware	
Processor	4 × logical CPU
Memory	4 GB
Network interface	1 × 1 Gbit/s LAN or 1 × 10 Gbit/s LAN
Software	
Operating system	Microsoft Windows Server 2008 Enterprise x64 Edition SP2

Details	
See disclosure	http://www.vmware.com/a/assets/vmmark/pdf/2015-05-05-Fujitsu-PRIMEQUEST2800E2-40.pdf http://www.vmware.com/a/assets/vmmark/pdf/2015-05-05-Fujitsu-PRIMEQUEST2800E2-70.pdf http://www.vmware.com/a/assets/vmmark/pdf/2015-05-12-Fujitsu-PRIMEQUEST2800E2-80.pdf http://www.vmware.com/a/assets/vmmark/pdf/2015-05-12-Fujitsu-PRIMEQUEST2800E2-88.pdf http://www.vmware.com/a/assets/vmmark/pdf/2015-05-05-Fujitsu-PRIMEQUEST2800E2-40-serverPPKW.pdf

Some components may not be available in all countries or sales regions.

Benchmark results

The PRIMEQUEST 2800E is a server measured with VMmark V2 to offer the option of partitionability. This extremely flexible feature makes it possible to split an individual PRIMEQUEST 2800E2 server into up to four fully independent individual systems/partitions. Each of these partitions runs an independent operating system instance (host). Due to partitionability it is possible to optimally adapt the hardware to suit a specific load profile. Thus, it can for example make sense to configure 2-socket partitions for VMs with relatively few vCPUs, whereas on the other hand 4 or 8-socket partitions can be more efficient for VMs with many vCPUs. A mix of 2 × 2-socket partitions and 1 × 4-socket partition is also possible in an individual PRIMEQUEST 2800E2 server.

The measurements listed below demonstrate the outstanding flexibility of the PRIMEQUEST 2800E2 and show that this flexibility is not bought by means of a performance-limiting overhead.

Overview of the VMmark V2 measurements presented here:

- Measurement with two ESXi hosts in two PRIMEQUEST 2800E2 (8-socket, “matched pair”)
- Measurement with two ESXi hosts in one single PRIMEQUEST 2800E2 (4-socket, “matched pair”)
- Measurement with four ESXi hosts in two PRIMEQUEST 2800E2 (4-socket, “uniform hosts”)
- Measurement with eight ESXi hosts in two PRIMEQUEST 2800E2 (2-socket, “uniform hosts”)
- Scaling comparison

The processors used, which with a good hypervisor setting could make optimal use of their processor features, were the essential prerequisites for achieving all PRIMEQUEST 2800E2 result. These features include Hyper-Threading. All this has a particularly positive effect during virtualization.

All VMs, their application data, the host operating system as well as additionally required data were on a powerful Fibre Channel disk subsystem. As far as possible, the configuration of the disk subsystem takes the specific requirements of the benchmark into account. The use of flash technology in the form of SAS SSDs and PCIe-SSDs in the powerful Fibre Channel disk subsystem resulted in further advantages in response times of the storage medium used.

The network connection to the load generators was implemented via 10Gb LAN ports. The infrastructure-workload connection between the hosts was by means of 1Gb LAN ports.

All the components used were optimally attuned to each other.

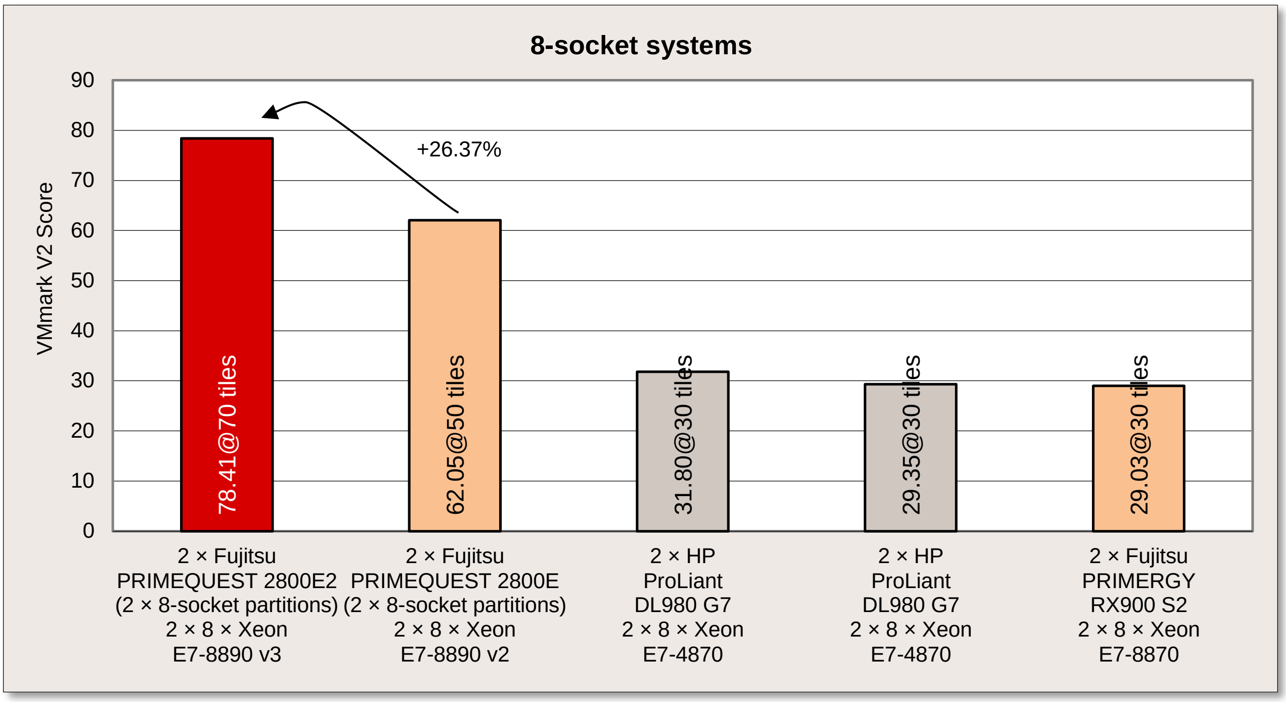
Measurement with two ESXi hosts in two PRIMEQUEST 2800E2 (8-socket, "matched pair")

"Performance Only" measurement result

On May 5, 2015 Fujitsu achieved with two PRIMEQUEST 2800E2 systems with Xeon E7-8890 v3 processors and VMware ESXi 6.0.0 a VMmark V2 score of "78.41@70 tiles" in a system configuration with a total of 2 × 144 processor cores and when using two identical servers/partitions in the "System under Test" (SUT). With this result the PRIMEQUEST 2800E2 is in the official VMmark V2 ranking the most powerful server and thus achieves the absolutely best VMmark V2 value (valid as of benchmark results publication date).

All comparisons for the competitor products reflect the status of 5th May 2015. The current VMmark V2 results as well as the detailed results and configuration data are available at http://www.vmware.com/a/vmmark/.

The diagram shows the result of the PRIMEQUEST 2800E2 in comparison with all 8-socket systems.



The table opposite shows the difference in the score (in %) between the Fujitsu system and the other 8-socket systems.

8-socket systems	VMmark V2 score	Difference
Fujitsu PRIMEQUEST 2800E2	78.41@70 tiles	
Fujitsu PRIMEQUEST 2800E	62.05@50 tiles	26.37%
HP ProLiant DL980 G7	31.80@30 tiles	146.57%
HP ProLiant DL980 G7	29.35@30 tiles	167.16%
Fujitsu PRIMERGY RX900 S2	29.03@30 tiles	170.10%

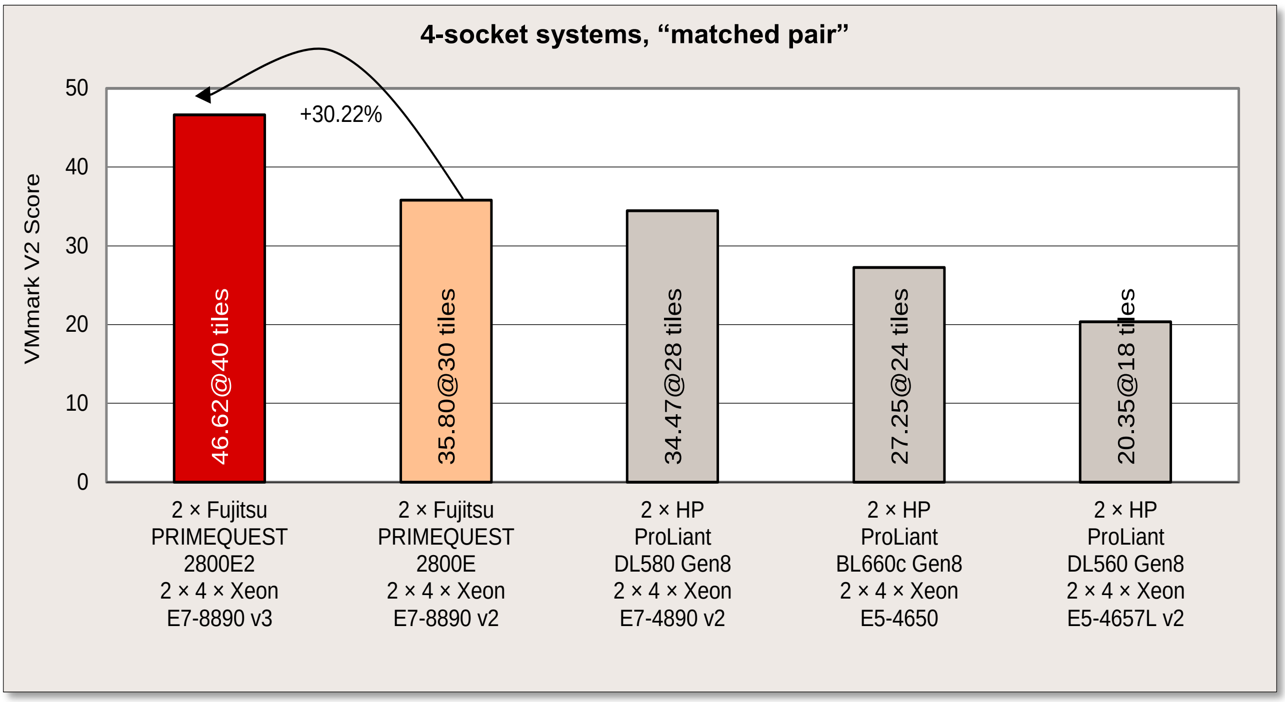
Measurement with two ESXi hosts in one single PRIMEQUEST 2800E2 (4-socket, “matched pair”)

“Performance Only” measurement result

On May 5, 2015 Fujitsu achieved with one single PRIMEQUEST 2800E2 system with Xeon E7-8890 v3 processors and VMware ESXi 6.0.0 a VMmark V2 score of “46.62@40 tiles” in a system configuration with a total of 2 × 72 processor cores and when using two identical servers/partitions in the “System under Test” (SUT). With this result the PRIMEQUEST 2800E2 is in the official VMmark V2 ranking the most powerful 4-socket server in a “matched pair” configuration consisting of two identical hosts (valid as of benchmark results publication date).

All comparisons for the competitor products reflect the status of 5th May 2015. The current VMmark V2 results as well as the detailed results and configuration data are available at http://www.vmware.com/a/vmmark/.

The diagram shows the result of the PRIMEQUEST 2800E2 in comparison with the best 4-socket systems in a “matched pair” configuration.



The table opposite shows the difference in the score (in %) between the Fujitsu system and other 4-socket systems in a “matched pair” configuration.

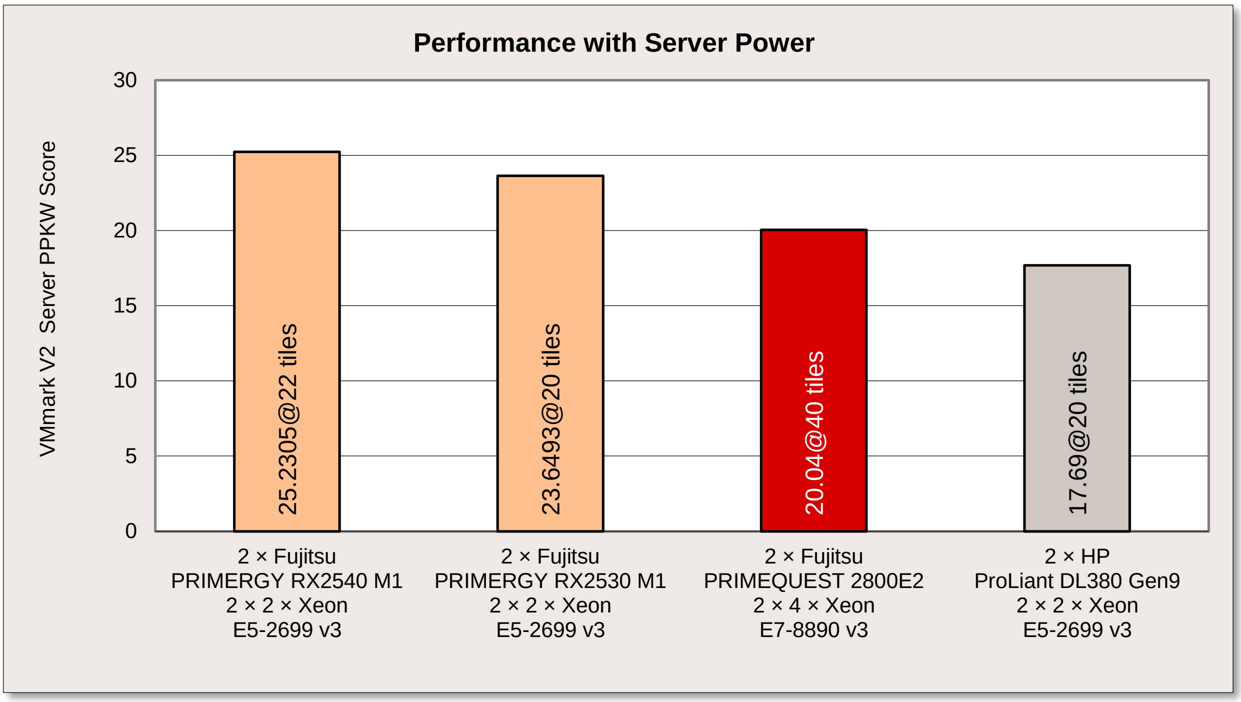
4-socket systems, “matched pair”	VMmark V2 score	Difference
Fujitsu PRIMEQUEST 2800E2	46.62@40 tiles	
Fujitsu PRIMEQUEST 2800E	35.80@30 tiles	30.22%
HP ProLiant DL580 Gen8	34.47@28 tiles	35.25%
HP ProLiant BL660c Gen8	27.25@24 tiles	71.08%
HP ProLiant DL560 Gen8	20.35@18 tiles	129.09%

“Performance with Server Power” measurement result

On May 5, 2015 Fujitsu achieved with one single PRIMEQUEST 2800E2 system with Xeon E7-8890 v3 processors and VMware ESXi 6.0.0 a VMmark V2 “Server PPKW Score” of “20.041@40 tiles” in a system configuration with a total of 2 × 72 processor cores and when using two identical servers/partitions in the “System under Test” (SUT). With this result the PRIMEQUEST 2800E2 is in the official VMmark V2 “Performance with Server Power” ranking the most energy-efficient 4-socket server worldwide (valid as of benchmark results publication date).

All comparisons for the competitor products reflect the status of 5th May 2015. The current VMmark V2 results as well as the detailed results and configuration data are available at http://www.vmware.com/a/vmmark/.

The diagram shows all VMmark V2 “Performance with Server Power“ results.



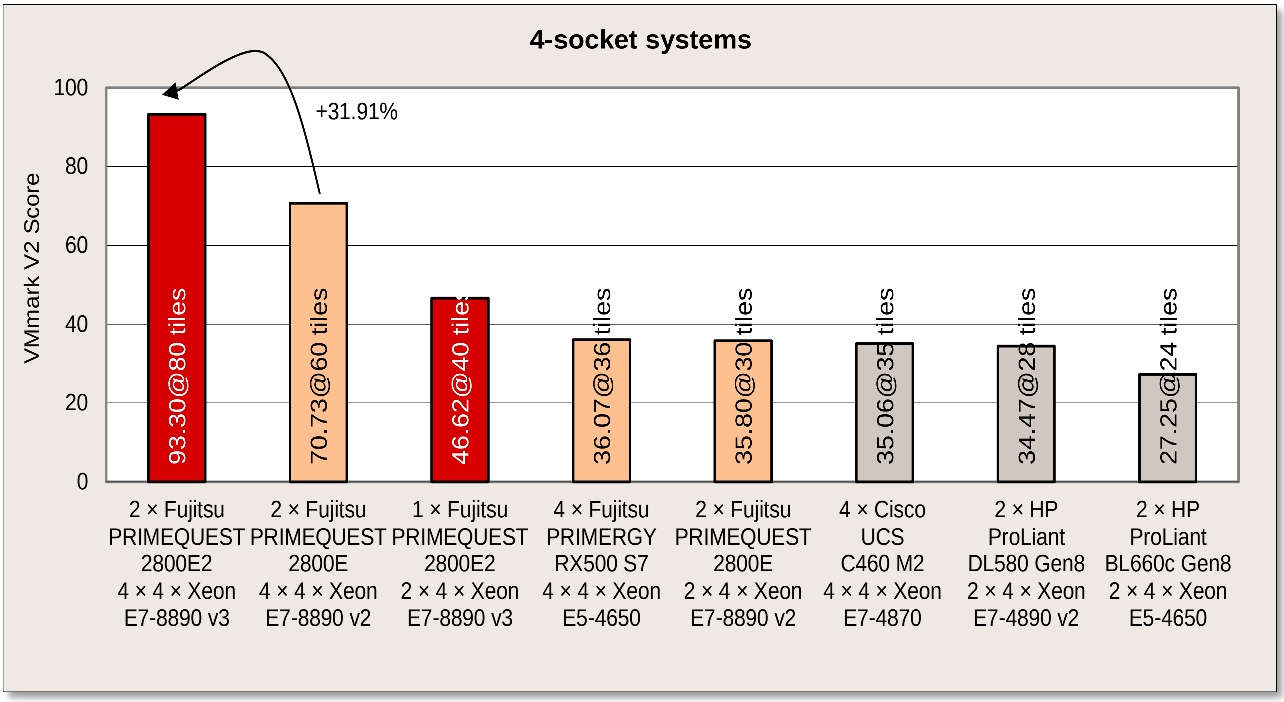
Measurement with four ESXi hosts in two PRIMEQUEST 2800E2 (4-socket, “uniform hosts”)

“Performance Only” measurement result

On May 12, 2015 Fujitsu achieved with two PRIMEQUEST 2800E2 systems with Xeon E7-8890 v3 processors and VMware ESXi 6.0.0 a VMmark V2 score of “93.30@80 tiles” in a system configuration with a total of 4 × 72 processor cores and when using four identical servers/partitions in the “System under Test” (SUT). With this result the PRIMEQUEST 2800E2 is in the official VMmark V2 ranking the most powerful 4-socket server (valid as of benchmark results publication date).

All comparisons for the competitor products reflect the status of 12th May 2015. The current VMmark V2 results as well as the detailed results and configuration data are available at http://www.vmware.com/a/vmmark/.

The diagram shows the result of the PRIMEQUEST 2800E2 in comparison with the best 4-socket systems.



The table opposite shows the difference in the score (in %) between the Fujitsu system and other 4-socket systems.

4-socket systems	#ESXi hosts	VMmark V2 score	Difference
2 × Fujitsu PRIMEQUEST 2800E2	4	93.30@80 tiles	
2 × Fujitsu PRIMEQUEST 2800E	4	70.73@60 tiles	31.91%
2 × Fujitsu PRIMEQUEST 2800E2	2	46.62@40 tiles	100.13%
4 × Fujitsu PRIMERGY RX500 S7	4	36.07@36 tiles	158.66%
2 × Fujitsu PRIMEQUEST 2800E	2	35.80@30 tiles	160.61%
4 × Cisco UCS C460 M2	4	35.06@35 tiles	166.12%
2 × HP ProLiant DL580 Gen8	2	34.47@28 tiles	170.67%
2 × HP ProLiant BL660c Gen8	2	27.25@24 tiles	242.39%

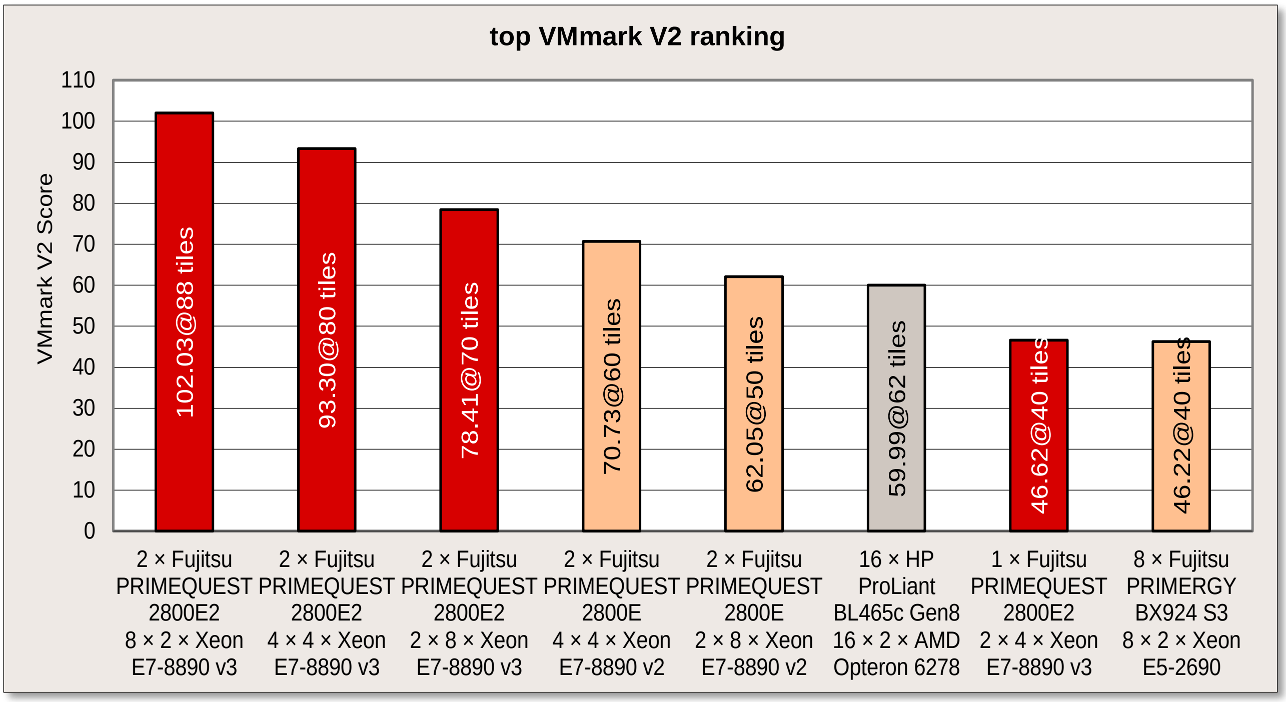
Measurement with eight ESXi hosts in two PRIMEQUEST 2800E2 (2-socket, "uniform hosts")

"Performance Only" measurement result

On May 12, 2015 Fujitsu achieved with two PRIMEQUEST 2800E2 systems with Xeon E7-8890 v3 processors and VMware ESXi 6.0.0 a VMmark V2 score of "102.03@88 tiles" in a system configuration with a total of 8 × 36 processor cores and when using eight identical servers/partitions in the "System under Test" (SUT). With this result the PRIMEQUEST 2800E2 is in the official VMmark V2 ranking the most powerful server and thus achieves the absolutely best VMmark V2 value (valid as of benchmark results publication date).

All comparisons for the competitor products reflect the status of 12th May 2015. The current VMmark V2 results as well as the detailed results and configuration data are available at http://www.vmware.com/a/vmmark/.

The diagram shows the top VMmark V2 ranking with the result of the PRIMEQUEST 2800E in comparison to the other VMmark V2 results.



The table below shows the difference in the score (in %) between the Fujitsu system and the other configurations.

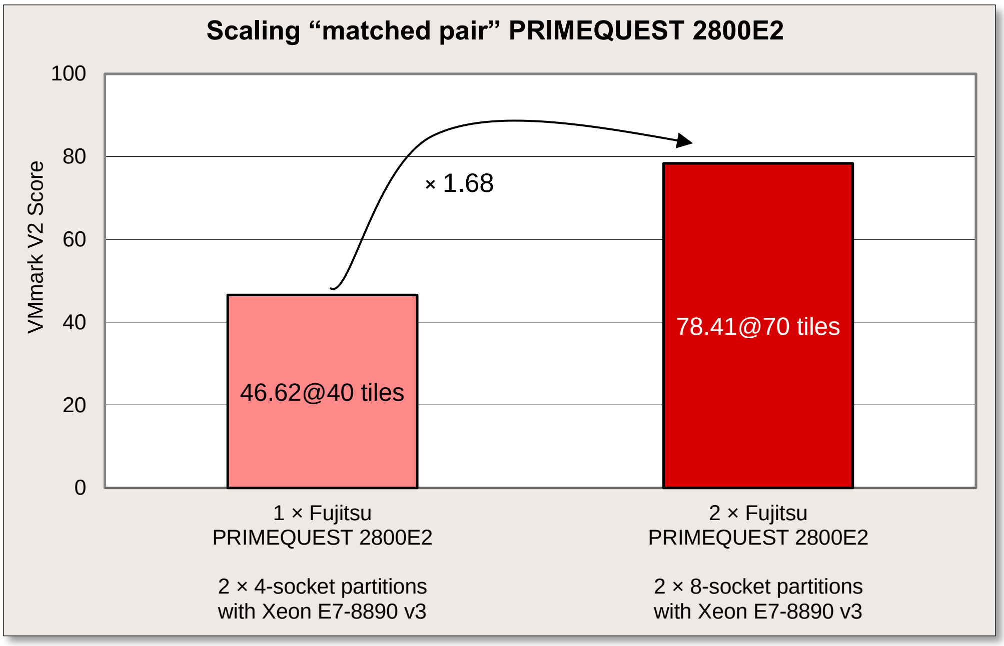
System units	#ESXi hosts	#Sockets	VMmark V2 Score	Difference
2 × Fujitsu PRIMEQUEST 2800E2	8	16 (2 × 8)	102.03@88 tiles	
2 × Fujitsu PRIMEQUEST 2800E2	4	16 (4 × 4)	93.30@80 tiles	9.36%
2 × Fujitsu PRIMEQUEST 2800E2	2	16 (2 × 8)	78.41@70 tiles	30.12%
2 × Fujitsu PRIMEQUEST 2800E	4	16 (4 × 4)	70.73@60 tiles	44.25%
2 × Fujitsu PRIMEQUEST 2800E	2	16 (2 × 8)	62.05@50 tiles	64.43%
16 × HP ProLiant BL465c Gen8	16	32 (16 × 2)	59.99@62 tiles	70.08%
1 × Fujitsu PRIMEQUEST 2800E2	2	8 (2 × 4)	46.62@40 tiles	118.85%
8 × Fujitsu PRIMERGY BX924 S3	8	16 (8 × 2)	46.22@40 tiles	120.75%

The gap between the configurations in first, second and third place is particularly notable. Due to the relatively few vCPUs per VM, the VMmark V2 load profile is very accommodating to systems with a few CPU sockets. In this case, the configuration with 8 × 2-socket partitions is more efficient than the configuration with 4 × 4-socket partitions or 2 × 8-socket partitions. This emphasizes how efficiently the PRIMEQUEST 2800E2 server can on account of the partitioning feature be adapted to suit a specific load profile.

Scaling comparison

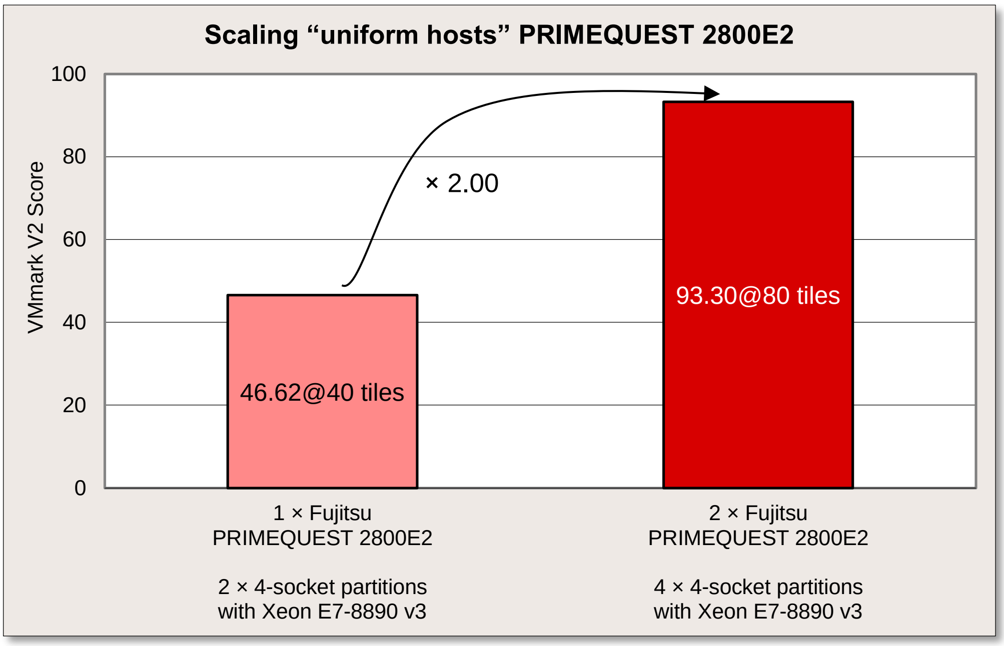
Also of interest is the scaling of virtualization performance, first in the scale-up and then in the scale-out scenario.

First the question arises here as to how well the performance scales from configurations with four sockets to configurations with eight sockets.



The better the scaling, the lower the overhead usually caused by the shared use of resources within a cluster. The scaling factor also depends on the application. If the server is used as a virtualization platform for server consolidation, the overall system scales with a factor of 1.68 respectively.

When operated with four hosts, the PRIMEQUEST 2800E2 achieves twice the performance as with two hosts, as is illustrated in the diagram below.



STREAM

Benchmark description

STREAM is a synthetic benchmark that has been used for many years to determine memory throughput and which was developed by John McCalpin during his professorship at the University of Delaware. Today STREAM is supported at the University of Virginia, where the source code can be downloaded in either Fortran or C. STREAM continues to play an important role in the HPC environment in particular. It is for example an integral part of the HPC Challenge benchmark suite.

The benchmark is designed in such a way that it can be used both on PCs and on server systems. The unit of measurement of the benchmark is GB/s, i.e. the number of gigabytes that can be read and written per second.

STREAM measures the memory throughput for sequential accesses. These can generally be performed more efficiently than accesses that are randomly distributed on the memory, because the processor caches are used for sequential access.

Before execution the source code is adapted to the environment to be measured. Therefore, the size of the data area must be at least 12 times larger than the total of all last-level processor caches so that these have as little influence as possible on the result. The OpenMP program library is used to enable selected parts of the program to be executed in parallel during the runtime of the benchmark, consequently achieving optimal load distribution to the available processor cores.

During implementation the defined data area, consisting of 8-byte elements, is successively copied to four types, and arithmetic calculations are also performed to some extent.

Type	Execution	Bytes per step	Floating-point calculation per step
COPY	a(i) = b(i)	16	0
SCALE	a(i) = q × b(i)	16	1
SUM	a(i) = b(i) + c(i)	24	1
TRIAD	a(i) = b(i) + q × c(i)	24	2

The throughput is output in GB/s for each type of calculation. The differences between the various values are usually only minor on modern systems. In general, only the determined TRIAD value is used as a comparison.

The measured results primarily depend on the clock frequency of the memory modules; the processors influence the arithmetic calculations.

This chapter specifies throughputs on a basis of 10 (1 GB/s = 10^9 Byte/s).

Benchmark environment

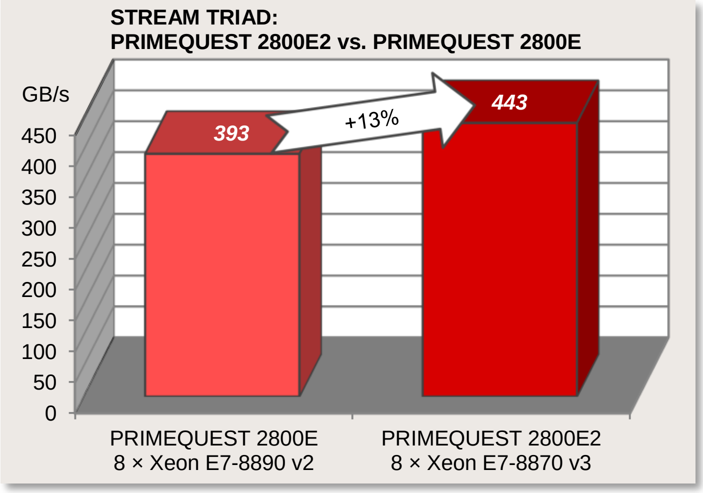
System Under Test (SUT)	
Hardware	
Model	PRIMEQUEST 2800E2
Processor	8 processors of Intel® Xeon® Processor E7-8800 v3 Product Family
Memory	64 × 32GB (2x16GB) 2Rx4 DDR4-2133 R ECC
Software	
BIOS settings	EnergyPerformance = Performance
Operating system	Red Hat Enterprise Linux Server release 6.6
Operating system settings	Transparent Huge Pages inactivated
Compiler	Intel C++ Composer XE 2015 for Linux
Benchmark	STREAM version 5.10

Some components may not be available in all countries or sales regions.

Benchmark results

Processor	Memory Frequency [MHz]	Max. Memory Bandwidth [GB/s]	Cores	Processor Frequency [GHz]	Number of Processors	TRIAD [GB/s]
Xeon E7-8893 v3	1600	102	4	3.20	8	397
Xeon E7-8891 v3	1600	102	10	2.80	8	436
Xeon E7-8860 v3	1600	102	16	2.20	8	427
Xeon E7-8867 v3	1600	102	16	2.50	8	442
Xeon E7-8870 v3	1600	102	18	2.10	8	443
Xeon E7-8880 v3	1600	102	18	2.30	8	442
Xeon E7-8890 v3	1600	102	18	2.50	8	442

The following diagram illustrates the throughput of the PRIMEQUEST 2800E2 in comparison to its predecessor, the PRIMEQUEST 2800E, in their most performant configuration.



Literature

PRIMEQUEST Servers

http://ts.fujitsu.com/primequest

PRIMEQUEST 2800E2

This White Paper:

http://docs.ts.fujitsu.com/dl.aspx?id=8608e639-9e8b-4e95-b2f2-a4b2b00339da
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PRIMEQUEST Performance

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Disk I/O: Performance of storage media and RAID controllers

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OLTP-2

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VMmark V2

Benchmark Overview VMmark V2
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vServCon

Benchmark Overview vServCon
http://docs.ts.fujitsu.com/dl.aspx?id=b953d1f3-6f98-4b93-95f5-8c8ba3db4e59

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