WHITE PAPER
FUJITSU PRIMERGY SERVERS
PERFORMANCE REPORT PRIMERGY BX960 S1

This document contains a summary of the benchmarks executed for the PRIMERGY BX960 S1.

The PRIMERGY BX960 S1 performance data are compared with the data of other PRIMERGY models and discussed. In addition to the benchmark results, an explanation has been included for each benchmark and for the benchmark environment.

Version

1.1a
2011-12-05

Contents

Document history

Version 1.0

First report version including the benchmark chapters

- SPECcpu2006
  Measurements with Xeon E7520, E7530, L7545, E7540, X7542, X7550, L7555 and X7560
- SPECjbb2005
  Measurement with Xeon L7555
- SAP SD
  Certification number 2010038
- vServCon
  Measurements with Xeon E7520, E7530, L7545, E7540, X7542, L7555, X7550 and X7560
- VMmark
  Measurements with Xeon E7540 and E7520

Version 1.1

New Benchmark chapters:

- OLTP-2
  Results for Xeon E7520, E7530, E7540, L7545, L7555, X7542, X7550, X7560

Updated benchmark chapters:

- VMmark V1
  New measurements with Xeon X7560

Version 1.1a

Minor corrections

Technical data

The PRIMERGY BX960 S1 Quad Socket Server Blades have an Intel 7500 chip set, two to four Intel Xeon Series 7500 processors (Quad-Core, Hexa-Core or Octo-Core), 32 DIMM slots for up to 512 GB DDR3-SDRAM, one 2-channel 10-GBit LAN controller and one onboard controller for up to two SSDs.

Detailed technical information is available in the

- data sheet PRIMERGY BX900 S1
- data sheet PRIMERGY BX960 S1

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 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 results

The PRIMERGY BX960 S1 was measured with Xeon series 7500 processors. The benchmark programs were compiled with Intel C++/Fortran Compiler 11.1 and run under SUSE Linux Enterprise Server 11 (64-bit).

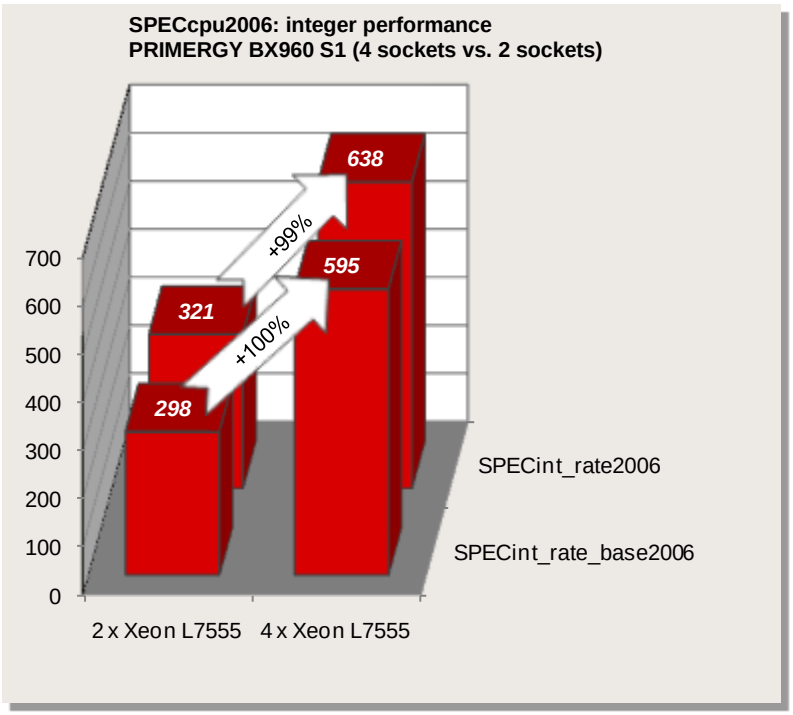
Processor	Cores	GHz	L3 cache	QPI Speed	TDP	SPECint_base2006		SPECint2006	
						2 chips	4 chips	2 chips	4 chips
Xeon E7520	4	1.87	18 MB	4.80 GT/s	95 Watt		20.6		22.4
Xeon E7530	6	1.87	12 MB	5.86 GT/s	105 Watt		22.2		24.3
Xeon L7545	6	1.87	18 MB	5.86 GT/s	95 Watt		25.0		28.0
Xeon E7540	6	2	18 MB	6.40 GT/s	105 Watt		24.2		26.7
Xeon X7542	6	2.67	18 MB	5.86 GT/s	130 Watt	28.1	n/a	31.0	n/a
Xeon X7550	8	2	18 MB	6.40 GT/s	130 Watt	24.6	n/a	27.2	n/a
Xeon L7555	8	1.87	24 MB	5.86 GT/s	95 Watt		25.9		29.5
Xeon X7560	8	2.27	24 MB	6.40 GT/s	130 Watt	28.0	n/a	31.3	n/a

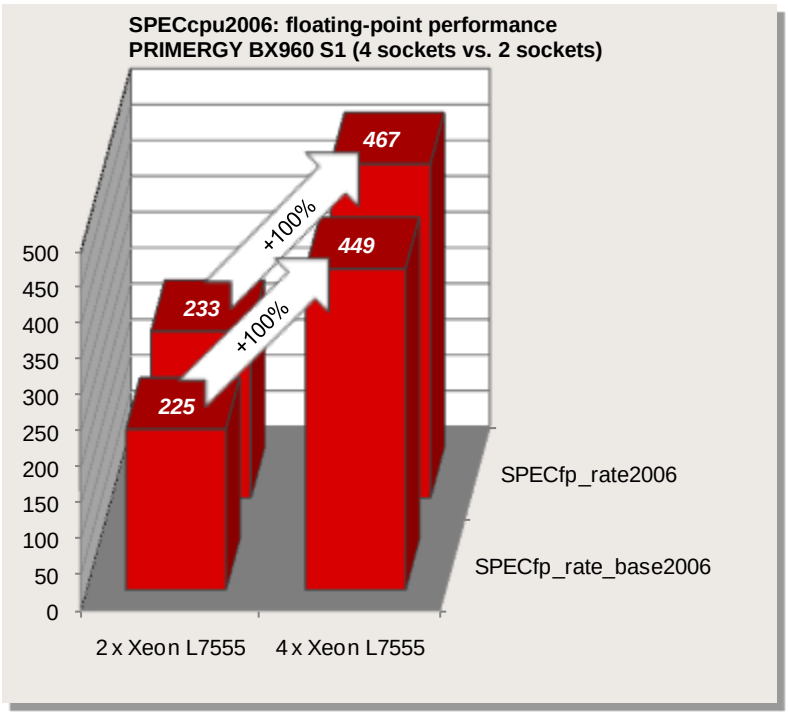
Processor	Cores	GHz	L3 cache	QPI Speed	TDP	SPECint_rate_base2006		SPECint_rate2006	
						2 chips	4 chips	2 chips	4 chips
Xeon E7520	4	1.87	18 MB	4.80 GT/s	95 Watt	155	311	165	335
Xeon E7530	6	1.87	12 MB	5.86 GT/s	105 Watt	221	441	237	473
Xeon L7545	6	1.87	18 MB	5.86 GT/s	95 Watt	227	454	244	489
Xeon E7540	6	2	18 MB	6.40 GT/s	105 Watt	243	487	259	524
Xeon X7542	6	2.67	18 MB	5.86 GT/s	130 Watt	247	n/a	265	n/a
Xeon X7550	8	2	18 MB	6.40 GT/s	130 Watt	315	n/a	338	n/a
Xeon L7555	8	1.87	24 MB	5.86 GT/s	95 Watt	298	595	321	638
Xeon X7560	8	2.27	24 MB	6.40 GT/s	130 Watt	348	n/a	375	n/a

Processor	Cores	GHz	L3 cache	QPI Speed	TDP	SPECfp_base2006		SPECfp2006	
						2 chips	4 chips	2 chips	4 chips
Xeon E7520	4	1.87	18 MB	4.80 GT/s	95 Watt		26.6		28.4
Xeon E7530	6	1.87	12 MB	5.86 GT/s	105 Watt		28.7		31.0
Xeon L7545	6	1.87	18 MB	5.86 GT/s	95 Watt		31.0		34.3
Xeon E7540	6	2	18 MB	6.40 GT/s	105 Watt		30.7		33.3
Xeon X7542	6	2.67	18 MB	5.86 GT/s	130 Watt	33.8	n/a	36.0	n/a
Xeon X7550	8	2	18 MB	6.40 GT/s	130 Watt	31.0	n/a	33.2	n/a
Xeon L7555	8	1.87	24 MB	5.86 GT/s	95 Watt		32.1		35.8
Xeon X7560	8	2.27	24 MB	6.40 GT/s	130 Watt	34.0	n/a	36.5	n/a

Processor	Cores	GHz	L3 cache	QPI Speed	TDP	SPECfp_rate_base2006		SPECfp_rate2006	
						2 chips	4 chips	2 chips	4 chips
Xeon E7520	4	1.87	18 MB	4.80 GT/s	95 Watt	132	262	138	274
Xeon E7530	6	1.87	12 MB	5.86 GT/s	105 Watt	174	338	180	356
Xeon L7545	6	1.87	18 MB	5.86 GT/s	95 Watt	182	353	189	375
Xeon E7540	6	2	18 MB	6.40 GT/s	105 Watt	196	376	202	399
Xeon X7542	6	2.67	18 MB	5.86 GT/s	130 Watt	203	n/a	210	n/a
Xeon X7550	8	2	18 MB	6.40 GT/s	130 Watt	240	n/a	247	n/a
Xeon L7555	8	1.87	24 MB	5.86 GT/s	95 Watt	225	449	233	467
Xeon X7560	8	2.27	24 MB	6.40 GT/s	130 Watt	257	n/a	265	n/a

The throughput with four processors both with the integer as well as the floating-point test suite is twice as large as that with two processors.





Benchmark environment

All SPECcpu2006 measurements were made on a PRIMERGY BX960 S1 with the following hardware and software configuration:

Hardware	
Model	PRIMERGY BX960 S1
CPU	Xeon E7520, E7530, L7545, E7540, X7542, X7550, L7555, X7560
Number of CPUs	2 chips: Xeon E7520: 8 cores, 4 cores per chip Xeon E7530, L7545, E7540, X7542: 12 cores, 6 cores per chip Xeon L7555, X7550, X7560: 16 cores, 8 cores per chip 4 chips: Xeon E7520: 16 cores, 4 cores per chip Xeon E7530, L7545, E7540: 24 cores, 6 cores per chip Xeon L7555: 32 cores, 8 cores per chip
Primary cache	32 KB instruction + 32 KB data on chip, per core
Secondary cache	256 KB on chip, per core
Other cache	Xeon E7530: 12 MB (I+D) on chip, per chip Xeon E7520, L7545, E7540, X7542, X7550: 18 MB (I+D) on chip, per chip Xeon L7555, X7560: 24 MB (I+D) on chip, per chip
Software	
Operating System	SUSE Linux Enterprise Server 11 (64-bit)
Compilers	Intel C++/Fortran Compiler 11.1

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

SPECjbb2005

Benchmark description

SPECjbb2005 is a Java business benchmark that focuses on the performance of Java Server platforms. SPECjbb2005 is essentially a modernized SPECjbb2000. The main differences are:

- The transactions have become more complex in order to cover a greater functional scope.
- The working set of the benchmark has been enlarged to the extent that the total system load has increased.
- SPECjbb2000 allows only one active Java Virtual Machine instance (JVM) whereas SPECjbb2005 permits several instances, which in turn achieves greater closeness to reality, particularly with large systems.

On the software side SPECjbb2005 primarily measures the performance of the JVM used with its just-in-time compiler as well as their thread and garbage collection implementation. Some aspects of the operating system used also play a role. As far as hardware is concerned, it measures the efficiency of the CPUs and caches, the memory subsystem and the scalability of shared memory systems (SMP). Disk and network I/O are irrelevant.

SPECjbb2005 emulates a 3-tier client/server system that is typical for modern business process applications with the emphasis on the middle-tier system:

- Clients generate the load, consisting of driver threads, which on the basis of TPC-C benchmark generate OLTP accesses to a database without thinking times.
- The middle tier system implements the business processes and the updating of the database.
- The database takes on the data management and is emulated by Java objects that are in the memory. Transaction logging is implemented on an XML basis.

The major advantage of this benchmark is that it includes all three tiers that run together on a single host. The performance of the middle-tier is measured. Large-scale hardware installations are thus avoided and direct comparisons between the SPECjbb2005 results from the various systems are possible. Client and database emulation are also written in Java.

SPECjbb2005 only needs the operating system as well as a Java Virtual Machine with J2SE 5.0 features.

The scaling unit is a warehouse with approx. 25 MB Java objects. Precisely one Java thread per warehouse executes the operations on these objects. The business operations are assumed by TPC-C:

- New Order Entry
- Payment
- Order Status Inquiry
- Delivery
- Stock Level Supervision
- Customer Report

However, these are the only features SPECjbb2005 and TPC-C have in common. The results of the two benchmarks are not comparable.

SPECjbb2005 has 2 performance metrics:

- bops (business operations per second) is the overall rate of all business operations performed per second.
- bops/JVM is the ratio of the first metrics and the number of active JVM instances.

In comparisons of various SPECjbb2005 results, both metrics must be specified.

The following rules, according to which a compliant benchmark run has to be performed, are the basis for these three metrics:

A compliant benchmark run consists of a sequence of measuring points with an increasing number of warehouses (and thus of threads) with the number in each case being increased by one warehouse. The run is started at one warehouse up through 2*MaxWh, but not less than 8 warehouses. MaxWh is the number of warehouses with the highest rate per second the benchmark expects. Per default the benchmark equates MaxWh with the number of CPUs visible by the operating system.

The metric bops is the arithmetic average of all measured operation rates with MaxWh warehouses up to 2*MaxWh warehouses.

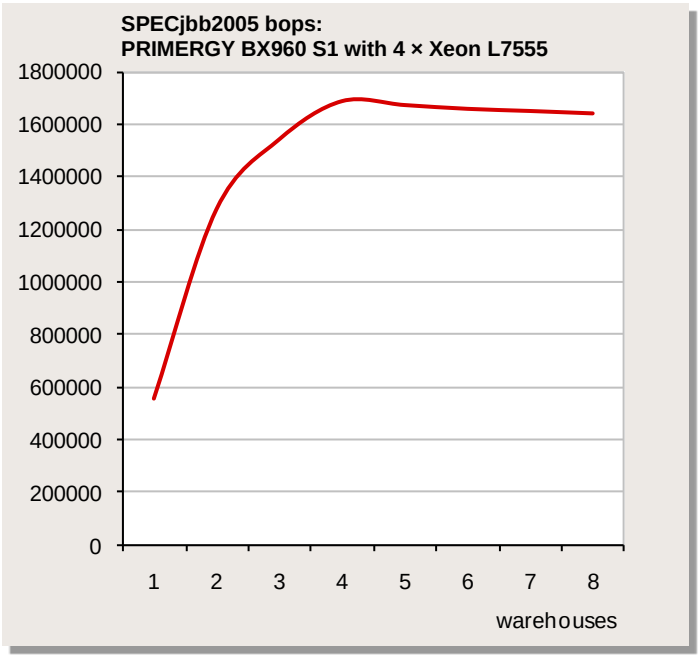
Benchmark results

In August 2010 the PRIMERGY BX960 S1 with four Xeon L7555 processors and a memory of 128 GB PC3-10600R DDR3-SDRAM was measured. The measurement was made under Windows Server 2008 Enterprise x64 Edition SP2. 16 J9 VM instances from IBM were used.

The following result was obtained:

SPECjbb2005 bops = 1662995

SPECjbb2005 bops/JVM = 103937



Benchmark environment

The SPECjbb2005 measurement was run on a PRIMERGY BX960 S1 with the following hardware and software configuration:

Hardware	
Model	PRIMERGY BX960 S1
CPU	Xeon L7555
Number of chips	4 chips, 32 cores, 8 cores per chip
Primary cache	32 kB instruction + 32 kB data on chip, per core
Secondary cache	¼ MB (I+D) on chip, per core
Other cache	24 MB (I+D) on chip, per chip
Memory	32 × 4 GB PC3-10600R DDR3-SDRAM
Software	
Operating System	Windows Server 2008 Enterprise x64 Edition SP2
JVM Version	IBM J9 VM (build 2.4, JRE 1.6.0 IBM J9 2.4 Windows Server 2008 amd64-64 jvmwa6460sr6-20090923_42924 (JIT enabled, AOT enabled)

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

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 results

The OLTP-2 values for the PRIMERGY BX960 S1 were determined for the Intel Xeon 75xx processor series with memory configurations of 64 GB, 128 GB, 256 GB and 512 GB. These results are based on the operating system Microsoft Windows Server 2008 R2 Enterprise and the database SQL Server 2008 R2 Enterprise x64 Edition. The database performance depends to a great degree on the configuration options of a system with hard disks and their controllers. Throughputs of the dimension specified here can be achieved if the typically external disk subsystem is not a bottleneck. Further information about the system configuration can be found in the section Benchmark environment.

The table provides an overview of the processors including their properties that have been released for the PRIMERGY BX960 S1.

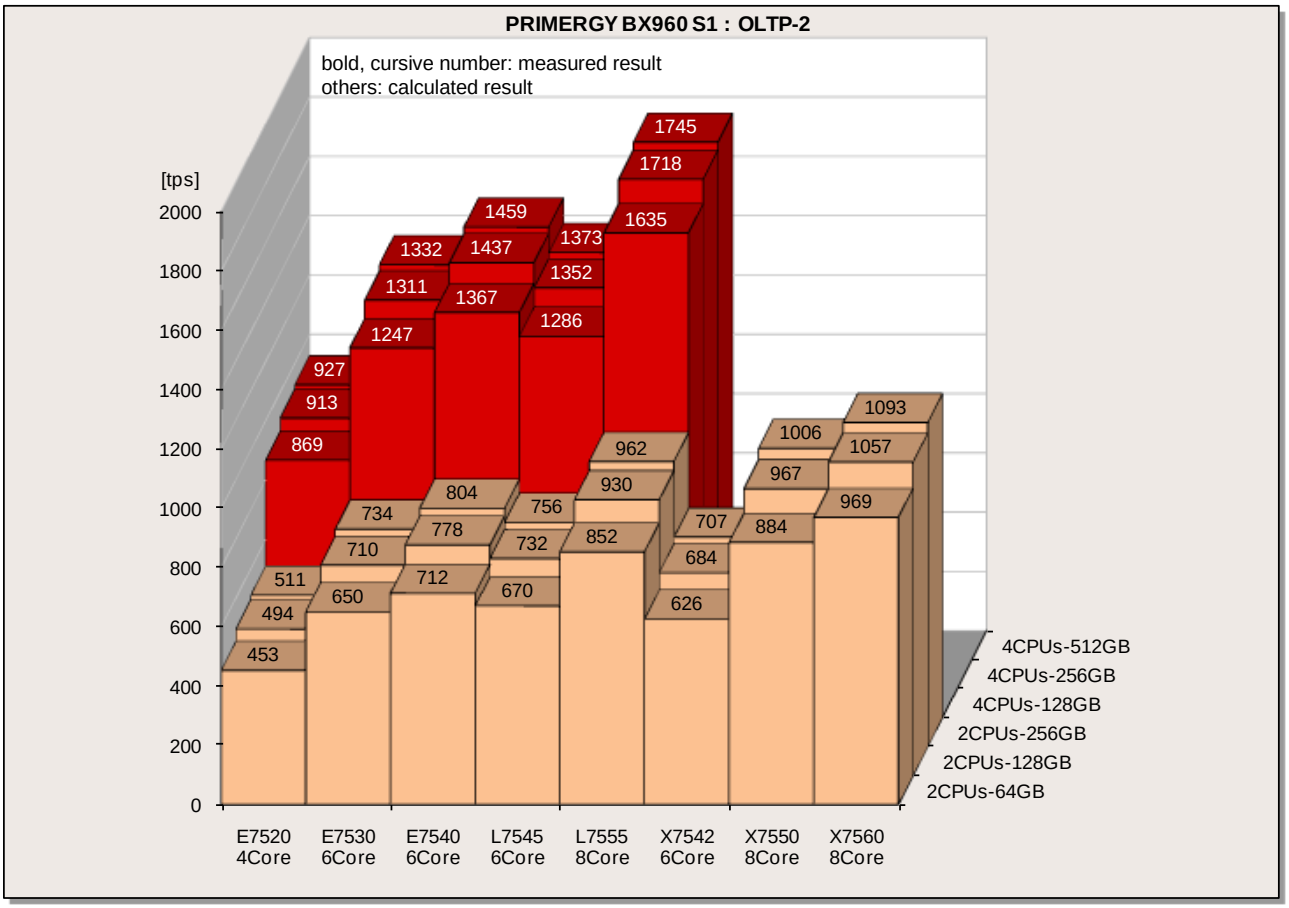
Processor	Cores/ Chip	HT	TM	Processor frequency	L3 Cache	QPI speed	Memory timing	TDP
E7520 (4 ×)	4	✓		1.86 GHz	18 MB	4.8 GT/s	800 MHz	95 watt
E7530 (4 ×)	6	✓	✓	1.86 GHz	12 MB	5.86 GT/s	978 MHz	105 watt
E7540 (4 ×)	6	✓	✓	2.0 GHz	18 MB	6.4 GT/s	1066 MHz	105 watt
L7545 (4 ×)	6	✓	✓	1.86 GHz	18 MB	5.86 GT/s	978 MHz	95 watt
L7555 (4 ×)	8	✓	✓	1.86 GHz	24 MB	5.86 GT/s	978 MHz	95 watt
X7542 (2 ×)	6		✓	2.66 GHz	18 MB	5.86 GT/s	978 MHz	130 watt
X7550 (2 ×)	8	✓	✓	2.0 GHz	18 MB	6.4 GT/s	1066 MHz	130 watt
X7560 (2 ×)	8	✓	✓	2.26 GHz	24 MB	6.4 GT/s	1066 MHz	130 watt

HT = Hyper-Threading, TM = Turbo mode, QPI = QuickPath Interconnect, GT = Giga transfer,
TDP = Thermal Design Power

As regards memory, the maximum configuration with 16 GB modules and two reduced configurations are considered. Here, the timing only depends on the processor type and not on the type or number of memory modules used. Further information about memory performance can be found in the White Paper Memory Performance of XEON 7500 (Nehalem-EX) Based Systems.

A guideline in the database environment for selecting main memory is that sufficient quantity is more important than the speed of the memory accesses.

The following diagram shows the OLTP-2 performance data of the PRIMERGY BX960 S1, which can be achieved with two and four processors of the Intel Xeon series and various memory configurations.



It becomes evident that due to the large number of released processors the PRIMERGY BX960 S1 covers a wide performance range. If you compare the OLTP-2 value of the processor (E7520) with the lowest performance (927 tps) and the processor (L7555) with the highest performance (1745 tps), both at maximum memory configuration, the result is an increase in performance by the factor of 1.9.

Based on the results achieved the processors can be divided into different groups:

At the lower end of the scale is the E7520 as a processor with only four cores, which does not support the turbo mode.

An increase in performance is achieved by the processors with six cores, which support both Hyper-Threading and the turbo mode (E7530, E7540 und L7545).

The processors L7555, X7550 and X7560 with their eight cores per CPU are to be found at the upper end of the performance scale.

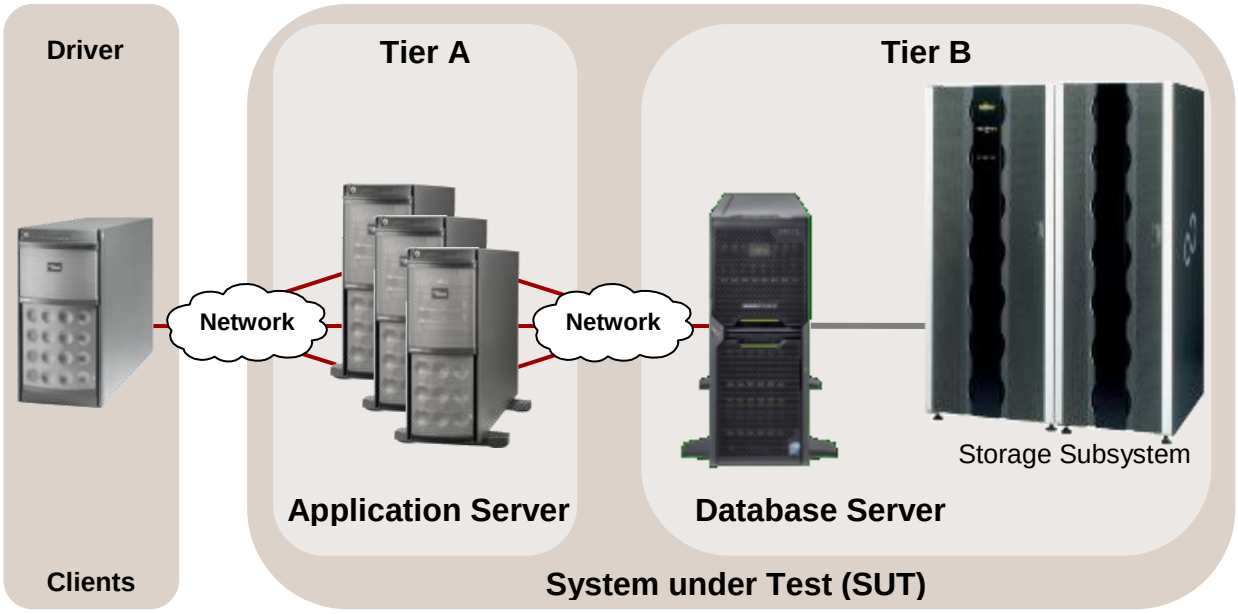
The X7542 processor, which has six cores and a high clock frequency, but no Hyper-Threading, is an exception. Database applications and the OLTP-2 load in particular benefit from doubling the logical processor cores through Hyper-Threading.

It was possible to improve the database throughput for all processor types by increasing the main memory.

However, with a server with four sockets the question arises as to how good is the performance scaling from two to four 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 database server, an increase in performance from a good 82% to 92% can be observed if you double the CPU number from two to four processors.

Benchmark environment

A typical OLTP-2 benchmark environment is shown symbolically in the following diagram:



Database Server (Tier B)		
Hardware		
System	PRIMERGY BX960 S1	
Processor	4 × Xeon E7520 (4C, 1.86 GHz) 4 × Xeon E7530 (6C, 1.86 GHz) 4 × Xeon L7545 (6C, 1.86 GHz) 4 × Xeon E7540 (6C, 2.0 GHz)	2 × Xeon X7542 (6C, 2.66 GHz) 4 × Xeon L7555 (8C, 1.86 GHz) 2 × Xeon X7550 (8C, 2.0 GHz) 2 × Xeon X7560 (8C, 2.26 GHz)
Memory	64 GB – 512 GB, 1333 MHz registered ECC DDR3 (8 GB DIMMs), or 1066 MHz registered ECC DDR3 (16 GB DIMMs)	
Settings (default)	Turbo Mode enabled, NUMA Support enabled, Hyper-Threading enabled	
Network interface	4 × LAN 1 Gb/s	
Disk subsystem	RAID 1 (OS) Operating system and database application RAID 10 (LOG) Sequential access, optimized to short response times RAID 5 (data) Random access, optimized to throughput	
Software		
Operating system	Windows Server 2008 R2 Enterprise	
Database	SQL Server 2008 R2 Enterprise x64	

Application Server (Tier A)	
Hardware	
System	PRIMERGY RX200 S6
Processor	2 × Xeon E5620 (4C, 2.40 GHz)
Memory	12 GB, 1333 MHz registered ECC DDR3
Network interface	2 × onboard LAN 1 Gb/s, 2 × Dual Port LAN 1Gb/s
Disk subsystem	1 × 73 GB 15k rpm SAS Drive
Software	
Operating system	Windows Server 2008 R2 Standard

Clients	
Hardware	
System	PRIMERGY RX200 S5
Processor	2 × Xeon X5570 (4C, 2.93 GHz)
Memory	24 GB, 1333 MHz registered ECC DDR3
Network interface	2 × onboard LAN 1 Gb/s
Disk subsystem	1 × 73 GB 15k rpm SAS Drive
Software	
Operating system	Windows Server 2008 R2 Standard
OLTP-2 software	EGen version 1.10.0

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

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, the 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.

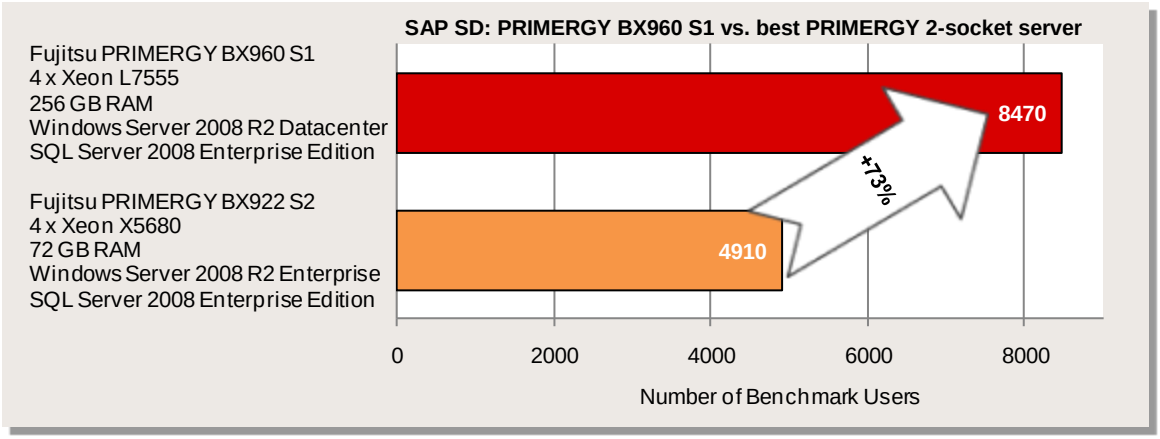
The entire specification of the benchmark developed by SAP AG, Walldorf, Germany can be found at: http://www.sap.com/benchmark.

Benchmark results

The certification number 2010038 from SAP specifies that the PRIMERGY BX960 S1, equipped with 4 Xeon L7555 processors, achieved the following result with SAP Enhancement Package 4 for SAP ERP 6.0 and SQL Server 2008 under Windows Server 2008 R2 Datacenter on 31st August 2010:

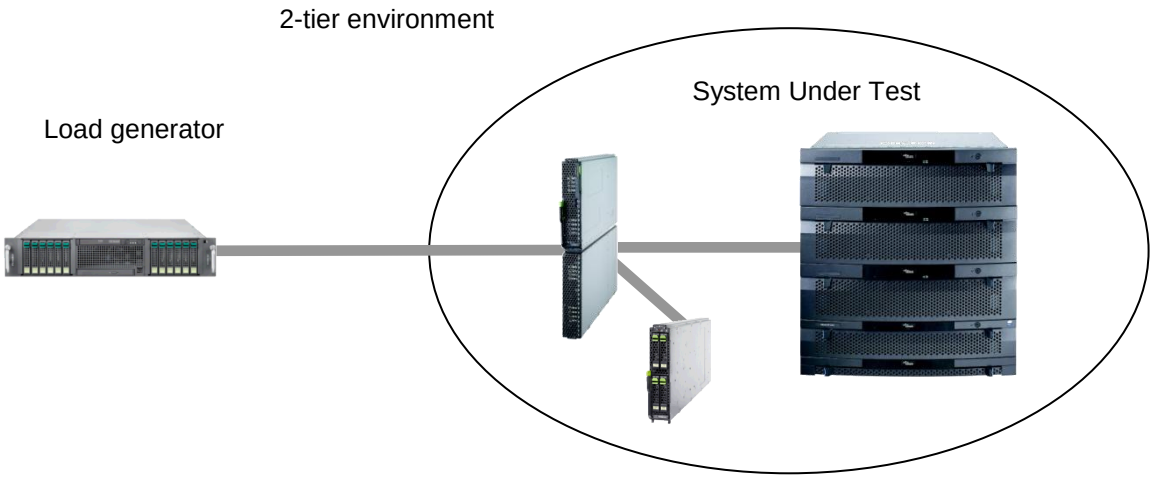
Certification number 2010038	
Number of SAP SD benchmark users	8,470
Average dialog response time	0.99 seconds
Throughput Fully processed order line items/hour dialog steps/hour SAPS	 924,330 2,773,000 46,220
Average database request time (dialog/update)	0.022 sec / 0.029 sec
CPU utilization of central server	96%
Operating system, central server	Windows Server 2008 R2 Datacenter
RDBMS	SQL Server 2008 Enterprise Edition
SAP Business Suite software	SAP enhancement package 4 for SAP ERP 6.0
Configuration Central server	PRIMERGY BX960 S1 4 processors / 32 cores / 64 threads Xeon L7555 256 GB main memory

The following diagram illustrates the throughput of the PRIMERGY BX960 S1 in comparison with the most performant PRIMERGY 2-socket server with each at maximum configuration.



Date: September 22, 2010

Benchmark environment



System Under Test (SUT)	
Hardware	
Server	PRIMERGY BX960 S1
Processor	4 x Xeon L7555
Memory	32 x 8 GB PC3-10600R DDR3-SDRAM
Disk subsystem	1 x PRIMERGY BX960 S1: PY FC Mezz Card 8Gb 2 Port (MC-FC82E) 1 x PRIMERGY SX940 S1: 1 x RAID Ctrl SAS 6G 5/6 512MB (D2616) 1 x RAID Contr BBU Upgrade for RAID 5/6 V16 2 x HD SAS 6G 73GB 15K HOT PLUG 2.5" EP 1 x HD SAS 6G 300GB 10K HOT PLUG 2.5" EP 1 x FibreCAT CX4-480
Software	
Operating system	Windows Server 2008 R2 Datacenter
Database	SQL Server 2008 Enterprise Edition
SAP Business Suite software	SAP enhancement package 4 for SAP ERP 6.0

Load generator	
Hardware	
Model	PRIMERGY RX300 S4
Processor	2 x Xeon X5460, 3.17 GHz, 12 MB L2 cache
Memory	12 GB PC2-5300F DDR2-SDRAM
Software	
Operating system	Linux 2.6.32

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

vServCon

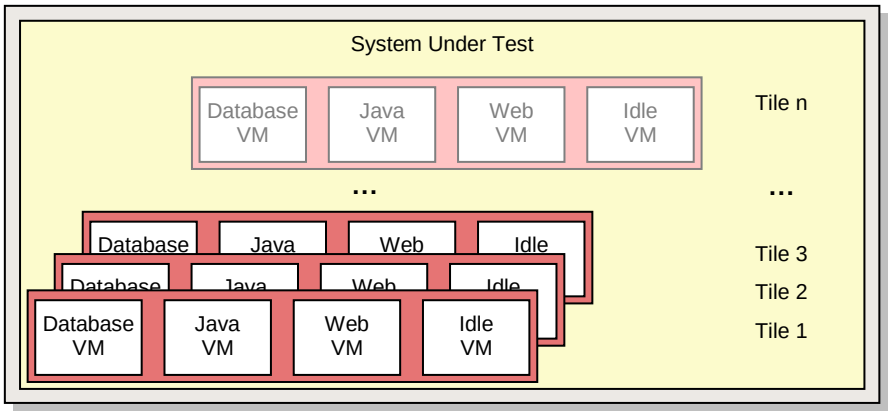
Benchmark description

vServCon is a benchmark used by Fujitsu Technology Solutions 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.

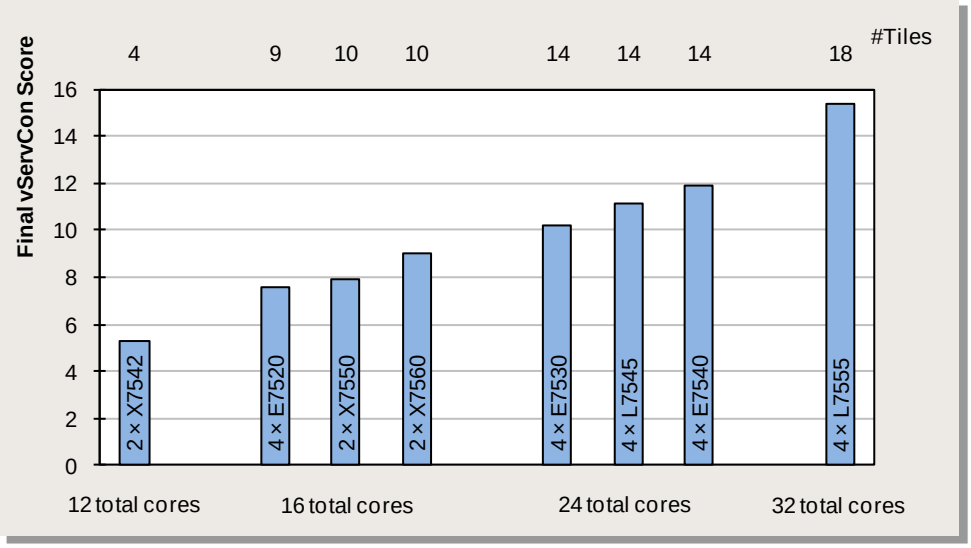
The progression of the vServCon scores for the tile numbers provides useful information about the scaling behavior of the "System under Test".

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 results

The PRIMERGY BX960 S1 is particularly suitable for running a high number of application VMs on account of its manifold expandability: up to 32 processor cores, 512 GB main memory and four 10 GbE ports (onboard) as well as due to further advances in processor technology. Compared with a system based on the previous processor generation, virtualization performance can be up to about 130% greater (measured in vServCon score). On the basis of the previously described vServCon profile almost optimal utilization of the CPU system resources is possible with up to 54 real application VMs (equivalent to 18 tiles) if the system is fully assembled with four processors.

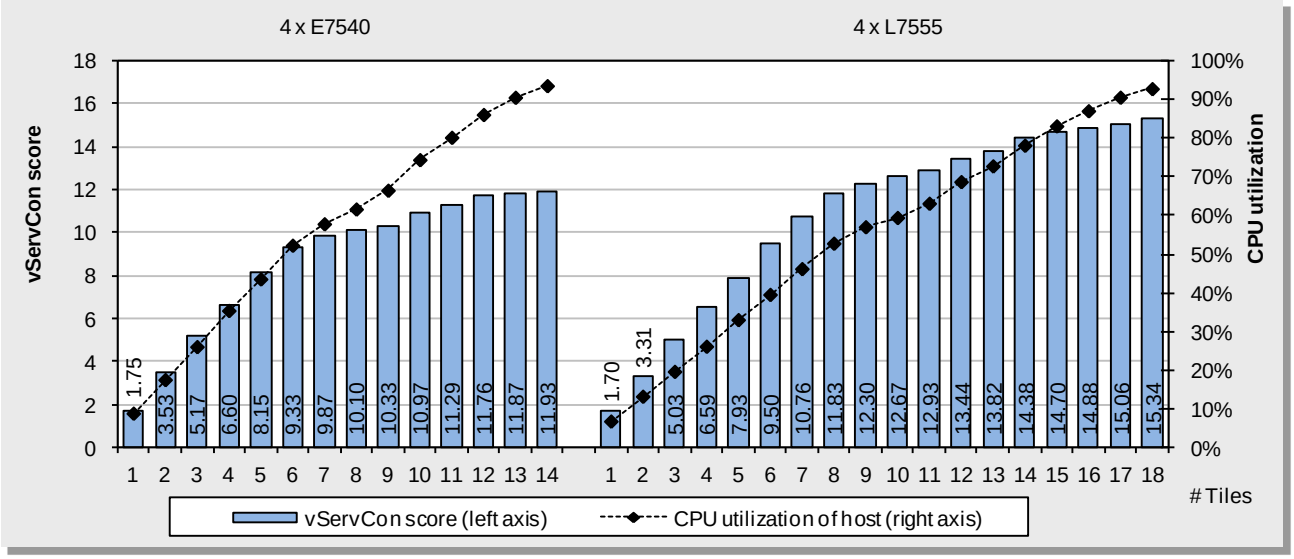


The first diagram compares the virtualization performance values that can be achieved with the individual processors. The processors released for the system have four, six or eight cores and differ regarding some additional technical details. The following table shows the main differences as well as the benchmark results for the processors selected. The meaning of the abbreviations is: QPI = QuickPath Interconnect, GT = Giga transfer, TDP = Thermal Design Power.

Processor	#cores	L3 cache	Processor frequency	QPI speed	Hyper-Threading	Turbo mode	TDP	#Tiles	Score
E7520 (4 ×)	4	18 MB	1.86 GHz	4.8 GT/s	✓		95 W	9	7.58
E7530 (4 ×)	6	12 MB	1.86 GHz	5.86 GT/s	✓	✓	105 W	14	10.23
E7540 (4 ×)	6	18 MB	2.0 GHz	6.4 GT/s	✓	✓	105 W	14	11.93
X7542 (2 ×)	6	18 MB	2.66 GHz	5.86 GT/s		✓	130 W	4	5.29
X7550 (2 ×)	8	18 MB	2.0 GHz	6.4 GT/s	✓	✓	130 W	10	7.90
X7560 (2 ×)	8	24 MB	2.26 GHz	6.4 GT/s	✓	✓	130 W	10	9.02
L7545 (4 ×)	6	18 MB	1.86 GHz	5.86 GT/s	✓	✓	95 W	14	11.17
L7555 (4 ×)	8	24 MB	1.86 GHz	5.86 GT/s	✓	✓	95 W	18	15.34

The effects of the memory configuration on performance are relatively complex. Please note: if fewer than four processors are configured, only those DIMM slots can be used that are directly connected to these processors. We recommend reading the White Paper "Memory Performance of XEON 7500 (Nehalem-EX) Based Systems". This also includes more information about the terms QPI and GT used in the above table. A guideline in the virtualization environment for selecting main memory is that sufficient quantity is more important than the speed of the memory accesses.

The next diagram illustrates the virtualization performance of the PRIMERGY BX960 S1 for increasing numbers of VMs based on the Xeon E7540 (6-core) and L7555 (8-core) processors. The respective CPU loads of the host have also been entered. The number of tiles with optimal CPU load is typically at about 90%; beyond that you have overload, which is where virtualization performance no longer increases, or sinks again.

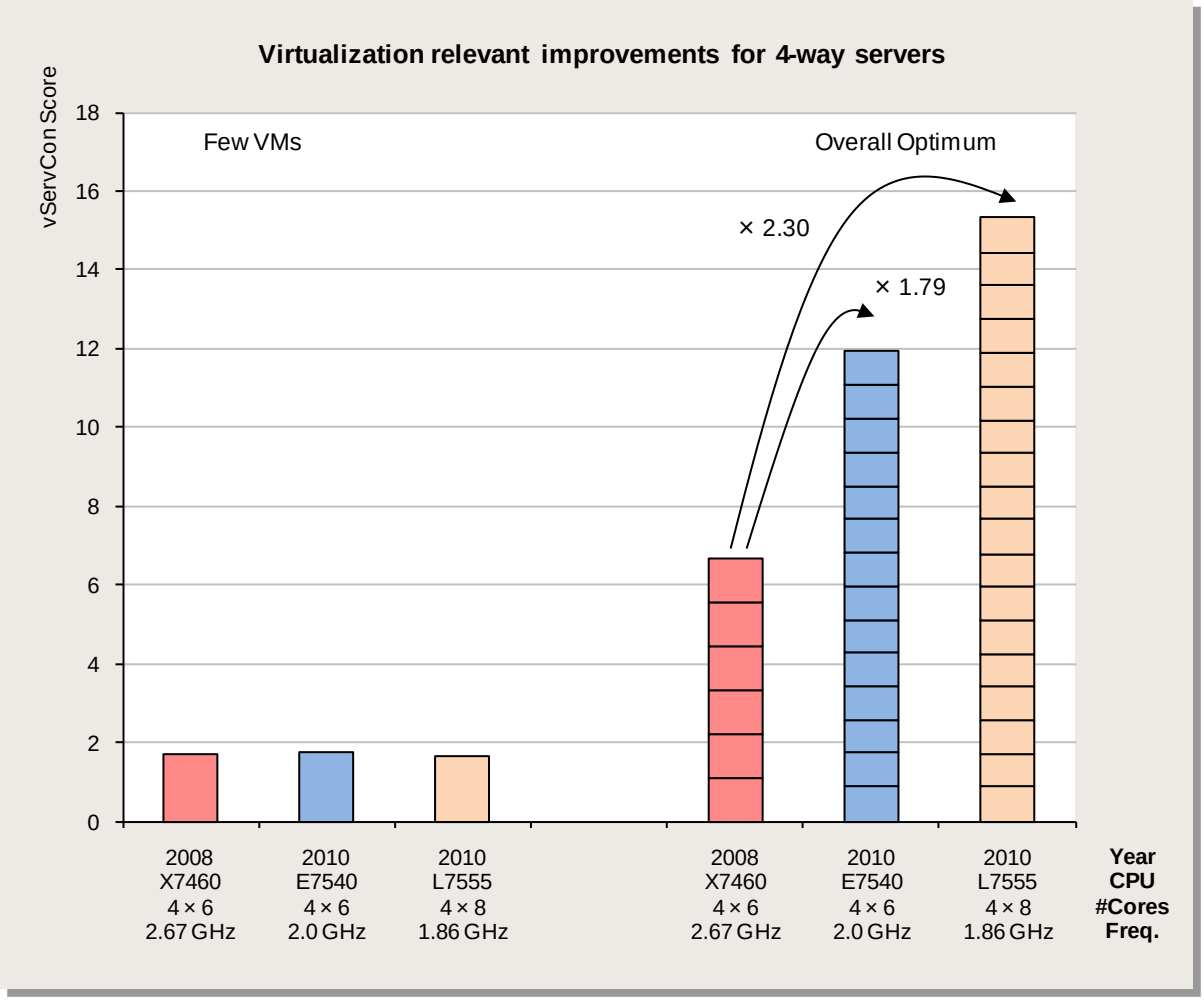


In addition to the increased number of physical cores, Hyper-Threading, which is supported by almost all Xeon processors in the 7500 series, is an additional reason for the high number of VMs that can be operated. As is known, a physical processor core is consequently divided into two logical cores so 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. 24 physical and thus 48 logical cores are available with the Xeon E7540 processor; 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 six 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 E7540 situation with 42 application VMs (14 tiles); the low load case is represented by three application VMs (one tile). 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 1.75 to 11.93/14=0.85, i.e. to 49%. 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.

The virtualization-relevant progress in processor technology since 2008 has an effect on the one hand on an individual VM and, on the other hand, on the possible maximum number of VMs up to CPU full utilization. The following comparison shows the proportions for both types of improvements. Three selected configurations are compared which have various processor frequencies: a 4-socket system from 2008 with 4 × Xeon X7460 and a PRIMERGY BX960 S1 with 4 × Xeon E7540 or 4 × Xeon L7555.



The progress for a few VMs (1 tile) is clear if one compares the 2008 system and the current system with the Xeon E7540 processor. Despite 25% lower processor frequency (2.0 GHz instead of 2.67 GHz) the more recent system has a slightly higher vServCon score. One main reason for this is the new processor feature Extended Page Tables (EPT)[1].

With a full load of the systems with VMs, the virtualization performance of the current system with Xeon E7540 6-core processors is almost twice as high despite the 25% lower processor frequency. One cause is the performance increase that can be realized for an individual VM (see score for a few VMs). The other reason is that more than twice as many VMs are possible with total optimum (e. g. via Hyper-Threading and the multiplied memory bandwidth). However, it can be seen that the optimum is achieved with 14 in contrast to 6 tiles with a somewhat reduced individual VM performance.

The score increase of the current system compared to the system with the previous processor generation at full load can only be completely appreciated when the corresponding reduction in electrical power consumption is also taken into consideration. The guideline is usually seen in TDP (Thermal Design Power). The Xeon X7460 processor used in 2008 has TDP of 130 W, whereas TDP for the Xeon E7540 processor currently in use is only 105 W.

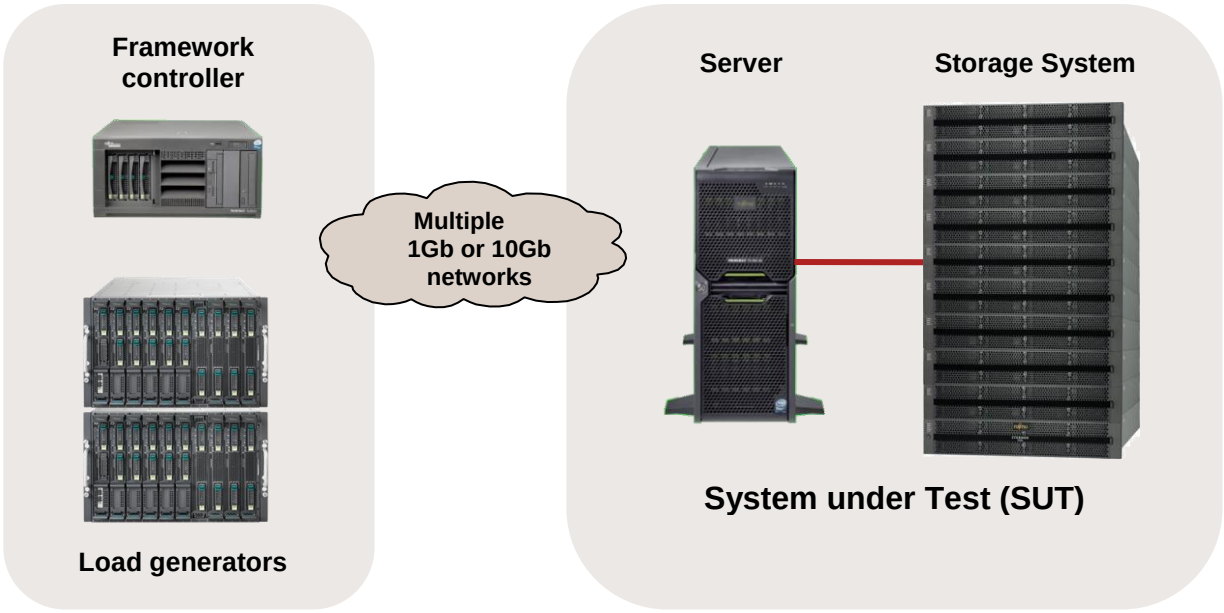
[1] EPT accelerates memory virtualization via hardware support for the mapping between host and guest memory addresses.

A further increase in the virtualization performance can be obtained by using a processor with a higher number of cores. If one considers (also with full load) the same measurements with the current system for the 8-core processor instead of the 6-core processor, you can see a clear improvement in comparison to the 2008 system. Despite the processor clock frequency which is 30% lower in this example, the virtualization performance increases by a factor of 2.30; the energy efficiency is better as a result of the processor TDP which has dropped to 95 W.

We must explicitly point out that the increased virtualization performance as seen in the score cannot be completely deemed as an improvement for one individual VM. More than approximately 30% to 50% increased throughput compared to an identically clocked processor of the Xeon 7400 generation from 2008 is not possible here. Performance increases in the virtualization environment since 2009 are mainly achieved by increases in the maximum number of VMs that can be operated.

Benchmark environment

The measurements were made with the environment described below:



SUT hardware		
Model	PRIMERGY BX960 S1	
Processor	4 × Xeon E7520 (4C, 1.86 GHz) 4 × Xeon E7530 (6C, 1.86 GHz) 4 × Xeon L7545 (6C, 1.86 GHz) 4 × Xeon E7540 (6C, 2.0 GHz)	2 × Xeon X7542 (6C, 2.66 GHz) 4 × Xeon L7555 (8C, 1.86 GHz) 2 × Xeon X7550 (8C, 2.0 GHz) 2 × Xeon X7560 (8C, 2.26 GHz)
Memory	256 GB (full configuration with 8 GB DIMMs)	
Network interface	3 × 10 Gbit LAN onboard; one for load, one for control, one for the host OS.	
Disk subsystem	No internal hard disks were used, but FibreCAT CX500 storage systems. One 50 GB LUN per tile for the "virtual disk files" of the VMs. Each LUN is a RAID 0 array consisting of 5 Seagate ST373454 disks (15 krpm).	
Storage connection	Via FC controller Emulex LPe12002	
SUT software		
Operating system	Hypervisor VMware ESX Server	
Version	Version 4.0 U2; Build 261974	
BIOS	Version Aptio 3.6 R1.01C.2873, default settings	
SUT: virtualization-specific details		
ESX settings	Default	
General details	Described in the Benchmark Overview vServCon.	
Load generator hardware		
Model	2 server blades per tile in PRIMERGY BX600 S3 chassis	
Processor	2 × Xeon 5130 each, 2000 MHz	
Memory	1 – 2 GB	
Network interface	2 × 1 GBit LAN each	
Operating system	W2K3 EE	

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

VMmark V1

Benchmark description

This section is based on VMmark benchmark version 1.1.1, referred to hereinafter in short as VMmark V1. VMmark V1 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. For a long time VMmark V1 was the only established virtualization benchmark which enabled a multivendor comparison. Benchmark results achieved with VMmark V1 could be submitted to VMware and were published on their Internet site after a successful review process. Today, VMmark V1 is only available for academic use and has been replaced by VMmark V2.

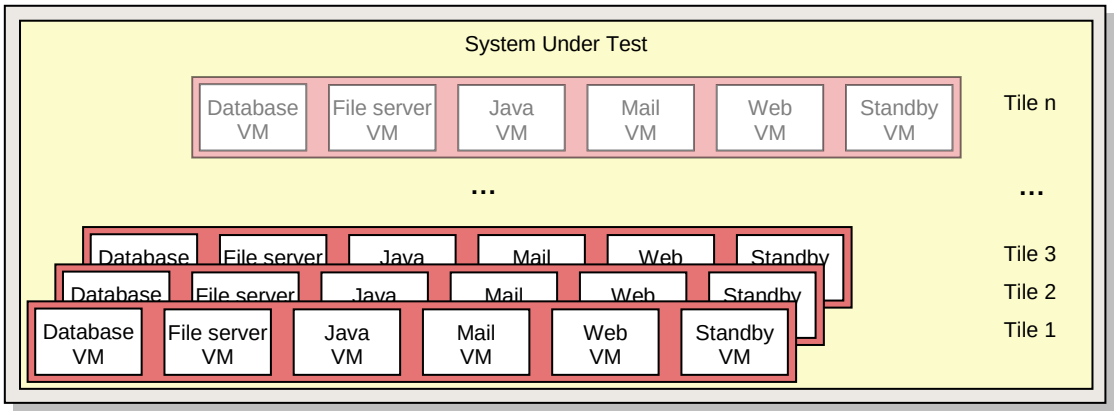
For a benchmark like VMmark V1 to fulfil its objective, it must map the real world of a data center regarding server consolidation; in other words it must consider existing servers with those application scenarios that are normally virtualized. These servers have weak utilization levels and the aim is thus to consolidate as many of them as possible as VMs. Therefore, such a benchmark must assess for a virtualization host both the suitably determined overall throughput across the various application VMs as well as the number of efficiently operable VMs.

The following solution concept has been established for these two objectives: a representative group of application scenarios is selected in the benchmark. They are started simultaneously as VMs on a virtualization host when making a measurement. Each of these VMs is operated with a suitable load tool at a defined lower load level. Such a group of VMs is known as a "tile".

A tile in VMmark V1 consists of six VMs; five of them are allocated to the selected application scenarios on a dedicated basis. A sixth is added, the so-called standby VM. VMmark V1 mandatorily allocates to each VM certain resources with regard to logical processors, memory and hard disk space. The table describes these six VMs and the load tools used to measure them.

Application scenario	Load tool
Database server	Sysbench
File server	Dbench (modified)
Java application server	SPECjbb2005 (modified)
Mail server	Loadsim 2003
Web server	SPECweb2005 (modified)
Standby server	-

Depending on the performance capability of the underlying server hardware, you will - as part of a measurement - mostly have to start several identical tiles in parallel in order to achieve a maximum overall performance.



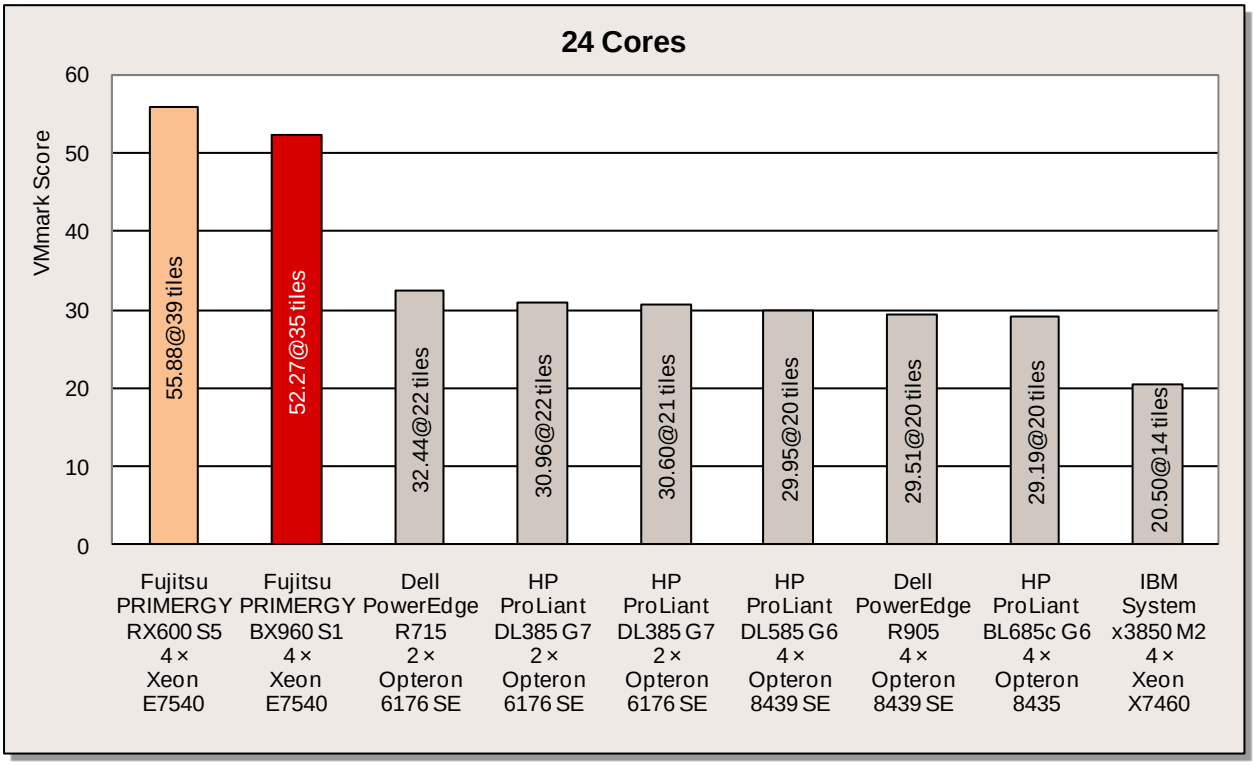
Each of the five VMmark V1 application scenarios provides a specific result for each VM. In order to derive a score the individual results are appropriately summarized for all VMs. The outcome is the VMmark V1 score for this tile number, that is why - in addition to the actual score - the number of tiles is always specified, e.g. "12.34@5 tiles".

A detailed description of VMmark V1 is available in the document Benchmark Overview VMmark V1.

Benchmark results

On June 29, 2010 Fujitsu was first in the VMmark V1 ranking for the 24-core category with a VMmark V1 score of "52.27@35 tiles" with the PRIMERGY BX960 S1 and VMware ESX v4.0 Update 2, which is more than 60% ahead of the next placed systems. The 7% improvement in performance of the PRIMERGY RX600 S5 in the following series of measurements in October 2010 was achieved solely as a result of further optimization. The fact that the PRIMERGY RX600 S5 and PRIMERGY BX960 S1 show a comparable performance with a comparable configuration is documented by the benchmark results with 16 processor cores in the next section.

The diagram shows the top results of the 24-core category with the result of the PRIMERGY BX960 S1 and the PRIMERGY RX600 S5 in comparison[2] to the competitor systems.



All scores as well as the detailed results and configuration data can be seen at http://www.vmware.com/products/vmmark/v1/results.html.

The main prerequisites for this increase in the virtualization performance were the processors of the Xeon 7500 series and the hypervisor version, which optimally uses the processor features. These features include the extended page tables (EPT)[3], Hyper-Threading and the fast memory connection within this processor architecture. All this has a particularly positive effect during virtualization.

A full memory configuration (512 GB with 32 × 16 GB DIMMs) was required to operate the system with optimal performance.

All VMs, their application data, as well as additionally required data were on a powerful fibre channel disk subsystem from ETERNUS DX80 systems with a total of 49 LUNs. The host operating system was installed on an SSD on the onboard SATA controller.

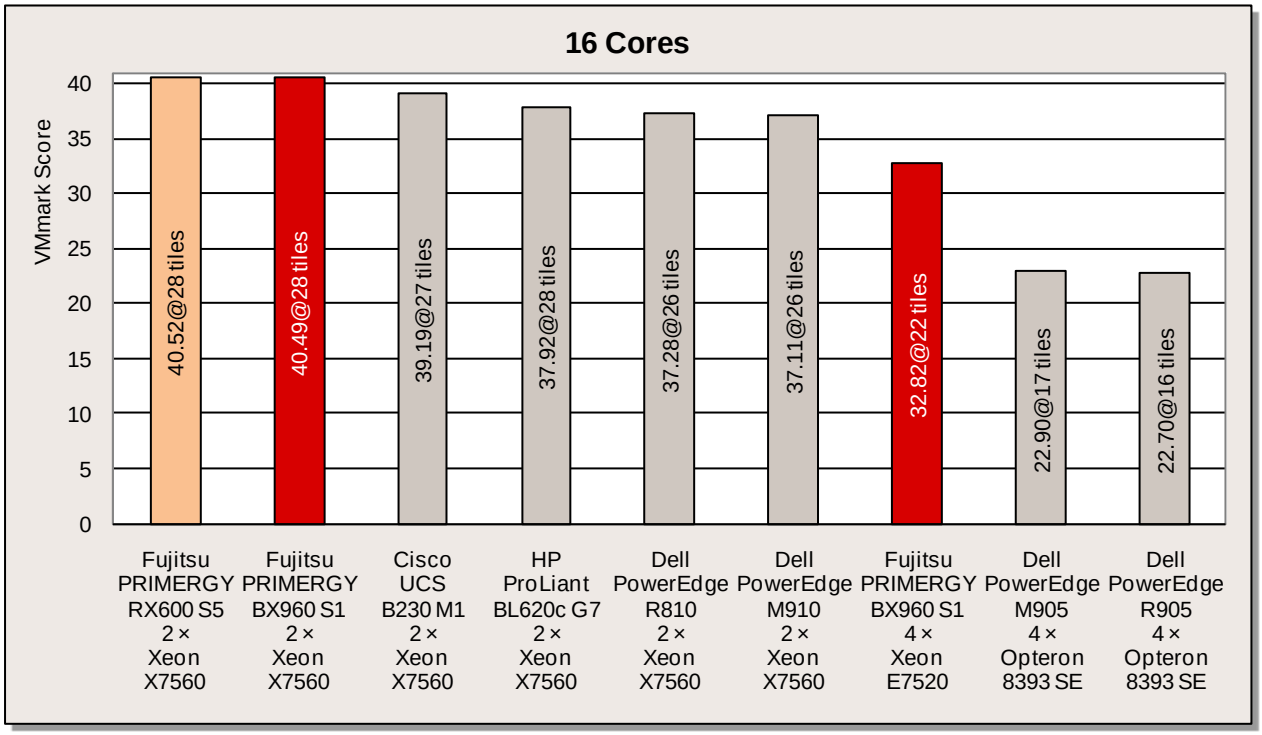
All the components used were optimally attuned to each other.

[2] The above comparisons for the competitor products reflect the status of 19th October 2010. The comparison is based on the VMmark V1 results for the 24-core server category. The VMmark V1 results are available at http://www.vmware.com/products/vmmark/v1/results.html.

[3] EPT accelerates memory virtualization via hardware support for the mapping between host and guest memory addresses.

On October 19, 2010 Fujitsu came second in the VMmark V1 ranking for the 16-core category with a VMmark V1 score of "40.49@28 tiles" with the PRIMERGY BX960 S1 and VMware ESX v4.0 Update 2, neck-and-neck with the PRIMERGY RX600 S5, the rack server that is also Nehalem-EX based. A gap of only 0.07% within the context of measuring inaccuracy shows that the 4-socket blade server - compared with the 4-socket rack server with comparable hardware - offers the same virtualization performance with a smaller form factor.

The following diagram shows the top results of the 16-core category with the result of the PRIMERGY BX960 S1 and the PRIMERGY RX600 S5 in comparison[4] to the competitor systems.



All scores as well as the detailed results and configuration data can be seen at http://www.vmware.com/products/vmmark/v1/results.html.

As with the results of the systems with 24-cores, the boost in performance in the 16-core category is also mainly due to the new processor architecture of the Xeon 7500 series (with features like Hyperthreading and EPT) with its fast memory connection and in combination with the hypervisor VMware ESX v4.0 Update 2.

A configuration with a total of 16 processor cores can be achieved in the PRIMERGY BX960 S1 with either two 8-core processors or four 4-core CPUs. In this comparison the configuration with two of the high-end Xeon X7560 processors offers a considerably better performance than four of the Xeon E7520 processors from the basic class of the Nehalem-EX processor family.

A memory configuration of 256 GB was required in the configuration with 16 processor cores for the VMmark V1 benchmark. This can be achieved for a configuration with four Xeon E7520 processors with 32 × 8 GB, whereas for a configuration with two processors only half the memory slots can be assigned as a result of the architecture and you then have to use a memory configuration of 16 × 16 GB.

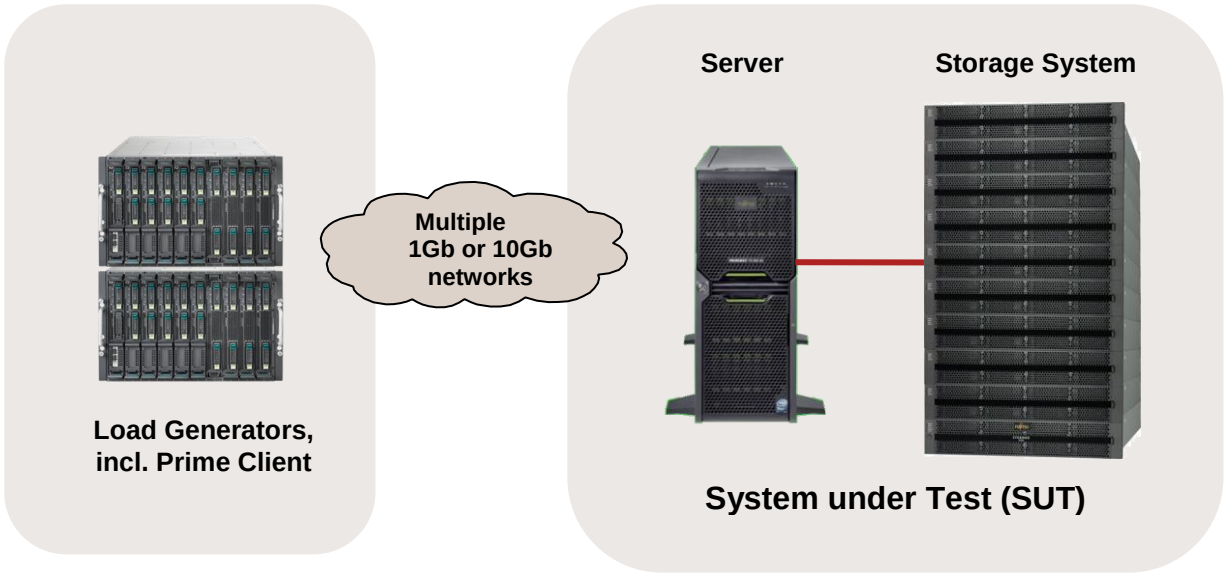
All VMs, their application data, as well as additionally required data were on a powerful fibre channel disk subsystem from ETERNUS DX80 systems with a total of 33 or 41 LUNs. The host operating system was installed on an SSD on the onboard SATA controller.

All the components used were optimally attuned to each other.

[4] The above comparisons for the competitor products reflect the status of 19th October 2010. The comparison is based on the VMmark V1 results for the 16-core server category. The VMmark V1 results are available at http://www.vmware.com/products/vmmark/v1/results.html.

Benchmark environment

The measurement set-up is symbolically illustrated below:



SUT hardware	
Model	PRIMERGY BX960 S1
Processor	2 × Xeon X7560 (8-core, 2.27 GHz) 4 × Xeon E7540 (6 core, 2.0 GHz) 4 × Xeon E7520 (4 core, 1.87 GHz)
Memory	512 GB (32 × 16 GB per DIMM, quad-rank), 1333 MHz registered ECC DDR3 or 256 GB (16 × 16 GB per DIMM, quad-rank), 1333 MHz registered ECC DDR3 or 256 GB (32 × 8 GB per DIMM, dual-rank), 1333 MHz registered ECC DDR3
Network interface	2 × integrated Intel 82599EB dual port 10GbE adapters
Disk subsystem	Internal: Intel SATA SSD 32GB on the onboard controller ICH10R for Host-OS. 8/9/11 Storage systems ETERNUS DX80 with a total of 172/196/244 hard disks in several RAID-0 arrays.
Storage connection	1 × dual-channel MC-FC82E (Emulex LPe12002 based)
SUT software	
Operating system	Hypervisor VMware ESX Server
ESX version	VMware ESX v4.0 Update 2; Build 257240 or Build 261974
BIOS version	Aptio 3.6 R1.01C.2873
Load generator hardware	
Model	server blade PRIMERGY BX620 S4 (1 per tile)
Processor	2 × Intel Xeon 5130, 2 GHz
Memory	3 GB
Network interface	1 × 1 GBit LAN each
Operating system	Microsoft Windows Server 2003 R2 Enterprise, updated with SP2 and KB955839
Details	
See disclosure	http://www.vmware.com/files/pdf/vmmark/VMmark-Fujitsu-2010-10-18-BX960.pdf http://www.vmware.com/files/pdf/vmmark/VMmark-Fujitsu-2010-06-29BX960S1-24core.pdf http://www.vmware.com/files/pdf/vmmark/VMmark-Fujitsu-2010-06-29BX960S1.pdf

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

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VMmark V1 Results
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vServCon

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