Principled Technologies®

TEST REPORT
DECEMBER 2007

SPECjbb2005 performance and power consumption on Dell, HP, and IBM 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 M600
- HP BladeSystem c-Class
- IBM BladeCenter H Type 8852

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 presents the performance/watt for each of the blade server systems by configuration. Higher results show better system performance/watt. We calculate performance/watt by dividing the SPECjbb2005 result by the average power consumption in watts during the period the system achieved peak performance.

Figure 1 shows the blades in the Dell PowerEdge M600 achieved the best performance/watt at every configuration. With 10 blades installed in all three systems, the Dell PowerEdge M600 achieved 24.59 percent higher performance/watt than the HP BladeSystem c-Class. The Dell PowerEdge M600 also achieved 28.76 percent higher performance/watt than the IBM BladeCenter H Type 8852.

In the maximum blades configuration, we installed the maximum number of blade servers in each chassis. This was 16 servers for the Dell and HP, but only 14 blades for the IBM. In the maximum blades configuration, The Dell PowerEdge M600 achieved 25.35 percent better performance/watt with 16 blades installed than the HP BladeSystem c-Class did with 16 blades installed. The Dell PowerEdge M600 achieved 28.58 percent better performance/watt with 16 blades installed than the IBM BladeCenter H Type 8852 with 14 blades installed. In comparing the maximum blades configuration for the Dell PowerEdge M600 and the IBM BladeCenter H Type 8852, we used the maximum number of blades each server would support: 16 in the Dell and 14 in the IBM. In this case, we are therefore normalizing a 16-blade result to a 14-blade result.

Furthermore, the Dell PowerEdge M600 achieved 31.95 and 27.83 percent higher performance/watt than the HP BladeSystem c-Class in one- and two-blade configurations, respectively. The Dell PowerEdge M600 achieved 88.16 and 65.17 percent higher performance/watt than the IBM BladeCenter H Type 8852 in the one- and two-blade configurations, respectively.

KEY FINDINGS

- The Dell PowerEdge M600 achieved better performance/watt than the HP BladeSystem c-Class or the IBM BladeCenter H Type 8852 at every configuration we tested (see Figure 1).
- With 10 blades installed in all three systems, the blades in the Dell PowerEdge M600 achieved 24.59 percent higher performance/watt than the HP BladeSystem c-Class and 28.76 percent higher than the IBM BladeCenter H Type 8852.
- With 16 blades in each chassis, the Dell PowerEdge M600 achieved 25.35 percent better performance/watt than the HP BladeSystem c-Class.
- At the maximum blades configuration, the Dell PowerEdge M600 achieved 28.58 percent better performance/watt with 16 blades than the IBM BladeCenter H Type 8852 did with 14 blades.
- With 16 blades, the Dell PowerEdge M600 used 18.55 percent less power per blade than the HP BladeSystem c-Class did with 16 blades and 11.76 percent less power per blade than the IBM BladeCenter H Type 8852 did with 14 blades.

	Dell PowerEdge M600 Blade System	HP BladeSystem c-Class	IBM BladeCenter H Type 8852	Percentage performance/ watt increase Dell over HP	Percentage performance/ watt increase Dell over IBM
1 blade	464.54	352.06	246.89	31.95	88.16
2 blades	642.40	502.52	388.93	27.83	65.17
10 blades	919.95	738.40	714.47	24.59	28.76
Maximum blades	958.86 (16 blades)	764.97 (16 blades)	745.70 (14 blades)	25.35	28.58

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. 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 M600, HP BladeSystem c-Class, and IBM BladeCenter H Type 8852 at all blade configurations. Lower power is better.

	Dell PowerEdge M600	HP BladeSystem c-Class	IBM BladeCenter H Type 8852
1 blade	383.75	510.57	681.88
2 blades	516.68	666.00	807.32
10 blades	1,588.15	1,975.38	1,853.73
Maximum blades	2,416.18 (16 blades)	3,035.87 (16 blades)	2,409.92 (14 blades)

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 Dell PowerEdge M600, HP BladeSystem c-Class, and IBM BladeCenter H Type 8852 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. The power the Dell PowerEdge M600 required running with 16 blades is almost identical to the power the IBM BladeCenter H Type 8853 required running with 14 blades.

	Dell PowerEdge M600	HP BladeSystem c-Class	IBM BladeCenter H Type 8852
1 blade	454.39	590.01	749.57
2 blades	656.45	821.71	954.79
10 blades	2,277.47	2,802.43	2,605.88
Maximum blades	3,524.19 (16 blades)	4,326.92 (16 blades)	3,494.45 (14 blades)

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-, maximum-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-, maximum-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 M600 with 1 blade installed in the chassis.

	SPECjbb2005 bops	Average power per blade (watts)	Performance/watt
System 1	211,081	454.39	464.54

Figure 4: SPECjbb2005 results, average power usage (in watts), and performance/watt for the Dell PowerEdge M600 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 M600 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	Average power per blade (watts)	Performance/watt
System 1	210,754	328.22	642.11
System 2	210,946	328.22	642.69
Average performance/watt			642.40

Figure 5: SPECjbb2005 results, average power usage (in watts), and performance/watt for the Dell PowerEdge M600 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 M600 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	Average power per blade (watts)	Performance/watt
System 1	209,976	227.75	921.97
System 2	211,440	227.75	928.40
System 3	212,122	227.75	931.39
System 4	196,571	227.75	863.11
System 5	211,368	227.75	928.08
System 6	211,277	227.75	927.68
System 7	209,919	227.75	921.72
System 8	210,591	227.75	924.67
System 9	211,792	227.75	929.94
System 10	210,096	227.75	922.50
Average performance/watt			919.95

Figure 6: SPECjbb2005 results, average power usage (in watts), and performance/watt for the Dell PowerEdge M600 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 Dell PowerEdge M600 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	Average power per blade (watts)	Performance/watt
System 1	211,626	220.26	960.79
System 2	210,538	220.26	955.85
System 3	211,956	220.26	962.29
System 4	211,223	220.26	958.96
System 5	211,357	220.26	959.57
System 6	210,810	220.26	957.09
System 7	210,810	220.26	957.09
System 8	210,289	220.26	954.72
System 9	210,827	220.26	957.17
System 10	210,982	220.26	957.87
System 11	211,456	220.26	960.02
System 12	210,711	220.26	956.64
System 13	211,745	220.26	961.33
System 14	211,525	220.26	960.34
System 15	212,135	220.26	963.10
System 16	211,218	220.26	958.94
Average performance/watt			958.86

Figure 7: SPECjbb2005 results, average power usage (in watts), and performance/watt for the Dell PowerEdge M600 during the median run for the 16-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 1 blade installed in the chassis.

	SPECjbb2005 bops	Average power per blade (watts)	Performance/watt
System 1	207,723	590.01	352.06

Figure 8: 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 9 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	Average power per blade (watts)	Performance/watt
System 1	206,882	410.86	503.54
System 2	206,048	410.86	501.51
Average performance/watt			502.52

Figure 9: 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 10 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	Average power per blade (watts)	Performance/watt
System 1	206,358	280.24	736.35
System 2	206,638	280.24	737.35
System 3	206,655	280.24	737.41
System 4	206,708	280.24	737.60
System 5	207,438	280.24	740.21
System 6	206,919	280.24	738.36
System 7	206,860	280.24	738.14
System 8	207,330	280.24	739.82
System 9	206,647	280.24	737.38
System 10	207,770	280.24	741.39
Average performance/watt			738.40

Figure 10: 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 11 shows the SPECjbb2005 results, average power per blade, and performance/watt for the HP BladeSystem c- Class 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	Average power per blade (watts)	Performance/watt
System 1	207,182	270.43	766.11
System 2	207,103	270.43	765.82
System 3	206,311	270.43	762.89
System 4	208,405	270.43	770.64
System 5	206,547	270.43	763.77
System 6	206,787	270.43	764.65
System 7	207,264	270.43	766.42
System 8	208,406	270.43	770.64
System 9	205,203	270.43	758.80
System 10	207,253	270.43	766.38
System 11	206,343	270.43	763.01
System 12	206,371	270.43	763.11
System 13	206,892	270.43	765.04
System 14	207,169	270.43	766.07
System 15	206,270	270.43	762.74
System 16	206,467	270.43	763.47
Average performance/watt			764.97

Figure 11: 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.

Figure 12 shows the SPECjbb2005 results, average power per blade, and performance/watt for the IBM BladeCenter H Type 8852 with 1 blade installed in the chassis.

	SPECjbb2005 bops	Average power per blade (watts)	Performance/watt
System 1	185,163	749.76	246.96

Figure 12: SPECjbb2005 results, average power usage (in watts), and performance/watt for the IBM BladeCenter H Type 8852 during the median run for the 1-blade configuration. Higher performance/watt is better.

Figure 13 shows the SPECjbb2005 results, average power per blade, and performance/watt for the IBM BladeCenter H Type 8852 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	Average power per blade (watts)	Performance/watt
System 1	185,080	477.39	387.69
System 2	186,269	477.39	390.18
Average performance/watt			388.93

Figure 13: SPECjbb2005 results, average power usage (in watts), and performance/watt for the IBM BladeCenter H Type 8852 during the median run for the 2-blade configuration. Higher performance/watt is better.

Figure 14 shows the SPECjbb2005 results, average power per blade, and performance/watt for the IBM BladeCenter Type H 8852 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	Average power per blade (watts)	Performance/watt
System 1	187,011	260.59	717.65
System 2	185,789	260.59	712.96
System 3	186,519	260.59	715.76
System 4	186,310	260.59	714.96
System 5	186,038	260.59	713.92
System 6	186,163	260.59	714.40
System 7	185,962	260.59	713.62
System 8	186,117	260.59	714.22
System 9	186,921	260.59	717.30
System 10	184,995	260.59	709.91
Average performance/watt			714.47

Figure 14: SPECjbb2005 results, average power usage (in watts), and performance/watt for the IBM BladeCenter H Type 8852 during the median run for the 10-blade configuration. Higher performance/watt is better.

Figure 15 shows the SPECjbb2005 results, average power per blade, and performance/watt for the IBM BladeCenter H Type 8852 with 14 blades installed in the chassis. We calculated the average performance/watt by averaging the performance/watt scores of the 14 systems.

	SPECjbb2005 bops	Average power per blade (watts)	Performance/watt
System 1	186,849	249.60	748.58
System 2	184,574	249.60	739.47
System 3	186,015	249.60	745.24
System 4	186,826	249.60	748.49
System 5	185,888	249.60	744.73
System 6	185,400	249.60	742.78
System 7	186,443	249.60	746.96
System 8	186,996	249.60	749.17
System 9	186,388	249.60	746.74
System 10	186,488	249.60	747.14
System 11	186,060	249.60	745.42
System 12	186,037	249.60	745.33
System 13	186,044	249.60	745.36
System 14	185,818	249.60	744.45
Average performance/watt			745.70

Figure 15: SPECjbb2005 results, average power usage (in watts), and performance/watt for the IBM BladeCenter H Type 8852 during the median run for the 14-blade configuration. Higher performance/watt is better.

Concerned about IBM's relatively low SPECjbb scores, we investigated further. We verified that the system's processors were running at full speed and there were no heat issues.

We tested all systems using 4GB of RAM. The IBM BladeCenter H Type 8852 had only 4 RAM slots, all of which were full. The Dell PowerEdge and HP BladeSystem each had 8 RAM slots, of which we used 4. RAM was running at 667 MHz for all three test systems.

As a sanity check, we ran SiSoftware Sandra's memory test, which reported the IBM server's memory bandwidth as half that of the Dell server's: 10,656 MB/s vs. 21,312 MB/s. SiSoftware Sandra also reported the IBM server had 2 memory channels, while the Dell server had 4 memory channels.

Sandra showed only that the IBM BladeCenter H Type 8852 used an Intel 5000P chipset, with no code names or other details. It did report that the memory controller supports 8 memory slots, the same as the Dell and the HP. It is possible that using the optional IBM BladeCenter Memory and I/O Expansion Blade, which provides 4 additional DIMM slots, is necessary to access the other two memory channels. The IBM documentation says that when the using the Memory expansion blade, the optimal memory configuration is to use 2 pairs of matching DIMMs; 1 pair on the board in slots 1 and 3 and the other pair on the expansion blade in slots 5 and 7. Because the system we tested did not ship with this part, we were unable to test this hypothesis.

In conclusion, we believe that the IBM BladeCenter H Type 8852's relatively low SPECjbb scores are probably a function of its lower memory bandwidth.

Power settings experiments

We ran one test with the maximum number of blades for each enclosure and the power settings on the enclosures as identical as possible. We used "AC redundant" for the Dell PowerEdge M600, "AC redundant" for the HP BladeSystem c-Class, and "Redundant without performance impact" for the IBM BladeCenter H Type 8852. Figure 16 shows the results of that test. As you can see, the results were so close to those of our main tests that we focused on the results of those tests. (As we noted earlier, the maximum number of blades is 16 for the Dell PowerEdge M600 and HP BladeSystem c-Class, but only 14 for the IBM BladeCenter H Type 8852.)

	Dell PowerEdge M600	HP BladeSystem c-Class	IBM BladeCenter H Type 8852
Average performance per watt (higher is better)	949.36	764.97	762.99
Average idle power, watts (lower is better)	2413.85	3,035.87	2392.73
Average run power per blade, watts (lower is better)	222.31	270.43	243.94
Average performance per blade, BOPS (higher is better)	211,054 (16 blades)	206,873.31 (16 blades)	186,121.79 (14 blades)

Figure 16: Results of single tests using each enclosure's maximum number of blades and the following power settings: "AC redundant" for the Dell PowerEdge M600, "AC redundant" for the HP BladeSystem c-Class, and "Redundant without performance impact" for the IBM BladeCenter H Type 8852.

Test methodology

Perform the following BIOS-level operations on every system before installing the OS:

1. Make sure systems are configured with RAID 1. Use the disk controller utility for this, not the OS.
2. Set the partition to be the whole disk.
3. Update the BIOS, if needed. Note: The preinstalled BIOS, version 1.05, on the IBM BladeCenter H Type 8852 gave the error "The BIOS does not support the current stepping of Processor P02". After upgrading to version 1.07, the error message no longer appeared.
4. Disable HW prefetcher and Adjacent line prefetcher in BIOS. Leave all other values at their defaults.

Create the base image:

1. For each installation, begin by installing a fresh copy of Microsoft Windows 2003 Server Enterprise x64 Edition Service Pack 2 on each blade server. (If you are using a support pack with an express install option, do *not* use it. Select Custom Install and only install drivers. Otherwise, you may be installing unnecessary software, which may affect the results of the test.)
   a. For the licensing mode, use the default setting of five concurrent connections.
   b. Enter a password for the administrator logon.
   c. Select Eastern Time Zone, and check date and time.
   d. Use typical settings for the Network installation.
   e. Assign a computer name. We used the format "<Brand>Server<#>", where Brand is Dell, HP, or IBM and X is the blade number in the chassis (1–16 for Dell and HP and 1–14 for IBM) (e.g., IBMServer1).
   f. Leave the default "WORKGROUP" for the workgroup.
   g. Finish installation.
   h. Install SP 2.
   i. Run Live update and install the following updates. Our update date was November 29, 2007.
      - Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB943460)
      - Windows Server 2003 Windows Malicious Software Removal Tool x64 - November 2007 (KB890830)
      - Windows Server 2003 Cumulative Security Update for Internet Explorer 6 for Windows Server 2003 x64 Edition (KB939653)
      - Windows Server 2003 Security Update for Outlook Express for Windows Server 2003 x64 Edition (KB941202)
      - Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB933729)
      - Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB936021) Windows Server 2003 Update for Windows Server 2003 x64 Edition (KB933360)
      - Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB938127)
      - Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB921503)
      - Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB936782)

- Windows Server 2003 Update for Windows Server 2003 x64 Edition (KB932596)
- Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB926122)
- Windows Server 2003 Security Update for Windows Media Player 6.4 (KB925398)
- Windows Server 2003 Update for Windows Server 2003 x64 Edition (KB936357)
- Windows Server 2003 Cumulative Security Update for Outlook Express for Windows Server 2003 x64 Edition (KB929123)
- Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB935839)
- Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB935840)
- Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB924667)
- Windows Server 2003 Update for Windows Server 2003 x64 Edition (KB927891)
- Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB932168)
- Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB930178)
- Windows Server 2003 Security Update for Windows Server 2003 x64 Edition (KB925902)

2. To improve Java performance, enable 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, select the following:
    - Control Panel→Administrative Tools→Local Security Policy→Local Policies→User Rights Assignment: Add Administrator
    - "Lock pages in memory," add users and/or groups
3. Turn the screen saver off.
4. Customize desktop to put My Computer on it.
5. Set screen to 10x7, 32-bit color.
6. In the Manage your server dialog, select "Don't display this page at logon."
7. Turn off Automatic updates.
8. Set the server to login automatically.
9. Install SPECjbb and the JVM on the server
10. Empty trash.
11. Create the image on server.

For all other blades, use Ghostcast to install the image. Use the system we just completed configuring to create a Ghost image on the server.

After capturing images to servers

1. Each server needs a unique host name. Change the host name from the one you used for the base image to one of the form "<Brand>Server<#>", where Brand is Dell, HP, or IBM and X is the blade number in the chassis (1–16 for Dell and HP and 1–14 for IBM) (e.g., IBMServer2).

We did a small amount of experimenting with the power settings on the enclosures. For the Dell PowerEdge M600, we tested with the Redundancy Policy to Power Supply Redundancy and checked Enable Dynamic Power Supply Engagement. For the HP BladeSystem c-Class, we tested with "Power Savings" enabled and the power supplies set to "AC Redundant." For the IBM BladeCenter H Type 8852, our experiments had no significant effect on the power savings. Before determining the final settings for each enclosure, we ran a single test with each enclosure's maximum number of blades; the Power settings section shows those results. The effect on the results of the Dell and IBM was less than 2% in all cases.

We tested with the following default settings for each enclosure:

Dell PowerEdge M600:

- Server Power Throttling Enabled: Checked
- Redundancy Policy: Power supply redundancy
- Enable Dynamic Power Supply Engagement: Checked

HP BladeSystem c-Class:

- Enclosure Power Mode: AC redundant
- Enable Dynamic Power Savings Mode: Checked

IBM BladeCenter H Type 8852:

- Domain 1: Non-redundant
- Domain 2: Non-redundant
- Acoustic mode: Disabled

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 each of the three servers has 6 power supplies, we used 6 Extech Power Analyzers for testing. We connected all Extech Power Analyzers to one 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(R) (build P27.4.0-10-90053-1.6.0_02-20071009-1827-windows-x86_64, compiled mode) 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, the text of which is as follows:

```
@echo off
set path="C:\jrockit-jdk1.6.0_02\bin";%path%

set JVM=2
:: Set JAVA_HOME to Java.exe path.
set JAVA_HOME="C:\jrockit-jdk1.6.0_02\bin"

:stage1
set PROPFILE=SPECjbb.props
set JAVAOPTIONS= -Xms256m -Xmx256m
rem set JBBJARS=.\jbb.jar;.\check.jar
set JBBJARS=.\jbb.jar;.\jbb_no_precompile.jar;.\check.jar;.\reporter.jar

set CLASSPATH=%JBBJARS%;%CLASSPATH%

:stage2

echo Using CLASSPATH entries:
for %%c in ( %CLASSPATH% ) do echo %%c
@echo on
start /b C:\jrockit-jdk1.6.0_02\bin\java.exe %JAVAOPTIONS% spec.jbb.Controller -
propfile %PROPFILE%
@echo off
set I=0
set J=F
:LOOP
set /a I=%I + 1
echo.
echo Starting JVM Number %I% with Affinity to CPU %J%
echo.

@echo on
start /AFFINITY %J% /B C:\jrockit-jdk1.6.0_02\bin\java.exe -Xms1600m -Xns1300m -
Xmx1600m -XXaggressive -XXlargepages -XXcallprofiling -Xgc:genpar -
XXthroughputCompaction -XXlazyUnlocking -XXtlasize:min=4k,preferred=256k
spec.jbb.JBBmain -propfile %PROPFILE% -id %I% > multi.%I%
@echo off
set J=%J%0
IF %I% == %JVM% GOTO END
GOTO LOOP
:END


:egress
```

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.
XXtlasize:min=4k,preferred=256k	This option sets the thread-local area size the JVM uses. We specified a minimum and preferred setting for testing.
-XXlargepages	This option tells the JVM to use large pages, if they are available, for the Java heap and other areas in the JVM.
-XXcallprofiling	This option enables the use of call profiling for code optimizations.

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

Figure 17 provides detailed configuration information about the enclosures, which we present in alphabetical order.

Enclosure	Dell PowerEdge M600	HP BladeSystem c-Class	IBM BladeCenter H Type 8852
General dimension information			
Height (inches)	17.5	17.5	15.75
Width (inches)	19	19	19
Depth (inches)	30.5	31.0	28.0
U size in server rack	10	10	9
Number of blades	16	16	14
Power supplies			
Total number	6	6	2
Wattage of each	2,360	2,250	2,900
Cooling fans			
Total number	9	10	2 blowers
Dimensions (H x W) of each	3.5 x 3	3.5 x 3	4.5x11.5
Voltage	12 volts	12 volts	200-240 volts
Amps	7 amps	16.5 amps	5.5 amps

Figure 17: Detailed configuration information about the enclosures.

Appendix B – Blade system configuration information

Figure 18 provides detailed configuration information about the blade server systems, which we present in alphabetical order.

Servers	Dell PowerEdge M600	HP BladeSystem c-Class	IBM BladeCenter H Type 8852
General processor setup			
Number of processor packages	2	2	2
Number of cores per processor package	4	4	4
Number of hardware threads per core	1	1	1
System Power Management Policy	Always on	Always on	Always on
CPU			
Vendor	Intel	Intel	Intel
Name	Quad-Core Intel Xeon processor E5345	Quad-Core Intel Xeon processor E5345	Quad-Core Intel Xeon processor E5345
Stepping	B	7	7
Socket type	LGA 771	LGA 771	LGA 771
Core frequency (GHz)	2.33 GHz	2.33 GHz	2.33 GHz
Front-side bus frequency (MHz)	1,333 MHz	1,333 MHz	1,333 MHz
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	2 x 4 MB (each 4 MB shared by two cores)	2 x 4 MB (each 4 MB shared by two cores)	2 x 4 MB (each 4 MB shared by two cores)
Platform			
Vendor and model number	Dell PowerEdge M600	HP ProLiant BL460c	BladeCenter HS21
Motherboard model number	Dell 0MY736	HP 435458-B21	IBM 8853C2U
Motherboard chipset	Intel 5000P	Intel 5000P	Intel 5000P
Motherboard revision number	X31	91	B1
BIOS name and version	Dell 0.2.11	HP I15 12/26/2006	IBM 1.07 10/26/2007
BIOS settings	Disabled Hardware Prefetcher and Adjacent Cache Line Prefetcher	Disabled Hardware Prefetcher and Adjacent Cache Line Prefetcher	Disabled Hardware Prefetcher and Adjacent Cache Line Prefetcher
Chipset INF driver	Intel 7.4.1005	HP 2.1.8	Intel 7.4.1005
Memory module(s)			
Vendor and model number	Samsung M395T2953EZ4-CE65	Micron MT18HTF12872FDY	Hynix HYMP512F72CP8D2-Y5
Type	PC2-5300	PC2-5300	PC2-5300
Speed (MHz)	667 MHz	667 MHz	667 MHz
Speed in the system currently running @ (MHz)	667 MHz	667 MHz	667 MHz
Timing/Latency (tCL-tRCD-iRP-tRASmin)	5-5-5-15	5-5-5-15	5-5-5-15
Size	4 GB (4 x 1 GB)	4 GB (4 x 1 GB)	4 GB (4 x 1 GB)
Number of RAM modules	4	4	4
Chip organization	Dual side	Dual side	Dual side

Servers	Dell PowerEdge M600	HP BladeSystem c-Class	IBM BladeCenter H Type 8852
Hard disk			
Vendor and model number	Fujitsu may2073rc	Seagate St973402SS	IBM 26K5777
Number of disks in system	2	2	2
Size	73 GB	72 GB	73.4 GB
Buffer size	16 MB	16 MB	8 MB
RPM	10,000	10,000	10,000
Type	SAS	SAS	SAS
Controller	Dell SAS 6/iR Integrated Blades Controller	Smart Array E200I controller	LSI Adapter, SAS 3000 series
Controller driver	Dell 1.24.4.0	HP 6.6.0.64	LSI 1.21.28.0
Operating system			
Name	Microsoft Windows Server 2003, Enterprise x64 Edition	Microsoft Windows Server 2003, Enterprise x64 Edition	Microsoft Windows Server 2003, Enterprise x64 Edition
Build number	3790	3790	3790
Service Pack	SP 2	SP 2	SP 2
Microsoft Windows update date	SP 2 plus updates through 11/29/07	SP 2 plus updates through 11/29/07	SP 2 plus updates through 11/29/07
File system	NTFS	NTFS	NTFS
Kernel	ACPI Multiprocessor x64-based PC	ACPI Multiprocessor x64-based PC	ACPI Multiprocessor x64-based PC
Language	English	English	English
Microsoft DirectX version	9.0c	9.0c	9.0c
Graphics			
Vendor and model number	ATI ES1000	ATI ES1000	ATI ES1000
Chipset	ATI ES1000	ATI ES1000	ATI ES1000
BIOS version	BK-ATI VER008.005.031.000	BK-ATI VER008.005.013.000	BK-ATI VER008.005.031.000
Type	Integrated	Integrated	Integrated
Memory size	32MB	32MB	16MB
Resolution	1,024 x 768	1,024 x 768	1,024 x 768
Driver	ATI 8.240.50.1000	ATI 8.24.3.0	ATI 8.24.3.0
Network card/subsystem			
Vendor and model number	Broadcom BCM5708S NetXtreme II GigE	HP NC373i Multifunction Gigabit Server Adapter	Broadcom BCM5708S NetXtreme II GigE
Type	Integrated	Integrated	Integrated
Driver	Broadcom 3.5.8.0	HP 3.0.5.0	Broadcom 3.0.5.0
Optical drive			
Vendor and model number	None installed	None installed	None installed
USB ports			
Number	2	2 (with adapter attached)	2
Type	USB 2.0	USB 2.0	USB 2.0

Figure 18: Detailed configuration information about the blade server systems.

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