

CONSOLIDATING WEB SERVERS WITH THE DELL POWEREDGE FX2 AND POWEREDGE FM120x4 MICROSERVER BLOCKS

PERFORMANCE AND EFFICIENCY WITH A DELL™ POWEREDGE™ FX2 SOLUTION

up to **12X** the simulated users



up to **6.7X** the power efficiency



The Dell PowerEdge FX2 enclosure with FM120x4 microservers excelled at Web server performance while making better use of power, which can translate into data center savings*.



POWERED BY THE INTEL® ATOM™ PROCESSOR C2000 PRODUCT FAMILY

*compared to ■ HP Moonshot 1500 System ■ HP ProLiant DL320e Gen8 v2 ■ HP ProLiant DL120 G7 ■ HP ProLiant DL360 G6

For companies that host Web servers, high performance and low power consumption are key to ensuring both happy customers and a reasonable operating budget. Consolidating your Web servers onto new infrastructure, especially converged architecture, can help you meet these needs.

The Dell PowerEdge FX2 enclosure is a shared infrastructure solution that can house four Intel Atom processor-powered PowerEdge FM120x4 microserver blocks, each containing four microservers that are optimal for running Web servers. In the Principled Technologies labs, we investigated how many legacy Web servers it could consolidate and compared its performance to both a new HP rack solution—the HP ProLiant DL320e Gen8 v2—and an HP shared infrastructure solution, the HP Moonshot 1500 with m300 server cartridges.

We found that the PowerEdge FX2 solution could consolidate 12 HP ProLiant DL360 G6 servers or 12 HP ProLiant DL120 G7 servers, with up to 6.7x the power efficiency. It would save 54.7 percent in power consumption vs. the performance-equivalent HP rack solution and 28.1 percent compared to the HP Moonshot 1500. The converged infrastructure of the Dell PowerEdge FX2 with FM120x4 microserver blocks provided better consolidation ratios, density, and power efficiency than both the HP Moonshot 1500 and HP ProLiant DL320e Gen8 v2 rack, which means that choosing it as a Web server consolidation platform could help you make the most of your IT budget.



A PRINCIPLED TECHNOLOGIES TEST REPORT

Commissioned by Dell Inc.

DECEMBER 2014

CONSOLIDATE TO CONVERGED INFRASTRUCTURE AND SAVE

Using the mWeb benchmark, we tested the Web server performance of the following:

- Dell PowerEdge FX2 with four Dell PowerEdge FM120x4 microserver blocks (16 server nodes) (Dell PowerEdge FX2)
- HP Moonshot 1500 System with 15 HP ProLiant m300 server cartridges (HP Moonshot 1500)
- HP ProLiant DL320e Gen8 v2 (HP ProLiant DL320e Gen8 v2)
- HP ProLiant DL120 G7 (G7 legacy server)
- HP ProLiant DL360 G6 (G6 legacy server)

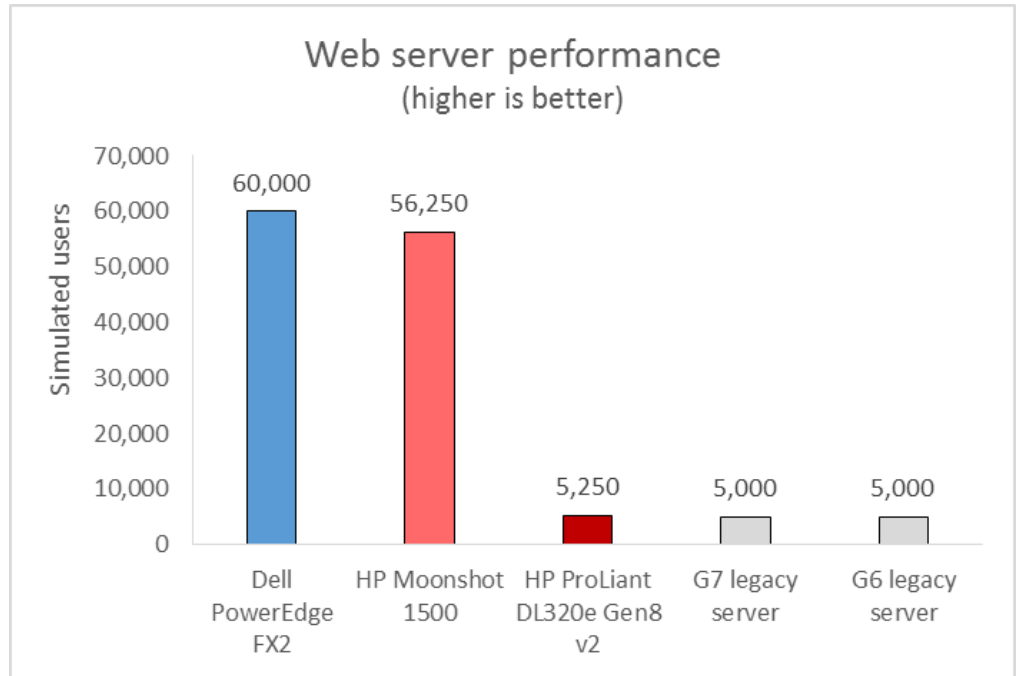
During our tests, we also measured power consumption to show the impact consolidating older Web servers could have on operating costs. For more information about the Dell PowerEdge FX2 and its components, see [Appendix A](#). For detailed system configuration information about all our test systems, see [Appendix B](#). See [Appendix C](#) for step-by-step details about our tests.

WHAT WE FOUND

About the results

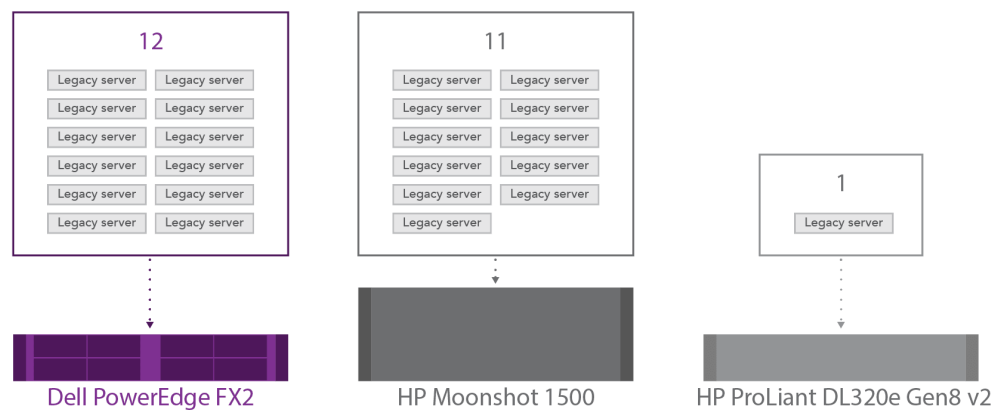
Primarily, your server environment needs to be able to support the Web servers you run with good performance for your customers. Figure 1 compares the Web server performance of the test systems, in number of simulated users the systems handled. The Dell PowerEdge FX2 delivered up to 12 times as much Web performance than the legacy systems, making it a good platform for Web server consolidation. Compared to the other current-generation systems, the HP ProLiant DL320e Gen8 v2 rack and the HP Moonshot 1500, the PowerEdge FX2 with Intel Atom processor-powered FM120x4 microserver blocks handled 1,042.9 percent and 6.7 percent more simulated users, respectively.

Figure 1: Web server performance for the systems we tested. Higher numbers are better.



The more servers you can consolidate, the bigger your savings can be. We extrapolated our performance results, in simulated users, to determine how many of the legacy servers the current generation servers could consolidate. As Figure 2 shows, the Dell PowerEdge FX2 with Intel Atom-powered FM120x4 microserver blocks delivered enough performance that it could consolidate 12 of the HP ProLiant DL360 G6 Web servers or 12 of the HP ProLiant DL120 G7 Web servers we tested. That’s 9.1 percent more than the HP Moonshot 1500 solution could consolidate and 12 times the HP ProLiant DL320e Gen8 v2, which would be unable to consolidate any G6 or G7 legacy servers.

Figure 2: Number of HP ProLiant DL360 G6 servers or HP ProLiant DL120 G7 servers the current generation servers could consolidate based on the Web server performance in our tests. Higher consolidation ratios are better.



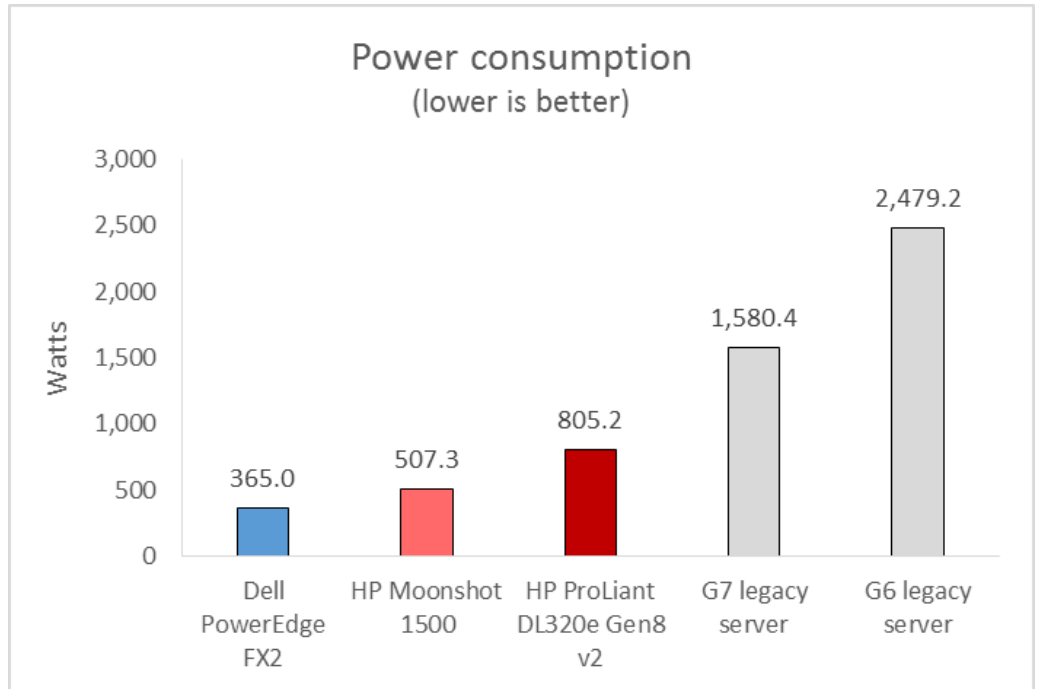
A benefit of the Intel Atom processor C2000 product family is that it can run typical Web server workloads while also reducing power consumption compared to the processors that rack servers use. The cost of power and cooling falls dramatically when you consolidate several older systems onto a more power-efficient, converged infrastructure solution. While delivering better performance, the Intel Atom-powered Dell PowerEdge FX2 solution also consumed a fraction of the power that a performance-equivalent legacy solution would. The Dell PowerEdge FX2 consumed 54.7 percent less power than a performance equivalent current-generation HP ProLiant DL320e Gen8 v2 rack server solution and 28.1 percent less power than the HP Moonshot 1500.

Figure 3 shows the active and idle power utilization of the full chassis or rack servers and estimated power per server node while running the workload. We calculated equivalent performance by extrapolating how many servers or cartridges the competitive and legacy servers would be needed to support the 60,000 simulated users the Dell PowerEdge FX2 solution supported. (See Figures 3 and 4.)

| | Power (W) | | | Power (W) for equivalent performance in simulated users |
|---------------------------------------|-------------------|-------|---------------------|---|
| | Active (per unit) | Idle | Active (per server) | |
| Dell PowerEdge FX2 (16 servers) | 365.0 | 207.9 | 22.8 | 365.0 |
| HP Moonshot 1500 (15 servers) | 475.6 | 315.6 | 31.7 | 507.3 |
| HP ProLiant DL320e Gen8 v2 (1 server) | 67.1 | 50.4 | 67.1 | 805.2 |
| G7 legacy server (1 server) | 131.7 | 81.0 | 131.7 | 1,580.4 |
| G6 legacy server (1 server) | 206.6 | 119.7 | 206.6 | 2,479.2 |

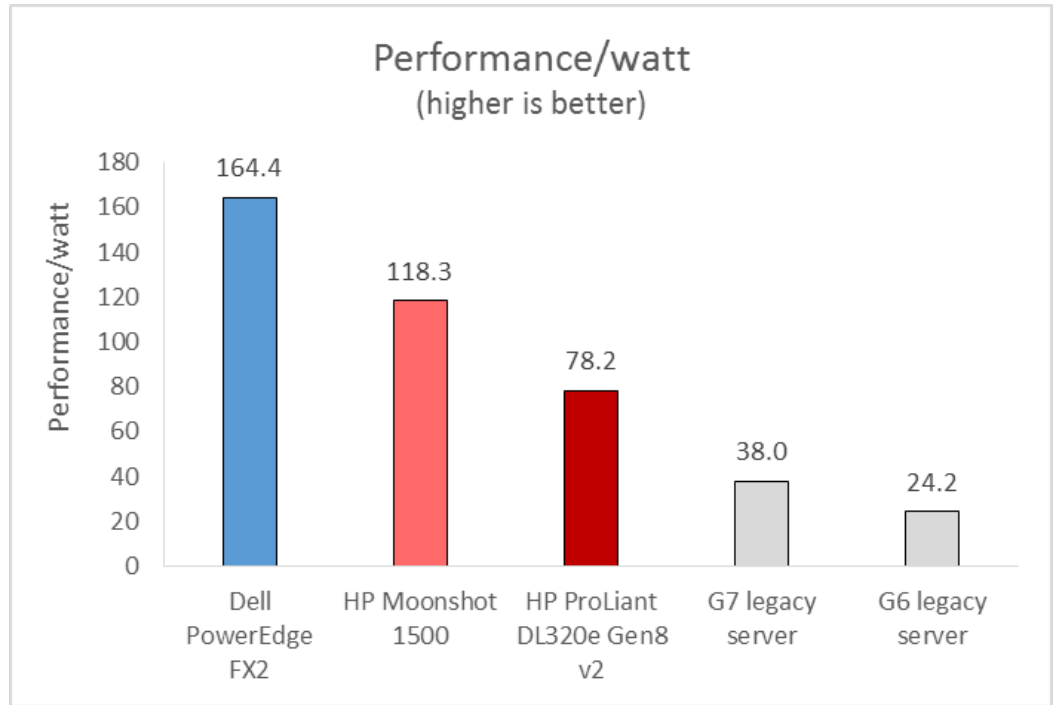
Figure 3: Power consumption data from our tests.

Figure 4: Power consumption for performance-equivalent solutions. Lower numbers are better.



Because both performance and power consumption are critical to running an efficient server infrastructure, looking at the performance you get per watt of power used can help you pick the right solution to meet these dual goals. The more performance per watt a system delivers, the better the ratio of performance and power efficiency. As Figure 5 shows, the Dell PowerEdge FX2 delivered the most performance per watt of all the systems we tested: 6.7 and 4.3 times the performance per watt of the G6 and G7 legacy servers, respectively, providing 110.1 percent more performance per watt than the HP ProLiant DL320e Gen8 v2, and 39.0 percent more than the HP Moonshot 1500.

Figure 5: Performance per watt that each of the solutions delivered. Higher numbers are better.



CONCLUSION

Consolidating Web servers to a new environment can save you a great deal on operating costs such as power and cooling, and the shared nature of converged infrastructure solutions can maximize these savings. In our tests, we found that the Dell PowerEdge FX2 enclosure with Intel Atom processor C2750-powered FM120 nodes provided better consolidation ratios and power efficiency than both the HP Moonshot 1500 shared infrastructure solution and the current-generation HP ProLiant DL320e Gen8 v2 rack server. The Dell PowerEdge FX2 could consolidate 12 legacy Web servers and deliver up to 6.7 times the power efficiency that legacy servers would use. It also delivered up to 110.1 percent more performance/watt compared to the current-generation Web server solutions we tested from HP.

As these results show, the Dell PowerEdge FX2 with FM120x4 microserver blocks could provide your organization with dramatic power savings through consolidation, all while providing the Web server performance you require.

APPENDIX A – ABOUT THE COMPONENTS

About the Dell PowerEdge FX2 enclosure

The Dell PowerEdge FX2 enclosure has a standard 2U footprint and features a modular design that can hold different combinations of compute and storage nodes to meet your specific goals. The PowerEdge FX2 fits four half-width or eight quarter-width compute nodes to increase the compute density in your rack and optimize the space in your data center. You can deploy the FX2 solution like a traditional rack-mounted server while gaining the benefits and features that more expensive dense blade solutions provide. Important features of the FX2 enclosure include:

- Up to eight low-profile PCIe expansion slots
- Two pass-through or optional networking FN I/O Aggregator modules
- Embedded network adapters within the server nodes
- Offers both chassis-based management through the Chassis Management Controller and rack-based management through Integrated Dell Remote Access (iDRAC) with Lifecycle Controller on each compute node

The Dell PowerEdge FX2 enclosure fits a number of server and storage options, including the PowerEdge FM120, PowerEdge FC430, PowerEdge FC630 servers, PowerEdge FC830, and PowerEdge FD332 storage node – all Intel-powered.

For more information about the Intel-powered Dell PowerEdge FX2 solution, visit www.dell.com/us/business/p/poweredge-fx/pd.

About the Dell PowerEdge FM120 microserver and Dell PowerEdge FM120x4 microserver block

The Dell PowerEdge FM120x4 server sled, a half-width compute module, holds four independent single-socket microservers that each feature an Intel Atom C2000 processor. Each FM120 microserver comes with two 1GbE ports, up to two DIMMs of memory and either two 1.8 SATA SSDs or one 2.5" HDD. The FM120x4 is a dense option that fits into the PowerEdge FX2, which can hold four FM120x4 sleds (for 16 microservers total, up to 128 cores, and 32 DIMMs of memory) in 2U of rack space and is suited for scale-out Web servers

To learn more about the Intel Atom-powered Dell PowerEdge FM120, visit www.dell.com/learn/us/en/uscorp1/videos~en/documents~poweredge-fm120-server.aspx.

About the Intel Atom processor C2000 product family

The Intel Atom processor C2000 family incorporates five models ranging from a two-core, 1.7 GHz CPU to an eight-core, 2.4 GHz CPU. The C2000 family is made of 64-bit system-on-chip (SoC) processors for lightweight scale-out workloads such as Web servers or cold data analytics. The Intel Atom C2000 family is designed for extreme

density and energy-efficiency for these workloads. These processors have built-in GbE, SATA, and USB ports and have server-class features such as Error Correcting Code (ECC) memory and Intel Virtualization Technology®.

To learn more about the Intel Atom processor C2000 product family and the C2750 we used in our tested, visit www.intel.com/content/www/us/en/intelligent-systems/rangeley/atom-c2000-product-family-based-platforms-overview.html.

About the mWeb benchmark

The mWeb benchmark evaluates Web-server performance by studying the performance of an ecommerce Web site fronted by a Web server running on the server test, under varying numbers of simulated users. These users follow a prescribed workload to browse the catalog of products, customize products, add them to a shopping cart, and place orders. The application framework for the Web site uses PHP and runs on the server under test. The benchmark does not use a backend database, as a real Web application might, to be able to concentrate on the server's ability to perform dynamic Web server requests. Instead, the benchmark simulates the backend database with a lightweight application, running on an auxiliary server, which responds quickly to client requests. The benchmark looked at numbers of users in 250-user blocks. The threshold for an acceptable request was as follows:

- 95% of the requests should be completed by three seconds
- 99% of the requests should be completed by five seconds

APPENDIX B – SYSTEM CONFIGURATION INFORMATION

Figure 6 provides detailed configuration information for the Dell PowerEdge FM120x4 microserver blocks. We used 16 nodes in four Dell FM120x4 sleds in an FX2 enclosure.

| System | Dell PowerEdge FM120x4 |
|---------------------------------------|-----------------------------|
| General | |
| Number of processor packages | 1 |
| Number of cores per processor | 8 |
| Number of hardware threads per core | 1 |
| System power management policy | Default |
| CPU | |
| Vendor | Intel |
| Name | Atom |
| Model number | C2750 |
| Stepping | B0 |
| Socket type | FCBGA1283 |
| Core frequency (GHz) | 2.4 |
| Bus frequency | N/A |
| L1i cache | 32 KB (per core) |
| L1d cache | 24 KB (per core) |
| L2 cache | 1 MB (shared per two cores) |
| Platform | |
| Vendor and model number | Dell PowerEdge FM120x4 |
| BIOS name and version | H02 (06/24/2014) |
| BIOS settings | Default |
| Memory module(s) | |
| Total RAM in system (GB) | 16 |
| Vendor and model number | SK Hynix HMT41GU7AFR8A-PB |
| Type (MHz) | PC3-12800E |
| Speed (MHz) | 1,600 |
| Speed running in the system | 1,600 |
| Timing/Latency (tCL-tRCD-tRP-tRASmin) | 11-11-11 11 |
| Size (GB) | 8 |
| Number of RAM module(s) | 4 |
| Chip organization | Double-sided |
| Rank | Dual |
| Solid-state drives | |
| Vendor and model number | Intel SSDSC1NB080G4R |
| Number of disks in system | 2 |
| Size (GB) | 80 |
| Type | SATA SSD |
| Disk controller | |
| Vendor and model | Intel, integrated SoC |
| Controller driver | sd_mod |

| System | Dell PowerEdge FM120x4 |
|-------------------------|--|
| RAID configuration | None |
| Operating system | |
| Name | Red Hat Enterprise Linux 6.6 x86_64 |
| Patches | All vendor patches as of 18 December 2014 |
| File system | ext4 |
| Kernel | 2.6.32-504.1.3.el6.x86_64 |
| Language | English |
| Ethernet | |
| Vendor and model number | Intel Ethernet Connection I354 1.0 GbE Backplane |
| Type | Integrated |
| Driver (Module) | igb |
| Driver version | 5.0.5-k |

Figure 6: System configuration information for the Dell PowerEdge FM120x4 server blocks.

Figure 7 provides detailed configuration information for the HP ProLiant m300 Server Cartridges in the HP Moonshot system. We used 15 nodes and 2 HP Moonshot-45G Switch Modules for our tests. We applied the updates in the HP Moonshot Component Release Pack, version 2014.11.0, to the chassis, server cartridges, and switch modules.

| System | HP ProLiant m300 server cartridge |
|-------------------------------------|-----------------------------------|
| General | |
| Number of processor packages | 1 |
| Number of cores per processor | 8 |
| Number of hardware threads per core | 1 |
| System power management policy | Default |
| CPU | |
| Vendor | Intel |
| Name | Atom |
| Model number | C2750 |
| Stepping | B0 |
| Socket type | FCBGA1283 |
| Core frequency (GHz) | 2.4 |
| Bus frequency | N/A |
| L1i cache | 32 KB (per core) |
| L1d cache | 24 KB (per core) |
| L2 cache | 1 MB (shared per two cores) |
| Platform | |
| Vendor and model number | HP 734619-B21 |
| BIOS name and version | H02 (06/24/2014) |
| BIOS settings | Default |
| Memory module(s) | |
| Total RAM in system (GB) | 32 |
| Vendor and model number | SK Hynix HMT41GA7AFR8A-PB |

| System | HP ProLiant m300 server cartridge |
|---------------------------------------|--|
| Type | PC3-12800E |
| Speed (MHz) | 1,600 |
| Speed running in the system (MHz) | 1,600 |
| Timing/Latency (tCL-tRCD-tRP-tRASmin) | 11-11-11 |
| Size (GB) | 8 |
| Number of RAM module(s) | 4 |
| Chip organization | Double-sided |
| Rank | Dual |
| Hard disk | |
| Vendor and model number | Seagate ST9500620NS |
| Number of disks in system | 1 |
| Size (GB) | 500 |
| Buffer size (MB) | 64 |
| Speed (RPM) | 7,200 |
| Type | SATA |
| Disk controller | |
| Vendor and model | Intel, integrated SoC |
| Controller driver | sd_mod |
| RAID configuration | None |
| Operating system | |
| Name | Red Hat Enterprise Linux 6.6 x86_64 |
| Patches | All vendor patches as of 18 December 2014 |
| File system | ext4 |
| Kernel | 2.6.32-504.1.3.el6.x86_64 |
| Language | English |
| Ethernet | |
| Vendor and model number | Intel Ethernet Connection I354 1.0 GbE Backplane |
| Type | Integrated |
| Driver (Module) | igb |
| Driver version | 5.0.5-k |

Figure 7: System configuration information for the HP ProLiant m300 server cartridges for the HP Moonshot system.

Figure 8 provides detailed configuration information for the HP ProLiant rack servers we used in our tests.

| System | HP ProLiant DL360 G6 | HP ProLiant DL120 G7 | HP ProLiant DL320e Gen8 v2 |
|-------------------------------------|---|---|---|
| Power supplies | | | |
| Total number | 2 | 1 | 1 |
| Vendor and model number | HP DPS-460EB | Delta Electronics DPS-400AB-4 | Delta Electronics DPS-250AB-95 |
| Wattage of each | 460 W | 400 | 250 |
| Cooling fans | | | |
| Total number | 6 | 4 | 3 |
| Vendor and model number | Delta Electronics GFB0412EHS | Delta Electronics GFB0412EHS | Delta Electronics FFB0412UHN |
| Dimensions (h x w) of each | 40 mmx 40 mm x 56 mm | 40 mmx 40 mmx 56 mm | 40mm x 40mm x 28mm |
| Volts | 12 | 12 | 12 |
| Amps | 1.82 | 1.82 | 0.75 |
| General | | | |
| Number of processor packages | 1 | 1 | 1 |
| Number of cores per processor | 4 | 4 | 4 |
| Number of hardware threads per core | 2 | 2 | 1 |
| System power management policy | Maximum Performance | Maximum Performance | Maximum Performance |
| CPU | | | |
| Vendor | Intel | Intel | Intel |
| Name | Xeon | Xeon | Xeon |
| Model number | X5570 | X5570 | E3-1220 v3 |
| Stepping | D0 | D0 | 3 |
| Socket type | FCLGA1366 | FCLGA1366 | FCLGA1150 |
| Core frequency (GHz) | 2.93 | 2.93 | 3.10 |
| Bus frequency (MHz) | 1,333 | 1,333 | 1,333 |
| L1i cache | 32 KB (per core) | 32 KB (per core) | 32 KB (per core) |
| L1d cache | 32 KB (per core) | 32 KB (per core) | 32 KB (per core) |
| L2 cache | 256 KB (per core) | 256 KB (per core) | 256 KB (per core) |
| L3 cache | 8 MB (shared) | 8 MB (shared) | 8 MB (shared) |
| Platform | | | |
| Vendor and model number | HP ProLiant DL360 G6 | HP ProLiant DL120 G7 | HP ProLiant DL320e Gen8 v2 |
| Motherboard model number | HP 4K0936 | HP 4111-36 | HP 12025-2 |
| Motherboard chipset | Intel 5520 | Intel C200 | Intel C204 |
| BIOS name and version | HP 07/02/2013 | HP 07/01/2013 | HP P80 (03/28/2014) |
| BIOS settings | All default settings except Turbo mode disabled | All default settings except Turbo mode disabled | All default settings except Turbo mode disabled |

| System | HP ProLiant DL360 G6 | HP ProLiant DL120 G7 | HP ProLiant DL320e Gen8 v2 |
|---------------------------------------|---|---|---|
| Memory module(s) | | | |
| Total RAM in system (GB) | 16 | 16 | 16 |
| Vendor and model number | HP 500203-061 | Kingston KVR1333D3E9S/4G | HP 669239-081 |
| Type | PC3-10600R | PC3-10600 | PC3-12800E |
| Speed (MHz) | 1,333 | 1,333 | 1,6000 |
| Speed running in the system (MHz) | 1,333 | 1,333 | 1,600 |
| Timing/Latency (tCL-tRCD-tRP-tRASmin) | 9-9-9-24 | 9-8-7-6 | CL11 |
| Size (GB) | 4 | 4 | 8 |
| Number of RAM module(s) | 4 | 4 | 2 |
| Chip organization | Double-sided | Double-sided | Double-sided |
| Rank | Dual | Dual | Dual |
| Hard disk 1 | | | |
| Vendor and model number | HP DG0146FARVU | Seagate ST373454SS | Western Digital WD5003ABYX |
| Number of disks in system | 2 | 2 | 2 |
| Size (GB) | 146 | 73 | 500 |
| Buffer size (MB) | 16 | 8 | 64 |
| Rotational speed (RPM) | 10,000 | 15,000 | 7,200 |
| Type | SAS | SATA | SATA |
| Hard disk 2 | | | |
| Vendor and model number | HP EG0300FBDSP | N/A | N/A |
| Number of disks in system | 2 | N/A | N/A |
| Size (GB) | 300 | N/A | N/A |
| Buffer size (MB) | 16 | N/A | N/A |
| Rotational speed (RPM) | 10,000 | N/A | N/A |
| Type | SAS | N/A | N/A |
| Disk controller | | | |
| Vendor and model | HP P410i | HP P212 | HP B120i |
| Controller cache (MB) | 512 | 256 | N/A |
| Controller driver | hpsa 3.4.4-1-RH2 | hpsa 3.4.4-1-RH2 | hpvsa 1.2.8-140 |
| Controller firmware | 6.60 | 8.40.41.00 | 3.54.0 |
| RAID configuration | RAID 0 | RAID 0 | RAID 10 |
| Operating system | | | |
| Name | Red Hat Enterprise Linux 6.6 x86_64 | Red Hat Enterprise Linux 6.6 x86_64 | Red Hat Enterprise Linux 6.6 x86_64 |
| Patches | All vendor patches as of 18 December 2014 | All vendor patches as of 18 December 2014 | All vendor patches as of 18 December 2014 |
| File system | ext4 | ext4 | ext4 |
| Kernel | 2.6.32-504.1.3.el6.x86_64 | 2.6.32-504.1.3.el6.x86_64 | 2.6.32-504.1.3.el6.x86_64 |
| Language | English | English | English |

| System | HP ProLiant DL360 G6 | HP ProLiant DL120 G7 | HP ProLiant DL320e Gen8 v2 |
|-------------------------|--|---|--|
| Ethernet 1 | | | |
| Vendor and model number | Intel 82576 Gigabit Network Connection | Intel 82574L Gigabit Network Connection | Broadcom NetXtreme II BCM5720 Gigabit Ethernet |
| Type | PCIe, x4 | PCIe, x1 | PCIe, x2 |
| Driver (module) | igb | e1000e | tg3 |
| Driver version | 5.0.5-k | 2.3.2-k | 3.137 |
| Ethernet 2 | | | |
| Vendor and model number | Broadcom® NetXtreme® II BCM5709 Gigabit Ethernet | N/A | N/A |
| Type | PCIe, x4 | N/A | N/A |
| Driver (Module) | bnx2 | N/A | N/A |
| Driver version | 2.2.4 | N/A | N/A |
| Ethernet 3 | | | |
| Vendor and model number | Intel 82598EB 10-Gigabit AT Network Connection | N/A | N/A |
| Type | PCIe, x4 | N/A | N/A |
| Driver (Module) | ixgbe | N/A | N/A |
| Driver version | 3.19.1-k | N/A | N/A |
| USB ports | | | |
| Number | 4 | 7 | 7 |
| Type | 2.0 | 2.0 | 2.0 |

Figure 8: System configuration information for the rack servers we used in our tests.

APPENDIX C – HOW WE TESTED

We used the following steps to configure the two enclosures, their servers and stand-alone servers for the web-application environment; and the servers for the mWeb test-harness.

Configuring the Dell PowerEdge FX2 enclosure and FM120x4 sleds

1. We logged onto the FX2 chassis management controller as root.
2. For each FM120x4 sled, we set its network uplink topology to the "isolated networks" method.
3. For each FM120x4 sled, we connected two Ethernet cables from the sled's ports on the enclosure's first I/O passthrough module to two ports on an Ethernet switch, here the ports are members of a LAG and members of the 192.168.17.0/24 VLAN.
4. For each FM120x4 sled, we connected two Ethernet cables from the sled's ports on the enclosure's second I/O passthrough module to two ports on an Ethernet switch, here the ports are members of a LAG and members of the 192.168.18.0/24 VLAN.
5. For each FM120 server, we set the BIOS settings to default with the power profile set to maximum performance.

Configuring the HP Moonshot System

1. We logged onto the HP Moonshot's chassis manager.
2. We applied the latest firmware updates to the chassis, switches, and server cartridges.

Configuring the HP rack servers

1. For each HP rack server, we set the BIOS settings to default with the power profile set to maximum performance.

Installing Red Hat Enterprise Linux 6

The servers under test ran Red Hat Enterprise Linux 6.6. We used our lab's PXE and NFS installation framework to install the OS, additional packages, and initial configuration for each of the servers under test. The kickstart template for each server follows with tags HOSTNAME, IPADR_1 and IPADR_2 representing the server's host name and two IP addresses, respectively, is in Figure 9. We used sed to replace the tags with the server's hostname and IP addresses in the template to create the kickstart file for that server's installation.

```
install
nfs --server=192.168.17.12 --dir=/mnt/2
lang en_US.UTF-8
keyboard us
network --onboot yes --device em1 --mtu=1500 --bootproto static --ip IPADR_1 --netmask
255.255.255.0 --noipv6 --hostname HOSTNAME
network --onboot yes --device em2 --mtu=1500 --bootproto static --ip IPADR_2--netmask
255.255.255.0 --noipv6
rootpw --iscrypted
$6$3Hi5OI82ZxDfphFd$fxaZC8455RNsOub0UUXxT3vBdsJFyEOL.4Z63Yrhfzcf3ygnkdBSybsLYJIZU/JKcV30kLTZ2cCV
TeTaKvGB0
# Shutdown after installation
shutdown
firewall --disabled
authconfig --enablesshadow --passalgo=sha512
selinux --disabled
timezone --utc America/New_York
bootloader --location=mbr --driveorder=sda --append="crashkernel=auto rhgb quiet"
clearpart --all --drives=sda --initlabel
part /boot --fstype=ext4 --size=500
part pv.008002 --grow --size=1
```

```
volgroup vg00 --pesize=4096 pv.008002
logvol / --fstype=ext4 --name=lv_root --vgname=vg00 --grow --size=1024
logvol swap --name=lv_swap --vgname=vg00 --grow --size=10240 --maxsize=10240

%packages
@Base
@Core
@base
@development
@performance
@php
@server-platform
@server-platform-devel
@system-admin-tools
autoconf
automake
certmonger
gcc
gcc-c++
httpd
httpd-devel
libmemcached
memcached
mod_ssl
php
php-cli
php-common
php-mysql
php-pdo
php-pear
sysstat
zlib-devel
-MYSQL-python
-PyGreSQL
-avahi
-byacc
-crypto-utils
-cscope
-ctags
-cvs
-diffstat
-doxxygen
-ecryptfs-utils
-elfutils
-gcc-gfortran
-git
-gtk2
-httpd-manual
-indent
-intltool
-mod_perl
-mod_wsgi
-mysql
-mysql-connector-odbc
-mysql-libs
-mysql-server
-perl-DBD-MySQL
-php-gd
-php-xml
-postfix
-postgresql
-postgresql-docs
-postgresql-libs
```



```

-postgresql-odbc
-postgresql-server
-python-psycopg2
-rcs
-selinux-policy
-selinux-policy-targeted
-subversion
-swig
-sysklogd
-systemtap
-trousers
-webalizer

%end

%post

sed -i 's/^server/#server/' /etc/ntp.conf
echo "server 192.168.17.1 iburst" >> /etc/ntp.conf

mkdir /root/.ssh
cat > /root/.ssh/authorized_keys <<EOF
ssh-dss
AAAAB3NzaC1kc3MAAACBAJPAqpZUYReR5AWBsQy1wxaLBQ1KS/ihY8iIuJbkAVtXuijHO8gahjQ331opUEw+tc3lwoFhsIBNm
DDqYUy/nXX2kLPGNUXYA8Hnexi6665ffffUEwa4RjwQCR4dEBWdHrGogG7bds118Tf0chCz1y91m1o/IUTXraW7t/8jyAHxYLA
AAAFQDAhHAnS6LF6RuA73keh6mi8Q+YsQAAAEIAhQpMV1SkFGGpt8wUwPjAkKlp8sLJKM8e0JvBTZKLfsrIX1C9GJntogNIQR
rzlxzCNLfcFf032B2p60Ibi6LZFHeh6BoKeVTh9QumBrV5g6Dufs2K4bIYm1/MdeKGOSa/KoOAhIykPO8dqZXK9KeYprSZFIK
Oilx2bIg4DT7AZPsAAACBAImpGm8ry6hYq5QWeK7EBk/nsHHFGuk67QXMonvJ7YSVzyN5NBa2yG3grJRUIFsHM36wX7/PudlJ
lI+Ditb8xOpDnoa2T6GtF4Aot9zZLx/LyQaUNTVJGdlLIE7wi2ekwr2uXyNy/EuZeXLg4/n/7B5cA+YNawDRyQgJG9qM9Azg
sfgd@pc
EOF

service ntpdate start
chkconfig ntpd on

for i in atd autofs cups ip6tables iptables kdump mdmonitor netfs nfslock portreserve \
    postfix rpcbind rpcgssd
do
    chkconfig $i off
done

%end

```

Figure 9: Linux kickstart template for the SUTs.

Configuring Red Hat Enterprise Linux for mWeb benchmark

1. We obtained the source code for the Apache web-server module `mod_fcgid`, `mod_fcgid-2.3.9.tar.gz`, from http://httpd.apache.org/download.cgi#mod_fcgid
2. We compiled and installed the `mod_fcgid` module as follows.

```

tar xvzf mod_fcgid-2.3.9.tar.gz
cd mod_fcgid-2.3.9
./configure.apxs
make -j 4
make install

```
3. We installed the mWeb static and PHP-based dynamic files from the Dell-provided archive, `htdocs.tgz`.

```

tar xvzf htdocs.tgz -C /var/www/

```

4. We modified the Apache web server configuration by adjusting these setting in the file `/etc/httpd/conf/httpd.conf` as indicated in Figure 10.

```
@@ -67,26 +67,26 @@
#
# Timeout: The number of seconds before receives and sends time out.
#
+Timeout 200

#
# KeepAlive: Whether or not to allow persistent connections (more than
# one request per connection). Set to "Off" to deactivate.
#
+KeepAlive on

#
# MaxKeepAliveRequests: The maximum number of requests to allow
# during a persistent connection. Set to 0 to allow an unlimited amount.
# We recommend you leave this number high, for maximum performance.
#
+MaxKeepAliveRequests 0

#
# KeepAliveTimeout: Number of seconds to wait for the next request from the
# same client on the same connection.
#
+KeepAliveTimeout 1

##
## Server-Pool Size Regulation (MPM specific)
@@ -100,12 +100,12 @@
# MaxClients: maximum number of server processes allowed to start
# MaxRequestsPerChild: maximum number of requests a server process serves
<IfModule prefork.c>
+StartServers      3000
+#MinSpareServers  5
+MaxSpareServers   1000
+ServerLimit       12000
+MaxClients        12000
+MaxRequestsPerChild 0
</IfModule>

# worker MPM
@@ -116,11 +116,12 @@
# ThreadsPerChild: constant number of worker threads in each server process
# MaxRequestsPerChild: maximum number of requests a server process serves
<IfModule worker.c>
+StartServers      400
+MaxClients        12000
+ServerLimit       12000
+#MinSpareThreads  25
+MaxSpareThreads   1000
+#ThreadsPerChild  25
+MaxRequestsPerChild 0
</IfModule>

@@ -133,7 +134,10 @@
# prevent Apache from glomming onto all bound IP addresses (0.0.0.0)
#
#Listen 12.34.56.78:80
+#Listen 80
+
+Listen 0.0.0.0:10001
```

```

+##Listen 0.0.0.0:40051

#
# Dynamic Shared Object (DSO) Support
@@ -169,7 +173,7 @@
LoadModule ext_filter_module modules/mod_ext_filter.so
LoadModule mime_magic_module modules/mod_mime_magic.so
LoadModule expires_module modules/mod_expires.so
+##LoadModule deflate_module modules/mod_deflate.so
LoadModule headers_module modules/mod_headers.so
LoadModule usertrack_module modules/mod_usertrack.so
LoadModule setenvif_module modules/mod_setenvif.so
@@ -194,9 +198,9 @@
LoadModule proxy_http_module modules/mod_proxy_http.so
LoadModule proxy_ajp_module modules/mod_proxy_ajp.so
LoadModule proxy_connect_module modules/mod_proxy_connect.so
+##LoadModule cache_module modules/mod_cache.so
LoadModule suexec_module modules/mod_suexec.so
+##LoadModule disk_cache_module modules/mod_disk_cache.so
LoadModule cgi_module modules/mod_cgi.so
LoadModule version_module modules/mod_version.so

@@ -328,7 +332,7 @@
# http://httpd.apache.org/docs/2.2/mod/core.html#options
# for more information.
#
+ Options +Indexes +FollowSymLinks

#
# AllowOverride controls what directives may be placed in .htaccess files.
@@ -406,7 +410,7 @@
# for additional configuration directives. See also the AllowOverride
# directive.
#
+##AccessFileName .htaccess

#
# The following lines prevent .htaccess and .htpasswd files from being
@@ -440,10 +444,10 @@
# contents of the file itself to determine its type. The MIMEMagicFile
# directive tells the module where the hint definitions are located.
#
+##<IfModule mod_mime_magic.c>
+## MIMEMagicFile /usr/share/magic.mime
+## MIMEMagicFile conf/magic
+##</IfModule>

#
# HostnameLookups: Log the names of clients or just their IP addresses
@@ -489,7 +493,7 @@
# alert, emerg.
#
LogLevel warn
+BufferedLogs on
#
# The following directives define some format nicknames for use with
# a CustomLog directive (see below).
@@ -533,7 +537,7 @@
# Set to "EMail" to also include a mailto: link to the ServerAdmin.
# Set to one of: On | Off | EMail
#
+##ServerSignature On

```

```

#
# Aliases: Add here as many aliases as you need (with no limit). The format is
@@ -776,14 +780,14 @@
# If the AddEncoding directives above are commented-out, then you
# probably should define those extensions to indicate media types:
#
+#AddType application/x-compress .Z
AddType application/x-gzip .gz .tgz

#
# MIME-types for downloading Certificates and CRLs
#
+#AddType application/x-x509-ca-cert .crt
+#AddType application/x-pkcs7-crl .crl

#
# AddHandler allows you to map certain file extensions to "handlers":
@@ -805,7 +809,7 @@
# (This is enabled by default to allow the Apache "It Worked" page
# to be distributed in multiple languages.)
#
+#AddHandler type-map var

#
# Filters allow you to process content before it is sent to the client.
@@ -1007,3 +1011,22 @@
#   ErrorLog logs/dummy-host.example.com-error_log
#   CustomLog logs/dummy-host.example.com-access_log common
#</VirtualHost>
+<VirtualHost 0.0.0.0:40051>
+
+   LoadModule ssl_module modules/mod_ssl.so
+
+   ErrorLog logs/ssl_error_log1
+   LogLevel warn
+
+   SSLEngine on
+   SSLVerifyClient none
+   SSLProxyEngine off
+   SSLVerifyDepth 0
+   SSLOptions +OptRenegotiate +FakeBasicAuth -StrictRequire
+
+   SSLCipherSuite RC4-SHA:RC4-MD5:AES128-SHA
+   SSLCertificateFile /var/www/html/certs/server.crt
+   SSLCertificateKeyFile /var/www/html/certs/server.key
+
+</VirtualHost>

```

Figure 10: Configuration changes for the Apache web server.

5. We modified the configuration of the fcgid Apache module by adjusting these setting in the file `/etc/httpd/conf.d/fcgid.conf` as indicated in Figure 11.

```

# This is the Apache server configuration file for providing FastCGI support
# through mod_fcgid
#
# Documentation is available at
# http://httpd.apache.org/mod_fcgid/mod/mod_fcgid.html

LoadModule fcgid_module modules/mod_fcgid.so

# Use FastCGI to process .fcg .fcgi & .fpl scripts
AddHandler fcgid-script fcg fcgi fpl

```

```
# Sane place to put sockets and shared memory file
FcgidIPCDir /var/run/mod_fcgid
FcgidProcessTableFile /var/run/mod_fcgid/fcgid_shm
```

Figure 11: Configuration changes for the Apache fcgid module.

6. We modified the configuration of the PHP Apache module by adjusting these setting in the file `/etc/httpd/conf.d/php.conf` as indicated by the patch file in Figure 12.

```
diff -rupN httpd.orig/conf.d/php.conf httpd/conf.d/php.conf
--- php.conf-orig
+++ php.conf
@@ -4,25 +4,55 @@
#
<IfModule prefork.c>
    LoadModule php5_module modules/libphp5.so
-</IfModule>
-<IfModule worker.c>
-    LoadModule php5_module modules/libphp5-zts.so
-</IfModule>
-
+#    PHPIniDir /var/www/html/php1
#
# Cause the PHP interpreter to handle files with a .php extension.
#
-AddHandler php5-script .php
-AddType text/html .php
+    AddHandler php5-script .php
+    AddType text/html .php
+</IfModule>
+<IfModule !prefork.c>
+#    LoadModule php5_module modules/libphp5-zts.so
+    LoadModule fcgid_module /usr/lib64/httpd/modules/mod_fcgid.so
+    AddHandler fcgid-script .php
+</IfModule>

#
# Add index.php to the list of files that will be served as directory
# indexes.
#
-DirectoryIndex index.php
+#DirectoryIndex index.php

#
# Uncomment the following line to allow PHP to pretty-print .phps
# files as PHP source code:
#
#AddType application/x-httpd-php-source .phps
+
+<IfModule mod_fcgid.c>
+
+    FcgidWrapper /var/www/cgi-bin/php.fcgi .php
+
+    FcgidIPCDir                /dev/shm/fcgidsock1
+    FcgidProcessTableFile      /dev/shm/fcgid_shm1
+
+    FcgidMaxRequestsPerProcess    0
+
+    FcgidMaxProcesses           64
+    FcgidMaxProcessesPerClass   64
+    FcgidMinProcessesPerClass   4
+
```

```

+      #FcgidTimeScore                24
+
+      FcgidIdleScanInterval           3600
+      FcgidIdleTimeout                0
+      FcgidProcessLifeTime           0
+
+      FcgidBusyTimeout                70
+      FcgidIOTimeout                 70
+      FcgidBusyScanInterval           30
+      FcgidZombieScanInterval         30
+
+      #FcgidMaxRequestLen             104857600
+
+</IfModule>

```

Figure 12: Configuration changes for the Apache PHP module.

7. We modified the configuration of the SSL Apache module by adjusting these setting in the file `/etc/httpd/conf.d/ssl.conf` as indicated by the patch file in Figure 13.

```

--- ssl.conf.orig
+++ ssl.conf
@@ -15,7 +15,7 @@ LoadModule ssl_module modules/mod_ssl.so
 # When we also provide SSL we have to listen to the
 # the HTTPS port in addition.
 #
-Listen 443
+Listen 0.0.0.0:40051

##
## SSL Global Context
@@ -33,13 +33,13 @@ SSLPassPhraseDialog builtin
 # Inter-Process Session Cache:
 # Configure the SSL Session Cache: First the mechanism
 # to use and second the expiring timeout (in seconds).
-SSLSessionCache shmcb:/var/cache/mod_ssl/scache(512000)
+SSLSessionCache shmcb:/var/cache/mod_ssl/scache(1024000)
 SSLSessionCacheTimeout 300

# Semaphore:
# Configure the path to the mutual exclusion semaphore the
# SSL engine uses internally for inter-process synchronization.
-SSLMutex default
+SSLMutex pthread

# Pseudo Random Number Generator (PRNG):
# Configure one or more sources to seed the PRNG of the
@@ -66,11 +66,13 @@ SSLRandomSeed connect builtin
 #
 SSLCryptoDevice builtin
 #SSLCryptoDevice ubsec
+#SSLCryptoDevice rsax

```

Figure 13: Configuration changes for the Apache SSL module.

8. For all servers under test except the HP m300 servers, which had one hard drive, we formatted, partitioned the auxiliary disk volume.

```

parted /dev/sdb mklabel
parted /dev/sdb mkpart primary "1 -1"

```

9. We created a filesystem on this partition and mounted it at `/mnt/SSDWeb1`:

```

mkfs.ext4 /dev/sdb1

```

```

mkdir -p /mnt/SSDWeb1
mount /dev/sdb1 /mnt/SSDWeb1
echo "/dev/sdb1 /mnt/SSDWeb1 etx4 defaults 1 1" >> /etc/fstab
chown -R apache:apache /mnt/SSDWeb1 var/www/html

```

10. We generated new SSL server certificates by executing the following commands.

```

cd /var/www/html/certs
sh ./certmak.sh

```

11. We created a symbolic link from the web application's data directory to the auxiliary filesystem.

```

cd /var/www/html
mkdir -p /mnt/SSDWeb1/e-commerce/images
ln -s e-commerce/images /mnt/SSDWeb1/e-commerce/images

```

12. We generated workload data for a maximum of 10,000 simultaneous sessions.

```

cd /var/www/html/wafgen/unix
sed -i 's/^ SIMULTANEOUS_SESSIONS=.* / SIMULTANEOUS_SESSIONS=10000/' \
    e-commerce_productline_props.rc e-commerce_image_props.rc
cd ..
sh Wafgen.sh unix/e-commerce_image_props.rc
sh Wafgen.sh unix/e-commerce_productline_props.rc

```

13. We modified the PHP configuration file by adjusting these settings in the file /etc/php.ini

```

include_path = ".:usr/share/pear:/usr/share/php:/var/www/html/Smarty-2.6.22/libs"
date.timezone = America/New_York
session.save_path = "2;/var/lib/php/session"

```

14. We generated a two-layer PHP session tree by running the following script.

```

sh mod_files.sh /var/lib/php/session 2 5
#!/bin/sh
# mod_files.sh
if test "$2" = ""; then
    echo "usage: $0 basedir depth" ; exit 1
fi
if test "$2" = "0"; then
    exit 0
fi
hash_chars="0 1 2 3 4 5 6 7 8 9 a b c d e f"
if test "$3" -a "$3" -ge "5"; then
    hash_chars="$hash_chars g h i j k l m n o p q r s t u v"
    if test "$3" -eq "6"; then
        hash_chars="$hash_chars w x y z A B C D E F G H I J K L M N O P Q R S T
U V W X Y Z - ,"
    fi
fi

```

```

for i in $hash_chars; do
    newpath="$1/$i"
    mkdir $newpath || exit 1
    sh $0 $newpath `expr $2 - 1` $3
done

```

Configuring the mWeb auxiliary servers

We configured 16 mWeb auxiliary servers as 16 VMware guests. Each guest hosted the mWeb backend server and ran the mWeb client.

1. On the ESXi vSphere client, we created 16 Windows 2012 R2 SP1 guests having 2 vCPUs, 20GB of vRAM, and two vNICs
2. We started the guests.
3. We logged on the first guest, and set its IP addresses, installed the current set of Windows patches, set the time zone, and synchronized its time.
4. We disabled Internet Explorer Enhanced Security and the Windows Firewall.
5. We installed Oracle Java SE 1.7u1 x64.
6. We extracted the mWeb software from the Dell-provided archive.
7. We set the permissions for user ISUR on directory C:\WWW to Full control.
8. We added the IIS role with the ISAPI extensions and without the Static Content Compression option.
9. We opened the IIS manager.
10. We created two Web sites: BeSimA, listening on port 81, and BeSimB, listening on port 82.
11. We added two script maps to the IIS Handler mappings. The first, named MapA, mapped "*.dll" to executable C:\www\besimA\BeSim.dll. The second, named MapB, mapped "*.dll" to executable C:\www\besimB\BeSim.dll.
12. We opened the advanced-settings configuration wizard for the BeSimA application pool and altered the following settings:

| | |
|--|----------------------------|
| (General) | |
| .NET Framework Version | -> No Managed Code |
| Queue Length | -> 60000 |
| (Process Model) | |
| Identity | -> ApplicationPoolIdentity |
| Load User Profile | -> False |
| Ping Enabled | -> False |
| (Rapid-Fail Protection) Enabled | -> False |
| (Recycling) | |
| Disable Overlapped Recycle Specific Time | -> True |
| (Generate Recycle Event Log Entry) | -> TimeSpan[]Array |
| Isapi Reported Unhealthy | -> True |
| Request Time Interval | -> True |
13. We repeated step 12 for BeSimB's application pool.
14. We repeated steps 3-13 for each guest.

Running the mWeb benchmark

We assigned one VMware guest to each SUT. Each client on the guest sent requests to the SUT's two IP addresses in order to balance traffic between two network paths.

When testing one of the HP rack servers, we used one VMware guest. When testing the FM120x4 servers, we started the Apache web server on each server, and used 16 guests. When testing the HP Moonshot, we started the Apache web server on each server, and used 15 guests.

Each run consistent of the following steps.

1. We started the Apache web server on the SUT (or SUTs in the case of the FM120 and m300 tests).
2. On each guest needed for this run, we shutdown and restarted IIS.
3. We deleted the IIS on the backend simulator.
4. We killed all Java processes on the each client.
5. We deleted the mWeb logs on each client.
6. On each client, we started 16 Java mWeb clients, half using network 192.168.17.0/24 and half using network 192.168.18.0/24. We used the using the following script, which in this client (having IP addresses 192.1168.17.108 and 192.168.18.108), to send requests to the SUT with IP addresses 192.168.17.48 and 192.168.18.48.

```
@set cp=-classpath ..\bin\specweb2009.jar specwebclient
@set vm=-server -Djava.rmi.server.hostname=%1 -Xms640m -Xmx640m -Xss128k -
XX:+ForceTimeHighResolution -XX:-UseParallelOldGC -Xincgc

@set c1=192.168.17.108
@set c2=192.168.18.108
@set s1=192.168.17.48
@set s2=192.168.18.48
@set l=C:\mWeb\logs\

start /min java.exe %vm% %cp% -p 100 -cip %c1% -sip %s1% -lo %l%log100.txt -
le %l%error100.txt

start /min java.exe %vm% %cp% -p 101 -cip %c1% -sip %s1% -lo %l%log101.txt -
le %l%error101.txt

start /min java.exe %vm% %cp% -p 102 -cip %c1% -sip %s1% -lo %l%log102.txt -
le %l%error102.txt

start /min java.exe %vm% %cp% -p 103 -cip %c2% -sip %s2% -lo %l%log103.txt -
le %l%error103.txt

start /min java.exe %vm% %cp% -p 104 -cip %c1% -sip %s1% -lo %l%log104.txt -
le %l%error104.txt

start /min java.exe %vm% %cp% -p 105 -cip %c2% -sip %s2% -lo %l%log105.txt -
le %l%error105.txt
```

```

start /min java.exe %vm% %cp% -p 106 -cip %c1% -sip %s1% -lo %l%log106.txt -
le %l%error106.txt

start /min java.exe %vm% %cp% -p 107 -cip %c2% -sip %s2% -lo %l%log107.txt -
le %l%error107.txt

start /min java.exe %vm% %cp% -p 108 -cip %c1% -sip %s1% -lo %l%log108.txt -
le %l%error108.txt

start /min java.exe %vm% %cp% -p 109 -cip %c2% -sip %s2% -lo %l%log109.txt -
le %l%error109.txt

start /min java.exe %vm% %cp% -p 110 -cip %c1% -sip %s1% -lo %l%log110.txt -
le %l%error110.txt

start /min java.exe %vm% %cp% -p 111 -cip %c2% -sip %s2% -lo %l%log111.txt -
le %l%error111.txt

start /min java.exe %vm% %cp% -p 112 -cip %c1% -sip %s1% -lo %l%log112.txt -
le %l%error112.txt

start /min java.exe %vm% %cp% -p 113 -cip %c2% -sip %s2% -lo %l%log113.txt -
le %l%error113.txt

start /min java.exe %vm% %cp% -p 114 -cip %c1% -sip %s1% -lo %l%log114.txt -
le %l%error114.txt

start /min java.exe %vm% %cp% -p 115 -cip %c2% -sip %s2% -lo %l%log115.txt -
le %l%error115.txt

```

7. On each client, we modified the mWeb configuration file "test.config, as follows

The variable WEB_SERVER was set to the first IP address fir this client's SUT.

The variables WEB_PORT and "SSL_PORT" were set to 10001 and d40051, respectively.

The variables BESIM_SERVER was set to a list of both IP address of the client, e.g., for the client in step 6, "192.168.17.108 192.168.18.108".

The variable BESIM_PORT was set to the list "81 82".

The variable CLIENTS was set to a list of the 16 IP address and ports used by this guest's java cleints. For the example in step 6, this list would be "192.168.17.108:100 192.168.18.108:101 192.168.17.108:102 192.168.18.108:103 192.168.17.108:104 192.168.18.108:105 192.168.17.108:106 192.168.18.108:107 192.168.17.108:108 192.168.18.108:109 192.168.17.108:110 192.168.18.108:111 192.168.17.108:112 192.168.18.108:113 192.168.17.108:114 192.168.18.108:115"

The variable SIMULTANEOUS_SESSIONS saw set to the total number of sessions, e.g., 5000, that were divided among the 16 client processes.

8. The test commences when the following script is run on each guest.

```

java -Xms512m -Xmx512m -classpath ..\bin\specweb2009.jar;..\lib\jcommon-
1.0.15.jar;..\lib\jfreechart-1.0.12.jar specweb

```

9. This script printed the results of the test, specifically, whether the SUT could process the chosen number of sessions, to the directory C:\mWeb\Execution\results.

ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.
1007 Slater Road, Suite 300
Durham, NC, 27703
www.principledtechnologies.com

We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.

Principled Technologies is a registered trademark of Principled Technologies, Inc.
All other product names are the trademarks of their respective owners.

Disclaimer of Warranties; Limitation of Liability:

PRINCIPLED TECHNOLOGIES, INC. HAS MADE REASONABLE EFFORTS TO ENSURE THE ACCURACY AND VALIDITY OF ITS TESTING, HOWEVER, PRINCIPLED TECHNOLOGIES, INC. SPECIFICALLY DISCLAIMS ANY WARRANTY, EXPRESSED OR IMPLIED, RELATING TO THE TEST RESULTS AND ANALYSIS, THEIR ACCURACY, COMPLETENESS OR QUALITY, INCLUDING ANY IMPLIED WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE. ALL PERSONS OR ENTITIES RELYING ON THE RESULTS OF ANY TESTING DO SO AT THEIR OWN RISK, AND AGREE THAT PRINCIPLED TECHNOLOGIES, INC., ITS EMPLOYEES AND ITS SUBCONTRACTORS SHALL HAVE NO LIABILITY WHATSOEVER FROM ANY CLAIM OF LOSS OR DAMAGE ON ACCOUNT OF ANY ALLEGED ERROR OR DEFECT IN ANY TESTING PROCEDURE OR RESULT.

IN NO EVENT SHALL PRINCIPLED TECHNOLOGIES, INC. BE LIABLE FOR INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH ITS TESTING, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. IN NO EVENT SHALL PRINCIPLED TECHNOLOGIES, INC.'S LIABILITY, INCLUDING FOR DIRECT DAMAGES, EXCEED THE AMOUNTS PAID IN CONNECTION WITH PRINCIPLED TECHNOLOGIES, INC.'S TESTING. CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES ARE AS SET FORTH HEREIN.
