

DELL VS. SUN SERVERS: R910 & R810 JAVA PERFORMANCE COMPARISON SPECjbb2005

**Dell™ PowerEdge™
R910 delivers 120%
better performance**



versus



Sun "SPARC" Enterprise T5240
Dual Sun UltraSPARC T2 Plus, 1.60 GHz



PowerEdge R910 server
Dual Intel® Xeon® Processor
X7560, 2.27 GHz
Red Hat® Enterprise Linux® 5.4

On the SPECjbb2005 benchmark

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OUR FINDINGS

The latest, most powerful Dell PowerEdge servers deliver better performance than Sun SPARC Enterprise servers. In Principled Technologies' tests in our labs, the Dell PowerEdge R910 and R810 servers, each with two Intel Xeon Processor X7560s, delivered higher performance results than the publicly available benchmark scores of the Sun SPARC Enterprise T5240 server. These results demonstrate the potential performance benefits of the Dell servers.

OUR PROCESS

We used the industry-standard SPECjbb2005 benchmark to focus on and measure the Java performance of the Dell PowerEdge servers. We then compared our results to publicly available SPECjbb2005 results of the Sun server.



PROJECT OVERVIEW

The Dell PowerEdge R910 server achieved a SPECjbb2005 score of 931,315, a 120.3 percent increase over the Sun SPARC Enterprise T5240 server, which achieved a SPECjbb2005 score of 422,782.¹ (See Figure 1.)

The Dell PowerEdge R810 server achieved a SPECjbb2005 score of 943,614, a 123.2 percent increase over the Sun SPARC Enterprise T5240 server, which achieved a SPECjbb2005 score of 422,782.² (See Figure 1.)

SPECjbb2005 is an industry-standard benchmark created by the Standard Performance Evaluation Corp. (SPEC) to measure a server's Java performance. (Note: SPEC and SPECjbb2005 are trademarks of the Standard Performance Evaluation Corporation.) SPEC modeled SPECjbb2005 on the three-tier client/server architecture, with the middle layer as the primary focus. According to SPEC, "Random input selection represents the first (user) tier. SPECjbb2005 fully implements the middle tier business logic. The third tier is represented by tables of objects, implemented by Java Collections, rather than a separate database."
www.spec.org/jbb2005/docs/UserGuide.html.

SPECjbb2005 utilizes multiple special data groups and multiple threads as it runs. Each data unit is a "warehouse," a roughly 25MB collection of data objects.

Each thread represents an active user posting transaction requests within a warehouse. The benchmark run begins with one warehouse and then increases the number of warehouses; its goal is to saturate the server's processor capacity. As the number of warehouses

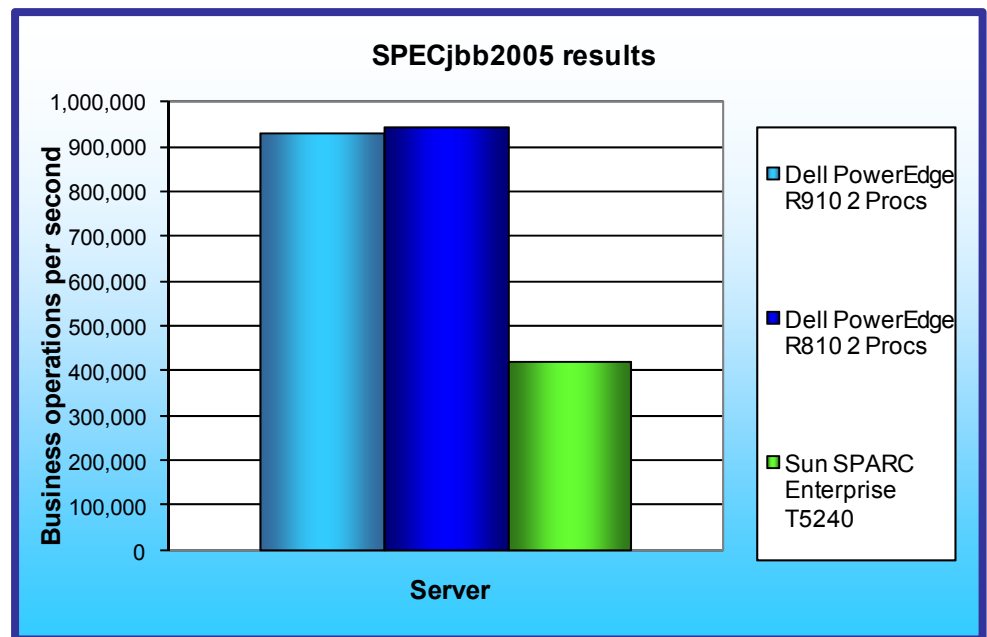


Figure 1: SPECjbb 2005 performance results. Higher numbers are better.

increases, so does the number of threads. The benchmark's results portray the server's throughput in business

¹ Source: Principled Technologies®, Inc., "Dell vs. Sun servers: R910 & R810 Java performance comparison SPECjbb2005," a February 2010 report commissioned by Dell. For the latest SPECjbb2005 benchmarks, visit www.spec.org.

² *Ibid.*

operations per second or SPECjbb2005 bops. A higher number of SPECjbb2005 bops is better. (For more information on SPECjbb2005, go to www.spec.org.)

Due to licensing issues, we did not actually test SPECjbb2005 on the Sun SPARC Enterprise T5240. Instead, we used the highest posted result for the Sun system on SPEC’s site (<http://www.spec.org/osg/jbb2005/results/res2009q3/jbb2005-20090810-00764.html>).

Figure 2 shows the system configuration overview for the similarly configured Dell PowerEdge R910, Dell PowerEdge R810, and Sun SPARC Enterprise T5240 servers.

Servers	Dell PowerEdge R910	Dell PowerEdge R810	Sun SPARC Enterprise T5240
Processors	Dual Intel Xeon Processor X7560, 2.27 GHz	Dual Intel Xeon Processor X7560, 2.27 GHz	Dual Sun UltraSPARC T2 Plus, 1.60 GHz
Memory	32 x 4GB PC3-8500 DDR3	32 x 4GB PC3-8500 DDR3	16 x 4GB DDR2
Hard disks	2 x 73GB, SAS	2 x 146GB, SAS	1 x 146GB, SCSI
Operating system	Red Hat® Enterprise Linux® 5.4 (2.6.18-164.9.1.el5)	Red Hat Enterprise Linux 5.4 (2.6.18-164.9.1.el5)	OpenSolaris 2009.06
JVM	IBM® J9 VM (build 2.4, JRE 1.6.0 IBM J9 2.4 Linux amd64-64 jvms6460sr7-20091214_49398 (JIT enabled, AOT enabled))	IBM J9 VM (build 2.4, JRE 1.6.0 IBM J9 2.4 Linux amd64-64 jvms6460sr7-20091214_49398 (JIT enabled, AOT enabled))	Java HotSpot™ 32-Bit Server VM on Solaris, version 1.6.0_14 Performance Release

Figure 2: System configuration overview for the three test servers. See Appendix A for more details on the Dell PowerEdge servers.

WHAT WE FOUND

Figure 3 shows the median SPECjbb2005 results for all servers. In our test, we ran multiple JVMs at the same time, a common practice on servers with many processors.

	Dell PowerEdge R910	Dell PowerEdge R810	Sun SPARC Enterprise T5240
JVM 1	115,328	113,359	26,331
JVM 2	116,450	121,663	26,295
JVM 3	116,928	114,710	26,413
JVM 4	117,609	122,224	26,187
JVM 5	114,406	114,982	26,335
JVM 6	116,214	115,259	26,243
JVM 7	118,011	119,837	26,822
JVM 8	116,369	121,580	26,181

	Dell PowerEdge R910	Dell PowerEdge R810	Sun SPARC Enterprise T5240
JVM 9	N/A	N/A	26,751
JVM 10	N/A	N/A	26,733
JVM 11	N/A	N/A	26,819
JVM 12	N/A	N/A	26,176
JVM 13	N/A	N/A	26,764
JVM 14	N/A	N/A	26,249
JVM 15	N/A	N/A	26,238
JVM 16	N/A	N/A	26,245
Total score	931,315	943,614	422,782

Figure 3: SPECjbb2005 results for each server by JVM. Higher numbers are better.

To compute the overall score for the system, SPECjbb2005 sums the scores of all the JVMs. SPECjbb2005 computes the score of each JVM by taking the average of the results during mixes when the server is running at peak performance. (In SPEC's terms, these results are from "compliant" runs, which means we can disclose them publicly though we are not posting them on the SPEC Web site with all the files SPEC requires. We do present here all the data necessary to reproduce these results.)

Figure 4 shows the results by warehouse for the Dell PowerEdge R910 server for all three runs. Run 2 produced the median results.

Dell PowerEdge R910			
	Run 1	Run 2	Run 3
Warehouse	JVM 1		
1	42,557	40,779	42,616
2	95,831	92,368	93,090
3	106,830	108,654	111,052
4	117,775	116,237	119,135
5	116,786	115,788	118,738
6	115,985	115,118	117,761
7	115,111	115,059	117,381
8	114,720	114,435	116,721
Score	116,075	115,328	117,947
Warehouse	JVM 2		
1	42,078	44,924	42,040
2	94,187	96,439	97,261
3	106,411	109,909	109,091
4	116,430	118,119	118,511
5	115,432	117,237	118,170
6	114,664	116,288	117,156
7	114,178	115,573	115,826

Dell PowerEdge R910			
8	114,736	115,031	115,950
Score	115,070	116,450	117,123
Warehouse	JVM 3		
1	41,703	43,130	44,280
2	94,437	97,638	96,962
3	105,963	109,674	110,702
4	117,706	117,472	117,003
5	116,847	118,288	116,069
6	115,483	117,028	115,766
7	114,835	116,339	114,246
8	113,918	115,513	114,723
Score	115,758	116,928	115,561
Warehouse	JVM 4		
1	42,261	43,234	41,486
2	96,522	88,129	84,788
3	107,389	110,349	108,572
4	119,563	118,428	117,731
5	119,631	118,921	116,598
6	118,122	117,582	115,433
7	118,355	116,974	114,883
8	117,921	116,142	114,780
Score	118,719	117,609	115,885
Warehouse	JVM 5		
1	41,477	40,859	39,144
2	96,130	90,706	78,370
3	110,625	108,518	108,256
4	117,700	115,468	116,099
5	117,478	115,764	114,444
6	116,058	114,713	114,266
7	115,761	113,714	113,111
8	115,109	112,371	113,865
Score	116,421	114,406	114,357
Warehouse	JVM 6		
1	45,477	44,110	42,906
2	97,174	96,723	94,759
3	110,927	109,196	109,408
4	120,088	117,528	117,404
5	118,458	116,957	117,230
6	117,263	115,964	116,893
7	116,105	115,471	117,024
8	116,625	115,151	116,686
Score	117,708	116,214	117,047

Dell PowerEdge R910			
Warehouse	JVM 7		
1	42,153	43,505	43,429
2	92,759	96,769	96,668
3	110,692	108,056	109,603
4	118,143	119,082	117,911
5	118,402	118,483	116,487
6	116,869	118,093	115,664
7	116,603	117,671	115,783
8	115,846	116,724	114,895
Score	117,173	118,011	116,148
Warehouse	JVM 8		
1	41,507	41,344	42,149
2	95,202	93,835	82,139
3	111,723	106,156	110,823
4	117,836	117,407	118,244
5	116,401	116,290	117,327
6	115,441	116,534	116,512
7	115,173	116,171	115,306
8	114,594	115,442	115,592
Score	115,889	116,369	116,596
SPECjbb2005 bops/JVM	116,602	116,414	116,333
Total score	932,813	931,315	930,664

Figure 4: SPECjbb2005 results for the Dell PowerEdge R910 server. Higher numbers are better.

Figure 5 shows the results by warehouse for the Dell PowerEdge R810 server for all three runs. Run 3 produced the median results.

Dell PowerEdge R810			
	Run 1	Run 2	Run 3
Warehouse	JVM 1		
1	41,253	43,705	42,694
2	91,704	93,810	92,410
3	104,755	107,919	103,921
4	116,337	117,208	115,707
5	114,723	115,575	113,952
6	114,033	115,228	112,490
7	113,349	114,018	112,282
8	111,899	112,835	112,362
Score	114,068	114,973	113,359

Dell PowerEdge R810

Warehouse	JVM 2		
1	41,624	43,303	42,426
2	94,313	94,795	96,010
3	110,313	113,211	112,001
4	121,304	123,884	123,394
5	120,873	122,611	122,891
6	119,462	121,867	121,603
7	118,335	120,513	120,940
8	117,363	120,218	119,485
Score	119,468	121,819	121,663
Warehouse	JVM 3		
1	40,673	41,805	42,162
2	92,090	93,520	92,439
3	107,609	109,628	108,570
4	114,935	116,932	117,108
5	114,724	116,600	115,358
6	114,046	115,289	114,471
7	112,861	115,015	113,375
8	112,848	113,666	113,238
Score	113,883	115,500	114,710
Warehouse	JVM 4		
1	43,420	40,460	38,351
2	94,007	94,957	96,131
3	111,185	110,520	109,649
4	123,859	121,778	123,908
5	123,010	121,376	123,307
6	122,019	119,844	121,952
7	121,136	119,169	121,154
8	121,033	118,610	120,799
Score	122,211	120,155	122,224
Warehouse	JVM 5		
1	42,707	41,174	44,961
2	94,495	92,331	94,715
3	107,159	107,461	105,457
4	114,890	115,040	117,023
5	114,773	114,980	115,522
6	113,824	113,755	115,204
7	112,959	112,974	113,922
8	112,384	112,228	113,239
Score	113,766	113,795	114,982
Warehouse	JVM 6		
1	44,994	44,670	42,668

Dell PowerEdge R810			
2	93,781	93,451	93,275
3	107,407	110,198	109,503
4	115,720	118,460	116,591
5	114,786	117,119	116,070
6	112,349	115,798	115,017
7	112,267	115,395	114,773
8	111,111	115,123	113,843
Score	113,246	116,379	115,259
Warehouse	JVM 7		
1	42,273	43,000	42,128
2	96,831	97,093	95,401
3	114,194	113,063	112,391
4	123,923	123,769	121,230
5	123,684	123,353	121,103
6	122,165	121,494	120,118
7	121,831	120,105	119,198
8	121,066	120,317	117,534
Score	122,534	121,808	119,837
Warehouse	JVM 8		
1	40,808	41,641	42,249
2	94,546	95,421	97,008
3	112,157	107,433	113,539
4	121,485	123,553	123,959
5	120,613	121,928	122,420
6	119,680	121,067	121,022
7	119,092	120,625	120,338
8	118,335	120,552	120,161
Score	119,841	121,545	121,580
SPECjbb2005 boops/JVM	117,377	118,247	117,952
Total score	939,017	945,974	943,614

Figure 5: SPECjbb2005 results for the Dell PowerEdge R810 server. Higher numbers are better.

HOW WE TESTED

Adjusting BIOS settings

We used all of the default BIOS settings on the Dell PowerEdge R910 server and the Dell PowerEdge R810 server. Among these settings were the following:

- Hardware Prefetcher enabled
- Adjacent Cache Line Prefetch enabled

- Node Interleaving disabled
- C States enabled

Setting up and configuring the Dell PowerEdge R910 and the Dell PowerEdge R810

We began by installing a fresh copy of Red Hat Enterprise Linux Server 5.4. We installed the default packages, disabled the firewall, and disabled SELinux. We made no additional changes to the default installation options.

After the base installation, we updated the kernel on the Dell PowerEdge R810 and Dell PowerEdge R910 from 2.6.18-164.el5 to 2.6.18-164.9.1.el5. This new kernel provided proper Nehalem-EX support in Red Hat for the Dell PowerEdge R910 and the Dell PowerEdge R810.

In addition to installing the Nehalem-EX Red Hat Enterprise Linux, we created hugepages by adding the following text to the `/etc/sysctl.conf` file:

```
vm.nr_hugepages=32000
```

SPECjbb2005 configuration

We used SPECjbb2005 version 1.07, dated March 15, 2006. We followed SPEC's run rules. (For more information about SPECjbb2005 and its run rules, see www.spec.org/jbb2005/docs/RunRules.html.) We installed SPECjbb2005 by copying the contents of the SPECjbb2005 CD to the directory `/SPECjbb2005` on each server's hard disk.

SPECjbb2005 requires a Java Virtual Machine on the system under test. We used the IBM J9 VM (build 2.4, JRE 1.6.0 IBM J9 2.4 Linux amd64-64 jvms6460sr7-20091214_49398 (JIT enabled, AOT enabled)) JVM for this testing and left the default installation settings.

After installation, as per the run rules, we edited the `SPECjbb_config.props` file in the root `SPECjbb2005` directory to include disclosure information about each server and our license information. SPECjbb2005 uses this file when generating the results output for each run. We also modified the `SPECjbb.props` file to change the number of JVM instances to 8 for the Dell PowerEdge R810 and R910 servers. This change allows a server to run 8 JVM instances during testing, depending on the server.

We created a shell file, which we placed in the root `SPECjbb2005` directory, to issue the Java run command to launch the benchmark. We used the shell file to begin the SPECjbb2005 test.

The following is the contents of the shell file that we used for the Dell PowerEdge R910 server and the Dell PowerEdge R810 server:

```
#!/bin/sh

echo
date

echo
echo Setting OS tuning options...

sleep 2

echo
PATH=/ibm-java-x86_64-60/jre/bin:$PATH
echo PATH="$PATH"

echo
java -version

sleep 1
echo
date

JVM_OPTIONS="-Xaggressive -Xcompressedrefs -Xgcpolicy:gencon -Xmn1400m -Xms1875m -
Xmx1875m -XlockReservation -Xnloa -XtlhPrefetch

-Xlp"

echo
echo Starting Controller
java -cp jbb.jar:check.jar -Xms256m -Xmx256m spec.jbb.Controller -propfile SPECjbb.props
&
sleep 5

echo "Starting instance 1"
numactl --physcpubind=0,2,16,18 --localalloc java -cp jbb.jar:check.jar $JVM_OPTIONS
spec.jbb.JBBmain -propfile SPECjbb.props -id 1 > multi.1 &

sleep 10

echo "Starting instance 2"
numactl --physcpubind=1,3,17,19 --localalloc java -cp jbb.jar:check.jar $JVM_OPTIONS
spec.jbb.JBBmain -propfile SPECjbb.props -id 2 > multi.2 &

sleep 10

echo "Starting instance 3"
numactl --physcpubind=4,6,20,22 --localalloc java -cp jbb.jar:check.jar $JVM_OPTIONS
spec.jbb.JBBmain -propfile SPECjbb.props -id 3 > multi.3 &

sleep 10

echo "Starting instance 4"
numactl --physcpubind=5,7,21,23 --localalloc java -cp jbb.jar:check.jar $JVM_OPTIONS
spec.jbb.JBBmain -propfile SPECjbb.props -id 4 > multi.4 &

sleep 10

echo "Starting instance 5"
```

```
numactl --physcpubind=8,10,24,26 --localalloc java -cp jbb.jar:check.jar $JVM_OPTIONS
spec.jbb.JBBmain -propfile SPECjbb.props -id 5 > multi.5 &

sleep 10

echo "Starting instance 6"
numactl --physcpubind=9,11,25,27 --localalloc java -cp jbb.jar:check.jar $JVM_OPTIONS
spec.jbb.JBBmain -propfile SPECjbb.props -id 6 > multi.6 &

sleep 10

echo "Starting instance 7"
numactl --physcpubind=12,14,28,30 --localalloc java -cp jbb.jar:check.jar $JVM_OPTIONS
spec.jbb.JBBmain -propfile SPECjbb.props -id 7 > multi.7 &

sleep 10

echo "Starting instance 8"
numactl --physcpubind=13,15,29,31 --localalloc java -cp jbb.jar:check.jar $JVM_OPTIONS
spec.jbb.JBBmain -propfile SPECjbb.props -id 8 > multi.8 &

sleep 10

date
```

To improve Java performance, we set Java options. The following list gives a brief description of all options we used for testing.³

- *-Xaggressive* turns on extra JVM performance optimizations.
- *-Xcompressedrefs* changes the JVM to use 32-bit reference values over 64-bit reference values.
- *-Xgcpolicy:gencon* sets the garbage collector policy to use both the combined and generational gcs to minimize gc time.
- *-Xmn1400m* sets the JVM nursery size.
- *-Xms1875m* sets the minimum heap size. We set the minimum and maximum heap sizes to be the same, so the heap size would stay a constant 1875MB.
- *-Xmx1875m* sets the maximum heap size.
- *-XlockReservation* turns on optimizations that presume a monitor is owned by the thread that last acquired it.
- *-Xnolooa* prevents allocation of large object areas.
- *-XtlhPrefetch* prefetches bytes in the thread local heap.
- *-Xlp* enables the use of hugepages for the IBM JVM.

³ Source:

http://publib.boulder.ibm.com/infocenter/javasdk/v6r0/index.jsp?topic=/com.ibm.java.doc.user.Inx.60/diag/appendixes/cmdline/commands_jvm.html

Conducting the test

To run the SPECjbb2005 test, we first mounted hugepages on our server using the following commands:

```
mkdir -p /mnt/hugepages  
mount none /mnt/hugepages -t hugetlbfs  
chmod 777 /mnt/hugepages
```

After we mounted hugepages, we ran the run shell script and the run took approximately 30 minutes to complete.

APPENDIX A – TEST SERVER INFORMATION

Figure 6 presents detailed information for the Dell PowerEdge test servers we used in this report.

Server	Dell PowerEdge R910	Dell PowerEdge R810
General dimension information		
Height (inches)	7.00	3.50
Width (inches)	17.25	17.25
Depth (inches)	29.00	29.00
U size in server rack (U)	4	2
Power supplies		
Total number	4	2
Brand and model	Dell Z1100P-00	Dell Z1100P-00
Wattage (W)	1,023	1,023
Cooling fans		
Total number	6	6
Dimensions (h x w)	5" x 5"	2.5" x 2.5 "
Voltage (V)	12	12
Amps (A)	4.80	0.95
General processor setup		
Number of processor packages	2	2
Number of cores per processor package	8	8
Number of hardware threads per core	2	2
CPU		
Vendor	Intel	Intel
Name	Xeon X7560	Xeon X7560
Stepping	D0	D0
Socket type	LGA1567	LGA1567
Core frequency (GHz)	2.27	2.27
L1 cache	32 KB + 32 KB	32 KB + 32 KB
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache (MB)	24	24
Platform		
Vendor and model number	Dell PowerEdge R910	Dell PowerEdge R810
Motherboard model number	0P658H	05W7DG
Motherboard revision number	X23	X03
BIOS name and version	Dell 1.0.1 (03/14/2010)	Dell 1.0.2 (03/14/2010)
BIOS settings	Default	Default
Memory modules		
Total RAM in system (GB)	128	128
Vendor and model number	Hynix HMT151R7BFR8C-G7	Hynix HMT151R7BFR8C-G7

Server	Dell PowerEdge R910	Dell PowerEdge R810
Type	PC3-8500 DDR3	PC3-8500 DDR3
Speed (MHz)	1,066	1,066
Speed in the system currently running @ (MHz)	1,066	1,066
Timing/latency (tCL-tRCD-iRP-tRASmin)	7-7-7-20	7-7-7-20
Size (GB)	128	128
Number of RAM modules	32 x 4 GB	32 x 4 GB
Chip organization	Double-sided	Double-sided
Hard disk		
Vendor and model number	Seagate ST973452SS	Seagate ST9146852SS
Number of disks in system	2	2
Size (GB)	73	146
Buffer size (MB)	16	16
RPM	15,000	15,000
Type	SAS 6.0 GB/s	SAS
Controller	LSI MegaSAS 9260	LSI MegaSAS 9260
Operating system		
Name	Red Hat Enterprise Linux 5.4	Red Hat Enterprise Linux 5.4
Kernel release	2.6.18-164.9.1.el5 x86_64	2.6.18-164.9.1.el5 x86_64
Kernel version	SMP Wed Dec 9 03:27:37 EST 2009	SMP Wed Dec 9 03:27:37 EST 2009
File system	ext3	ext3
Language	English	English
Network card/subsystem		
Vendor and model number	Broadcom NetXtreme II gigE 5709C Dual-Port Ethernet	Broadcom NetXtreme II gigE 5709C Dual-Port Ethernet
Type	PCI-E	Integrated
USB Ports		
Number	4	4
Type	2.0	2.0

Figure 6: Detailed configuration information for the Dell PowerEdge test servers.

APPENDIX B – SPECJBB2005 OUTPUT

This appendix provides the SPECjbb2005 output files from the median run for the test servers.

Red Hat Enterprise Linux 5.4 server: Dell PowerEdge R910

SPECjbb2005

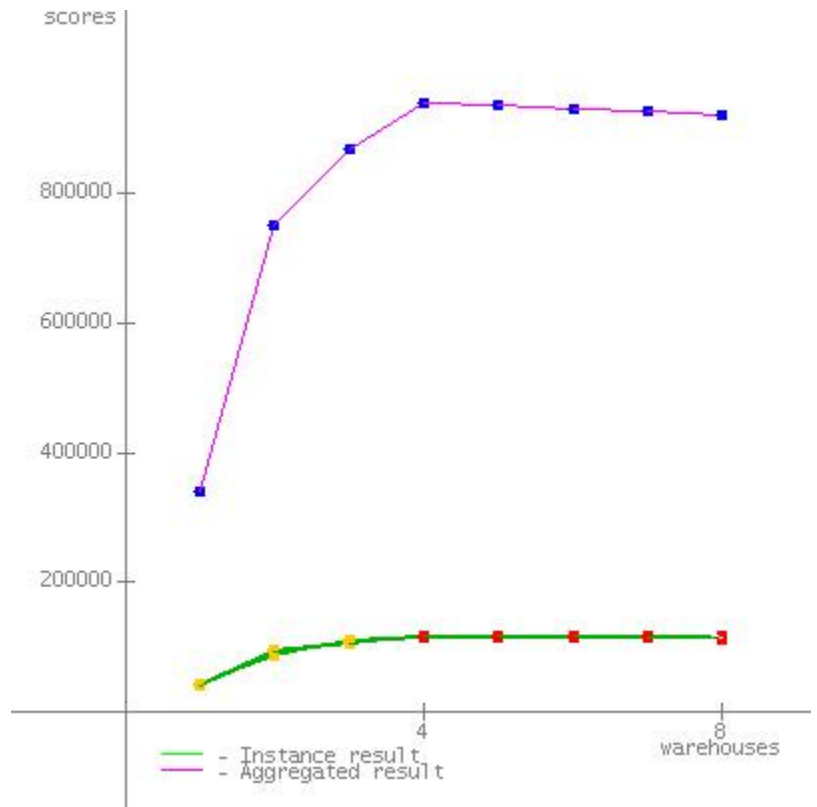
SPECjbb2005 bops = 931315, SPECjbb2005 bops/JVM = 116414

Dell PowerEdge

R910

IBM J9 1.6.0 SR7

JVM run	JVM Scores
1	115328
2	116450
3	116928
4	117609
5	114406
6	116214
7	118011
8	116369
SPECjbb2005 bops = 931315, SPECjbb2005 bops/JVM = 116414	



Hardware	
Hardware Vendor	Dell
Vendor URL	http://www.dell.com
Model	PowerEdge R910
Processor	Intel Xeon X7560
MHz	2270
# of Chips	2

Software	
Software Vendor	IBM
Vendor URL	http://www.ibm.com
JVM Version	IBM J9 VM (build 2.4, JRE 1.6.0 IBM J9 2.4 Linux amd64-64 jvms6460sr7-20091214_49398 (JIT enabled, AOT enabled)) JVM
JVM Command Line	java -Xaggressive -Xcompressedrefs -Xgcpolicy:gencon -Xmn1400m -Xms1875m -

# of Cores	16		Xmx1875m -XlockReservation -Xnloa -XtlhPrefetch -Xlp
# of Cores/Chip	2	JVM Initial Heap Memory (MB)	1875
HW Threading Enabled?	Yes	JVM Maximum Heap Memory (MB)	1875
Procs Avail to Java	32	JVM Address bits	64
Memory (MB)	131072	JVM CLASSPATH	jbb.jar: check.jar
Memory Details	Hynix HMT151R7BFR8C-G7	JVM BOOTCLASSPATH	/ibm-java-x86_64-60/jre/lib/amd64/compressedrefs/jclSC160/vm.jar: /ibm-java-x86_64-60/jre/lib/annotation.jar: /ibm-java-x86_64-60/jre/lib/beans.jar: /ibm-java-x86_64-60/jre/lib/java.util.jar: /ibm-java-x86_64-60/jre/lib/jndi.jar: /ibm-java-x86_64-60/jre/lib/logging.jar: /ibm-java-x86_64-60/jre/lib/security.jar: /ibm-java-x86_64-60/jre/lib/sql.jar: /ibm-java-x86_64-60/jre/lib/ibmorb.jar: /ibm-java-x86_64-60/jre/lib/ibmorbapi.jar: /ibm-java-x86_64-60/jre/lib/ibmcfw.jar: /ibm-java-x86_64-60/jre/lib/rt.jar: /ibm-java-x86_64-60/jre/lib/charsets.jar: /ibm-java-x86_64-60/jre/lib/resources.jar: /ibm-java-x86_64-60/jre/lib/ibmpkcs.jar: /ibm-java-x86_64-60/jre/lib/ibmcertpathfw.jar: /ibm-java-x86_64-60/jre/lib/ibmjgssfw.jar: /ibm-java-x86_64-60/jre/lib/ibmjssefw.jar: /ibm-java-x86_64-60/jre/lib/ibmsaslfw.jar: /ibm-java-x86_64-60/jre/lib/ibmjcefw.jar: /ibm-java-x86_64-60/jre/lib/ibmjgssprovider.jar: /ibm-java-x86_64-60/jre/lib/ibmjsseprovider2.jar: /ibm-java-x86_64-60/jre/lib/ibmcertpathprovider.jar: /ibm-java-x86_64-60/jre/lib/ibmxmlicrypto.jar: /ibm-java-x86_64-60/jre/lib/management-agent.jar: /ibm-java-x86_64-60/jre/lib/xml.jar: /ibm-java-x86_64-60/jre/lib/jlm.jar: /ibm-java-x86_64-60/jre/lib/javascript.jar
Primary cache		OS Version	Red Hat Enterprise Linux 5.4
Secondary cache			
Other cache	24 MB L3		
Filesystem	Ext3		
Disks	2 x 73 GB SAS		
Other hardware			

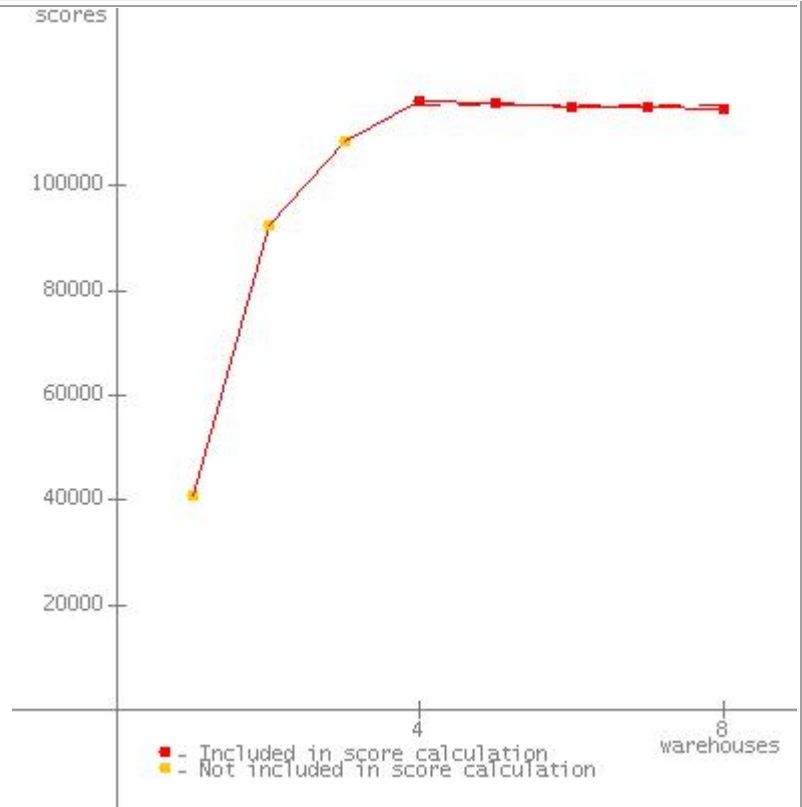
Other software	
AOT Compilation	
Tuning	
Operating system tunings	
<ul style="list-style-type: none"> vm.nr_hugepages=32000 	
Notes	

Test Information	
Tested by	Principled Technologies, Inc.
SPEC license #	3184
Test location	Durham, NC
Test date	Mar 10, 2010
H/w available	
JVM available	
OS available	Sept-2009
Other s/w available	

JVM 1 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	40799	
2	92368	
3	108654	
4	116237	*
5	115788	*
6	115118	*
7	115059	*
8	114435	*
SPECjbb200 5	(from 4 to 8)	115328 SPECjbb200 5 bops

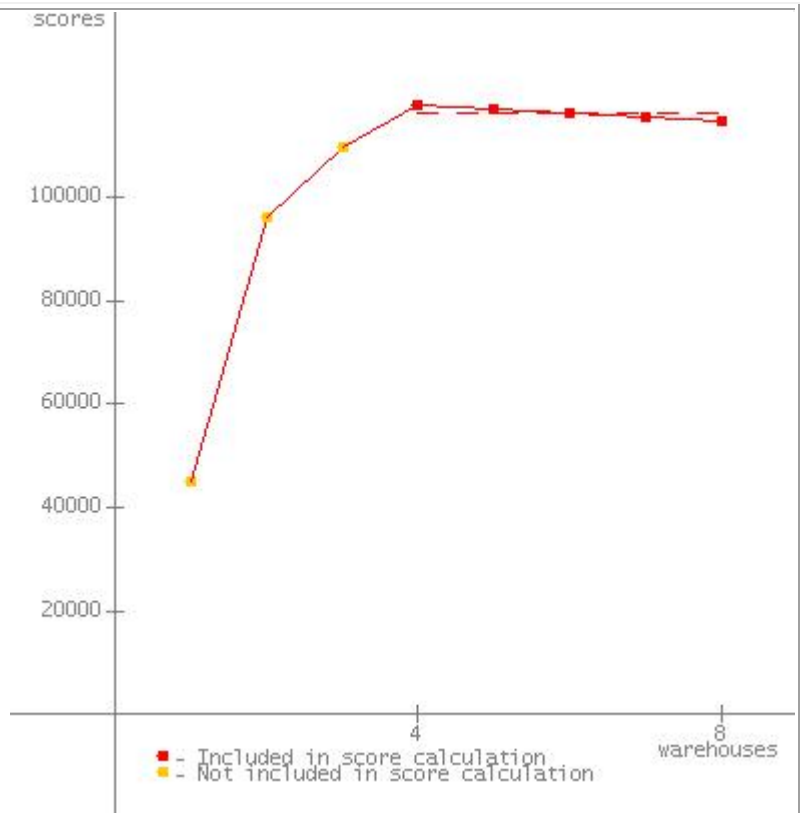


SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 10, 2010
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JVM 2 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	44924	
2	96439	
3	109909	
4	118119	*
5	117237	*
6	116288	*
7	115573	*
8	115031	*
SPECjbb200 5	(from 4 to 8)	116450 SPECjbb200 5 bops



SPEC license # 3184

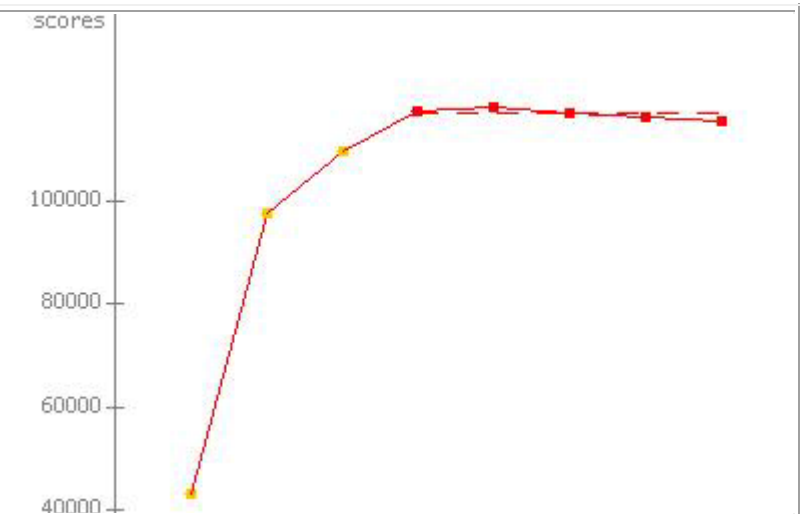
Tested by: Principled Technologies, Inc.

Test date: Mar 10, 2010

JVM 3 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	43130	
2	97638	
3	109674	
4	117472	*
5	118288	*
6	117028	*
7	116339	*
8	115513	*



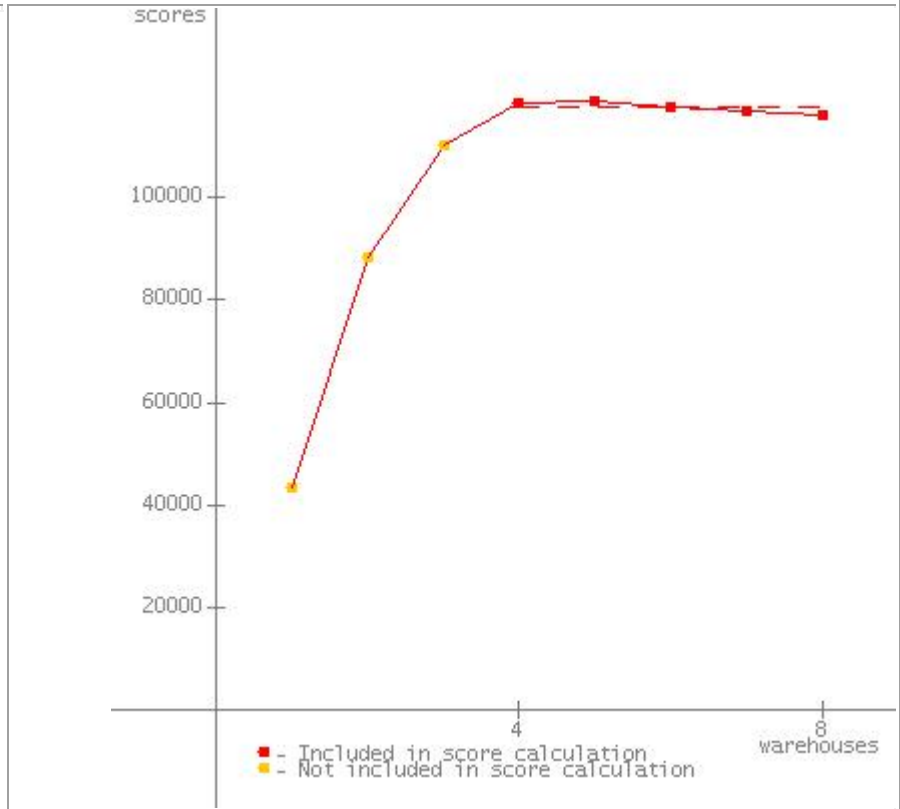
SPECjbb200 5	(from 4 to 8)	116928 SPECjbb200 5 bops
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SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 10, 2010
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JVM 4 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	43234	
2	88129	
3	110349	
4	118428	*
5	118921	*
6	117582	*
7	116974	*
8	116142	*
SPECjbb200 5	(from 4 to 8)	117609 SPECjbb200 5 bops



SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 10, 2010
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JVM 5 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	40859	
2	90706	
3	108518	

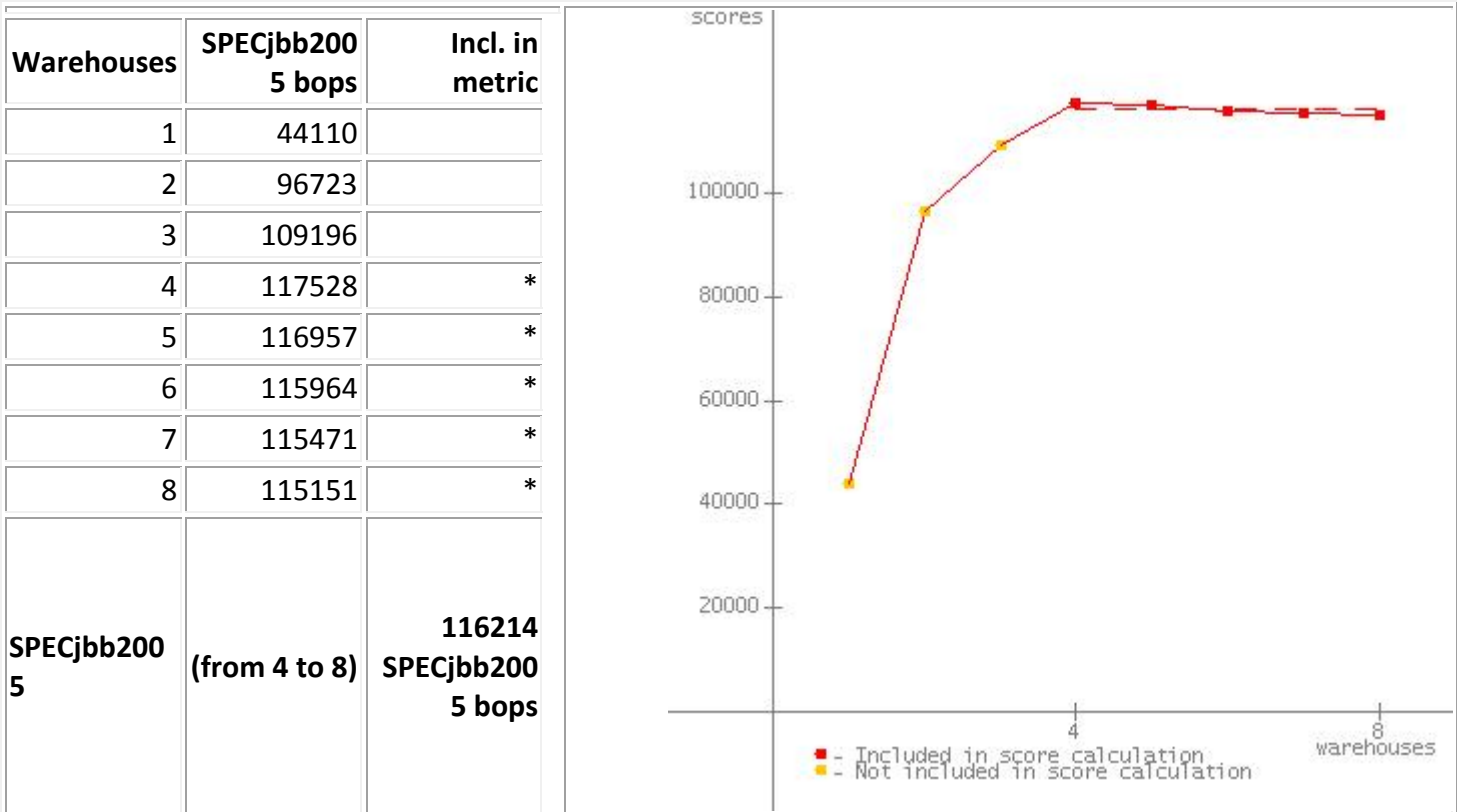


4	115468	*
5	115764	*
6	114713	*
7	113714	*
8	112371	*
SPECjbb200 5	(from 4 to 8)	114406 SPECjbb200 5 bops

SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 10, 2010
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JVM 6 Scores:

NO ERRORS. VALID RUN.



SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 10, 2010
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JVM 7 Scores:

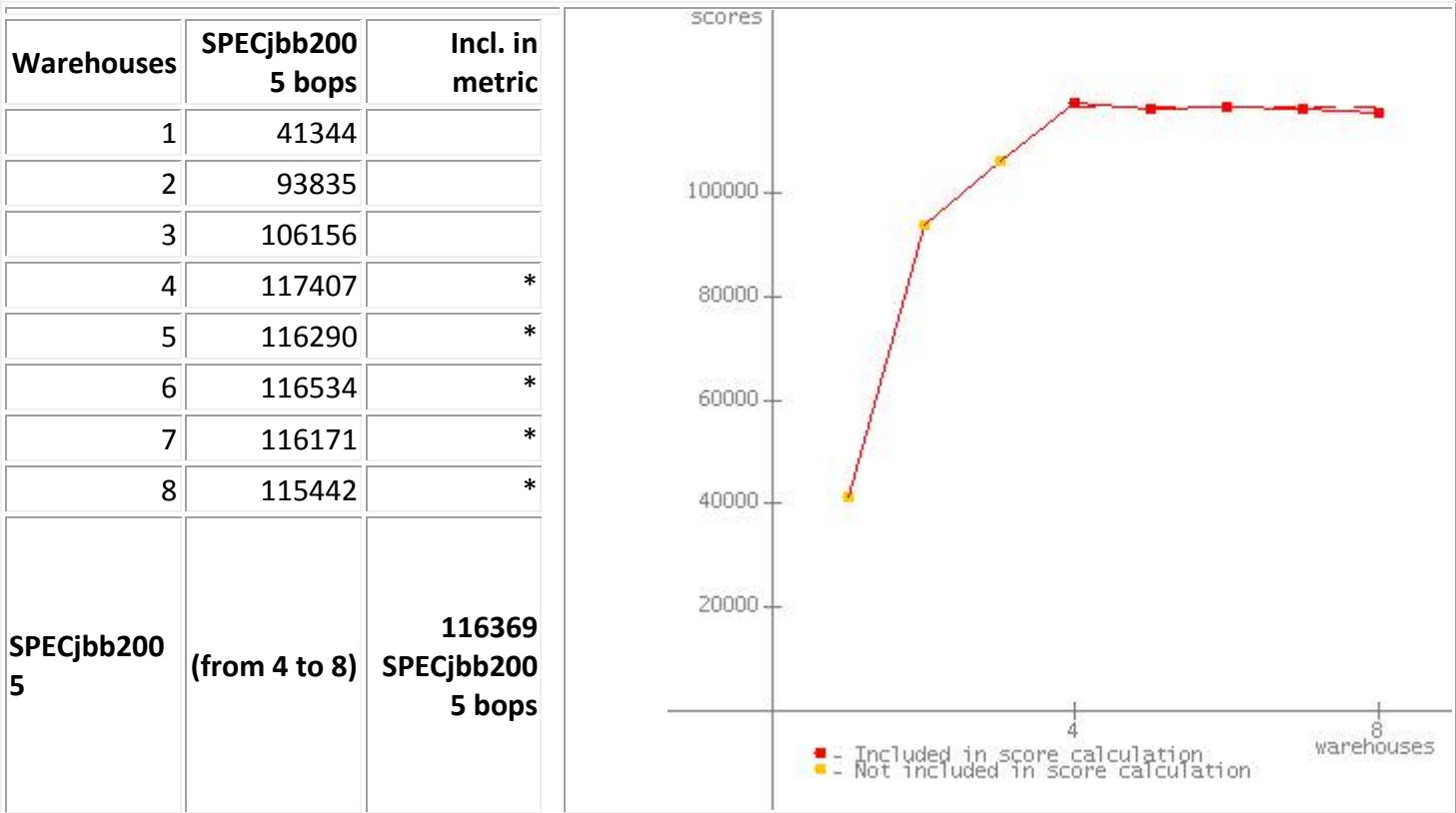
NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	43505	
2	96769	
3	108056	
4	119082	*
5	118483	*
6	118093	*
7	117671	*
8	116724	*
SPECjbb200 5	(from 4 to 8)	118011 SPECjbb200 5 bops

SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 10, 2010
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JVM 8 Scores:

NO ERRORS. VALID RUN.



SPEC license # 3184

Tested by: Principled Technologies, Inc.

Test date: Mar 10, 2010

SPECjbb2005 Version: [SPECjbb2005 1.07, March 15, 2006]
Reporting page, Copyright © 2005 SPEC. All rights reserved

Red Hat Enterprise Linux 5.4 server: Dell PowerEdge R810

SPECjbb2005

SPECjbb2005 bops = 943614, SPECjbb2005 bops/JVM = 117952

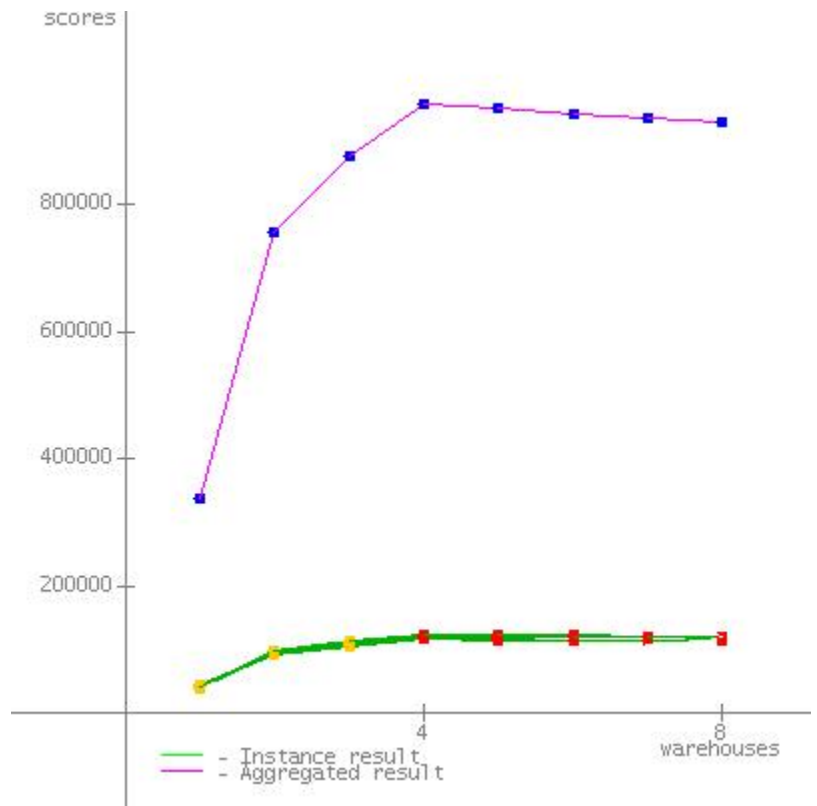
Dell PowerEdge

R810

IBM J9 1.6.0 SR7

JVM run	JVM Scores
1	113359
2	121663
3	114710
4	122224
5	114982
6	115259
7	119837
8	121580

**SPECjbb2005 bops = 943614,
SPECjbb2005 bops/JVM = 117952**



Hardware	
Hardware Vendor	Dell
Vendor URL	http://www.dell.com
Model	PowerEdge R910

Software	
Software Vendor	IBM
Vendor URL	http://www.ibm.com
JVM Version	IBM J9 VM (build 2.4, JRE 1.6.0 IBM J9 2.4 Linux amd64-64 jvmsx6460sr7-20091214_49398 (JIT

Processor	Intel Xeon X7560		enabled, AOT enabled)) JVM
MHz	2270		
# of Chips	2	JVM Command Line	java -Xaggressive -Xcompressedrefs -Xgcpolicy:gencon -Xmn1400m -Xms1875m -Xmx1875m -XlockReservation -Xnolua -XtlhPrefetch -Xlp
# of Cores	16	JVM Initial Heap Memory (MB)	1875
# of Cores/Chip	2	JVM Maximum Heap Memory (MB)	1875
HW Threading Enabled?	Yes	JVM Address bits	64
Procs Avail to Java	32	JVM CLASSPATH	jbb.jar: check.jar
Memory (MB)	131072	JVM BOOTCLASSPATH	/ibm-java-x86_64-60/jre/lib/amd64/compressedrefs/jclSC160/vm.jar: /ibm-java-x86_64-60/jre/lib/annotation.jar: /ibm-java-x86_64-60/jre/lib/beans.jar: /ibm-java-x86_64-60/jre/lib/java.util.jar: /ibm-java-x86_64-60/jre/lib/jndi.jar: /ibm-java-x86_64-60/jre/lib/logging.jar: /ibm-java-x86_64-60/jre/lib/security.jar: /ibm-java-x86_64-60/jre/lib/sql.jar: /ibm-java-x86_64-60/jre/lib/ibmorb.jar: /ibm-java-x86_64-60/jre/lib/ibmorbapi.jar: /ibm-java-x86_64-60/jre/lib/ibmcfw.jar: /ibm-java-x86_64-60/jre/lib/rt.jar: /ibm-java-x86_64-60/jre/lib/charsets.jar: /ibm-java-x86_64-60/jre/lib/resources.jar: /ibm-java-x86_64-60/jre/lib/ibmpkcs.jar: /ibm-java-x86_64-60/jre/lib/ibmcertpathfw.jar: /ibm-java-x86_64-60/jre/lib/ibmjgssf.jar: /ibm-java-x86_64-60/jre/lib/ibmjssefw.jar: /ibm-java-x86_64-60/jre/lib/ibmsaslfw.jar: /ibm-java-x86_64-60/jre/lib/ibmjcefw.jar: /ibm-java-x86_64-60/jre/lib/ibmjgssprovider.jar: /ibm-java-x86_64-60/jre/lib/ibmjsseprovider2.jar: /ibm-java-x86_64-60/jre/lib/ibmcertpathprovider.jar: /ibm-java-x86_64-60/jre/lib/ibmxmlicrypto.jar: /ibm-java-x86_64-60/jre/lib/management-agent.jar: /ibm-java-x86_64-60/jre/lib/xml.jar:
Memory Details	Hynix HMT151R7BFR8C-G7		
Primary cache			
Secondary cache			
Other cache	24 MB L3		
Filesystem	Ext3		
Disks	2 x 146 GB SAS		
Other hardware			

	/ibm-java-x86_64-60/jre/lib/jlm.jar: /ibm-java-x86_64-60/jre/lib/javascrip.jar
OS Version	Red Hat Enterprise Linux 5.4
Other software	

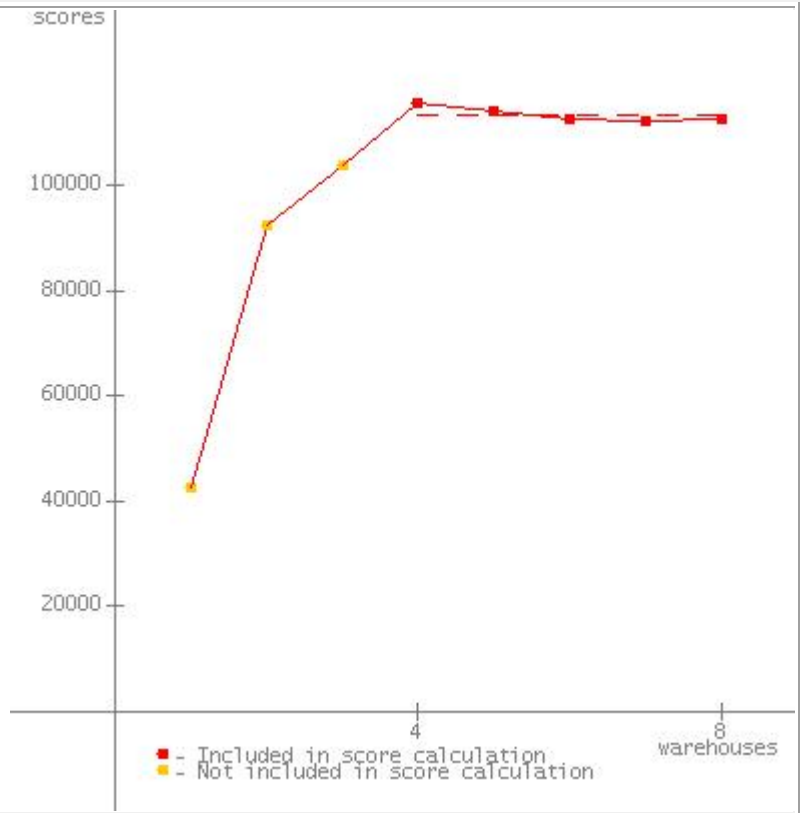
Test Information	
Tested by	Principled Technologies, Inc.
SPEC license #	3184
Test location	Durham, NC
Test date	Mar 7, 2010
H/w available	
JVM available	
OS available	Sept-2009
Other s/w available	Principled Technologies, Inc.

AOT Compilation	
Tuning	
Operating system tunings	
<ul style="list-style-type: none"> vm.nr_hugepages=32000 	
Notes	

JVM 1 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	42694	
2	92410	
3	103921	
4	115707	*
5	113952	*
6	112490	*
7	112282	*
8	112362	*
SPECjbb200 5	(from 4 to 8)	113359 SPECjbb200 5 bops



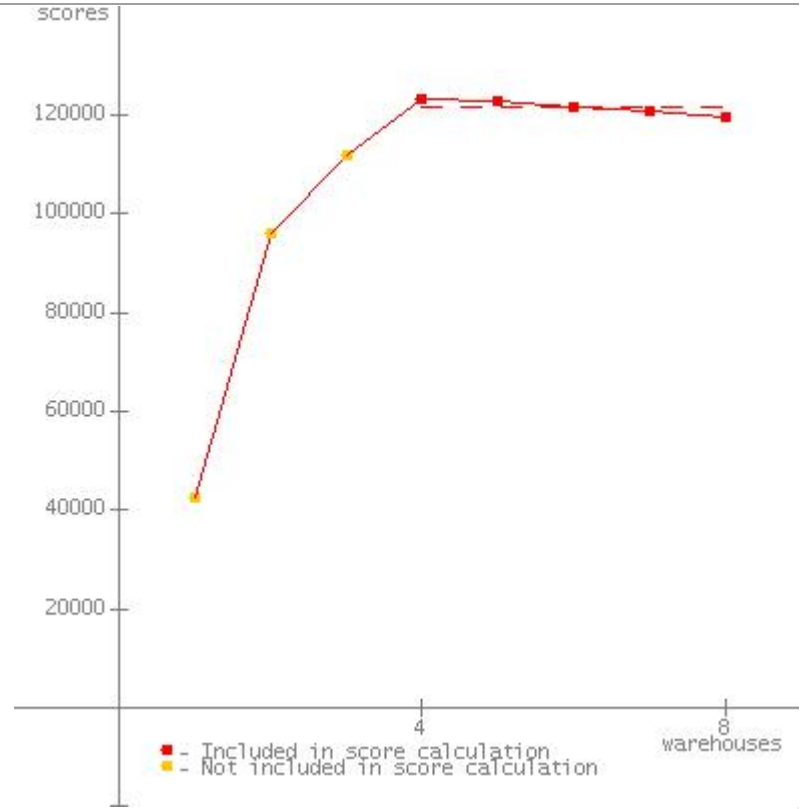
SPEC license # 3184	Tested by: Principled Technologies,	Test date: Mar 7, 2010
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	Inc.	
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JVM 2 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	42426	
2	96010	
3	112001	
4	123394	*
5	122891	*
6	121603	*
7	120940	*
8	119485	*
SPECjbb200 5	(from 4 to 8)	121663 SPECjbb200 5 bops

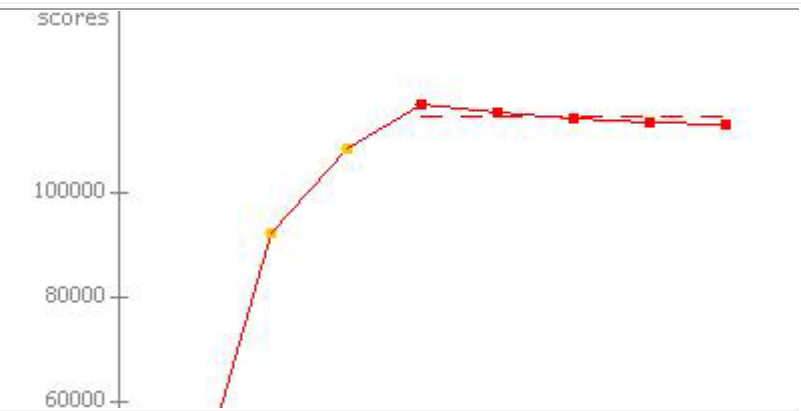


SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 7, 2010
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JVM 3 Scores:

NO ERRORS. VALID RUN.

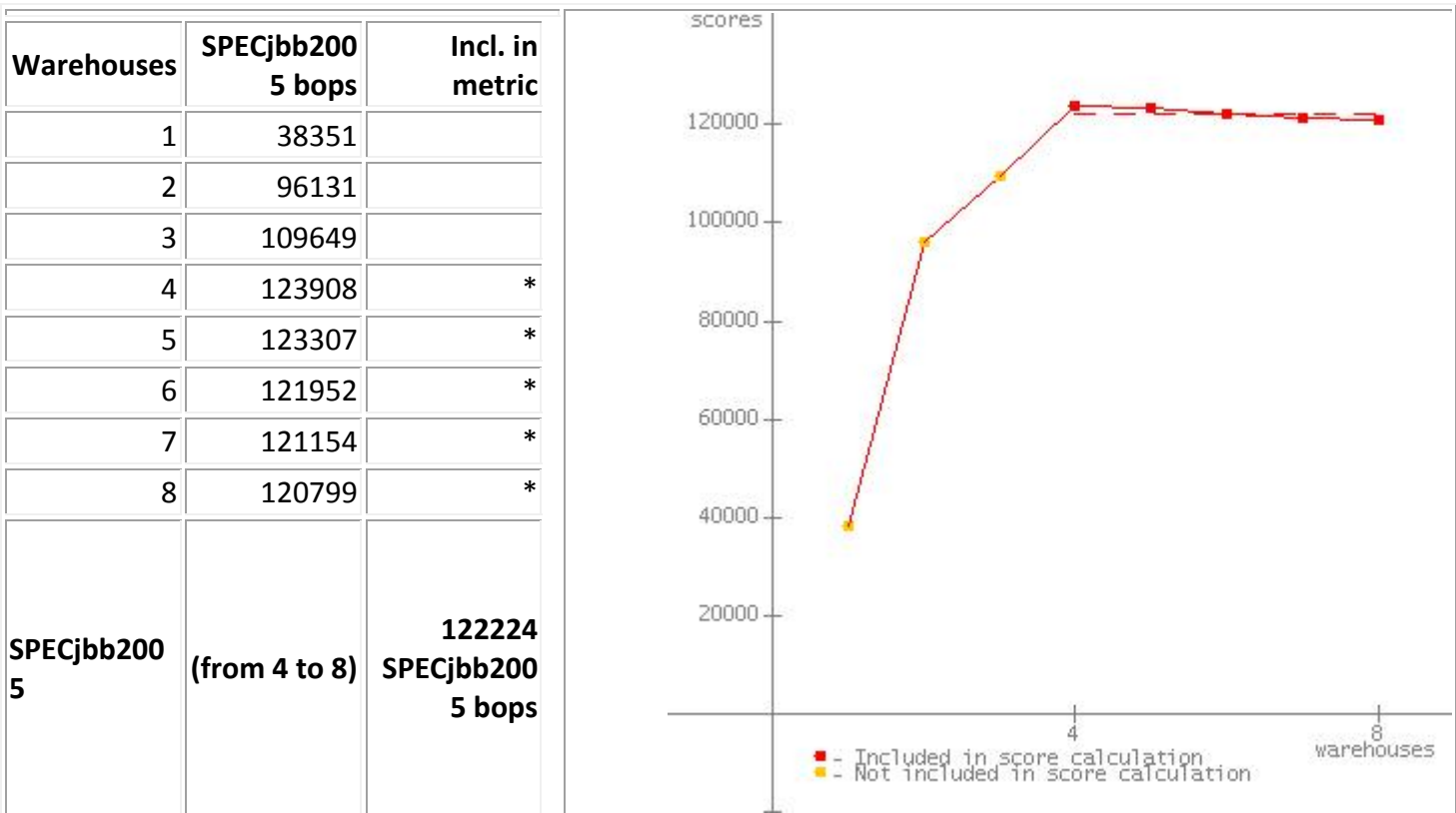
Warehouses	SPECjbb200 5 bops	Incl. in metric
1	42162	
2	92439	
3	108570	
4	117108	*
5	115358	*
6	114471	*



7	113375	*	
8	113238	*	
SPECjbb200 5	(from 4 to 8)	114710 SPECjbb200 5 bops	
SPEC license # 3184		Tested by: Principled Technologies, Inc.	Test date: Mar 7, 2010

JVM 4 Scores:

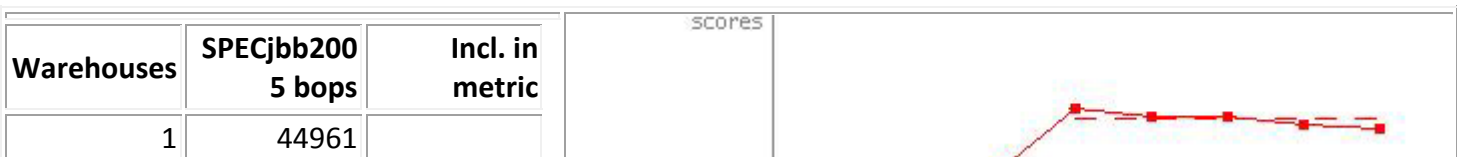
NO ERRORS. VALID RUN.



SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 7, 2010
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JVM 5 Scores:

NO ERRORS. VALID RUN.



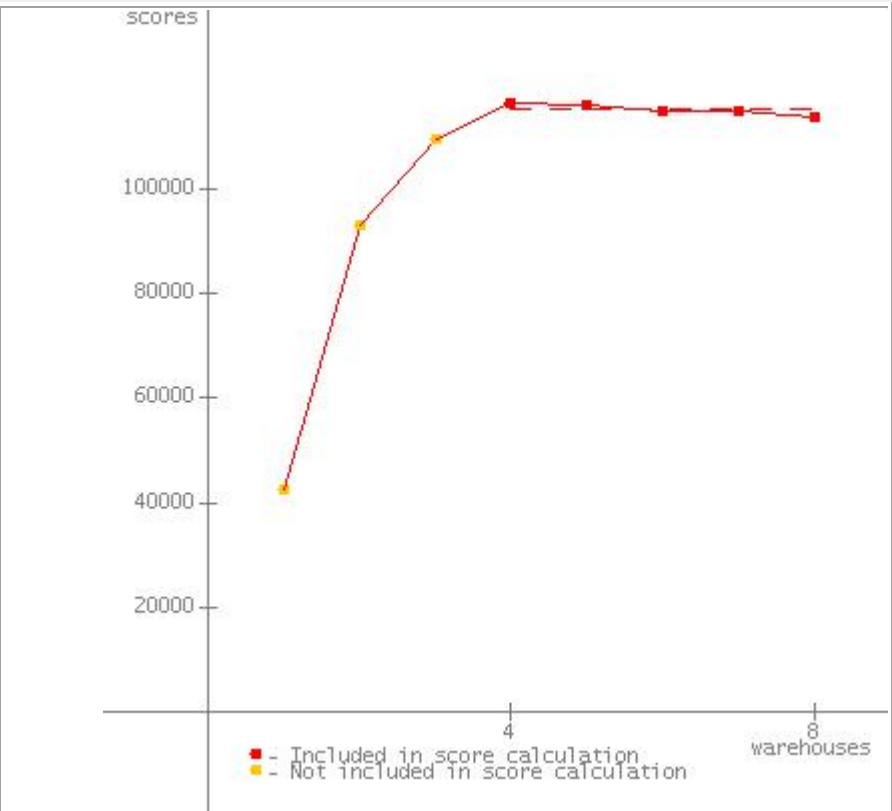
2	94715	
3	105457	
4	117023	*
5	115522	*
6	115204	*
7	113922	*
8	113239	*
SPECjbb200 5	(from 4 to 8)	114982 SPECjbb200 5 bops

SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 7, 2010
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JVM 6 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	42668	
2	93275	
3	109503	
4	116591	*
5	116070	*
6	115017	*
7	114773	*
8	113843	*
SPECjbb200 5	(from 4 to 8)	115259 SPECjbb200 5 bops

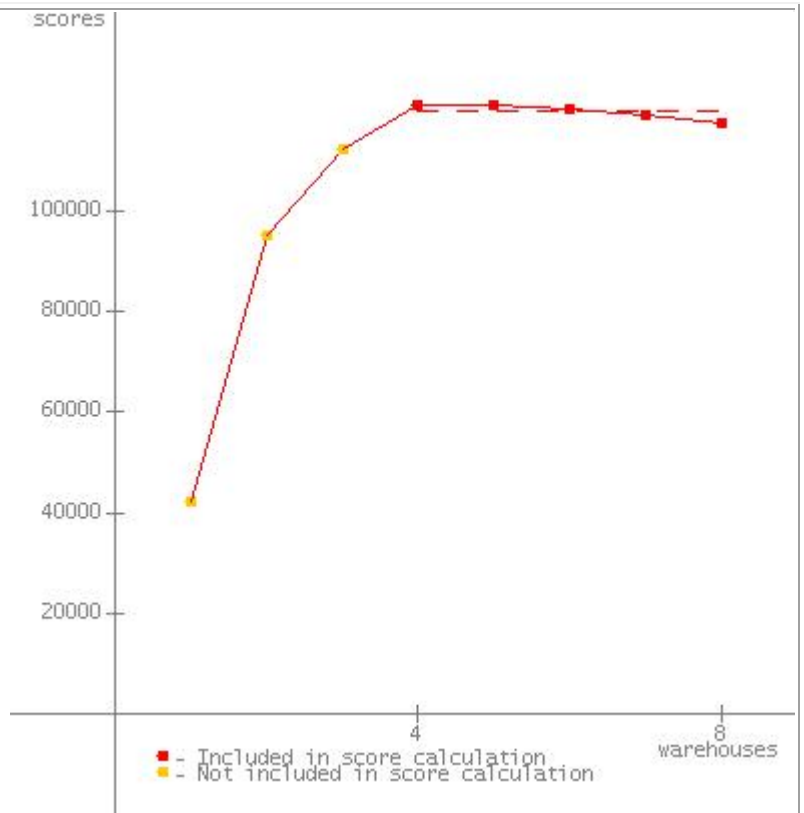


SPEC license # 3184	Tested by: Principled Technologies, Inc.	Test date: Mar 7, 2010
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JVM 7 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	42128	
2	95401	
3	112391	
4	121230	*
5	121103	*
6	120118	*
7	119198	*
8	117534	*
SPECjbb200 5	(from 4 to 8)	119837 SPECjbb200 5 bops



SPEC license # 3184

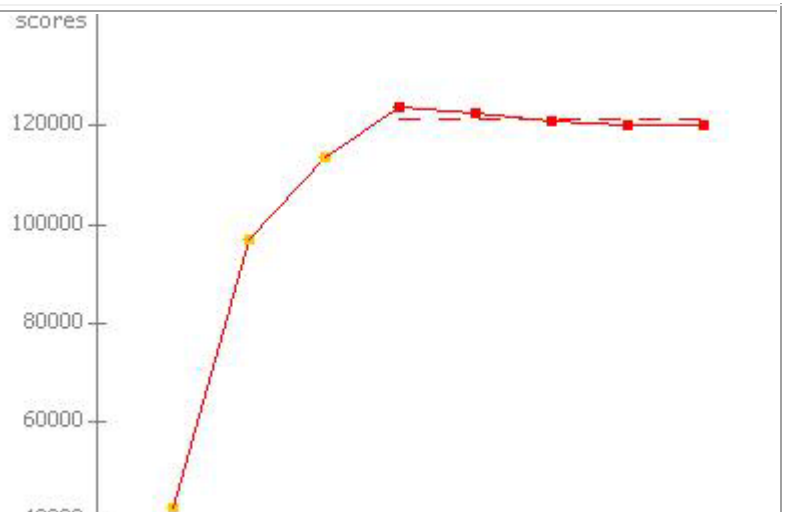
Tested by: Principled Technologies, Inc.

Test date: Mar 7, 2010

JVM 8 Scores:

NO ERRORS. VALID RUN.

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	42249	
2	97008	
3	113539	
4	123959	*
5	122420	*
6	121022	*
7	120338	*
8	120161	*



SPECjbb2005	(from 4 to 8)	121580 SPECjbb2005 bops	
SPEC license # 3184		Tested by: Principled Technologies, Inc.	Test date: Mar 7, 2010

SPECjbb2005 Version: [SPECjbb2005 1.07, March 15, 2006]
Reporting page, Copyright © 2005 SPEC. All rights reserved

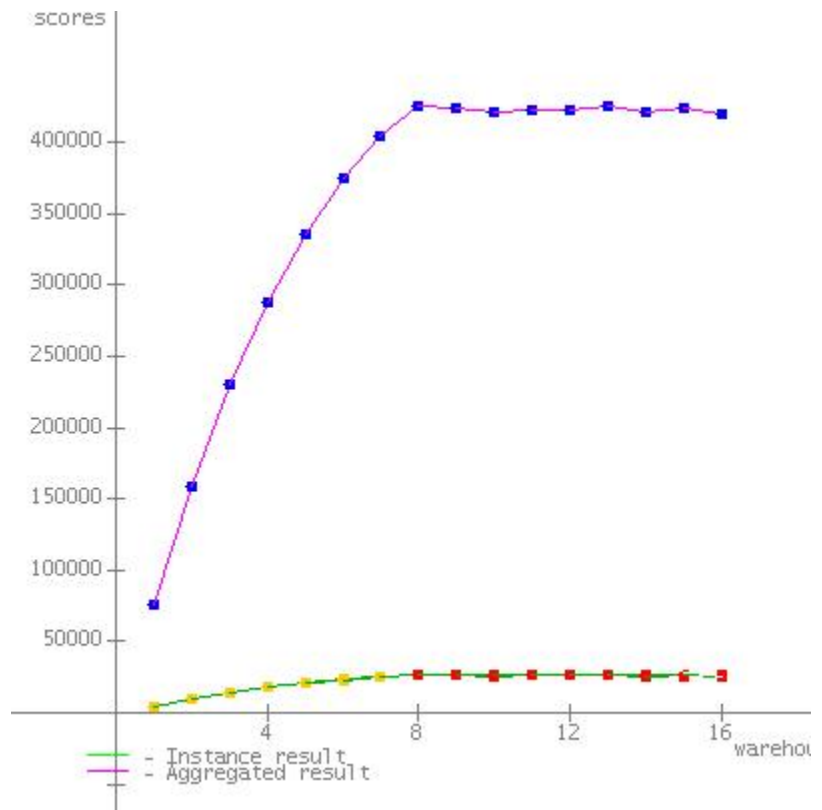
OpenSolaris 2009.06 server: Sun SPARC Enterprise T5240
<http://www.spec.org/osg/jbb2005/results/res2009q3/jbb2005-20090810-00764.html>

**SPECjbb2005 bops = 422782,
 SPECjbb2005 bops/JVM = 26424**

SPECjbb2005

Sun Microsystems, Inc. Sun SPARC Enterprise T5240
 Sun Microsystems, Inc. Java HotSpot(TM) 32-Bit
 Server VM on Solaris, version 1.6.0_14 Performance
 Release

JVM run	JVM Scores
1	26331
2	26295
3	26413
4	26187
5	26335
6	26243
7	26822
8	26181
9	26751
10	26733
11	26819
12	26176
13	26764
14	26249
15	26238
16	26245
SPECjbb2005 bops = 422782, SPECjbb2005 bops/JVM = 26424	



Hardware		Software	
Hardware Vendor	Sun Microsystems, Inc.	Software Vendor	Sun Microsystems, Inc.
Vendor URL	http://www.sun.com	Vendor URL	http://www.sun.com
Model	Sun SPARC Enterprise T5240	JVM Version	Java HotSpot(TM) 32-Bit Server VM on Solaris, version 1.6.0_14 Performance Release
		JVM Command	psrset -e processor set number pricntl -c FX -t 250 -e java

Processor	UltraSPARC(TM) T2 Plus
MHz	1582
# of Chips	2
# of Cores	16
# of Cores/Chip	8
HW Threading Enabled?	Yes
Procs Avail to Java	128
Memory (MB)	65536
Memory Details	16x 4GB DDR2-667 FBDIMMs
Primary cache	16KB(I)+8KB(D) per core
Secondary cache	4MB per chip
Other cache	
Filesystem	ZFS
Disks	1x 146GB SCSI DISK
Other hardware	

Line	-Xmx3g -Xms3g -Xmn2g -XX:+UseParallelOldGC -XX:+AggressiveOpts -XX:ParallelGCThreads=11 -XX:LargePageSizeInBytes=256m -XX:AllocatePrefetchStyle=2 -XX:BiasedLockingStartupDelay=500 -classpath jbb.jar:check.jar spec.jbb.JBBmain -profile SPECjbb.props -id <u>JVM id</u>
JVM Initial Heap Memory (MB)	3072
JVM Maximum Heap Memory (MB)	3072
JVM Address bits	32
JVM CLASSPATH	jbb.jar: check.jar
JVM BOOTCLASSPATH	/export2/benchmarks/java/jdk1.6.0_14/jre/lib/alt-rt.jar: /export2/benchmarks/java/jdk1.6.0_14/jre/lib/resources.jar: /export2/benchmarks/java/jdk1.6.0_14/jre/lib/rt.jar: /export2/benchmarks/java/jdk1.6.0_14/jre/lib/sunrsasign.jar: /export2/benchmarks/java/jdk1.6.0_14/jre/lib/jsse.jar: /export2/benchmarks/java/jdk1.6.0_14/jre/lib/jce.jar: /export2/benchmarks/java/jdk1.6.0_14/jre/lib/charsets.jar: : /export2/benchmarks/java/jdk1.6.0_14/jre/classes
OS Version	OpenSolaris 2009.06
Other software	

Test Information	
Tested by	Sun Microsystems, Inc.
SPEC license #	6
Test location	Burlington, MA.
Test date	Jul 24, 2009
H/w available	Jul-2009
JVM	May-2009

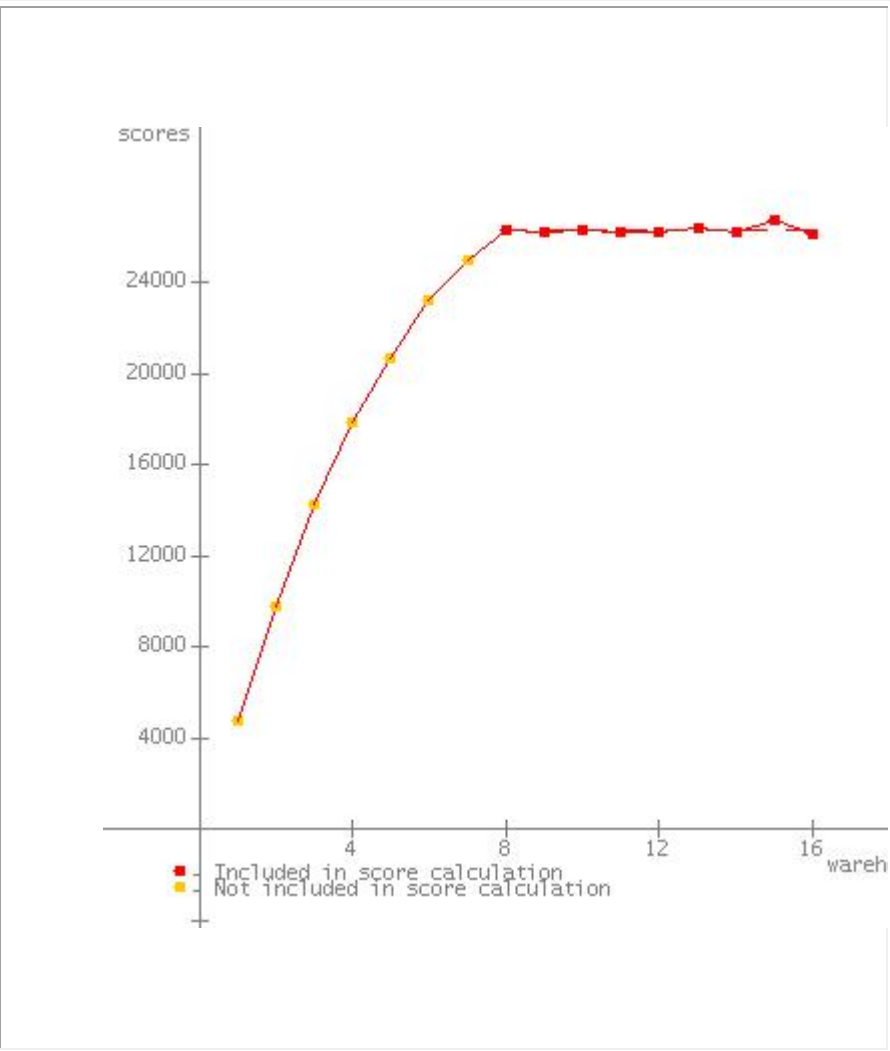
AOT Compilation	
Tuning	
Notes	
Each JVM was placed in the FX priority class with the pricntnl command. 15 JVMs were run in processor sets each containing one core. One JVM was run in the default processor set. The parameter expected_peak_warehouse was set to 8. This result was measured on the Sun SPARC Enterprise T5240. The Sun SPARC Enterprise T5240 and the Fujitsu SPARC Enterprise T5240	

available	
OS available	Jun-2009
Other s/w available	

are electronically equivalent.

JVM 1 Scores:

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	4750	
2	9784	
3	14242	
4	17844	
5	20733	
6	23204	
7	24984	
8	26371	*
9	26279	*
10	26326	*
11	26209	*
12	26221	*
13	26437	*
14	26215	*
15	26796	*
16	26128	*
SPECjbb200 5	(from 8 to 16)	26331 SPECjbb200 5 bops



SPEC license # 6 Tested by: Sun Microsystems, Inc. Test date: Jul 24, 2009

JVM 2 Scores:

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	4737	
2	9923	



3	14303	
4	17864	
5	20795	
6	23284	
7	25090	
8	26438	*
9	26421	*
10	26206	*
11	26330	*
12	26312	*
13	26304	*
14	26280	*
15	26438	*
16	25921	*
SPECjbb2005	(from 8 to 16)	26295 SPECjbb2005 bops

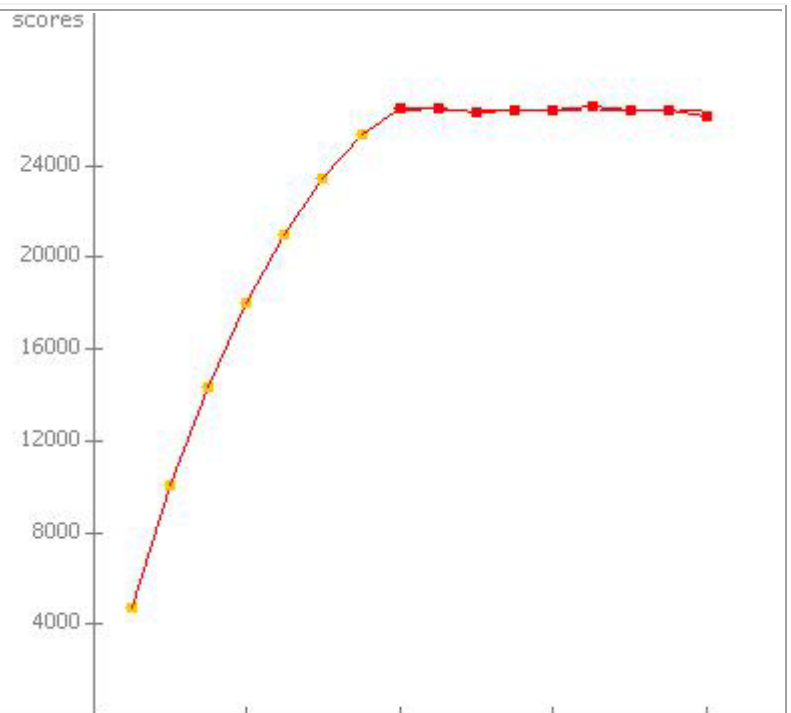
SPEC license # 6

Tested by: Sun Microsystems, Inc.

Test date: Jul 24, 2009

JVM 3 Scores:

Warehouses	SPECjbb2005 bops	Incl. in metric
1	4773	
2	10055	
3	14365	
4	18023	
5	20973	
6	23446	
7	25336	
8	26533	*
9	26508	*
10	26300	*
11	26442	*
12	26382	*

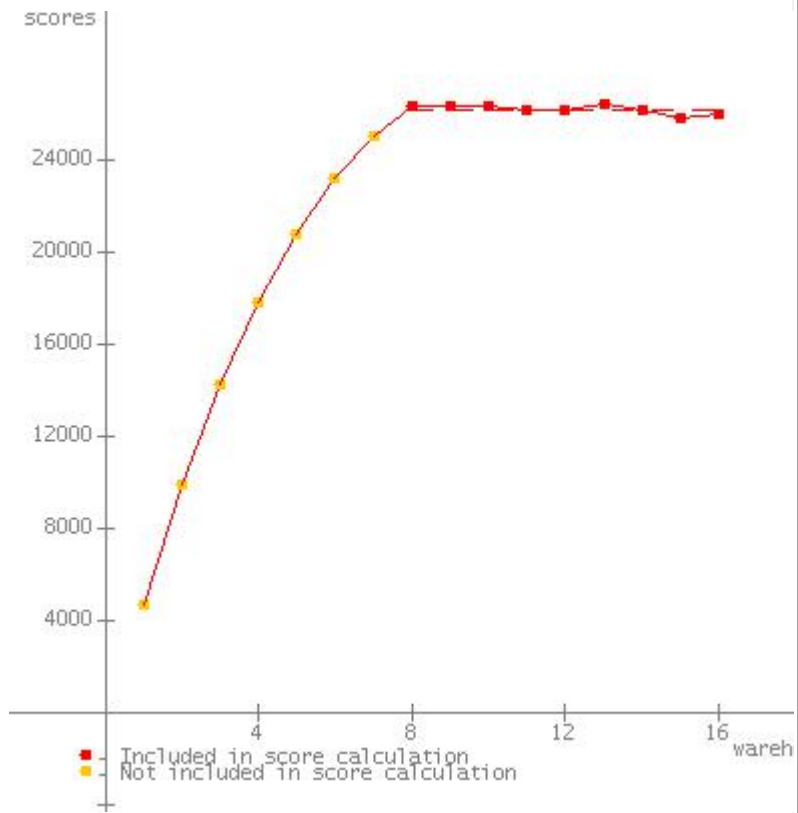


13	26617	*
14	26414	*
15	26378	*
16	26144	*
SPECjbb2005	(from 8 to 16)	26413 SPECjbb2005 bops

SPEC license # 6 **Tested by: Sun Microsystems, Inc.** **Test date: Jul 24, 2009**

JVM 4 Scores:

Warehouses	SPECjbb2005 bops	Incl. in metric
1	4707	
2	9920	
3	14258	
4	17860	
5	20760	
6	23245	
7	25037	
8	26349	*
9	26346	*
10	26321	*
11	26149	*
12	26139	*
13	26453	*
14	26129	*
15	25777	*
16	26023	*
SPECjbb2005	(from 8 to 16)	26187 SPECjbb2005 bops



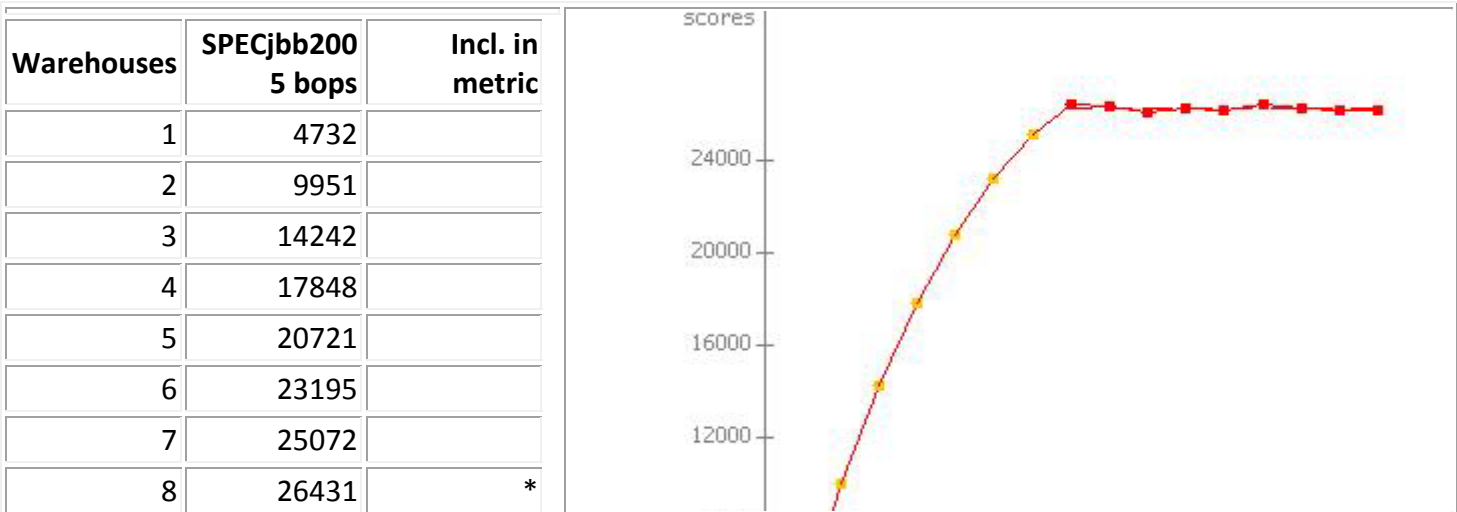
SPEC license # 6 **Tested by: Sun Microsystems, Inc.** **Test date: Jul 24, 2009**

JVM 5 Scores:

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	4667	
2	9962	
3	14376	
4	17952	
5	21016	
6	23384	
7	25434	
8	26456	*
9	26319	*
10	26140	*
11	26312	*
12	26332	*
13	26363	*
14	26285	*
15	26615	*
16	26196	*
SPECjbb200 5	(from 8 to 16)	26335 SPECjbb200 5 bops

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JVM 6 Scores:

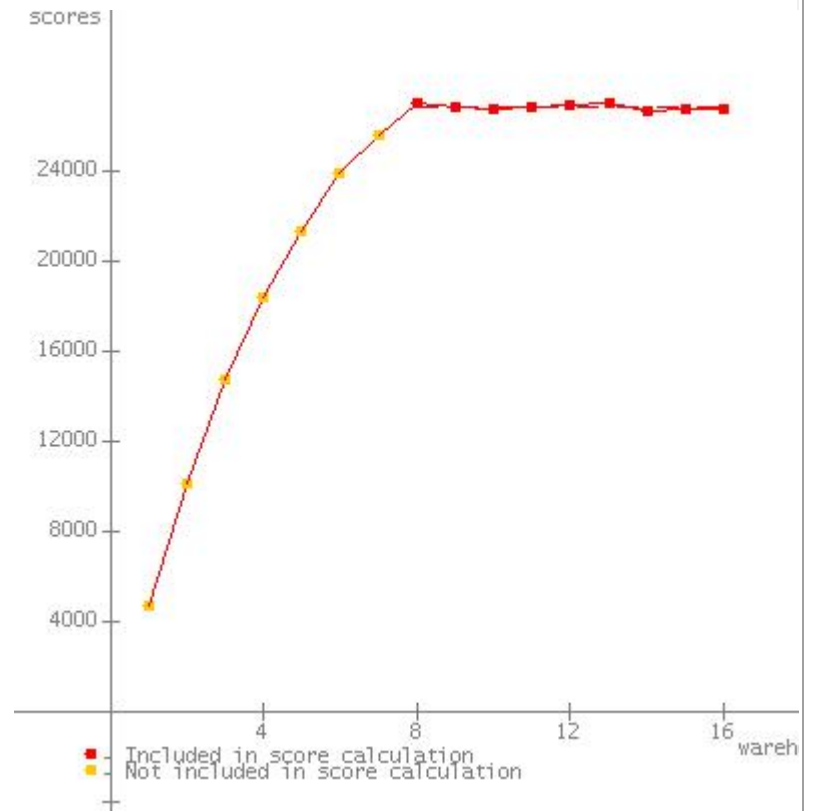


9	26305	*
10	26097	*
11	26252	*
12	26184	*
13	26410	*
14	26203	*
15	26177	*
16	26124	*
SPECjbb200 5	(from 8 to 16)	26243 SPECjbb200 5 bops

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JVM 7 Scores:

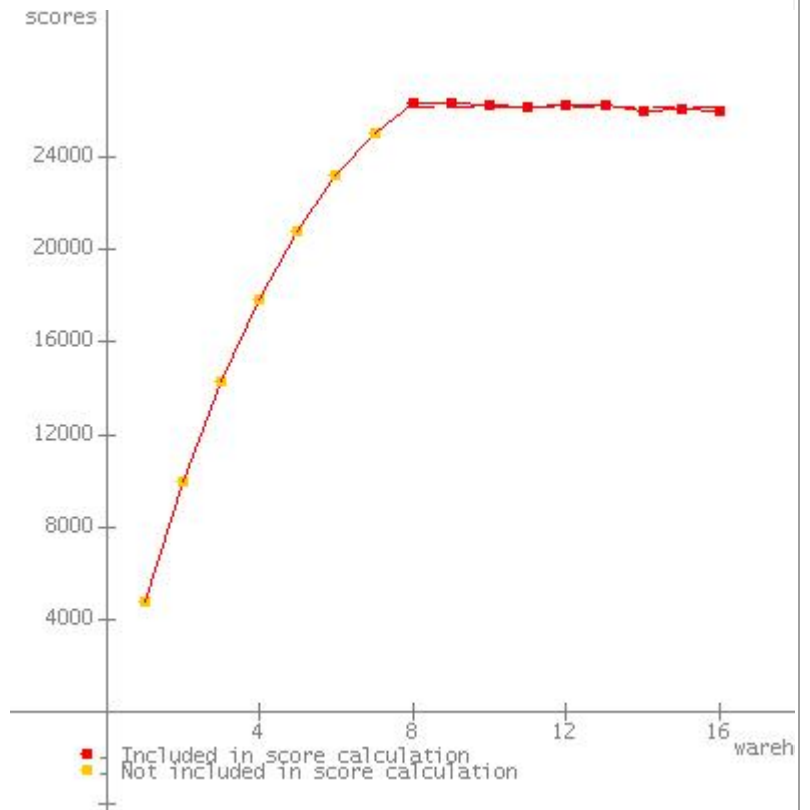
Warehouses	SPECjbb200 5 bops	Incl. in metric
1	4722	
2	10154	
3	14710	
4	18398	
5	21309	
6	23932	
7	25570	
8	27028	*
9	26865	*
10	26699	*
11	26808	*
12	26872	*
13	26956	*
14	26680	*
15	26758	*
16	26728	*
SPECjbb200 5	(from 8 to 16)	26822 SPECjbb200



		5 bops	
SPEC license # 6		Tested by: Sun Microsystems, Inc.	Test date: Jul 24, 2009

JVM 8 Scores:

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	4802	
2	9938	
3	14277	
4	17842	
5	20759	
6	23230	
7	25018	
8	26335	*
9	26359	*
10	26239	*
11	26189	*
12	26234	*
13	26269	*
14	25960	*
15	26046	*
16	25994	*
SPECjbb200 5	(from 8 to 16)	26181 SPECjbb200 5 bops



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JVM 9 Scores:

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	4749	
2	10023	
3	14570	
4	18243	

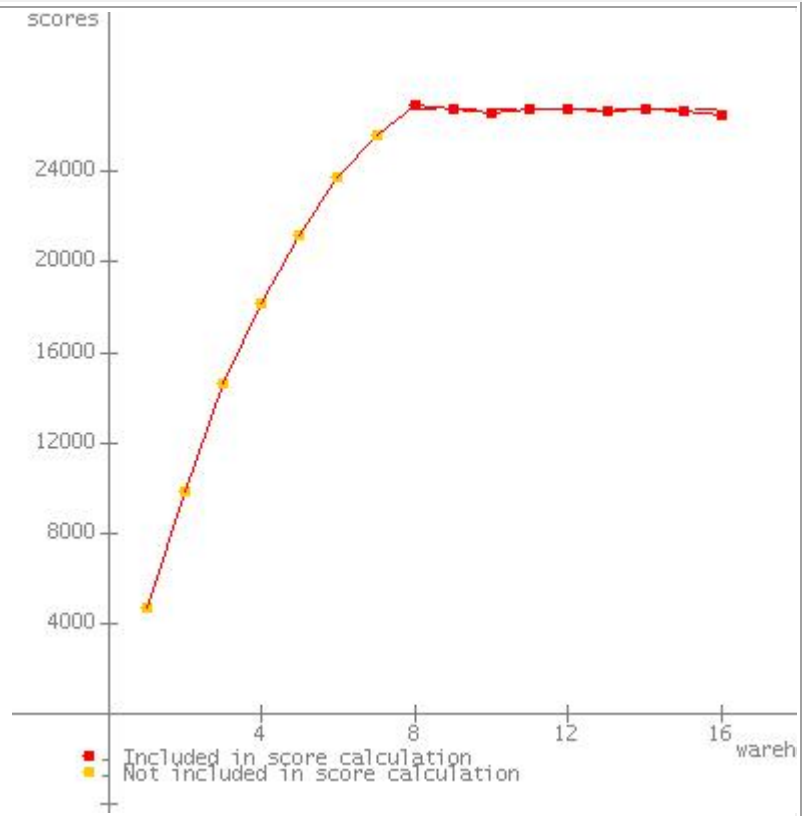


5	21170	
6	23766	
7	25582	
8	26867	*
9	26746	*
10	26579	*
11	26811	*
12	26725	*
13	27159	*
14	26708	*
15	26715	*
16	26448	*
SPECjbb2005	(from 8 to 16)	26751 SPECjbb2005 bops

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JVM 10 Scores:

Warehouses	SPECjbb2005 bops	Incl. in metric
1	4704	
2	9884	
3	14657	
4	18212	
5	21210	
6	23738	
7	25657	
8	26982	*
9	26800	*
10	26613	*
11	26796	*
12	26779	*
13	26720	*
14	26751	*

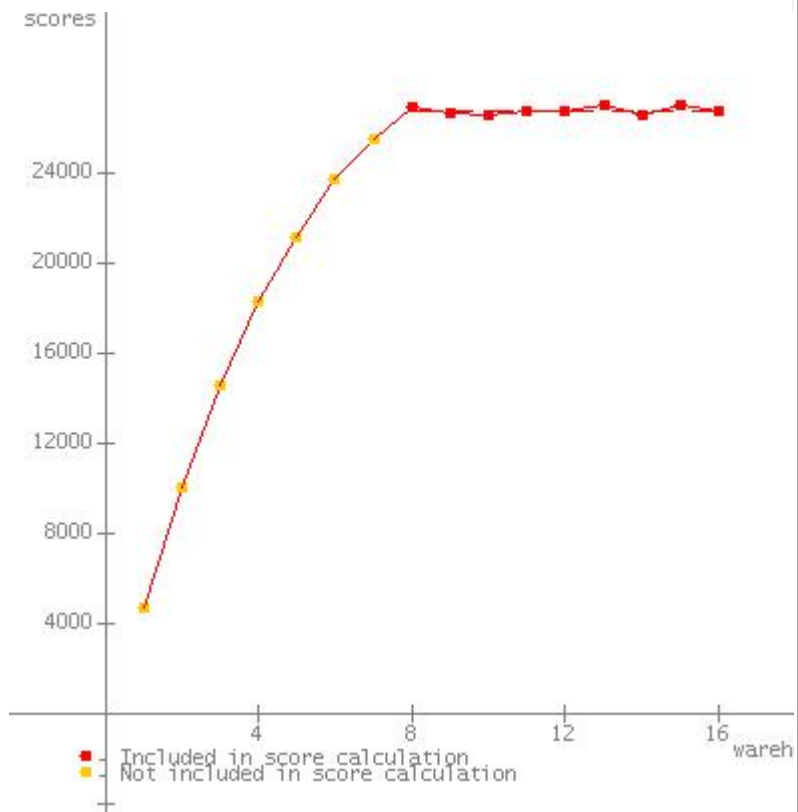


15	26645	*
16	26505	*
SPECjbb2005	(from 8 to 16)	26733 SPECjbb2005 bops

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JVM 11 Scores:

Warehouses	SPECjbb2005 bops	Incl. in metric
1	4736	
2	10037	
3	14616	
4	18298	
5	21179	
6	23803	
7	25544	
8	26940	*
9	26704	*
10	26614	*
11	26762	*
12	26808	*
13	27062	*
14	26578	*
15	27089	*
16	26815	*
SPECjbb2005	(from 8 to 16)	26819 SPECjbb2005 bops



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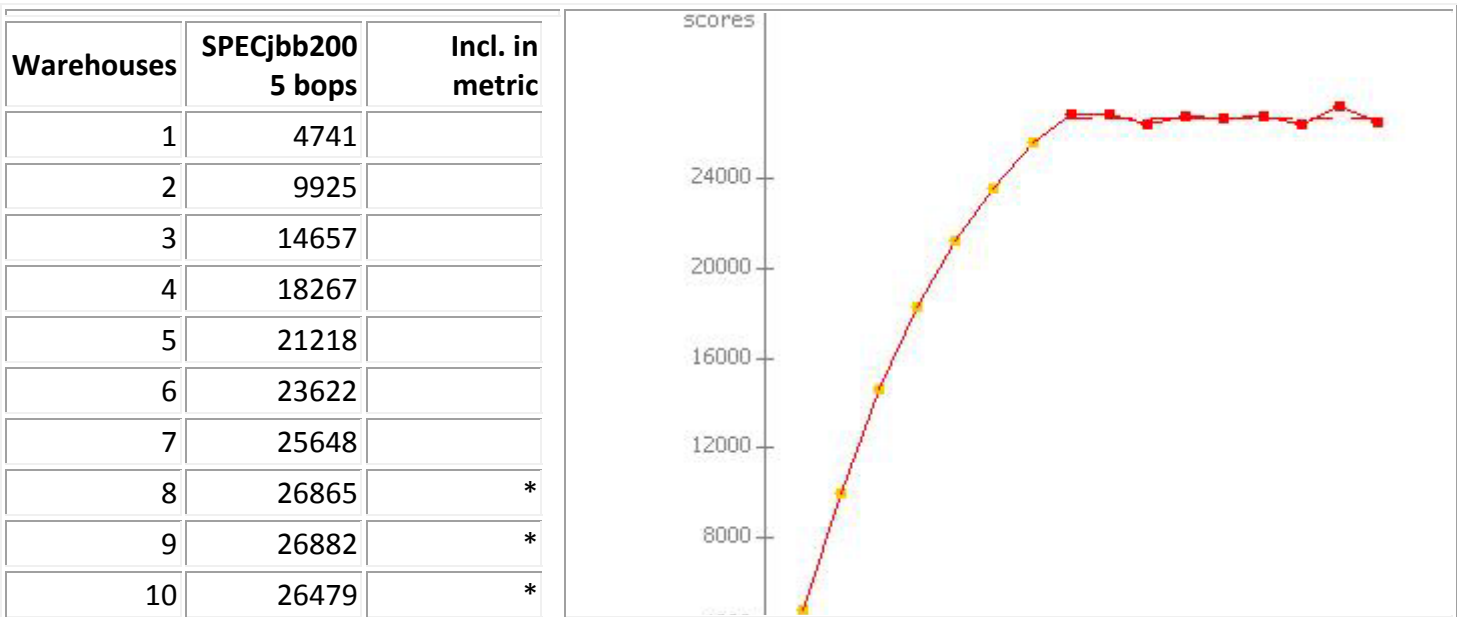
JVM 12 Scores:

Warehouses	SPECjbb2005 bops	Incl. in metric

1	4748	
2	9890	
3	14252	
4	17822	
5	20726	
6	23158	
7	24973	
8	26271	*
9	26184	*
10	26242	*
11	26105	*
12	26133	*
13	26227	*
14	25982	*
15	26157	*
16	26282	*
SPECjbb200 5	(from 8 to 16)	26176 SPECjbb200 5 bops

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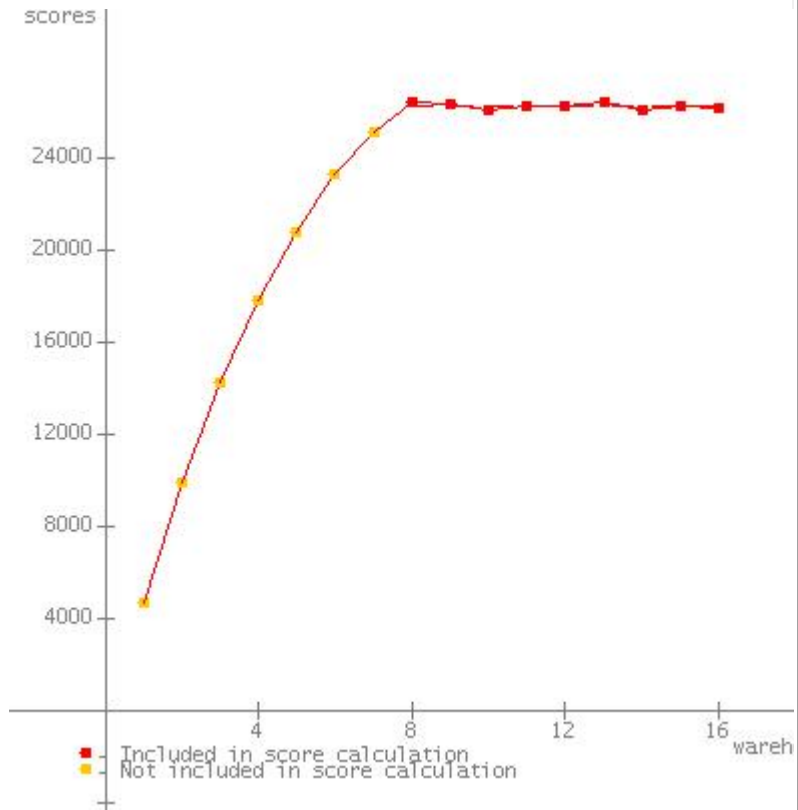
JVM 13 Scores:



11	26813	*
12	26722	*
13	26804	*
14	26460	*
15	27289	*
16	26560	*
SPECjbb2005	(from 8 to 16)	26764 SPECjbb2005 bops
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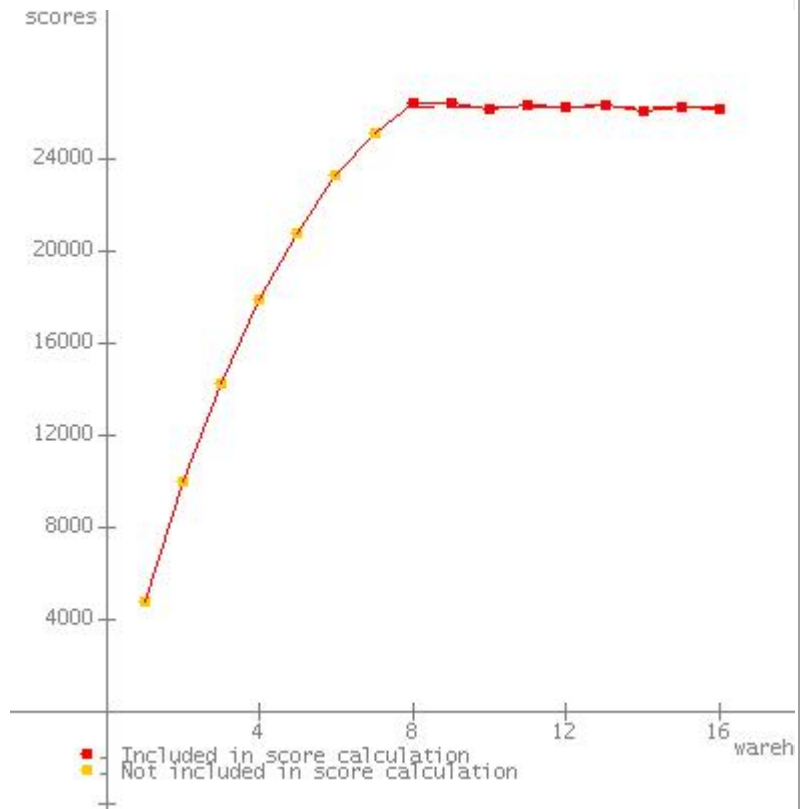
JVM 14 Scores:

Warehouses	SPECjbb2005 bops	Incl. in metric
1	4718	
2	9916	
3	14280	
4	17808	
5	20768	
6	23262	
7	25113	
8	26447	*
9	26325	*
10	26107	*
11	26265	*
12	26268	*
13	26439	*
14	26056	*
15	26206	*
16	26129	*
SPECjbb2005	(from 8 to 16)	26249 SPECjbb2005 bops
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JVM 15 Scores:

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	4785	
2	9993	
3	14275	
4	17878	
5	20775	
6	23302	
7	25079	
8	26422	*
9	26400	*
10	26131	*
11	26297	*
12	26251	*
13	26274	*
14	26084	*
15	26184	*
16	26101	*
SPECjbb200 5	(from 8 to 16)	26238 SPECjbb200 5 bops



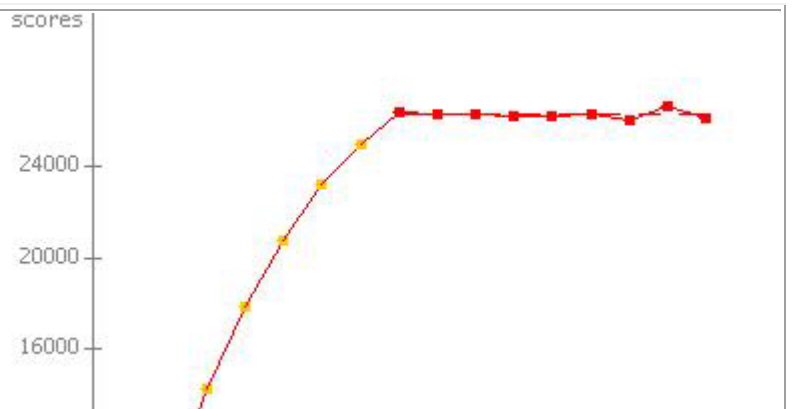
SPEC license # 6

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Test date: Jul 24, 2009

JVM 16 Scores:

Warehouses	SPECjbb200 5 bops	Incl. in metric
1	4741	
2	9925	
3	14247	
4	17874	
5	20722	
6	23223	



7	24988		
8	26332	*	
9	26284	*	
10	26278	*	
11	26218	*	
12	26148	*	
13	26226	*	
14	25970	*	
15	26647	*	
16	26099	*	
SPECjbb2005	(from 8 to 16)	26245	SPECjbb2005 bops
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SPECjbb2005 Version: [SPECjbb2005 1.07, March 15, 2006]
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Principled Technologies, Inc.
1007 Slater Road, Suite 250
Durham, NC, 27703
www.principledtechnologies.com

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