White Paper
FUJITSU Server PRIMEQUEST
Performance Report PRIMEQUEST 2800E

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

The PRIMEQUEST 2800E 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
1.2 2014-06-04

Contents

Document history

Version 1.0

New:

- Technical data
- SPECcpu2006
  Measurements with Intel® Xeon® Processor E7-8800 v2 Product Family
- Disk I/O
  Measurements with “RAID Ctrl SAS 6G 5/6 1GB (D3116C)” controller
- SAP SD
  Certification number 2014003
- vServCon
  Results for Intel® Xeon® Processor E7-8800 v2 Product Family
- STREAM
  Measurements with Intel® Xeon® Processor E7-8800 v2 Product Family

Version 1.1

New:

- TPC-E
  Measurement with Xeon E7-8890 v2
- VMmark V2
  Measurement with Xeon E7-8890 v2

Updated:

- SPECcpu2006
  Record information added
  Additional results for Intel® Xeon® Processor E7-8800 v2 Product Family
- STREAM
  Additional measurements with Intel® Xeon® Processor E7-8800 v2 Product Family

Version 1.2

New:

- OLTP-2
  Results for Intel® Xeon® Processor E7-8800 v2 Product Family

Updated:

- Technical data
  Text regarding Turbo mode updated

Technical data

PRIMEQUEST 2800E

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 2800E
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® C602J series
Number of sockets	2
Number of processors orderable	1 – 2
Processor type	Intel® Xeon® Processor E7-8800 v2 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 (1GbE) PQ2800E: 2 × 1 Gbit/s I/O Unit (10GbE ,2xbase T ports) PQ2800E: 2 × 10 Gbit/s
PCI slots	I/O Unit (1GbE) PQ2800E: 4 × PCI-Express 3.0 x8 I/O Unit (10GbE ,2xbase T ports) 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. All-Core Turbo Frequency [Ghz]	Max. Turbo Frequency [Ghz]	Max. Memory Frequency [MHz]	TDP [Watt]
Xeon E7-8893 v2	6	12	37.5	8.00	3.40	3.50	3.70	1600	155
Xeon E7-8857 v2	12	12	30	8.00	3.00	3.40	3.60	1600	130
Xeon E7-8850 v2	12	24	24	7.20	2.30	2.60	2.80	1333	105
Xeon E7-8870 v2	15	30	30	8.00	2.30	2.70	2.90	1600	130
Xeon E7-8880 v2	15	30	37.5	8.00	2.50	2.90	3.10	1600	130
Xeon E7-8890 v2	15	30	37.5	8.00	2.80	3.20	3.40	1600	155

All the processors that can be ordered with the PRIMEQUEST 2800E 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, whereas "Max. All-Core Turbo Frequency" specifies the theoretical frequency maximum when all the cores of a processor are active. 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 all-core 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 all-core 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 L DDR3-1600 R ECC (2 × 8 GB 1Rx4 PC3L-12800R)	16	1	4	1600	✓		✓	✓
32GB (2x16GB) 2Rx4 L DDR3-1600 R ECC (2 × 16 GB 2Rx4 PC3L-12800R)	32	2	4	1600	✓		✓	✓
64GB (2x32GB) 4Rx4 L DDR3-1600 LR ECC (2 × 32 GB 4Rx4 PC3L-12800L)	64	4	4	1600	✓	✓	✓	✓
128GB (2x64GB) 8Rx4 L DDR3-1333 LR ECC (2 × 64 GB 8Rx4 PC3L-10600L)	128	8	4	1333	✓	✓	✓	✓

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 2800E.

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 2800E
Processor	8 processors of Intel® Xeon® Processor E7-8800 v2 Product Family
Memory	64 × 32GB (2x16GB) 2Rx4 L DDR3-1600 R ECC
Software	
BIOS settings	Energy Performance = Performance
Operating system	Red Hat Enterprise Linux Server release 6.5
Operating system settings	echo always > /sys/kernel/mm/redhat_transparent_hugepage/enabled
Compiler	C/C++: Version 14.0.0.080 of Intel C++ Studio XE for Linux Fortran: Version 14.0.0.080 of Intel Fortran Studio XE for Linux

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

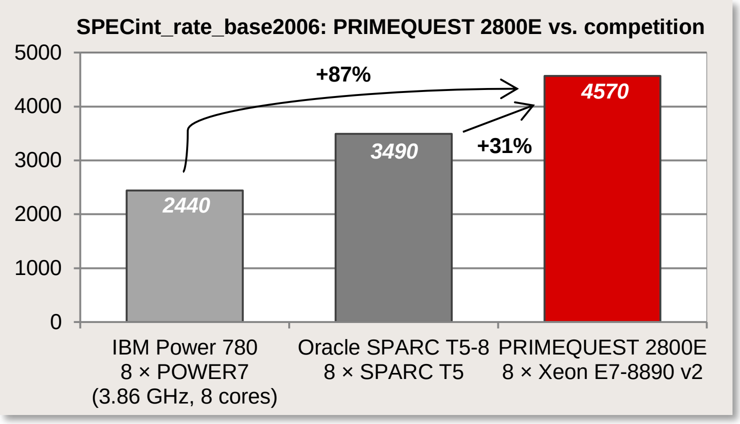
Benchmark results

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 (see the processor table in the section "Technical Data").

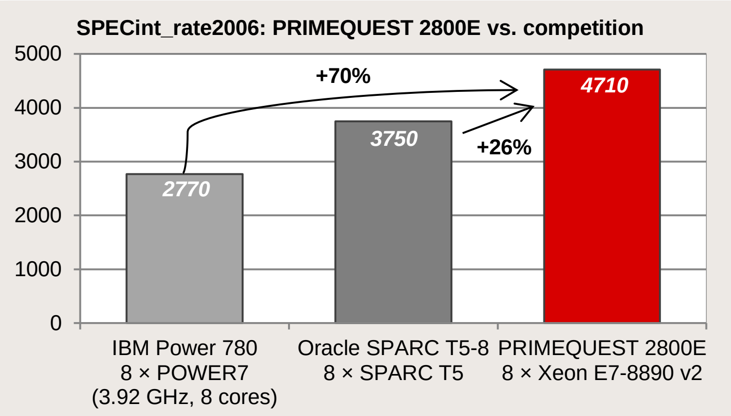
The results marked (est.) are estimates.

Processor	Number of processors	SPECint_rate_base2006	SPECint_rate2006	SPECfp_rate_base2006	SPECfp_rate2006
Xeon E7-8893 v2	8	2290	2380	1990	2050
Xeon E7-8857 v2	8	3520 (est.)		2850 (est.)	
Xeon E7-8850 v2	8	3140	3230	2530	2570
Xeon E7-8870 v2	8	3890	4000	2910	2970
Xeon E7-8880 v2	8	4300 (est.)		3150 (est.)	
Xeon E7-8890 v2	8	4570	4710	3240	3310

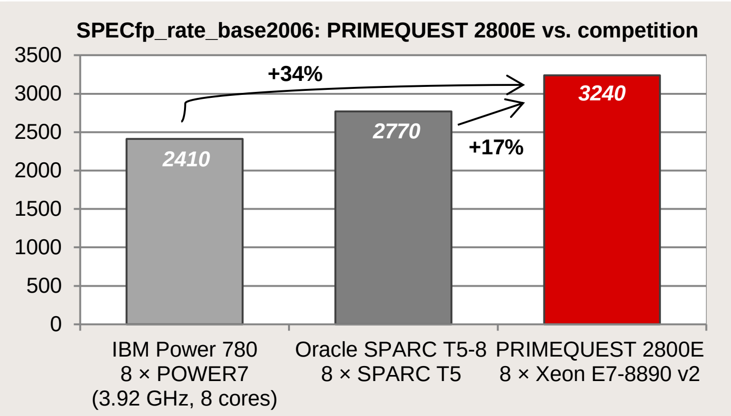
On 11th March 2014 the PRIMEQUEST 2800E with eight Xeon E7-8890 v2 processors was ranked first in the 8-socket systems category for the benchmark SPECint_rate_base2006.



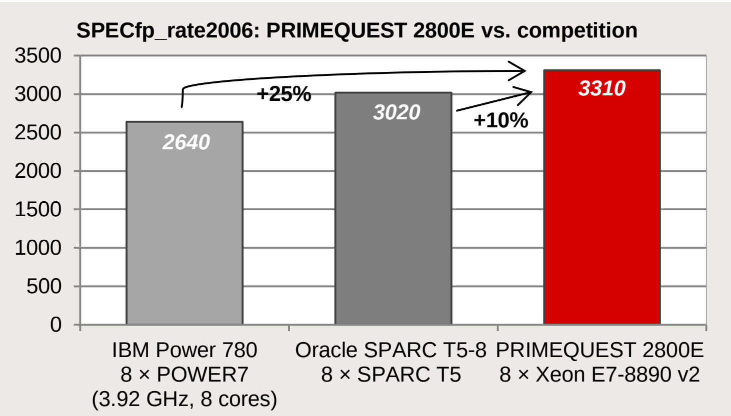
On 11th March 2014 the PRIMEQUEST 2800E with eight Xeon E7-8890 v2 processors was ranked first in the 8-socket systems category for the benchmark SPECint_rate2006.



On 11th March 2014 the PRIMEQUEST 2800E with eight Xeon E7-8890 v2 processors was ranked first in the 8-socket systems category for the benchmark SPECfp_rate_base2006.

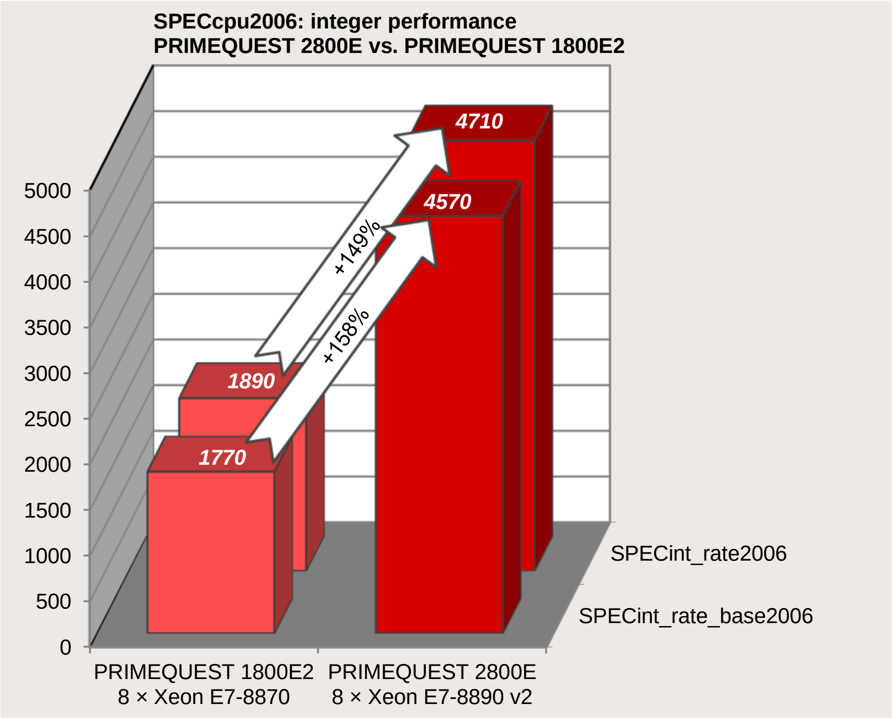


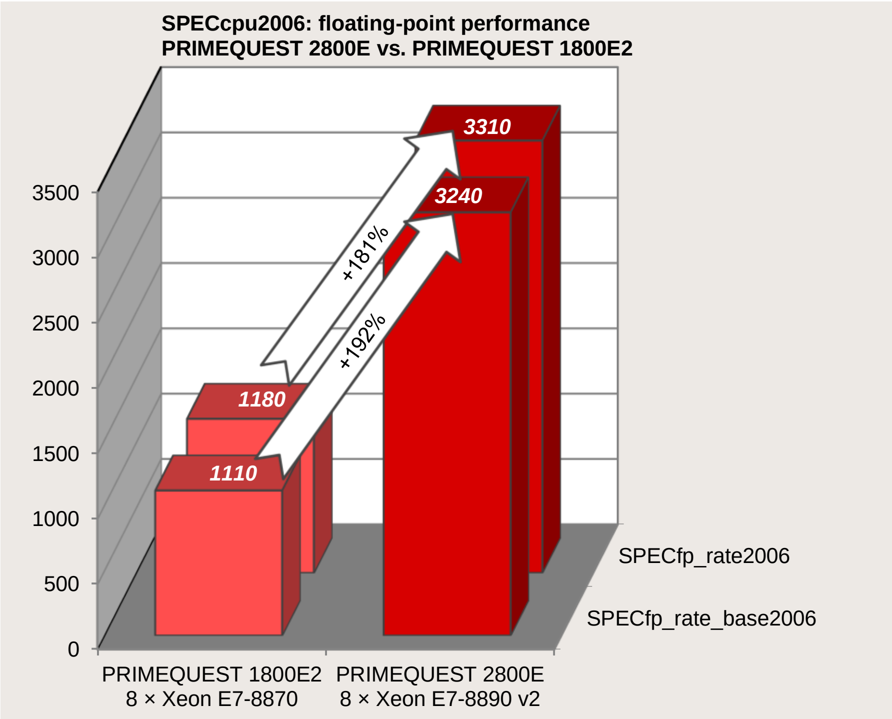
On 11th March 2014 the PRIMEQUEST 2800E with eight Xeon E7-8890 v2 processors was ranked first in the 8-socket systems category for the benchmark SPECfp_rate2006.



The current results can be found at http://www.spec.org/cpu2006/results.

The following two diagrams illustrate the throughput of the PRIMEQUEST 2800E in comparison to its predecessor PRIMEQUEST 1800E2, in their respective most performant configuration.





Disk I/O

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 hard disk 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 hard disk capacities 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 × “RAID Ctrl SAS 6G 5/6 1GB (D3116C)”
Drive	4 × EP HDD SAS 6 Gbit/s 2.5″ 15000 rpm 146 GB 4 × EP SSD SAS 12 Gbit/s 2.5″ 400 GB MLC MAIN
Software	
Operating system	Microsoft Windows Server 2012 Standard
Administration software	ServerView RAID Manager 5.7.2
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 2006.07.27.07
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 2800E in the light of disk-I/O performance. The selection of suitable components and the right settings of their parameters is important here. These two aspects should therefore be dealt with as preparation for the discussion of the performance values.

Components

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). When selecting the type of hard disk and number of hard disks you can move the weighting in the direction of storage capacity, performance, security or price. In order to enable a pre-selection of the hard disk types – depending on the required weighting – the hard disk types are divided into three classes:

- “Economic” (ECO): low-priced hard disks
- “Business Critical” (BC): very failsafe hard disks
- “Enterprise” (EP): very failsafe and very high-performance hard disks

The following table is a list of the hard disk types that have been available for the PRIMEQUEST 2800E since system release.

Drive class	Data medium type	Interface	Form factor	krpm
Enterprise	HDD	SAS 6G	2.5"	10, 15
Enterprise	SSD	SAS 12G	2.5"	-

SAS-HDDs with a rotational speed of 15 krpm have better access times and throughputs than comparable HDDs with a rotational speed of 10 krpm. The 6G interface has in the meantime established itself as the standard among the SAS-HDDs.

Of all the hard disk types SSDs offer on the one hand by far the highest transaction rates for random load profiles, and on the other hand the shortest access times. In return, however, the price per gigabyte of storage capacity is substantially higher.

More detailed performance statements about hard disk types are available in the white paper “Single Disk Performance”.

The maximum number of hard disks in the system depends on the system configuration. The PRIMEQUEST 2800E 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.

Subunit	Form factor	Interface	Number of PCIe controllers	Maximum number of hard disks
System Board	2.5"	SAS 6G	1	4
Disk Unit (1C)	2.5"	SAS 6G	1	4
Disk Unit (2C)	2.5"	SAS 6G	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.

After 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 2800E. 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
RAID Ctrl SAS 6G 5/6 1GB (D3116C) in System Board	LSI2208-1G (SB)	1 GB	SATA 3G/6G SAS 3G/6G	PCIe 3.0 x8	4 × 2.5"	0, 1, 1E, 5, 6, 10	-/✓
RAID Ctrl SAS 6G 5/6 1GB (D3116C) in Disk Unit (1C)	LSI2208-1G (DU-1C)	1 GB	SATA 3G/6G SAS 3G/6G	PCIe 3.0 x8	4 × 2.5"	0, 1, 1E, 5, 6, 10	-/✓
RAID Ctrl SAS 6G 5/6 1GB (D3116C) in Disk Unit (2C)	LSI2208-1G (DU-2C)	1 GB	SATA 3G/6G SAS 3G/6G	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	
LSI2208-1G (SB)	4 × SAS 6G	2060 MB/s	2.0	x4	**1716 MB/s**	-
LSI2208-1G (DU-1C)	4 × SAS 6G	2060 MB/s	2.0	x4	**1716 MB/s**	-
LSI2208-1G (DU-2C)	2 × SAS 6G	**1030 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 the hard disks has a great influence on disk-I/O performance. This is particular valid for HDDs. 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. The performance can as a result increase more than tenfold for specific access patterns and hard disk types. More information about the performance impact of the hard disk cache is available in the document "Single Disk Performance". 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 2800E if the configurations measured there are also supported by this system.

The performance values of the PRIMEQUEST 2800E 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 focus here is first placed on a single controller.

The performance values in the following tables use the established measurement variables, as already mentioned in the subsection Benchmark description. 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.

Random accesses (performance values in IO/s):

Configuration version: RAID Controller	Hard disk type	Form factor	#Disks	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]
LSI2208-1G (SB) / (DU-1C)	EP SAS HDD EP SAS SSD	2.5"	2	1	1109	863	*45000*	*9600*
			4	10	1936	1002	*51000*	*19400*
			4	0	2877	1462	126716	22378
			4	5	1630	924	*36000*	*9500*
LSI2208-1G (DU-2C)	EP SAS HDD EP SAS SSD	2.5"	2	1	1109	863	*45000*	*9600*
			2	0	1197	601	59060	9845

(*cursive*: calculated)

Sequential accesses (performance values in MB/s):

Configuration version: RAID Controller	Hard disk type	Form factor	#Disks	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]
LSI2208-1G (SB) / (DU-1C)	EP SAS HDD EP SAS SSD	2.5"	2	1	355	194	*1030*	*370*
			4	10	480	389	*1530*	*740*
			4	0	781	782	1534	1496
			4	5	605	584	*1510*	*1100*
LSI2208-1G (DU-2C)	EP SAS HDD EP SAS SSD	2.5"	2	1	355	194	*1030*	*370*
			2	0	389	386	1033	748

(*cursive*: calculated)

The use of one controller at its maximum configuration with powerful hard disks (configured as RAID 0) enables the PRIMEQUEST 2800E to achieve a throughput of up to 1534 MB/s for sequential load profiles and a transaction rate of up to 126716 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 10268 MB/s for sequential load profiles and a total transaction rate of up to 743104 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.

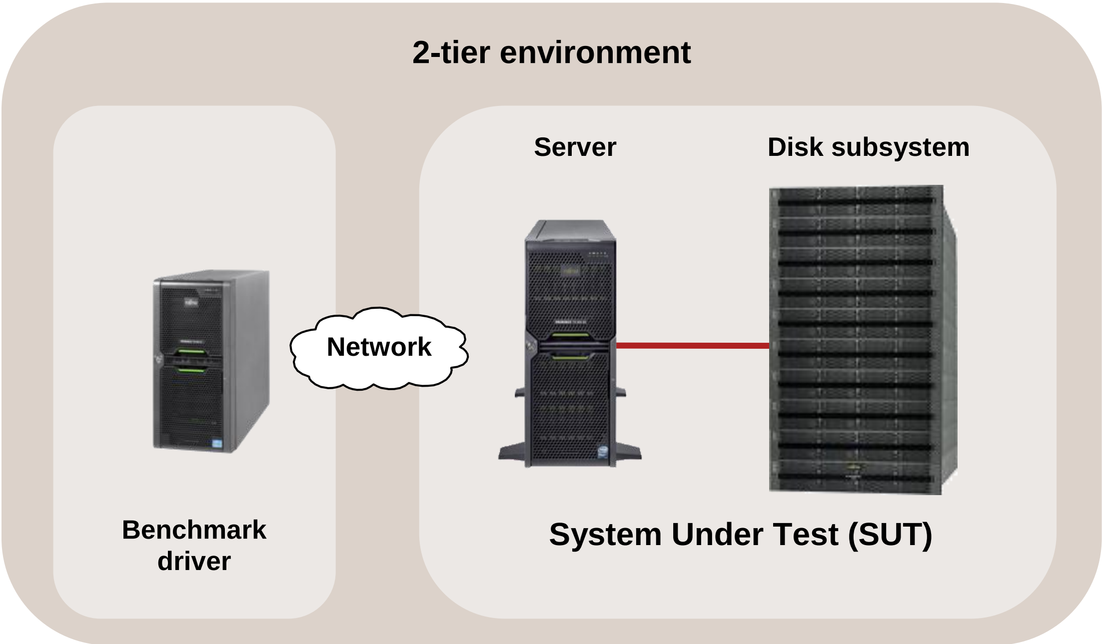
SAP AG has developed SAP Standard Application Benchmarks in order to verify the performance, stability and scaling of a SAP application system. The benchmarks, of which SD Benchmark is the most commonly used and most important, analyze the performance of the entire system and thus measure the quality 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 2800E
Processor	8 × Xeon E7-8890 v2
Memory	64 × 16GB (2x8GB) 1Rx4 L DDR3-1600 R ECC
Network interface	1Gbit/s LAN
Disk subsystem	PRIMEQUEST 2800E: 1 × RAID Controller 6Gbps 1GB Cache 1 × 300GB internal HDD 15krpm 3 × 600GB internal HDD 10krpm 1 × FC Ctrl 8Gb/s 2 Chan LPe12002 1 × FibreCAT CX4-480 Storage Unit
Power Supply Unit	4 × Power Supply 2.880W platinum hp
Software	
BIOS settings	Memory Operation Mode = Performance Mode DIMM Speed = Performance Mode
Operating system	Microsoft Windows Server 2012 Standard Edition
Database	Microsoft SQL Server 2012 Enterprise x64 Edition
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

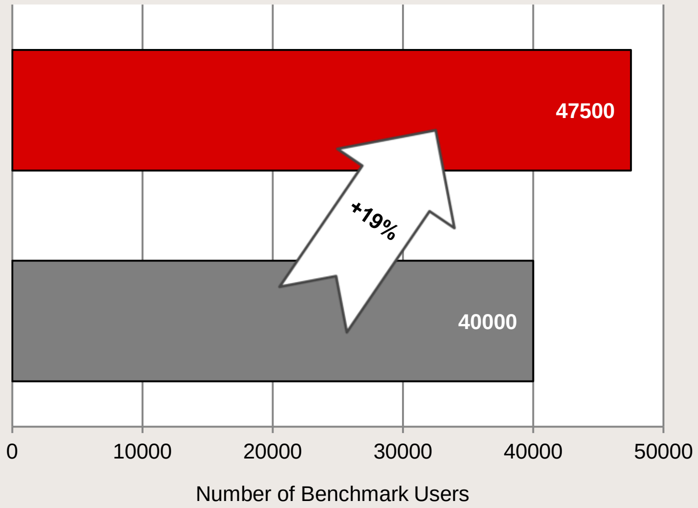
Certification number 2014003	
Number of SAP SD benchmark users	47500
Average dialog response time	0.97 seconds
Throughput Fully processed order line items/hour Dialog steps/hour SAPS	 5,193,670 15,581,000 259,680
Average database request time (dialog/update)	0.015 sec / 0.030 sec
CPU utilization of central server	99%
Operating system, central server	Windows Server 2012 Standard Edition
RDBMS	SQL Server 2012
SAP Business Suite software	SAP enhancement package 5 for SAP ERP 6.0
Configuration Central Server	Fujitsu PRIMEQUEST 2800E 8 processors / 120 cores / 240 threads Intel Xeon E7-8890 v2, 2.8GHz, 64KB L1 cache and 256KB L2 cache per core, 37.5 MB L3 cache per processor 1024 GB main memory

The PRIMEQUEST 2800E obtained the best 8 processor, two-tier SAP SD Standard Application Benchmark result (as of February 18, 2014). The latest SAP SD 2-tier results can be found at http://global.sap.com/solutions/benchmark/sd2tier.epx.

Two-Tier SAP SD results for 8 processor servers: PRIMEQUEST 2800E vs. next best 8-socket server

Fujitsu PRIMEQUEST 2800E
8 x Xeon E7-8890 v2
8 processors/120 cores/240 threads
1024 GB main memory
Windows Server 2012 Standard Edition
SQL Server 2012
SAP enhancement package 5 for SAP ERP 6.0
Certification number: 2014003

Oracle SPARC Server T5-8
8 x SPARC T5 3.6 GHz
8 processors/128 cores/1024 threads
2048 GB main memory
Solaris 11
Oracle 11g
SAP enhancement package 5 for SAP ERP 6.0
Certification number: 2013008

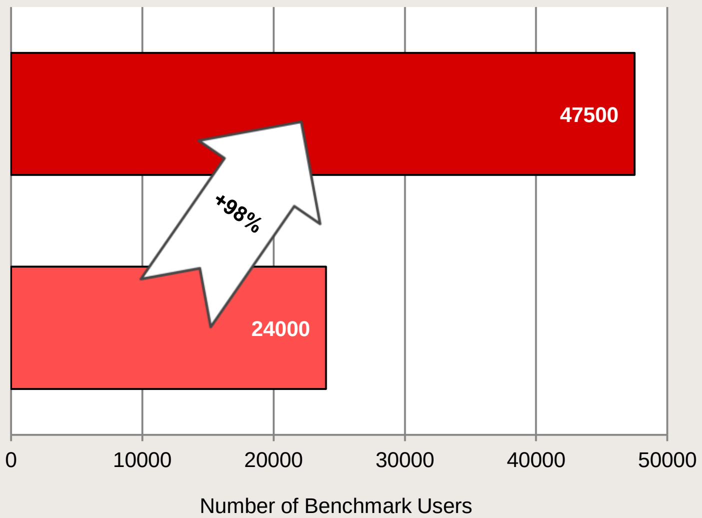


The following diagram illustrates the throughput of the PRIMEQUEST 2800E in comparison to its predecessor, the PRIMEQUEST 1800E2, in the respective most performant configuration.

Two-Tier SAP SD results: PRIMEQUEST 2800E vs. predecessor

Fujitsu PRIMEQUEST 2800E
8 x Xeon E7-8890 v2
8 processors/120 cores/240 threads
1024 GB main memory
Windows Server 2012 Standard Edition
SQL Server 2012
SAP enhancement package 5 for SAP ERP 6.0
Certification number: 2014003

Fujitsu PRIMEQUEST 1800E2
8 x Xeon E7-8870
8 processors/80 cores/160 threads
512 GB main memory
Windows Server 2008 R2 Enterprise Edition
SQL Server 2008
SAP enhancement package 4 for SAP ERP 6.0
Certification number: 2011017



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.

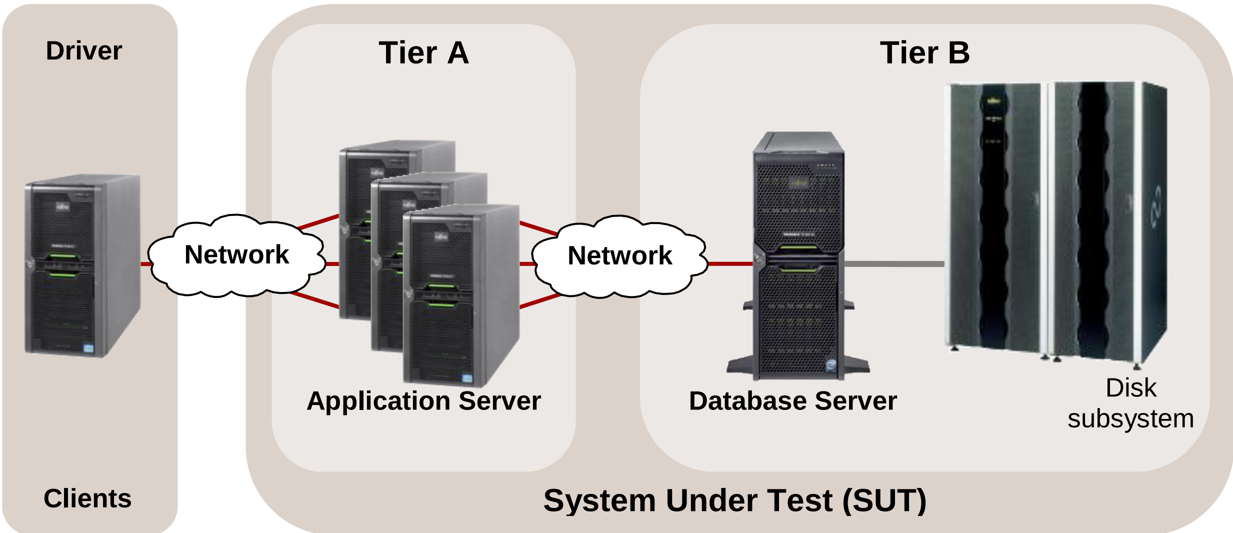
In contrast to benchmarks such as SPECint and TPC-E, which were standardized by independent bodies and for which adherence to the respective rules and regulations are monitored, OLTP-2 is an internal benchmark of Fujitsu. OLTP-2 is based on the well-known database benchmark TPC-E. OLTP-2 was designed 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:



Database Server (Tier B)	
Hardware	
Model	PRIMEQUEST 2800E
Processor	Intel® Xeon® Processor E7-8800 v2 Product Family
Memory	4096 GB: 64 × 64GB (2x32GB) 4Rx4 L DDR3-1600 LR ECC 2048 GB: 32 × 64GB (2x32GB) 4Rx4 L DDR3-1600 LR ECC 1024 GB: 16 × 64GB (2x32GB) 4Rx4 L DDR3-1600 LR ECC
Network interface	4 × onboard LAN 1 Gb/s
Disk subsystem	PRIMEQUEST 2800E: Onboard RAID Ctrl SAS 6G 5/6 1024MB (D3116C) 2 × 300 GB 10k rpm SAS Drives, RAID1 (OS), 2 × 400 GB SSD Drives, RAID1 (tempdb) 13 × LSI MegaRAID SAS 9286CV-8e 12 × JX40: 12 × 400 GB SSD Drive each, RAID5 (data) 1 × JX40: 12 × 300 GB 15k rpm SAS Drives, RAID10 (log)

Software	
BIOS	Version BA14025
Operating system	Microsoft Windows Server 2012 R2 Standard
Database	Microsoft SQL Server 2014 Enterprise

Application Server (Tier A)	
Hardware	
Model	2 × PRIMERGY RX200 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	2 × 250 GB 7.2k rpm SATA Drive
Software	
Operating system	Microsoft Windows Server 2012 Standard

Client	
Hardware	
Model	2 × PRIMERGY RX200 S7
Processor	2 × Xeon E5-2670
Memory	32 GB, 1600 MHz registered ECC DDR3
Network interface	2 × onboard LAN 1 Gb/s 1 × Dual Port LAN 1Gb/s
Disk subsystem	1 × 250 GB 7.2k rpm SATA Drive
Software	
Operating system	Microsoft Windows Server 2008 R2 Standard
Benchmark	OLTP-2 Software EGen version 1.12.0

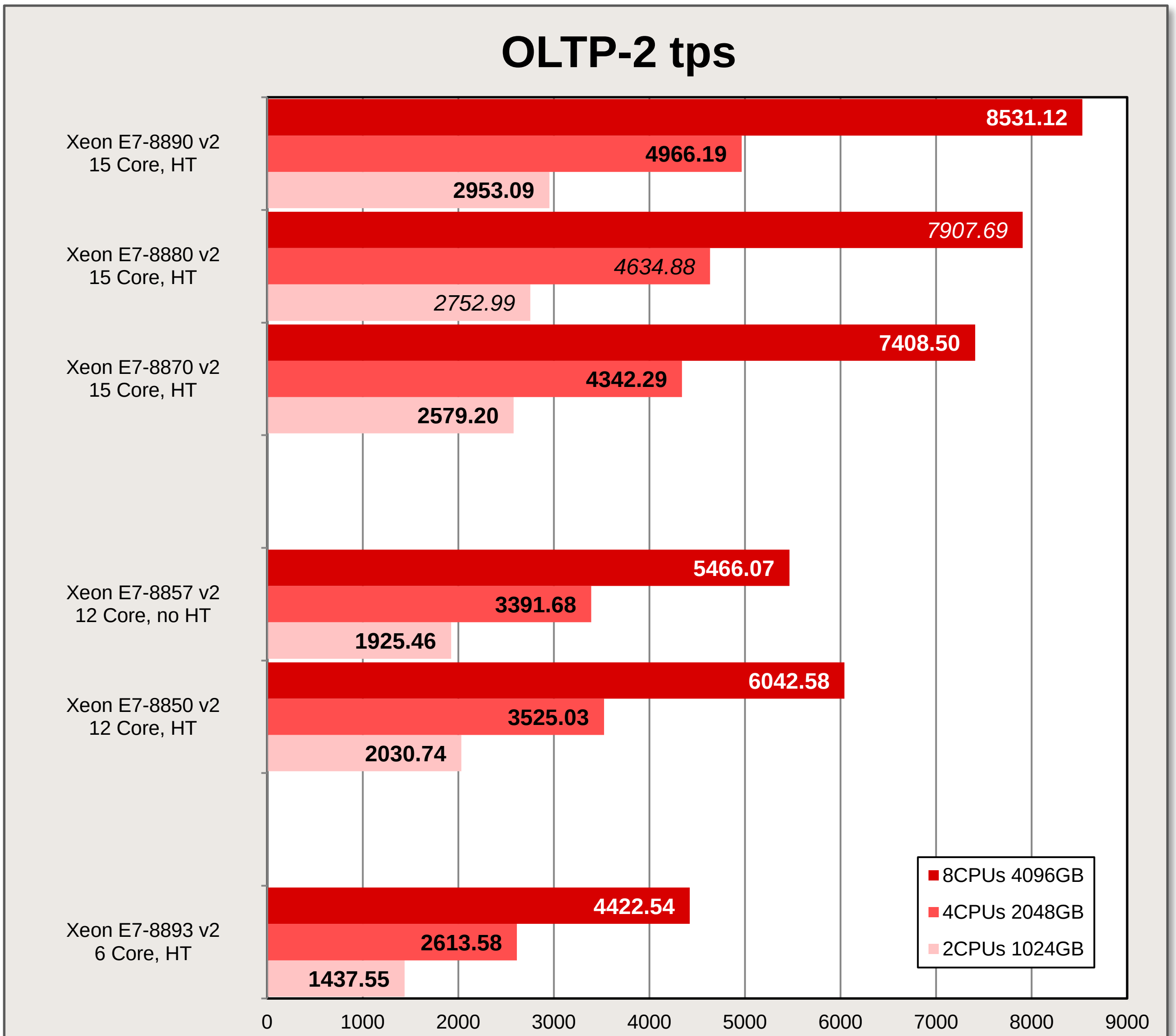
Some components may not be available in all countries / sales regions.

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 1333 MHz). Further information about memory performance can be found in the White Paper Memory performance of Xeon E7-8800 / 4800 v2 (Ivy Bridge-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 E7-8800 v2 Product Family.



HT: Hyper-Threading

bold: measured
cursive: calculated

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 v2) with the value of the processor with the highest performance (Xeon E7-8890 v2), the result is a 1.9-fold increase in performance.

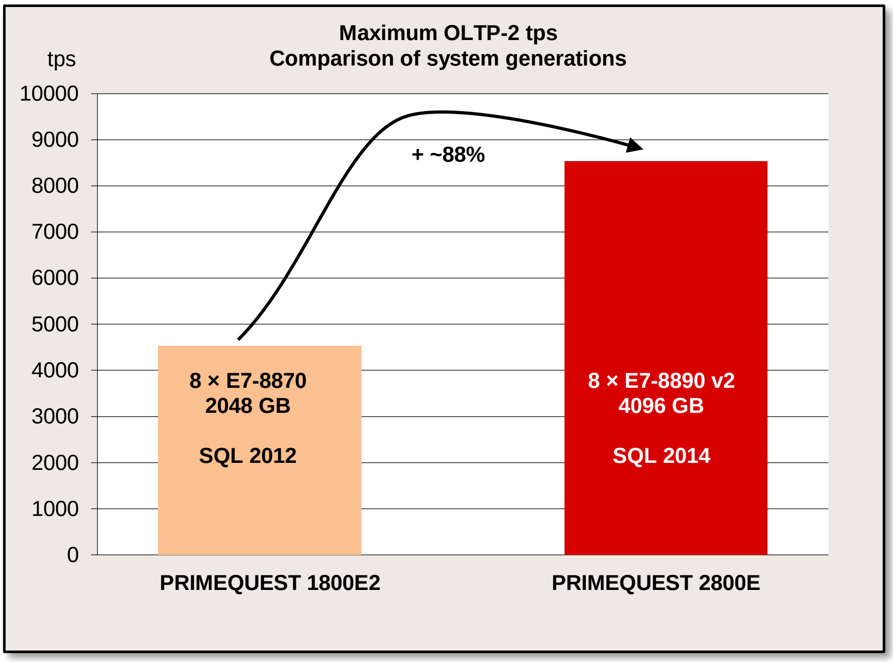
Based on the number of cores the processors can be divided into different performance groups:

The start is made with Xeon E7-8893 v2 as processor with four cores and Hyper-Threading.

The group of 12-core processors offers in this processor series a medium-range OLTP-2 performance. Due to the various technical features of the processors in this group (see. “Technical data”) it is possible to choose the right CPU depending on the usage scenario. Thus, the Xeon E7-8857 v2 with its high CPU frequency also supplies a good OLTP-2 value without Hyper-Threading.

The group of processors with 15 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 7408.50 tps (8 × Xeon E7-8870 v2) and 8531.12 tps (8 × Xeon E7-8890 v2) 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 88%.



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 April 2014 Fujitsu submitted a TPC-E benchmark result for the PRIMEQUEST 2800E with the 15-core processor Intel Xeon E7-8890 v2 and 4 TB memory.

The results show an enormous increase in performance compared with the PRIMEQUEST 1800E2 with a simultaneous reduction in costs.

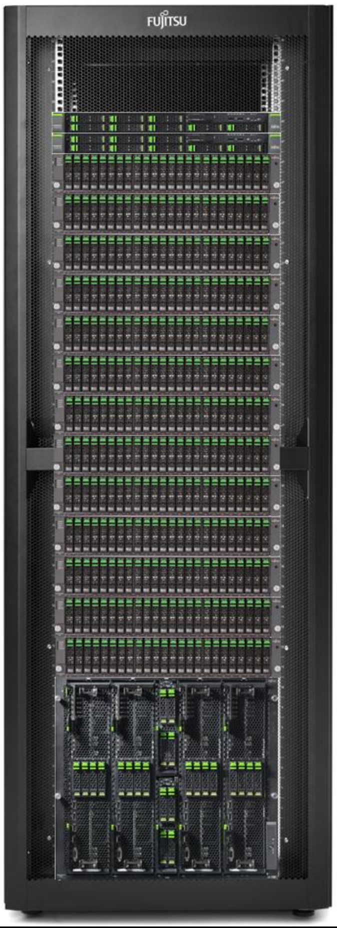
FUJITSU	FUJITSU Server PRIMEQUEST 2800E	**TPC-E 1.12.0** **TPC Pricing 1.7.0** Report Date April 14, 2014

TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
8,582.52 tpsE	**$ 205.43 USD per tpsE**	**May 1, 2014**	**$ 1,763,068 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**	**8/120/240**	**4 TB**

SUT



Tier A
2x PRIMERGY RX200 S8 (each with)
2x Intel Xeon E5-2667 v2 3.30 GHz
64 GB Memory
2x 250 GB 7.2k rpm SATA Drive
2x onboard LAN 1 Gb/s
1x Dual Port LAN 1 Gb/s

Tier B
PRIMEQUEST 2800E
8x Intel Xeon E7-8890 v2 2.80 GHz
4 TB Memory
2x 300 GB 10k rpm SAS Drives
2x 400 GB SSD Drives
4x onboard LAN 1 Gb/s
14x SAS RAID Controller

Storage
1x PRIMECENTER Rack
13x ETERNUS JX40
166x 400 GB SSD Drives
12x 300 GB 15k rpm SAS Drives

Initial Database Size	Redundancy Level 1	Storage
36,951 GB	**RAID-5 data and RAID-10 log** **RAID-1 tempdb**	**166 x 400 GB SSD** **12 x 300 GB 15k rpm HDD** **2 x 400 GB SSD tempdb**

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

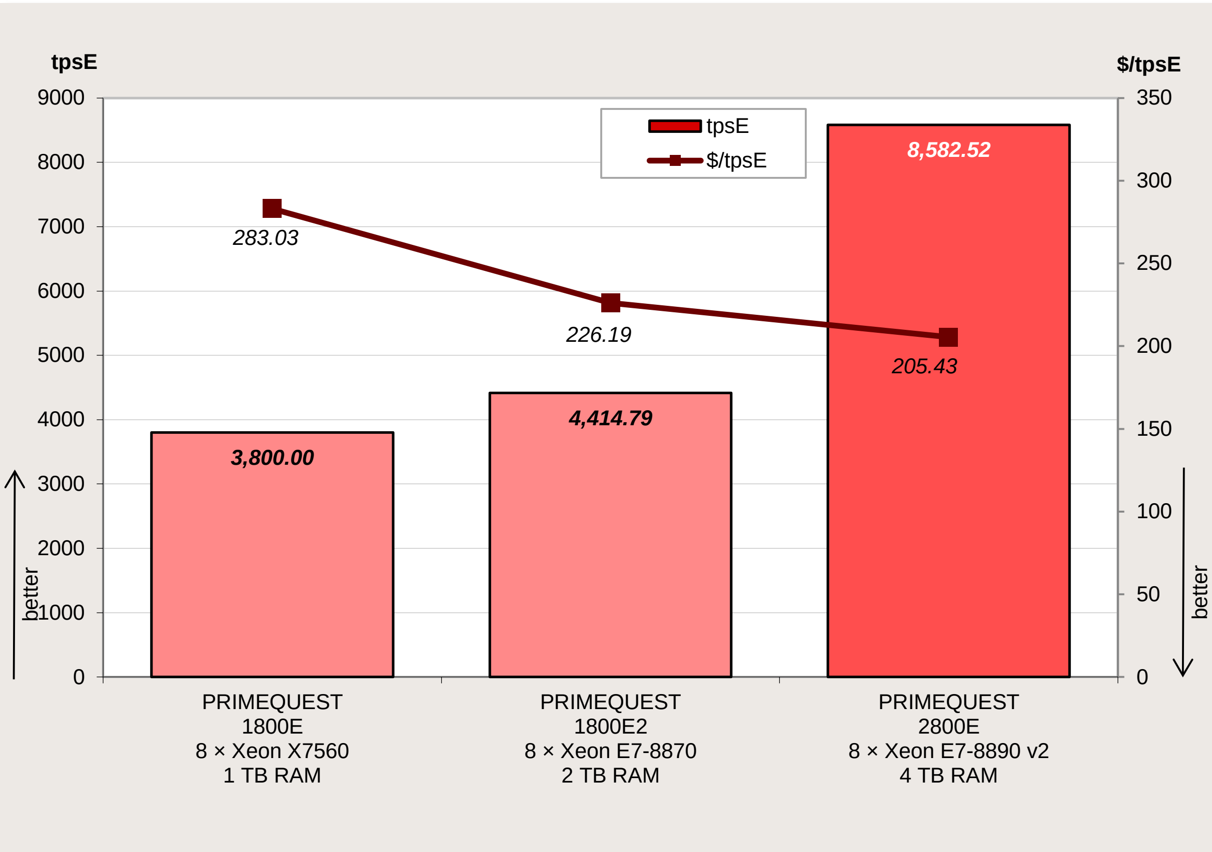
More details about this TPC-E result, in particular the Full Disclosure Report, can be found via the TPC web page http://www.tpc.org/tpce/results/tpce_result_detail.asp?id=114041401.

In April 2014, Fujitsu is represented with 15 results in the TPC-E list.

System and Processors	Throughput	Price / Performance	Watts/ tpsE	Availability Date
PRIMERGY TX300 S4 with 2 × Xeon X5460	317.45 tpsE	$523.49 per tpsE	-	August 30, 2008
PRIMERGY RX600 S4 with 4 × Xeon X7350	492.34 tpsE	$559.88 per tpsE	-	January 1, 2009
PRIMERGY RX600 S4 with 4 × Xeon X7460	721.40 tpsE	$459.71 per tpsE	-	January 1, 2009
PRIMERGY RX300 S5 with 2 × Xeon X5570	800.00 tpsE	$343.91 per tpsE	-	April 1, 2009
PRIMERGY RX600 S5 with 4 × Xeon X7560	2046.96 tpsE	$193.68 per tpsE	-	September 1, 2010
PRIMERGY RX900 S1 with 8 × Xeon X7560	3800.00 tpsE	$245.82 per tpsE	-	October 1, 2010
PRIMEQUEST 1800E with 8 × Xeon X7560	3800.00 tpsE	$283.03 per tpsE	-	October 1, 2010
PRIMERGY RX300 S6 with 2 × Xeon X5680	1246.13 tpsE	$191.48 per tpsE	-	November 1, 2010
PRIMERGY RX300 S6 with 2 × Xeon X5690	1268.30 tpsE	$183.94 per tpsE	0.93	March 1, 2011
PRIMERGY RX900 S2 with 8 × Xeon E7-8870	4555.54 tpsE	$217.27 per tpsE	1.00	July 1, 2011
PRIMEQUEST 1800E2 with 8 × Xeon E7-8870	4414.79 tpsE	$226.19 per tpsE	1.09	July 1, 2011
PRIMERGY RX300 S7 with 2 × Xeon E5-2690	1871.81 tpsE	$175.57 per tpsE	0.69	August 17, 2012
PRIMERGY RX500 S7 with 4 × Xeon E5-4650	2651.27 tpsE	$161.95 per tpsE	0.68	November 1, 2012
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

See the TPC web site for more information and all the TPC-E 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 2800E system.



In comparison with the PRIMEQUEST 1800E2 the increase in performance is +94% and in comparison with the PRIMEQUEST 1800E +126%. The price per performance is $205.43/tpsE. Compared with the PRIMEQUEST 1800E2 the costs are reduced to 91% and with the PRIMEQUEST 1800E to 73%.

The following overview shows the best TPC-E results (as of April 14th, 2014) and the corresponding price per performance ratios for configurations using eight processors. PRIMEQUEST 2800E with 8582.52 tpsE has the highest performance value of all TPC-E publications and the second-best price/performance value of $205.43/tpsE of all 8-socket systems.

System		Processor type	Microsoft SQL Server Version	tpsE (higher is better)	$/tpsE (lower is better)	availability date
Fujitsu	**PRIMEQUEST 2800E**	8×E7-8890 v2	SQL Server 2014 Enterprise Edition	**8582.52**	**205.43**	2014-05-01
IBM	System x3850 X5	8×E7-8870	SQL Server 2012 Enterprise Edition	5457.00	249.58	2013-03-08
NEC	Express5800/A1080a-E	8×E7-8870	SQL Server 2012 Enterprise Edition	4614.00	450.18	2012-04-02
IBM	System x3850 X5	8×E7-8870	SQL Server 2008 Enterprise Edition R2	4593.00	140.56	2011-08-26
Fujitsu	**PRIMERGY RX900 S2**	8×E7-8870	SQL Server 2008 Datacenter Edition R2	4555.00	217.27	2011-07-01
Fujitsu	**PRIMEQUEST 1800E2**	8×E7-8870	SQL Server 2008 Enterprise Edition R2	4414.00	226.19	2011-07-01
NEC	Express5800/A1080a-E	8×E7-8870	SQL Server 2008 Enterprise Edition R2	4200.00	287.42	2011-08-31
Fujitsu	**PRIMERGY RX900 S1**	8×X7560	SQL Server 2008 Datacenter Edition R2	3800.00	245.82	2010-10-01
Fujitsu	**PRIMEQUEST 1800E**	8×X7560	SQL Server 2008 Datacenter Edition R2	3800.00	283.03	2010-10-01
NEC	Express5800/A1080a-E	8×X7560	SQL Server 2008 Datacenter Edition R2	3141.00	768.92	2010-07-30
Unisys	ES7000 Model 7600R Enterprise Server (8s)	8×X7460	SQL Server 2008 Enterprise Edition x64	1165.00	783.56	2009-04-13
IBM	System x3950 M2	8×X7350	SQL Server 2008 Enterprise Edition x64	804.00	1450.05	2008-08-30

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

In the comparison it should be noted that the PRIMEQUEST 2800E was measured with the current Microsoft SQL Server 2014 version. A change in the Microsoft license policy for Microsoft SQL Server 2012 and 2014 compared with Microsoft SQL Server 2008 R2 results in various costs that influence the price/performance value. Due to the change from processor-based licenses for Microsoft SQL Server 2008 R2 to 2-core-based licenses for Microsoft SQL Server 2012 and 2014 the outcome for configurations with processors that have more than two cores is higher license costs with Microsoft SQL Server 2012 and 2014 than with Microsoft SQL Server 2008 R2.

vServCon

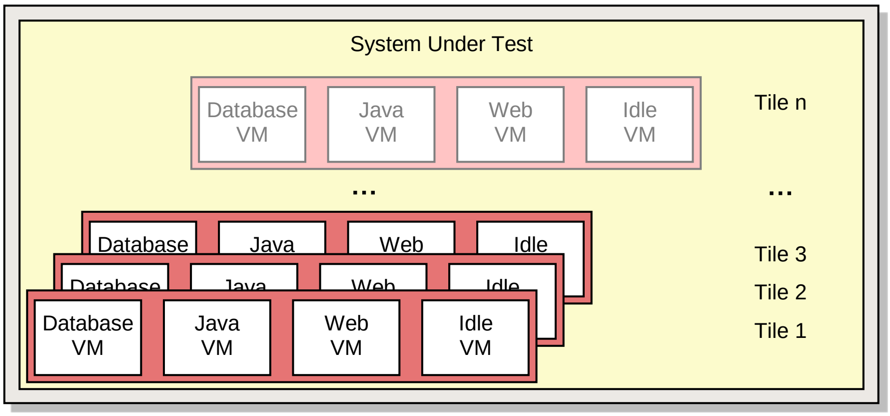
Benchmark description

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.

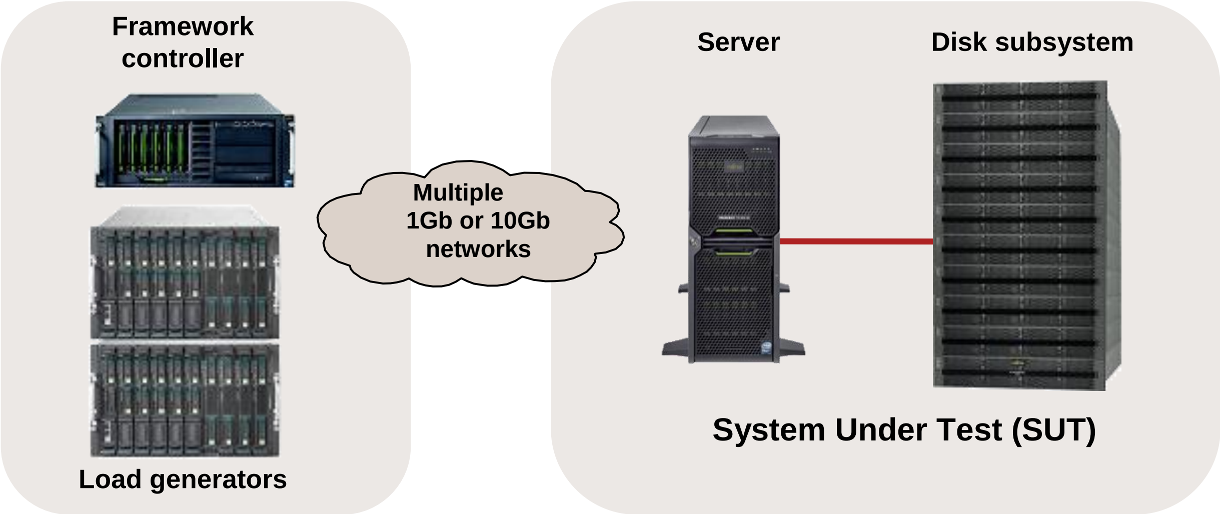
The progression of the vServCon scores for the tile numbers provides useful information about the scaling behavior of the “System under Test”.

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	
Model	PRIMEQUEST 2800E
Processor	Intel® Xeon® Processor E7-8800 v2 Product Family
Memory	2 TB: 64 × 32GB (2x16GB) 2Rx4 L DDR3-1600 R ECC
Network interface	1 × Eth FCoE Ctrl 2x10Gbit PCIe x8 OCe10102 MMF LC 1 × Eth Ctrl 2x1Gbit Cu Intel I350-T2
Disk subsystem	1 × PFC EP LPe16002 LP ETERNUS DX80 storage systems: Each tile: 50 GB LUN Each LUN: RAID 0 with 2 × Seagate ST3300657SS disks (15 krpm)
Software	
Operating system	VMware ESXi 5.5.0 Build 1331820

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 E7-8800 v2 Product 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.

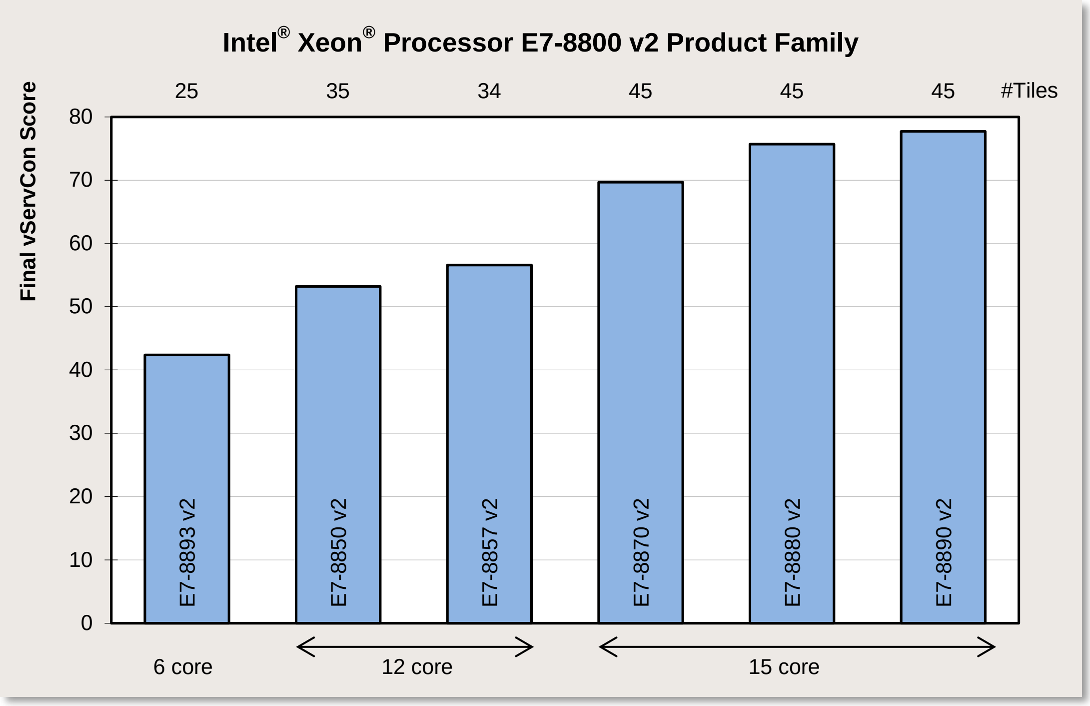
Processor			Score	#Tiles
Intel® Xeon® Processor E7-8800 v2 Product Family	6 Cores Hyper-Threading, Turbo Mode	E7-8893 v2	42.4	25
	12 Cores Turbo Mode	E7-8857 v2	56.6	34
	12 Cores Hyper-Threading, Turbo Mode	E7-8850 v2	53.2	35
	15 Cores Hyper-Threading, Turbo Mode	E7-8870 v2	69.7	45
		E7-8880 v2	75.7	45
		E7-8890 v2	81.6	45

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 77% 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 E7-8800 v2 (Ivy Bridge-EX) Based Systems.

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



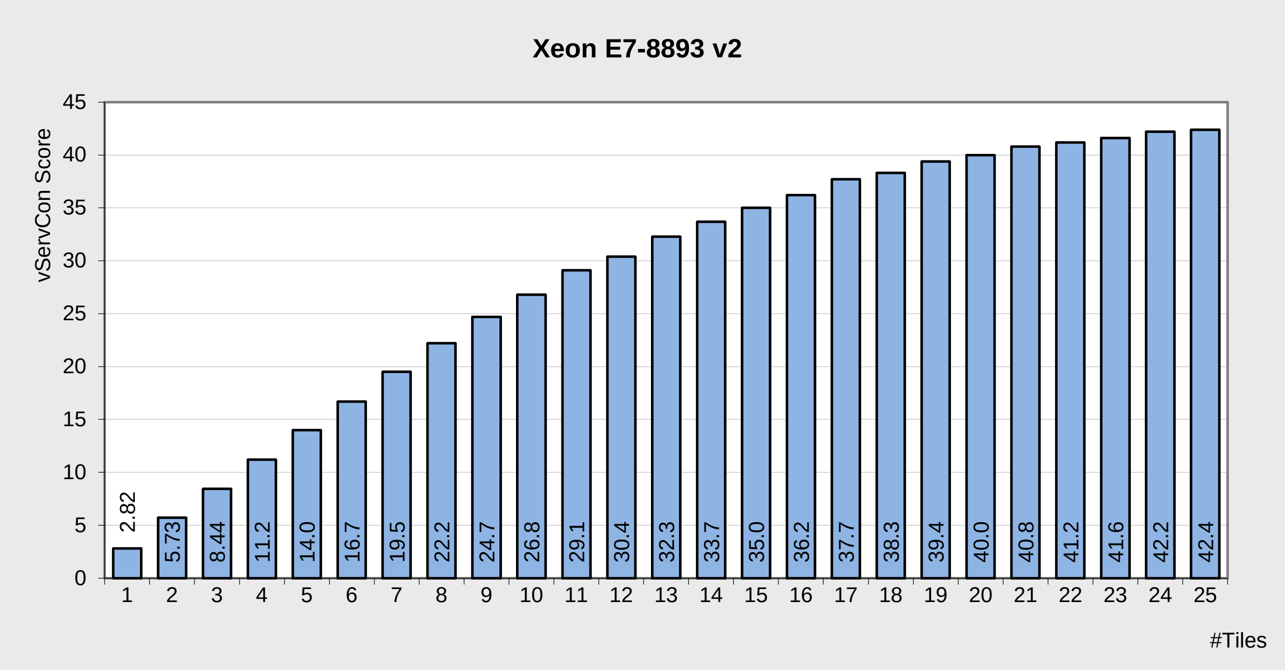
The Xeon E7-8893 v2 as the processor with six cores only makes the start.

An increase in performance is achieved by the processors with twelve cores (Xeon E7-8850 v2 and E7-8857 v2).

The groups of processors with 15 cores, which achieve a higher performance than the 6-core and 12-core processors, are to be found at the upper end of the performance scale. The Xeon E7-8857 v2 CPU from the 12-core processor group has the highest clock frequency per CPU core, while the Xeon E7-8890 v2 15-core processor provides the overall best performance.

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

The next diagram illustrates the virtualization performance for increasing numbers of VMs based on the Xeon E7-8893 v2 (6-Core) processor.



In addition to the increased number of physical cores, Hyper-Threading, which is supported by almost all Xeon E7 processors (except E7-8857 v2), 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. 48 physical and thus 96 logical cores are available with the Xeon E7-8857 v2 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 twelve 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 v2 situation with 75 application VMs (25 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 2.82 to 42.4/25=1.7, i.e. to 65%. 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.

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 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.

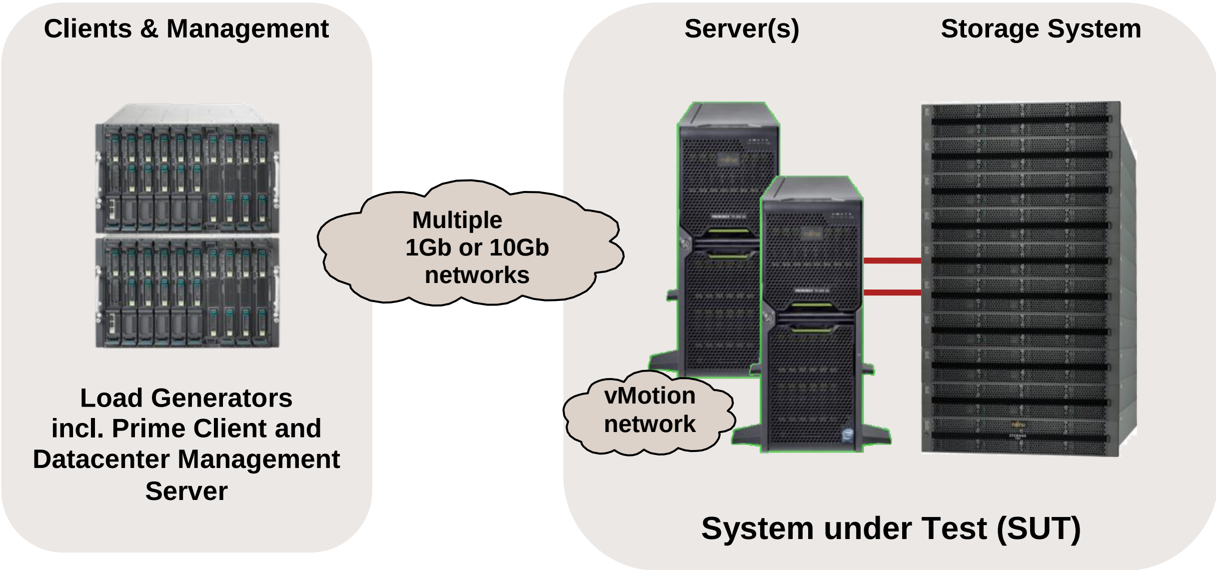
This score is determined from the individual results of the VMs and an infrastructure result. Each of the five VMmark V2 application or front-end VMs provides a specific benchmark result in the form of application-specific transaction rates for each VM. In order to derive a normalized score the individual 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”.

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 2800E
Number of partitions / Number of ESXi hosts	2 / 4
Disk subsystem	1 – 3 × PRIMERGY RX300 S8 configured as Fibre Channel target: 9 – 11 × SAS-SSD (400 GB) 2 × Fusion-io ioDrive®2 PCIe-SSD (1.2 TB) RAID 0 with several LUNs Total: 5176 GB / 9928 GB / 10.11 TB / 15.43 TB / 17.3 TB
Hardware per partition	
Processor	2 / 4 / 8 × Xeon E7-8890 v2
Memory	2-socket: 512 GB: 16 × 32GB (2x16GB) 2Rx4 L DDR3-1600 R ECC 4-socket: 1024 GB: 32 × 32GB (2x16GB) 2Rx4 L DDR3-1600 R ECC 8-socket: 2048 GB: 64 × 32GB (2x16GB) 2Rx4 L DDR3-1600 R ECC
Network interface	1 - 2 × FCoE Ctrl 10Gb/s 2 channel OCe10102 MMF 1 × Eth Ctrl 2x 1GbE Cu – PCIe x4 LP
Disk interface	1 – 2 × Dual port PFC EP LPe16002 LP
Software	
BIOS	Version 1.32 / 1.39
BIOS settings	See details
Operating system	VMware ESXi 5.5.0 Build 1331820
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	2 × PRIMERGY RX600 S6 1 – 2 × PRIMERGY RX500 S7
Processor	4 × Xeon E7-4870 (PRIMERGY RX600 S6) 4 × Xeon E5-4650 (PRIMERGY RX500 S7)
Memory	512 GB
Network interface	6 × 1 Gbit/s LAN
Software	
Operating system	VMware ESX 4.1.0 U2 Build 502767 (PRIMERGY RX600 S6) VMware ESX 4.1.0 U3 Build 800380 (PRIMERGY RX500 S7)
Load generator VM (per tile 1 load generator VM)	
Hardware	
Processor	4 × logical CPU
Memory	4 GB
Network interface	1 × 1 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/2014-04-01-Fujitsu-PRIMEQUEST2800E-16.pdf http://www.vmware.com/a/assets/vmmark/pdf/2014-04-01-Fujitsu-PRIMEQUEST2800E-30.pdf http://www.vmware.com/a/assets/vmmark/pdf/2014-04-01-Fujitsu-PRIMEQUEST2800E-50.pdf http://www.vmware.com/a/assets/vmmark/pdf/2014-04-01-Fujitsu-PRIMEQUEST2800E-32.pdf http://www.vmware.com/a/assets/vmmark/pdf/2014-04-01-Fujitsu-PRIMEQUEST2800E-60.pdf

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

Benchmark results

The PRIMEQUEST 2800E is the first server measured with VMmark V2 to offer the option of partitionability. This extremely flexible feature makes it possible to split an individual PRIMEQUEST 2800E 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 2800E server.

The measurements listed below demonstrate the outstanding flexibility of the PRIMEQUEST 2800E. In direct comparison with our competitors' conventional systems they also 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 2800E (8-socket, “matched pair”)
- Measurement with two ESXi hosts in two PRIMEQUEST 2800E (4-socket, “matched pair”)
- Measurement with two ESXi hosts in two PRIMEQUEST 2800E (2-socket, “matched pair”)
- Measurement with four ESXi hosts in one single PRIMEQUEST 2800E (2-socket, “uniform hosts”)
- Measurement with four ESXi hosts in two PRIMEQUEST 2800E (4-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 2800E 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.

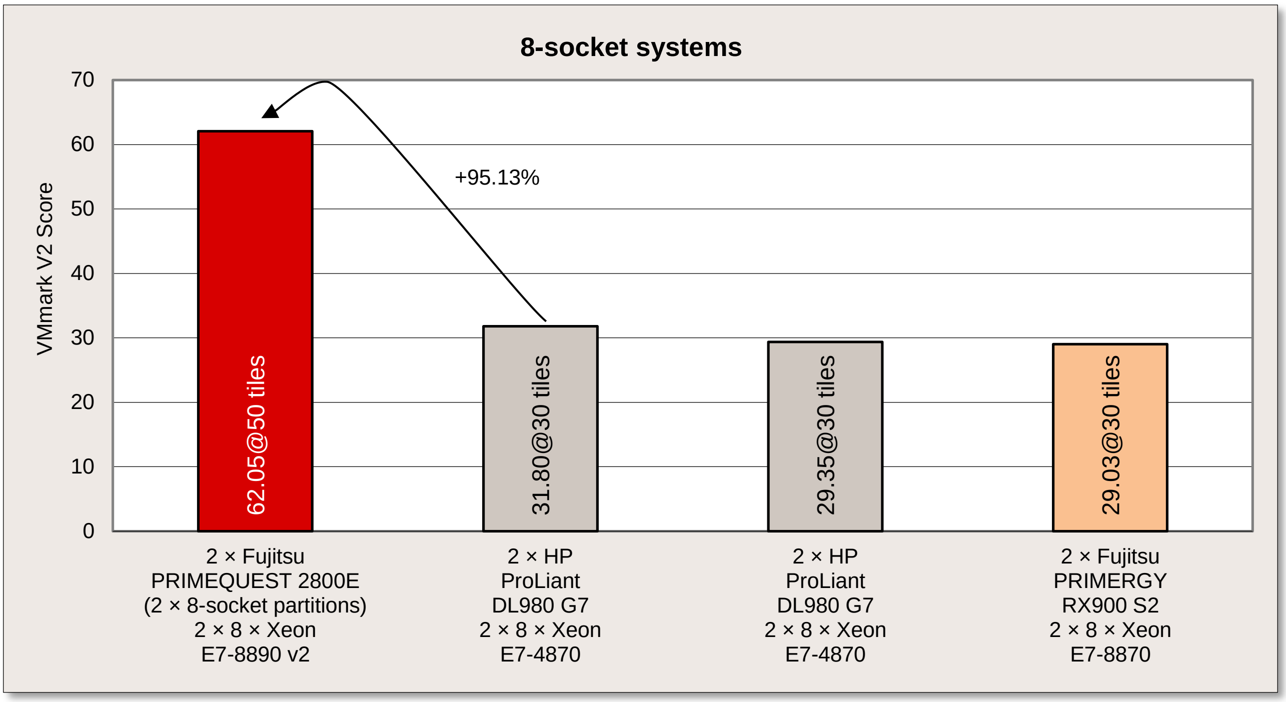
All the components used were optimally attuned to each other.

Measurement with two ESXi hosts in two PRIMEQUEST 2800E (8-socket, “matched pair”)

On April 1, 2014 Fujitsu achieved with two PRIMEQUEST 2800E systems with Xeon E7-8890 v2 processors and VMware ESXi 5.5.0 a VMmark V2 score of “62.05@50 tiles” in a system configuration with a total of 2 × 120 processor cores and when using two identical servers/partitions in the “System under Test” (SUT). With this result the PRIMEQUEST 2800E is in the official VMmark V2 ranking the most powerful 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 1st April 2014. 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 2800E 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.

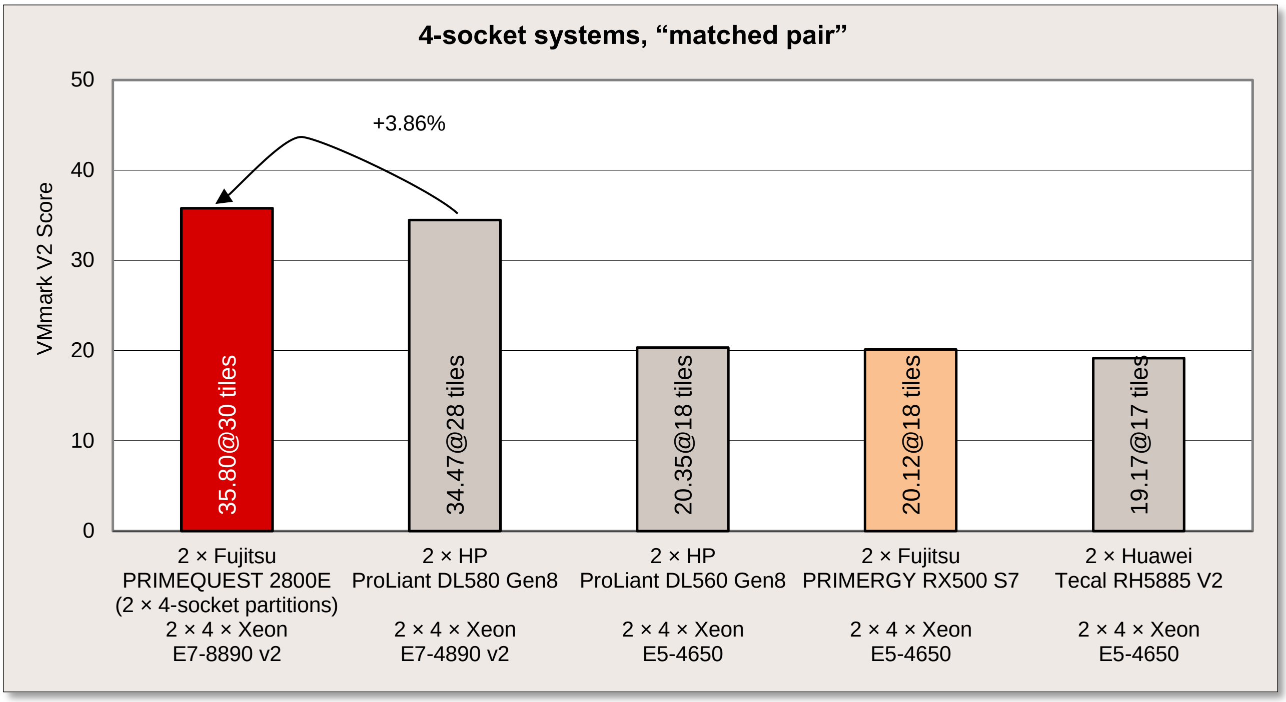
8-socket systems	VMmark V2 score	Difference
Fujitsu PRIMEQUEST 2800E	62.05@50 tiles	
HP ProLiant DL980 G7	31.80@30 tiles	95.13%
HP ProLiant DL980 G7	29.35@30 tiles	111.41%
Fujitsu PRIMERGY RX900 S2	29.03@30 tiles	113.74%

Measurement with two ESXi hosts in two PRIMEQUEST 2800E (4-socket, "matched pair")

On April 1, 2014 Fujitsu achieved with two PRIMEQUEST 2800E systems with Xeon E7-8890 v2 processors and VMware ESXi 5.5.0 a VMmark V2 score of "35.80@30 tiles" in a system configuration with a total of 2 × 60 processor cores and when using two identical servers/partitions in the "System under Test" (SUT). With this result the PRIMEQUEST 2800E 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 1st April 2014. 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 2800E 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 2800E	35.80@30 tiles	
HP ProLiant DL580 Gen8	34.47@28 tiles	3.86%
HP ProLiant DL560 Gen8	20.35@18 tiles	75.92%
Fujitsu PRIMERGY RX500 S7	20.12@18 tiles	77.93%
Huawei Tecal RH5885 V2	19.17@17 tiles	86.75%

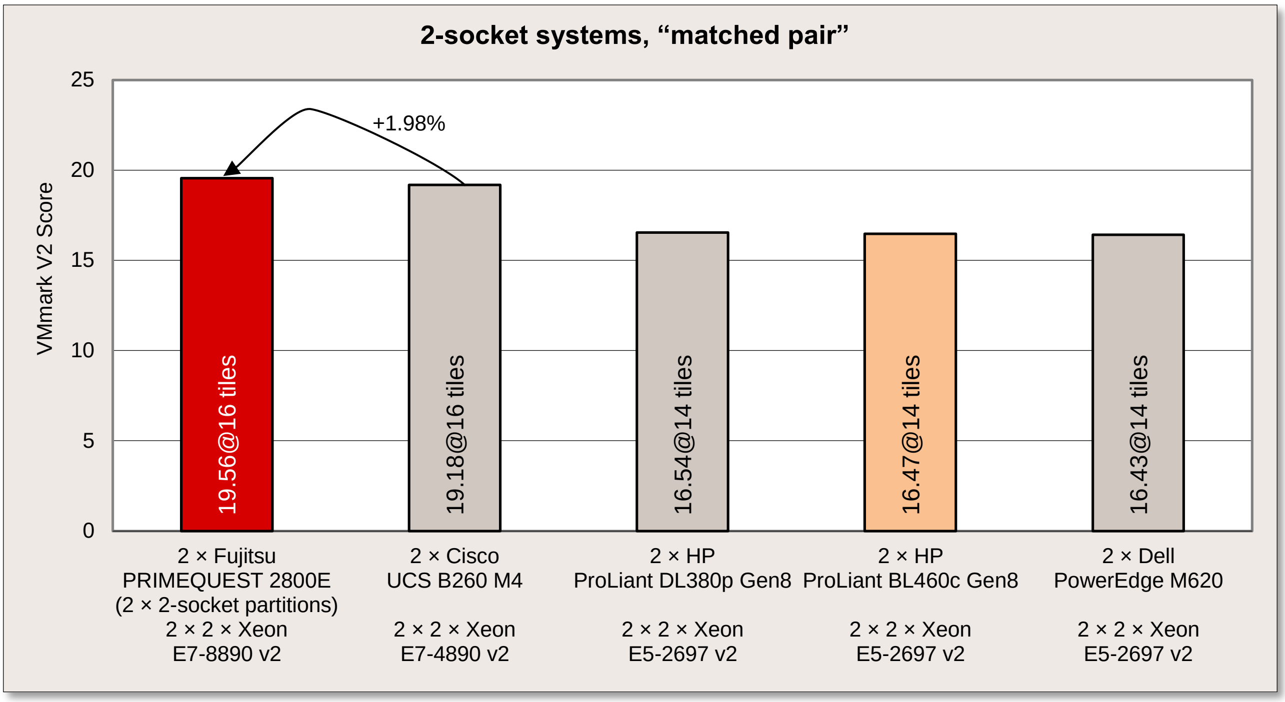
The gap between the system in first and second place is particularly notable. Although this is a native 4-socket system with the same processor architecture, the PRIMEQUEST 2800E server with 3.86% was able to take a clear lead. This shows that outstanding flexibility through partitionability is not bought by means of a practice-relevant overhead.

Measurement with two ESXi hosts in two PRIMEQUEST 2800E (2-socket, “matched pair”)

On April 1, 2014 Fujitsu achieved with two PRIMEQUEST 2800E systems with Xeon E7-8890 v2 processors and VMware ESXi 5.5.0 a VMmark V2 score of “19.56@16 tiles” in a system configuration with a total of 2 × 30 processor cores and when using two identical servers/partitions in the “System under Test” (SUT). With this result the PRIMEQUEST 2800E is in the official VMmark V2 ranking the most powerful 2-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 1st April 2014. 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 2800E in comparison with the best 2-socket systems in a “matched pair” configuration.



The table opposite shows the difference in the score (in %) between the Fujitsu system and other 2-socket systems in a “matched pair” configuration.

2-socket systems, “matched pair”	VMmark V2 score	Difference
Fujitsu PRIMEQUEST 2800E	19.56@16 tiles	
Cisco UCS B260 M4	19.18@16 tiles	1.98%
HP ProLiant DL380p Gen8	16.54@14 tiles	18.26%
HP ProLiant BL460c Gen8	16.47@14 tiles	18.76%
Dell PowerEdge M620	16.43@14 tiles	19.05%

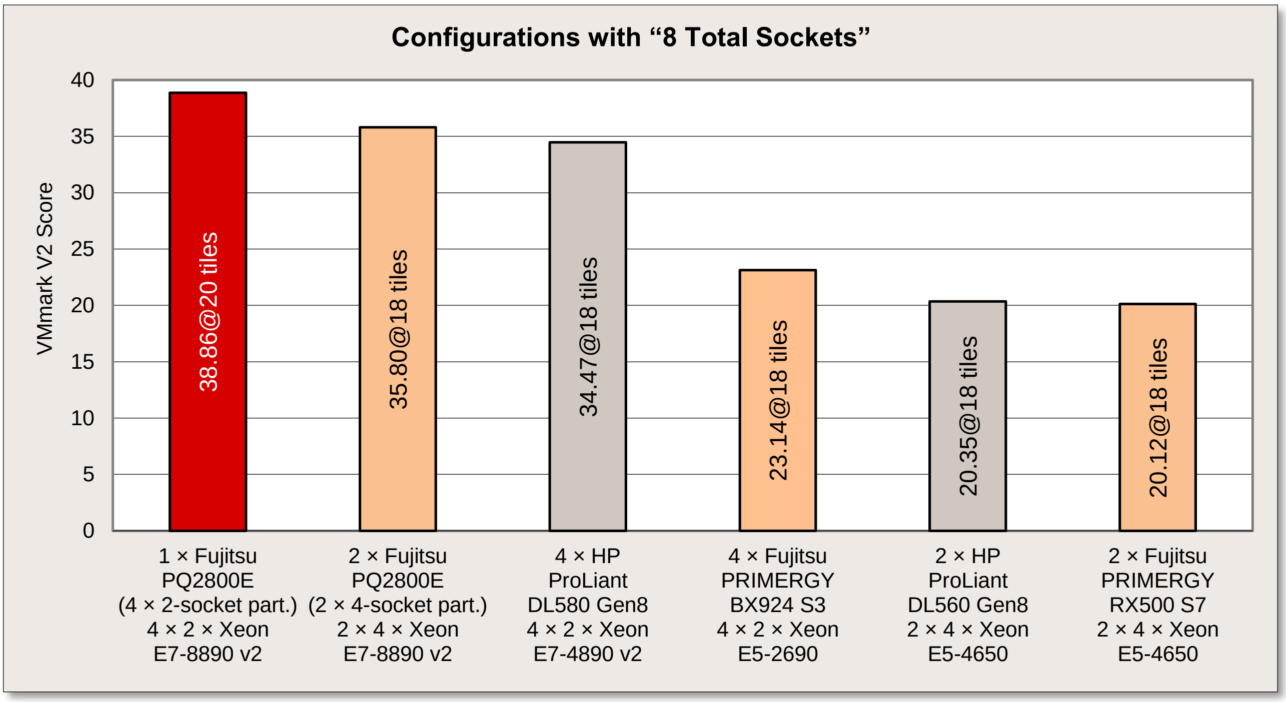
The gap between the system in first and second place is particularly notable. Although this is a native 2-socket system with the same processor architecture, the PRIMEQUEST 2800E server with 1.98% was able to take a clear lead. This shows that outstanding flexibility through partitionability is not bought by means of a practice-relevant overhead.

Measurement with four hosts in one single PRIMEQUEST 2800E (2-socket, "uniform hosts")

On April 1, 2014 Fujitsu achieved with one single PRIMEQUEST 2800E system with Xeon E7-8890 v2 processors and VMware ESXi 5.5.0 a VMmark V2 score of "38.86@32 tiles" in a system configuration with a total of 4 × 30 processor cores and when using four identical servers/partitions in the "System under Test" (SUT). With this result the PRIMEQUEST 2800E is in the official VMmark V2 ranking the most powerful server in a "uniform hosts" configuration consisting of a total of eight sockets (valid as of benchmark results publication date).

All comparisons for the competitor products reflect the status of 1st April 2014. 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 2800E in comparison with the best configurations with "8 Total Sockets".



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

8-socket configurations	VMmark V2 score	Difference
Fujitsu PRIMEQUEST 2800E (4 × 2-socket)	38.86@32 tiles	
Fujitsu PRIMEQUEST 2800E (2 × 4-socket)	35.80@30 tiles	8.55%
HP ProLiant DL580 Gen8	34.47@28 tiles	12.74%
Fujitsu PRIMERGY BX924 S3	23.14@20 tiles	67.93%
HP ProLiant DL560 Gen8	20.25@18 tiles	90.96%
Fujitsu PRIMERGY RX500 S7	20.12@18 tiles	93.14%

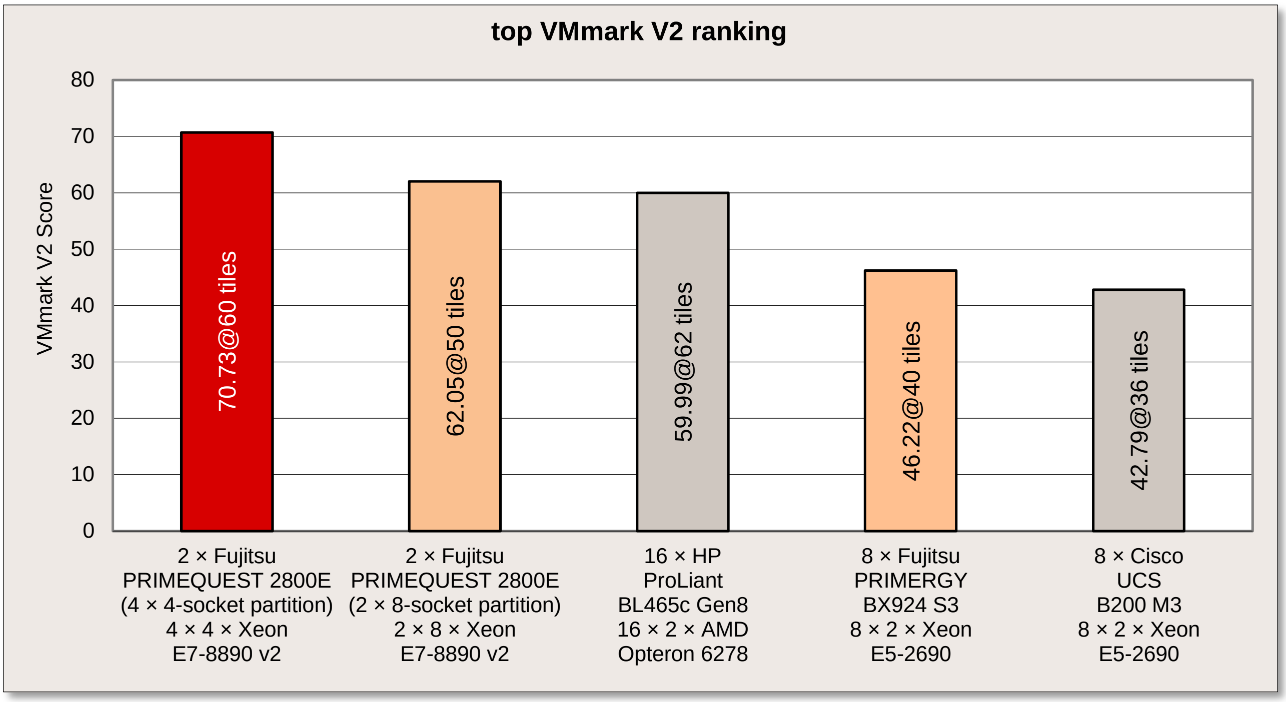
The gap between the configuration in first and second place is particularly notable. Due to the relatively few vCPUs per VM, the VMmark V2 load profile is very accommodating to 2-socket systems. In this case, the configuration with 4 × 2-socket partitions is more efficient than the configuration with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

Measurement with four ESXi hosts in two PRIMEQUEST 2800E (4-socket, "uniform hosts")

On April 1, 2014 Fujitsu achieved with two PRIMEQUEST 2800E systems with Xeon E7-8890 v2 processors and VMware ESXi 5.5.0 a VMmark V2 score of "70.73@60 tiles" in a system configuration with a total of 4 × 60 processor cores and when using four identical servers/partitions in the "System under Test" (SUT). With this result the PRIMEQUEST 2800E is in the official VMmark V2 ranking 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 1st April 2014. 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.

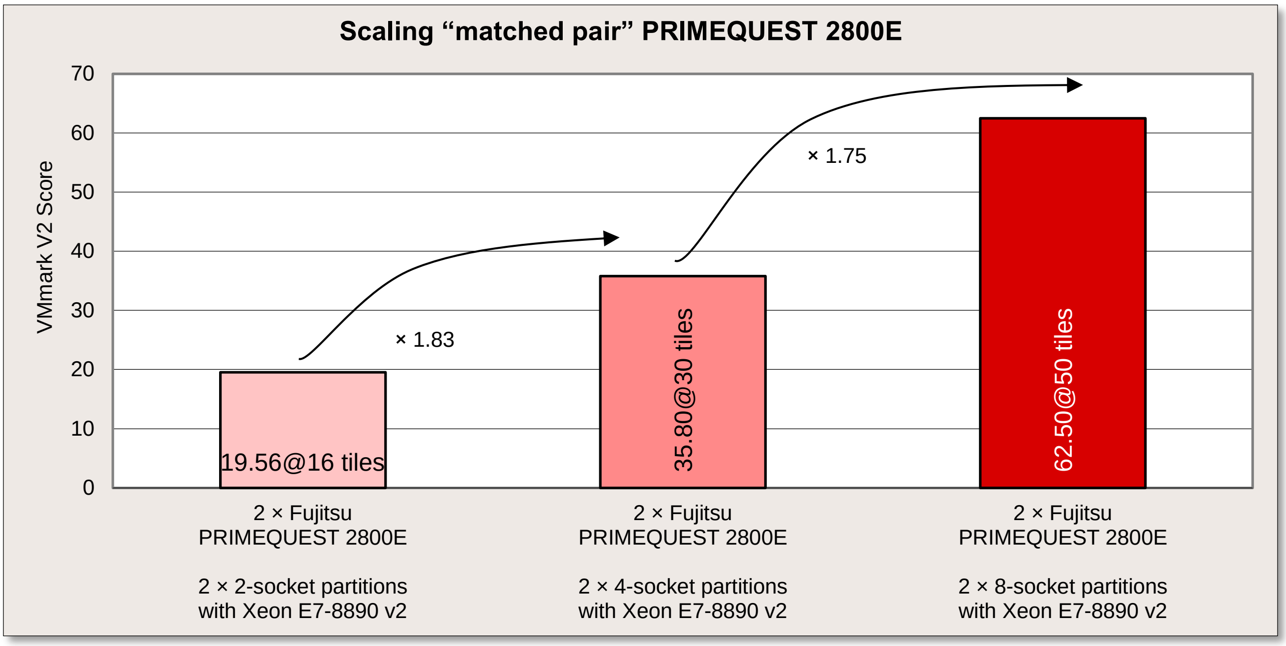
System units	#ESX hosts	#Sockets	VMmark V2 Score	Difference
2 × Fujitsu PRIMEQUEST 2800E	4	16 (4 × 4)	70.73@60 tiles	
2 × Fujitsu PRIMEQUEST 2800E	2	16 (2 × 8)	62.05@50 tiles	13.99%
16 × HP ProLiant BL465c Gen8	16	32 (16 × 2)	59.99@62 tiles	17.90%
8 × Fujitsu PRIMERGY BX924 S3	8	16 (8 × 2)	46.22@40 tiles	53.03%
8 × HP ProLiant DL560 Gen8	8	16 (8 × 2)	42.79@36 tiles	65.30%

The gap between the configuration in first and second 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 4 × 4-socket partitions is more efficient than the configuration with 2 × 8-socket partitions. This emphasizes how efficiently the PRIMEQUEST 2800E server can on account of the partitioning feature be adapted to suit a specific load profile.

Scaling comparison

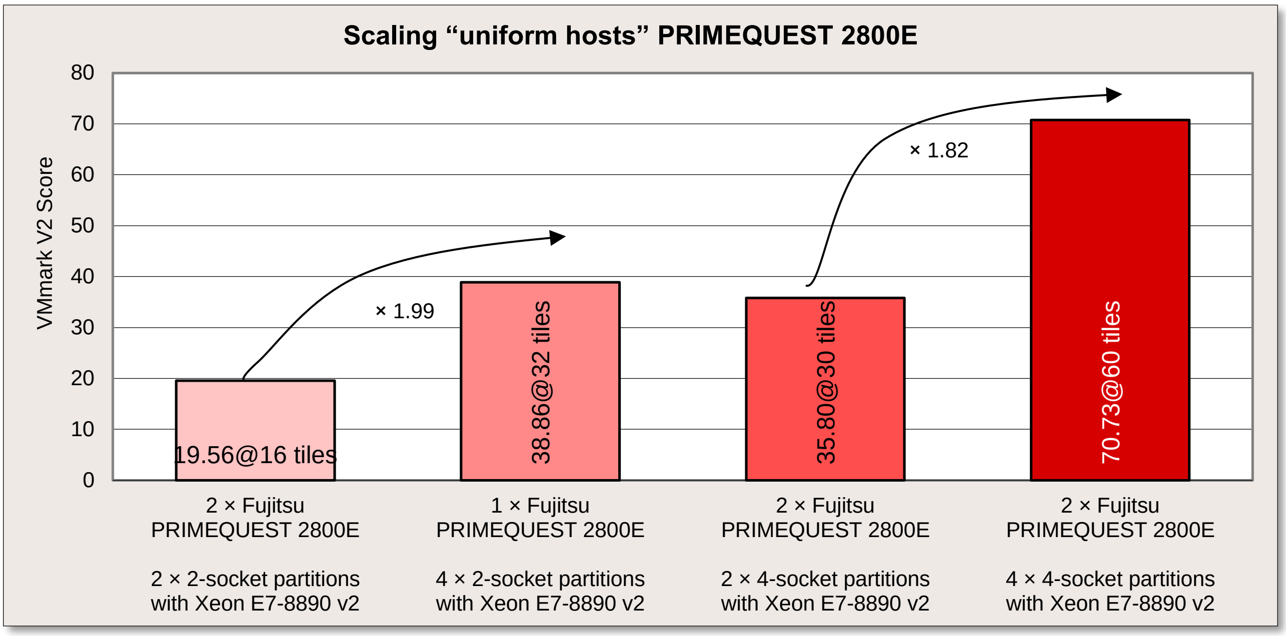
Also of interest is the scaling of virtualization performance, first in the scale-up and then in the scale-out scenario.

First the question arises here as to how well the performance scales from configurations with two sockets to configurations with four and 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 1.83 and 1.75 respectively.

When operated with four hosts, the PRIMEQUEST 2800E almost 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 CPU 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 four times larger than the total of all CPU 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 CPUs influence the arithmetic calculations. The accuracy of the results is approximately 5%.

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 2800E
Processor	8 processors of Intel® Xeon® Processor E7-8800 v2 Product Family
Memory	64 × 32GB (2x16GB) 2Rx4 L DDR3-1600 R ECC
Software	
BIOS settings	Hyper-Threading = Disabled
Operating system	Red Hat Enterprise Linux Server release 6.5
Operating system settings	echo never > /sys/kernel/mm/redhat_transparent_hugepage/enabled
Compiler	Intel C++ Composer XE 2013 SP1 for Linux Update 1
Benchmark	Stream.c Version 5.9

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

Benchmark results

Processor	Cores	Processor Frequency [Ghz]	Max. Memory Frequency [MHz]	TRIAD [GB/s]
8 × Xeon E7-8893 v2	6	3.40	1600	292
8 × Xeon E7-8857 v2	12	3.00	1600	376
8 × Xeon E7-8850 v2	12	2.30	1333	355
8 × Xeon E7-8870 v2	15	2.30	1600	380
8 × Xeon E7-8880 v2	15	2.50	1600	385
8 × Xeon E7-8890 v2	15	2.80	1600	393

The results depend primarily on the maximum memory frequency. The processors with only 6 cores, which do not fully utilize their memory controller, are an exception. The smaller differences with processors with the same maximum memory frequency are a result in arithmetic calculation of the different processor frequencies.

Literature

PRIMEQUEST Servers

http://ts.fujitsu.com/primequest

PRIMEQUEST 2800E

This White Paper:

http://docs.ts.fujitsu.com/dl.aspx?id=a0e6c1c7-7b8f-4d13-bb36-373db1d660b3
http://docs.ts.fujitsu.com/dl.aspx?id=9b063edc-40e6-4f0e-95f6-2b87e1d76bd5
http://docs.ts.fujitsu.com/dl.aspx?id=94da09b9-97a6-4723-adca-d59cd164bf28

Data sheet
http://docs.ts.fujitsu.com/dl.aspx?id=bbd6a7a8-0250-4385-98ff-0a51cc4971f4

PRIMEQUEST Performance

http://www.fujitsu.com/fts/x86-server-benchmarks

Performance of Server Components

http://www.fujitsu.com/fts/products/computing/servers/mission-critical/benchmarks/x86-components.html

Memory performance of Xeon E7-8800 / 4800 v2 (Ivy Bridge-EX) based systems
http://docs.ts.fujitsu.com/dl.aspx?id=8ff6579c-966c-4bce-8be0-fc7a541b4a02

Single Disk Performance
http://docs.ts.fujitsu.com/dl.aspx?id=0e30cb69-44db-4cd5-92a7-d38bacec6a99

RAID Controller Performance
http://docs.ts.fujitsu.com/dl.aspx?id=e2489893-cab7-44f6-bff2-7aeea97c5aef

Disk I/O

Basics of Disk I/O Performance
http://docs.ts.fujitsu.com/dl.aspx?id=65781a00-556f-4a98-90a7-7022feacc602

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OLTP-2

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STREAM

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http://docs.ts.fujitsu.com/dl.aspx?id=da0ce7b7-3d80-48cd-9b3a-d12e0b40ed6d

VMmark V2

Benchmark Overview VMmark V2
http://docs.ts.fujitsu.com/dl.aspx?id=2b61a08f-52f4-4067-bbbf-dc0b58bee1bd

VMmark V2
http://www.vmmark.com

vServCon

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

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