SPECjbb2005 performance and power consumption on Dell and HP blade servers

Executive summary

Dell Inc. (Dell) commissioned Principled Technologies (PT) to measure the SPECjbb2005 performance per watt of the following dual-socket blade servers:

- Dell PowerEdge 1955 Blade System
- HP BladeSystem c-Class

In this section, we present the best results for each server. For complete details of the performance of each Java Virtual Machine (JVM) by warehouse for each server, see the Test results section.

Figure 1 illustrates the performance/watt for each of the blade server systems by configuration. Higher results show better system performance/watt, which lets a system perform better with less power.

We calculate performance/watt by dividing the SPECjbb2005 result by the average power consumption in watts during the period the system achieved peak performance.

KEY FINDINGS

- The blades in the Dell PowerEdge 1955 Blade System achieved better performance/watt than the HP BladeSystem c-Class at every configuration we tested (see Figure 1).

- With 10 blades installed in both systems, the blades in the Dell PowerEdge 1955 Blade System achieved 8.73 percent higher performance/watt than the HP BladeSystem c-Class.

- At the maximum blades configuration, the blades in the Dell PowerEdge 1955 Blade System achieved 4.17 percent better performance/watt with 10 blades installed than the HP BladeSystem c-Class did with 16 blades installed.

Figure 1 shows the blades in the Dell PowerEdge 1955 Blade System achieved better performance/watt at every blade configuration. With 10 blades installed in both systems, the Dell PowerEdge 1955 Blade System achieved 8.73 percent higher performance/watt than the HP BladeSystem c-Class. At the maximum blades configuration, which is the total number of blade servers installed in the chassis, the Dell PowerEdge 1955 Blade System achieved 4.17 percent better performance/watt with 10 blades installed than the HP BladeSystem c-Class did with 16 blades installed.

Furthermore, the Dell PowerEdge 1955 Blade System achieved 6.42 and 5.88 percent higher performance/watt than the HP BladeSystem c-Class in one- and two-blade configurations, respectively.

	Dell PowerEdge 1955 Blade System	HP BladeSystem c-Class	Percentage performance/watt increase Dell over HP
1 blade	323.23	303.74	6.42
2 blades	460.46	434.90	5.88
10 blades	697.70	641.71	8.73
Maximum blades (10 for Dell, 16 for HP)	697.70	669.75	4.17

Figure 1: Performance/watt results for each server by blade configuration. Higher numbers are better.

Workload

SPECjbb2005 is an industry-standard benchmark created by the Standard Performance Evaluation Corp. (SPEC) to measure a server's Java performance. (Note: SPEC and the 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," which is 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 increases, so does the number of threads. The benchmark's results portray the server's throughput in business operations per second or SPECjbb2005 bops. A higher number of SPECjbb2005 bops is better. (For more information on SPECjbb2005, go to www.spec.org.)

Test results

For testing, we installed a given number of blade servers into the chassis and ran SPECjbb2005 on all servers. Before starting the SPECjbb2005 benchmark, we logged into the system and allowed the servers to sit idle for 10 minutes. We then started recording power for 2 minutes. This process meant that all systems were idle for 12 minutes before we began the benchmark.

In each test configuration, we ran 2 JVM instances at the same time, a common practice on servers with many processors. 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 our testing, all servers achieved peak performance during mixes 4 through 8. (In SPEC's terms, these results are from "compliant" runs, meaning that we can disclose them publicly without posting them on the SPEC Web site with all the files SPEC usually requires. We do present here all the data necessary to reproduce these results.) In the tables below, we show the SPECjbb2005 results for each blade for a given configuration.

Figure 2 shows the idle power usage (in watts) for the Dell PowerEdge 1955 Blade System and HP BladeSystem c-Class at all blade configurations. Lower power is better.

	Dell PowerEdge 1955 Blade System	HP BladeSystem c-Class
1 blade	489.11	526.86
2 blades	636.75	683.12
10 blades	1,841.32	1,993.59
Maximum blades (10 for Dell, 16 for HP)	1,841.32	3,071.28

Figure 2: Idle power usage (in watts) of the test servers during the median peak runs for each blade configuration. Lower numbers are better.

Figure 3 shows the average power usage (in watts) for the Dell PowerEdge 1955 Blade System and HP BladeSystem c-Class at all blade configurations. Lower power is better. To calculate the average power, we recorded the power during the SPECjbb2005 benchmark and averaged the power during the period the system achieved peak performance.

	Dell PowerEdge 1955 Blade System	HP BladeSystem c-Class
1 blade	584.22	614.93
2 blades	816.59	858.07
10 blades	2,699.26	2,909.85
Maximum blades (10 for Dell, 16 for HP)	2,699.26	4,458.02

Figure 3: Average power usage (in watts) of the test servers during the median peak runs for each blade configuration. Lower numbers are better.

To calculate the performance/watt we used the following formula:

Performance/watt = the benchmark's score/average power consumption in watts during the period the system achieved peak performance.

For the 2-, 10-, and 16-blade configurations, we divided the average power shown in Figure 3 by the number of blades. We then divided the benchmark's score for each blade by the average power. The formula for these blade configurations were as follows:

Performance/watt by blade (2-, 10-, and 16-blade configurations) = (benchmark score by blade/[total average power/number of blades])

We then averaged the performance/watt for all blades in the given configurations.

For each configuration, we performed 3 runs of SPECjbb2005 and recorded the power during these runs. The results below are the median of 3 test runs.

Figure 4 shows the SPECjbb2005 results, average power per blade, and performance/watt for the Dell PowerEdge 1955 Blade System with 1 blade installed in the chassis.

	SPECjbb2005 bops	SPECjbb2005 bops/JVM	Average power per blade watts)	Performance/ watt
System 1	188,838	94,419	584.22	323.23

Figure 4: SPECjbb2005 results, average power usage (in watts), and performance/watt for the Dell PowerEdge 1955 Blade System during the median run for the 1-blade configuration. Higher performance/watt is better.

Figure 5 shows the SPECjbb2005 results, average power per blade, and performance/watt for the Dell PowerEdge 1955 Blade System with 2 blades installed in the chassis. We calculated the average performance/watt by averaging the performance/watt scores of the 2 systems.

	SPECjbb2005 bops	SPECjbb2005 bops/JVM	Average power per blade watts)	Performance/ watt
System 1	187,728	93,864	408.29	459.79
System 2	188,275	94,138	408.29	461.13
Average performance/watt				460.46

Figure 5: SPECjbb2005 results, average power usage (in watts), and performance/watt for the Dell PowerEdge 1955 Blade System during the median run for the 2-blade configuration. Higher performance/watt is better.

Figure 6 shows the SPECjbb2005 results, average power per blade, and performance/watt for the Dell PowerEdge 1955 Blade System with 10 blades installed in the chassis. We calculated the average performance/watt by averaging the performance/watt scores of the 10 systems.

	SPECjbb2005 bops	SPECjbb2005 bops/JVM	Average power per blade watts)	Performance/ watt
System 1	187,656	93,828	269.93	695.21
System 2	188,435	94,218	269.93	698.10
System 3	187,204	93,602	269.93	693.54
System 4	188,600	94,300	269.93	698.71
System 5	188,260	94,130	269.93	697.45
System 6	188,392	94,196	269.93	697.94
System 7	188,443	94,222	269.93	698.13
System 8	189,199	94,600	269.93	700.93
System 9	189,448	94,724	269.93	701.85
System 10	187,633	93,817	269.93	695.13
Average performance/watt				697.70

Figure 6: SPECjbb2005 results, average power usage (in watts), and performance/watt for the Dell PowerEdge 1955 Blade System during the median run for the 10-blade configuration. Higher performance/watt is better.

Figure 7 shows the SPECjbb2005 results, average power per blade, and performance/watt for the HP BladeSystem c-Class with 1 blade installed in the chassis.

	SPECjbb2005 bops	SPECjbb2005 bops/JVM	Average power per blade watts)	Performance/ watt
System 1	186,779	93,390	614.93	303.74

Figure 7: SPECjbb2005 results, average power usage (in watts), and performance/watt for the HP BladeSystem c-Class during the median run for the 1-blade configuration. Higher performance/watt is better.

Figure 8 shows the SPECjbb2005 results, average power per blade, and performance/watt for the HP BladeSystem c-Class with 2 blades installed in the chassis. We calculated the average performance/watt by averaging the performance/watt scores of the 2 systems.

	SPECjbb2005 bops	SPECjbb2005 bops/JVM	Average power per blade watts)	Performance/ watt
System 1	185,838	92,919	429.04	433.15
System 2	187,343	93,672	429.04	436.66
Average performance/watt				434.90

Figure 8: SPECjbb2005 results, average power usage (in watts), and performance/watt for the HP BladeSystem c-Class during the median run for the 2-blade configuration. Higher performance/watt is better.

Figure 9 shows the SPECjbb2005 results, average power per blade, and performance/watt for the HP BladeSystem c-Class with 10 blades installed in the chassis. We calculated the average performance/watt by averaging the performance/watt scores of the 10 systems.

	SPECjbb2005 bops	SPECjbb2005 bops/JVM	Average power per blade watts)	Performance/ watt
System 1	186,967	93,484	290.98	642.53
System 2	187,198	93,599	290.98	643.33
System 3	186,438	93,219	290.98	640.71
System 4	185,798	92,899	290.98	638.51
System 5	186,462	93,231	290.98	640.80
System 6	187,008	93,504	290.98	642.67
System 7	186,256	93,128	290.98	640.09
System 8	187,865	93,933	290.98	645.62
System 9	187,061	93,531	290.98	642.85
System 10	186,237	93,119	290.98	640.02
Average performance/watt				641.71

Figure 9: SPECjbb2005 results, average power usage (in watts), and performance/watt for the HP BladeSystem c-Class during the median run for the 10-blade configuration. Higher performance/watt is better.

Figure 10 shows the SPECjbb2005 results, average power per blade, and performance/watt for the Dell PowerEdge 1955 Blade System with 16 blades installed in the chassis. We calculated the average performance/watt by averaging the performance/watt scores of the 16 systems.

	SPECjbb2005 bops	SPECjbb2005 bops/JVM	Average power per blade watts)	Performance/ watt
System 1	186,695	93,348	278.63	670.06
System 2	186,287	93,144	278.63	668.59
System 3	187,131	93,566	278.63	671.62
System 4	186,474	93,237	278.63	669.26
System 5	187,639	93,820	278.63	673.44
System 6	186,293	93,147	278.63	668.61
System 7	187,637	93,819	278.63	673.44
System 8	186,737	93,369	278.63	670.21
System 9	185,785	92,893	278.63	666.79
System 10	187,363	93,682	278.63	672.45
System 11	186,877	93,439	278.63	670.71
System 12	186,042	93,021	278.63	667.71
System 13	186,889	93,445	278.63	670.75
System 14	186,427	93,214	278.63	669.09
System 15	185,202	92,601	278.63	664.70
System 16	186,285	93,143	278.63	668.58
Average performance/watt				669.75

Figure 10: SPECjbb2005 results, average power usage (in watts), and performance/watt for the HP BladeSystem c-Class during the median run for the 16-blade configuration. Higher performance/watt is better.

Test methodology

For each installation, we began by installing a fresh copy of Microsoft Windows 2003 Server Enterprise x64 Edition Service Pack 2 on each blade server as follows:

1. Assign a computer name of "BrandServerX", where Brand is either Dell or HP and X is the blade number in the chassis (1–10 for Dell and 1–16 for HP).
2. For the licensing mode, use the default setting of 5 concurrent connections.
3. Enter a password for the administrator logon.

4. Select Eastern Time Zone.
5. Use typical settings for the Network installation.
6. Use "workgroup" for the workgroup.

With the exception of disabling HW Prefetcher and Adjacent Cache Line Prefetcher, we used the default BIOS settings on all servers.

To improve Java performance, we enabled large pages in memory on all servers. To enable this service, the administrator must first assign additional privileges to the user who will be running the application. We assigned this privilege only to the administrator, because we used that account for our tests. To enable large pages, we selected the following:

- Control Panel→Administrative Tools→Local Security Policy
- Local Policies→User Rights Assignment
- "Lock pages in memory," add users and/or groups

Power measurement procedure

To record each blade system's power consumption during testing, we used an Extech Instruments (www.extech.com) 380803 Power Analyzer/Datalogger. We connected the power cord from the system's power supply to the Power Analyzer's output load power outlet. We then plugged the power cord from the Power Analyzer's input voltage connection into a power outlet. We used this setup for each power supply in the chassis.

Because the Dell PowerEdge 1955 Blade System has 4 power supplies, we used 4 Extech Power Analyzers for testing. With the HP BladeSystem c-Class, we used 6 Extech Power Analyzers to accommodate its 6 power supplies. We connected all Extech Power Analyzers to 1 monitoring system to record the power draw of the systems.

We used the Power Analyzer's Data Acquisition Software (version 2.11) to capture all recordings. We installed the software on a separate PC, to which we connected all Power Analyzers via a separated RS-232 cable for each Extech. We captured power consumption at 1-second intervals.

To gauge the idle power usage, we recorded the power usage for 2 minutes while each server was running the operating system but otherwise idle.

To compute the total power, we took the wattage sum from each of the meters. We averaged the power usage during the period the server was running the benchmark. We call this time the power measurement interval. See Figures 2 (idle power consumption) and 3 (average peak power) for the results of these measurements.

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 C:\SPECjbb2005v1.07 on the server's hard disk.

SPECjbb2005 requires a Java Virtual Machine on the system under test. We used the BEA JRockit 5.0 (P27.1.1 build P27.1.1-4-77276-1.5.0_10-20070220-1537-win-x86_64 JDK for Microsoft Windows) 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 the 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 2. This change allows a server to run 2 JVM instances during testing.

We created a batch file, which we placed in the root SPECjbb2005 directory, to issue the Java run command to launch the benchmark. During testing, we used the command prompt window within Microsoft Windows Server 2003 x64 Edition to run this batch file. Figure 11 shows the contents of this file.

Figure 11: The text of the batch file we used to execute the SPECjbb2005 benchmark on all servers.

In the batch file we set the Java options that control the performance of the JVM as follows:

Xms1600m	This option 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 1600 MB.
Xns1300m	This option sets the nursery size to 1300 MB.
Xmx1600m	This option sets the maximum heap size.
XXaggressive	This option essentially tells the JVM to perform at maximum speed.
Xgc:genpar	This option tells Java to use generational parallel garbage collection.
XXthroughputCompaction	This option adjusts the compaction ratio dynamically based on live data in the heap.
XXlazyUnlocking	This option determines when the JVM releases locks.
XXtlasize128k	This option sets the thread-local area size the JVM uses. We specified a minimum and preferred setting for testing.

Test execution

For us to calculate the average power during peak performance, we needed all systems to be running at maximum performance at the same time. To achieve this, we needed all blade servers to start SPECjbb2005 at the same time, which we accomplished by using batch files to start SPECjbb2005 on all systems under test.

On each system under test, we created a batch file in the startup folder that would start as soon as the operating system loaded and then sleep, or sit idle, for 720 seconds. After 720 seconds, the batch file would search, once per second, for a run.txt file in the SPECjbb2005 directory. To begin the test, we used a batch file on a controller system that copied the run.txt file to all systems. Once that batch file had copied the run.txt file to the systems under test, the running batch files would start the SPECjbb2005 benchmark. By starting SPECjbb2005 this way, we ensured that all clients started within 1 second of each other.

Appendix A – Enclosure configuration information

This appendix provides detailed configuration information about the enclosures, which we present in alphabetical order.

Enclosure	Dell PowerEdge 1955 Blade System	HP BladeSystem c-Class
General dimension information		
Height (inches)	12.0	17.5
Width (inches)	17.5	17.5
Depth (inches)	29.0	31.0
U size in server rack	7	10
Number of blades	10	16
Power supplies		
Total number	4	6
Wattage of each	2,100	2,250
Cooling fans		
Total number	4	10
Dimensions (H x W) of each	5.5 x 5.5	3.5 x 3
Voltage	24 volts	12 volts
Amps	2.3 amps	16.5 amps

Appendix B – Blade system configuration information

This appendix provides detailed configuration information about the blade server systems, which we present in alphabetical order.

Servers	Dell PowerEdge 1955 blade server	HP ProLiant BL460c
General processor setup		
Number of processor packages	2	2
Number of cores per processor package	4	4
Number of hardware threads per core	1	1
System Power Management Policy	Always On	Always On
CPU		
Vendor	Intel	Intel
Name	Quad-Core Intel Xeon processor X5345	Quad-Core Intel Xeon processor X5345
Stepping	7	7
Socket type	LGA 771	LGA 771
Core frequency (GHz)	2.33 GHz	2.33 GHz
Front-side bus frequency (MHz)	1333 MHz	1333 MHz
L1 Cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 Cache	2 x 4MB (each 4MB shared by 2 cores)	2 x 4MB (each 4MB shared by 2 cores)
Platform		
Vendor and model number	Dell PowerEdge 1955	HP ProLiant BL460c
Motherboard model number	Dell 0MY759	HP 435458-B21
Motherboard chipset	Intel 5000P	Intel 5000P
Motherboard revision number	A00	91
BIOS name and version	Dell 1.1.0 10/18/2006	HP I15 12/26/2006
BIOS settings	Disabled Hardware Prefetcher and Adjacent Cache Line Prefetch	Disabled Hardware Prefetcher and Adjacent Cache Line Prefetch
Chipset INF driver	7.3.0	HP 2.1.8
Memory module(s)		
Vendor and model number	Hyundai HYMP512F72BP8N3-Y5	Micron MT18HTF12872FDY
Type	PC2-5300	PC2-5300
Speed (MHz)	667 MHz	667 MHz
Speed in the system currently running @ (MHz)	667 MHz	667 MHz
Timing/Latency (tCL-tRCD-iRP-tRASmin)	5-5-5-15	5-5-5-15
Size	4 GB (4 x 1GB)	4 GB (4 x 1GB)
Number of RAM modules	4	4
Chip organization	Dual side	Dual side

Servers	Dell PowerEdge 1955 blade server	HP ProLiant BL460c
Hard disk		
Vendor and model number	Fujitsu MAY2073RC	Seagate St973402SS
Number of disks in system	2	2
Size	73 GB	72 GB
Buffer Size	16 MB	16 MB
RPM	10,000	10,000
Type	SAS	SAS
Controller	Dell SAS 5/iR Integrated controller	Smart Array E200I controller
Controller driver	Dell 1.21.8.0	HP 6.6.0.64
Operating system		
Name	Microsoft Windows Server 2003, Enterprise Edition	Microsoft Windows Server 2003, Enterprise Edition
Build number	3790	3790
Service Pack	SP 2	SP 2
Microsoft Windows update date	SP 2 only	SP 2 only
File system	NTFS	NTFS
Kernel	ACPI Multiprocessor-based PC	ACPI Multiprocessor-based PC
Language	English	English
Microsoft DirectX version	9.0c	9.0c
Graphics		
Vendor and model number	ATI ES1000	ATI ES1000
Chipset	ATI ES1000	ATI ES1000
BIOS version	BK-ATI VER008.005.028.000	BK-ATI VER008.005.013.000
Type	Integrated	Integrated
Memory size	16MB	32MB
Resolution	1024 x 768	1024 x 768
Driver	ATI 8.19.4.0	ATI 8.24.3.0
Network card/subsystem		
Vendor and model number	Broadcom BCM5708S NetXtreme II Gigabit Ethernet adapter	HP NC373i Multifunction Gigabit Server Adapter
Type	Integrated	Integrated
Driver	Broadcom 2.6.14.0	HP 3.0.5.0
Optical drive		
Vendor and model number	None installed	None installed
USB ports		
Number	2 (with adapter attached)	2 (with adapter attached)
Type	USB 2.0	USB 2.0

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