

Dell™ PowerEdge™ M820 server solution with Dell Compellent™ storage

**Lower database
licensing costs**

Better performance



using Oracle® Database 11g R2
versus HP ProLiant BL460c G7 with HP StorageWorks EVA4400 storage

Upgrading a data center requires more than just selecting new equipment – considerations range from performance to energy, and of course, software licensing costs. How do you select a solution that maximizes your capital when it comes to a significant recurring cost such as licensing costs? Many enterprise applications base licenses on the server core count, which means that choosing high-performing servers that do more with fewer cores can save your organization significant money.

We examined the licensing-cost implications of selecting a Dell PowerEdge M820 blade server solution to replace a previous-generation HP ProLiant BL680c G7 blade server solution, specifically when running Oracle Database 11g R2. Over three years, the 32-core Dell PowerEdge M820 solution could save up to \$315,400 in Oracle Database licensing in a server-versus-server scenario as compared to the 40-core HP ProLiant BL680c G7 solution when using Oracle Database 11g R2.

In addition to maximizing licensing cost savings, you want to ensure that a potential upgrade will maintain, or even exceed, the performance capabilities of your prior hardware. Principled Technologies tested the PowerEdge M820 with a latest generation storage Dell Compellent SC8000 SAN solution, and found that it provided



much better performance than a previous-generation HP ProLiant BL680c G7 server and HP EVA StorageWorks solution.

Licensing costs for high-end enterprise applications can make all the difference to your data center's bottom line. Choose a more powerful server with fewer cores and watch the licensing savings roll in, leaving your staff more time to innovate and freeing up capital to improve infrastructure.

LOWER LICENSING COSTS WITH THE DELL POWEREDGE M820

By running software with core-based pricing on a 32-core Dell PowerEdge M820 server with Intel Xeon processors E5-4650 rather than on a server with a higher core count, an organization can save significantly on license costs.

We compared the Oracle Database 11g R2 Enterprise Edition licensing costs for a 32-core Dell PowerEdge M820 server to the costs to license a 40-core HP ProLiant BL680c G7. We found that a single 32-core Dell PowerEdge M820 server can save up to \$315,400 in three-year costs for Oracle Database 11g R2 Enterprise Edition per-core licenses and Software Update License and Support compared to a single 40-core previous-generation server, while delivering superior performance.

- With 20 percent fewer cores than a 40-core server, the 32-core Dell PowerEdge M820 can save 20 percent on costs for software licensed on per-core basis.
- In our testing for this report, we ran Oracle Database 11g R2 Enterprise Edition, which can use either Processor or by Named User Plus licensing. We calculate prices for Processor licensing, the type of licensing that an enterprise would select if it had third-party users or a large number of internal users. The number of required processor licenses is based on core count, with each license supporting two x86 cores. Compared to the 40-core HP ProLiant BL680c G7 server that we tested, a fully licensed Dell PowerEdge M820 server requires four fewer Oracle Database 11g R2 Enterprise Edition processor licenses, saving \$315,400 for licenses and three years of Software Update License and Support (SaS) protection.¹

Your organization could potentially increase core-based software license savings by consolidating the workloads of older, higher-core servers onto the 32-core Dell PowerEdge M820 server. To simulate a consolidation scenario, Principled Technologies tested the Dell PowerEdge M820 server with Dell Compellent storage and the previous-generation HP ProLiant BL680c G7 server with the previous-generation HP EVA4400

¹ We used prices for the Oracle Database Enterprise Edition Processor License and Software License and Support (SaS) from the Oracle Technology Global Price list on the Oracle site: <http://www.oracle.com/us/corporate/pricing/technology-price-list-070617.pdf> dated July 19, 2012. The Oracle Processor Core Factor Table last updated July 19, 2012 shows Intel E5-series and E7-series processors with a Core Processor Licensing Factor of 0.5.

storage. In both cases, we ran an OLTP workload using Oracle Database 11g R2. In this simulated upgrade and consolidation scenario, we achieved a performance improvement of 195.4 percent when using the Dell PowerEdge M820 with the Dell Compellent SC8000 SAN. Because each hardware configuration will vary in an upgrade situation, consolidation amounts will also vary.

The database performance improvement of 195.4 percent that the Dell PowerEdge M820 server with Dell Compellent SC8000 storage provided over the HP ProLiant BL680c G7 server with HP EVA 4400 storage means that a single PowerEdge M820 solution delivered the performance of 2.95 HP ProLiant BL680c G7 solutions in our tests.

To avoid having to calculate software costs for partial servers, we round 2.95 to 3, and compare costs for one Dell PowerEdge M820 solutions versus three HP ProLiant BL680c G7 solutions. A Dell PowerEdge M820 server with Dell Compellent SC8000 storage could provide similar performance and save as much as \$3,469,400 in Oracle Database 11g R2 Enterprise Edition processor licenses and three-year SaS costs compared to three HP ProLiant BL680c G7 servers with HP EVA 4400 storage.

- Compared to three 40-core servers, a 32-core Dell PowerEdge M820 server can save over 73.3 percent in both license count and software costs for software licensed on a per-core basis.
- The 32-core Dell PowerEdge M820 server would require 16 Oracle Database 11g R2 Enterprise Edition processor licenses compared to 60 licenses for three 40-core HP ProLiant BL680c G7 servers.
- For Oracle Database 11g R2 Enterprise Edition licenses, savings for 44 fewer processor licenses could reach \$3,469,400 for the license and three years of SaS protection.

For further detail on our cost comparison, see [Appendix C](#).

ABOUT THE DELL POWEREDGE M820 SOLUTION

Features of the Dell PowerEdge M820 blade server

The new Intel® Xeon® processor E5-4650-powered Dell PowerEdge M820 blade server pushes the limits for computing power in a high-density blade environment; its full-height blade chassis capable of supporting four processors and 1.5TB of RAM to drive your most demanding applications. Features include:

- **Enterprise database-ready.** Full-height blades capable of handling eight-core Intel Xeon processor E5-4600-series units in a four-socket configuration have the power needed to drive the most computation-intensive applications.

- **Memory.** The PowerEdge M820 supports up to 1.5TB of DDR3 RAM across 48 slots, providing both capacity and bandwidth to maximize throughput and reduce storage I/O.
- **Management.** The Dell OpenManage™ suite of tools, combined with the Integrated Dell Remote Access Controller (iDRAC7), give you maximum flexibility in administering your computing infrastructure.
- **Connectivity.** Snap-in FlexIO technology provides the backbone for a flexible, high-speed interconnect fabric. With options including 1Gb and 10Gb Ethernet, Fibre Channel, InfiniBand®, and the new Dell Force10 MXL 10/40GbE blade switches, connectivity options are flexible.
- **Power efficiency.** Dell PowerEdge M820 servers implement leading industry power-efficiency standards, and are designed to optimize performance while maintaining low power consumption, saving energy and money.
- **Virtualization-ready.** The M820 contains two SD card slots for hypervisor, redundant hypervisor and/or vFlash media support, and supports various hypervisor software.

About the Dell Compellent SC8000 SAN

With Dell Compellent storage, Dell aims to deliver resilient storage solutions that increase business continuity by providing high availability. According to Dell, Compellent storage brings flexibility to your data center by providing scalable adaptable storage that can handle the growth of your business and adapt with new technologies.

The storage we used in our tests, the Dell Compellent SC8000 SAN, has the capacity to support up to 960 SAS drives, and is compatible with SSD, SAS, and NL-SAS drives. The array is also backwards compatible with existing Compellent Fibre Channel and SATA drives, allowing for a mix of drive types in the same SAN. The Dell Compellent SC8000 uses the power of two 2.5GHz Intel Sandy Bridge processors to power your database workloads, and supports a combination of RAID levels for your data.

Dell Compellent Storage Area Networks are based on Dell Fluid Data Architecture, which is intended to put the right data in the right place at the right time to ensure responsive ad hoc queries and data analysis. Dell Compellent Storage Center works with Oracle 11g Automatic Storage Management (ASM) to provide an application-aware data protection capability. In addition, Compellent's Data Progression and Dynamic Capacity work with Oracle ASM to enable thin replication and automated tiered storage.

- Compellent Data Progression dynamically moves enterprise data to the optimal tier based on actual use. For instance, the most active blocks will reside on high-performance SSDs, Fibre Channel drives, or SAS drives, while infrequently

accessed data migrates to lower-cost, high-capacity SAS drives. Dell Compellent FastTrack places frequently accessed data on the outer sections of the disk to improve performance even further.

- Dell Compellent enables virtualized storage at the disk level, creating a dynamic pool of shared storage resources available to multiple servers. With read/write operations spread across all drives, multiple requests can be processed in parallel, boosting system performance. Compellent allows for changes to RAID levels and storage tiers on the fly, even while the volumes are in use.
- Dell Compellent's thin provisioning software, Dynamic Capacity, strives to deliver higher storage utilization by eliminating pre-allocated but unused capacity. Dynamic Capacity separates allocation from utilization, enabling users to provision volumes upfront while only consuming disk space when data is written.

For more information about the Dell Compellent SC8000, visit

<http://www.compellent.com/Products/Hardware/Controllers.aspx>.

About the Dell PowerConnect M8428-k converged 10GbE switch

The Dell PowerConnect M8428-k switch for the Dell PowerEdge M1000e blade enclosure provides provides ten 10GbE ports and four Fibre Channel ports. The switch is capable of FCoE switching and 8Gb FC switching at wire speed.

WHAT WE TESTED

About DVD Store Version 2.1

To create our real-world ecommerce workload, we used the DVD Store Version 2.1 (DS2) benchmarking tool. DS2 models an online DVD store, where customers log in, search for movies, and make purchases. DS2 reports these actions in orders per minute (OPM) that the system could handle, to show what kind of performance you could expect for your customers. The DS2 workload also performs other actions, such as adding new customers, to exercise the wide range of database functions you would need to run your ecommerce environment. For more information about the DS2 tool, see <http://www.delltechcenter.com/page/DVD+Store>.

IN CONCLUSION

Minimizing licensing costs for enterprise applications is vital to organizations looking to keep costs down. When your applications use per-core licensing, choosing higher-performance servers with fewer cores dramatically reduces your software-related spending. The Dell PowerEdge M820 blade solution with Compellent storage could deliver up to \$315,400 in savings as compared to a single HP ProLiant BL680c G7 solution, and if consolidating multiple workloads, could deliver even more savings in licensing costs when running Oracle Database 11g Release 2 – all while maintaining or exceeding previous performance levels.

APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 1 provides detailed configuration information for the test systems.

System	Dell PowerEdge M820	HP ProLiant BL680c G7
Power supplies	(Dell PowerEdge M1000e Blade Enclosure)	(HP BladeSystem c7000 Blade Enclosure)
Total number	6	6
Vendor and model number	Dell A236P-00	HP 588603-B21
Wattage of each (W)	2,360	2,450
Cooling fans	(Dell PowerEdge M1000e Blade Enclosure)	(HP BladeSystem c7000 Blade Enclosure)
Total number	9	10
Vendor and model number	Dell YK776 Rev. X50	HP 412140-B21
Dimensions (h x w) of each	3.1" x 3.5"	3.5" x 3.0"
Volts	12	12
Amps	7.0	16.5
General		
Number of processor packages	4	4
Number of cores per processor	8	10
Number of hardware threads per core	2	2
System power management policy	Balanced	Balanced
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-4650	E7-8867L
Stepping	S4S	S8S
Socket type	LGA2011	LGA1567
Core frequency (GHz)	2.70	2.13
Bus frequency (GT/s)	8.0	6.4
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache (MB)	20	30
Platform		
Vendor and model number	Dell PowerEdge M820	HP ProLiant BL680c G7
Motherboard model number	R58H9	644498-001
BIOS name and version	Dell 1.0.2 6/5/2012	HP I25 4/20/2012
BIOS settings	Performance	Max Performance
Memory module(s)		
Total RAM in system (GB)	512	128
Vendor and model number	Samsung M393B2G70BH0-YH9	Samsung M393B5170GB0-CH9Q8
Type	PC3L-10600R	PC3-10600R
Speed (MHz)	1,333	1,333
Speed running in the system (MHz)	1,333	1,333

System	Dell PowerEdge M820	HP ProLiant BL680c G7
Timing/Latency (tCL-tRCD-tRP-tRASmin)	9-9-9-24	9-9-9-24
Size (GB)	16	4
Number of RAM module(s)	32	32
Chip organization	Double-sided	Double-sided
Rank	Dual	Dual
Operating system		
Name	Oracle Linux Server	Oracle Linux Server
Build number	6.3 GNOME 2.28.2	6.3 GNOME 2.28.2
File system	Ext4	Ext4
Kernel	Linux 2.6.32-279.el6.x86_64	Linux 2.6.32-279.el6.x86_64
Language	English	English
Graphics		
Vendor and model number	Matrox® G200eR2	ATI ES1000
Graphics memory (MB)	Integrated	Integrated
RAID controller		
Vendor and model number	Dell PERC H710 Mini	HP Smart Array P410i
Firmware version	21.0.1-0132	5.7
Cache size (MB)	512	256
Hard drives		
Vendor and model number	Seagate ST9300653SS	HP EH0146FARWD
Number of drives	2	2
Size (GB)	300	146
Buffer size (MB)	64	16
RPM	15,000	15,000
Type	SAS	SAS
Ethernet adapters		
First network adapter		
Vendor and model number	Intel Ethernet 10G 82599EB	2 x HP FlexFabric 10 Gb NC553i
Type	Integrated	PCI Embedded
Second network adapter		
Vendor and model number	Broadcom® NetXtreme® II BCM57810 10 Gb Converged network adapter	2 x QLogic® QMH2462 4Gb dual port FC HBA
Type	Mezzanine Card	
Optical drive(s)		
Vendor and model number	N/A	N/A
Type	N/A	N/A
USB ports		
Number	3 external, 1 internal	2 external (via HP SUV connector), 1 internal
Type	2.0	2.0

Figure 1: System configuration information for the test systems.

APPENDIX B – TEST STORAGE CONFIGURATION

Figure 2 provides detailed information for the test storage.

Storage array	Dell Compellent SC8000	HP StorageWorks EVA4400
Number of active storage controllers	2	2
Number of active storage ports	4	4
Firmware revision	6.1.2	10001000
Storage controller model	CT-SC8000	HSV300
Tray 1		
Number of disks	9	12
Disk vendor and model number	Seagate ST9300653SS	HP BF146DA47C
Disk size (GB)	279	146
Disk buffer size (MB)	64	16
Disk RPM	15,000	15,000
Disk type	SAS	FC
Firmware revision	XQB4	HP07
Tray 2		
Disk type 1		
Number of disks	20	11
Disk vendor and model number	Hitachi HUSSL4020ASS600	HP BF146DA47A
Disk size (GB)	200	146
Disk buffer size (MB)	N/A	16
Disk RPM	N/A	15,000
Disk type	SSD	FC
Firmware revision	A170	HP02
Disk type 2		
Number of disks	N/A	1
Disk vendor and model number	N/A	HP BF1465A477
Disk size (TB)	N/A	146
Disk buffer size (MB)	N/A	16
Disk RPM	N/A	15,000
Disk type	N/A	FC
Firmware revision	N/A	HP03
Tray 3		
Disk type 1		
Number of disks	N/A	11
Disk vendor and model number	N/A	HP BF146DA47C
Disk size (GB)	N/A	146
Disk buffer size (MB)	N/A	16
Disk RPM	N/A	15,000
Disk type	N/A	FC
Firmware revision	N/A	HP07

Storage array	Dell Compellent SC8000	HP StorageWorks EVA4400
Disk type 2		
Number of disks	N/A	1
Disk vendor and model number	N/A	HP BF146DA47A
Disk size (GB)	N/A	146
Disk buffer size (MB)	N/A	16
Disk RPM	N/A	15,000
Disk type	N/A	FC
Firmware revision	N/A	HP02
Tray 4		
Number of disks	N/A	12
Disk vendor and model number	N/A	HP BF146DA47C
Disk size (GB)	N/A	146
Disk buffer size (MB)	N/A	16
Disk RPM	N/A	15,000
Disk type	N/A	FC
Firmware revision	N/A	HP07
Tray 5		
Number of disks	N/A	10
Disk vendor and model number	N/A	HP BF146DA47A
Disk size (GB)	N/A	146
Disk buffer size (MB)	N/A	16
Disk RPM	N/A	15,000
Disk type	N/A	FC
Firmware revision	N/A	HP02

Figure 2: Configuration information for the test storage.

APPENDIX C – SOFTWARE LICENSING DETAILS

Savings details

Save 20% in software license counts and costs for software licensed on a purely per-core basis

The Oracle Technology Global Price List on the Oracle Web site prices the Oracle Database 11g R2 Enterprise Edition license pack at \$47,500 USD.² Oracle Software Update License and Support, priced at 22 percent of the license cost per year, adds \$10,450 per year, or \$31,450 over three years, and brings the three-year cost of each license to \$78,850. We use those prices and do not apply any quantity discounts in our analysis.

Figure 3 shows that with 20 percent fewer cores, the Dell PowerEdge M820 requires 20 percent fewer core licenses than the HP ProLiant BL680c G7. License count is the number of cores times a multiplier found in the Oracle Processor Core Factor table.³ The table shows a multiplier of 0.5 for both the E5-4650 processor type of the Dell PowerEdge M820 and the E7-8867L processor type of the HP ProLiant BL680c G7, so the required number of Oracle Database 11g R2 Enterprise Edition processor licenses equals half the core count of the server for a fully licensed server.

	Dell PowerEdge M820 solution	HP ProLiant BL680c G7 solution	Dell PowerEdge M820 savings	Dell PowerEdge M820 percentage savings
Oracle Processor Core Factor ⁴	0.5	0.5	N/A	N/A
Total physical cores per server	32	40	8	20%
Oracle Database 11g R2 Enterprise Edition processor license count	16	20	4	20%

Figure 3: Oracle Database 11g R2 Enterprise Edition processor license counts for the two tested solutions.

Figure 4 shows the Oracle Database 11g R2 Enterprise Edition software savings for the 32-core Dell PowerEdge M820 server. The Dell PowerEdge M820 server saves 20 percent on license cost.

² <http://www.oracle.com/us/corporate/pricing/technology-price-list-070617.pdf>

³ <http://www.oracle.com/us/corporate/contracts/processor-core-factor-table-070634.pdf>

⁴ *Ibid.*

	Cost per processor license	16 licenses for 1x 32-core Dell PowerEdge M820	20 licenses for 1x 40-core HP ProLiant BL680c G7	Dell PowerEdge M820 savings
Oracle Database 11g R2 Enterprise Edition license cost for all server cores	\$47,500.00	\$760,000.00	\$950,000.00	\$190,000.00
Three-year cost for SaS	\$31,350.00	\$501,600.00	\$627,000.00	\$125,400.00
Three-year cost for licenses and SaS	\$78,850.00	\$1,261,600.00	\$1,577,000.00	\$315,400.00

Figure 4: Three-year Oracle Database 11g R2 Enterprise Edition software savings for 32-core Dell PowerEdge M820 server vs. a 40-core server using prices in US dollars from the Oracle Technology Global Price List.⁵

Depending on existing software license agreements, an enterprise migrating workloads from older servers to newer Dell PowerEdge M820 servers might be able to transfer or upgrade existing licenses at no cost or at lower cost than shown here. The organization could save on support costs proportionate to the lower license count of the newer servers.

Our test results show the potential for consolidation and further software savings for the Dell PowerEdge M820 solution.

The single server license calculations in Figures 8 and 9 do not take into account the superior performance of the Dell PowerEdge M820 server solution. In our tests, a Dell PowerEdge M820 server solution delivered 195.4 percent better performance, or 2.95 times the performance of an HP ProLiant BL680c G7 server solution. Using that performance result to calculate a consolidation factor, one Dell PowerEdge M820 solution could support the workload nearly three HP ProLiant BL680c G7 solutions. The software savings for that consolidation factor would be correspondingly higher than the one-to-one comparison in the previous figure. Rather than attempt to calculate license counts for a fraction of an HP server, we, do a slight rounding, and calculate Oracle Database 11g R2 Enterprise Edition license counts for one Dell PowerEdge M820 server vs. the three HP ProLiant BL680c G7 servers. Figure 5 shows the consolidation calculations.

	Dell PowerEdge M820 solution	HP ProLiant BL680c G7 solution
Percentage better performance for Dell PowerEdge M820 server	195.4%	
Server count for performance- equivalent solutions	1	2.954
Server count for performance- equivalent solutions (rounded)	1	3
Total core count for performance- equivalent solutions	32	120

Figure 5: Consolidation calculations for the solutions.

Figure 6 summarizes the potential for Oracle Database 11g R2 Enterprise Edition software savings in the consolidation scenario. Savings of \$3,469,400 for the Dell PowerEdge M820 server are 73.3 percent of the three-year cost of Oracle Database 11g R2 Enterprise Edition licenses and SaS for the three 40-core HP ProLiant BL680c G7 servers.

⁵ <http://www.oracle.com/us/corporate/pricing/technology-price-list-070617.pdf>

	Cost per processor license	1 x 32-core Dell PowerEdge M820 solution	3 x 40-core HP ProLiant BL680c G7 solution	Savings for Dell PowerEdge M820 solution
Number Oracle Database 11g R2 Enterprise Edition licenses needed per solution	N/A	16	60	44.00
Oracle Database Enterprise Edition processor license cost	\$47,500.00	\$760,000.00	\$2,850,000.00	\$2,090,000.00
Oracle Database Enterprise Edition 3-years SaS	\$31,350.00	\$501,600.00	\$1,881,000.00	\$1,379,400.00
Oracle Database Enterprise Edition 3-year total for license and SaS	\$78,850.00	\$1,261,600.00	\$4,731,000.00	\$3,469,400.00

Figure 6: Software savings in our consolidation scenario.

APPENDIX D – HOW WE TESTED

Figures 7 and 8 show how we cabled the Dell PowerEdge M820 solution and the HP BL680c G7 solution.

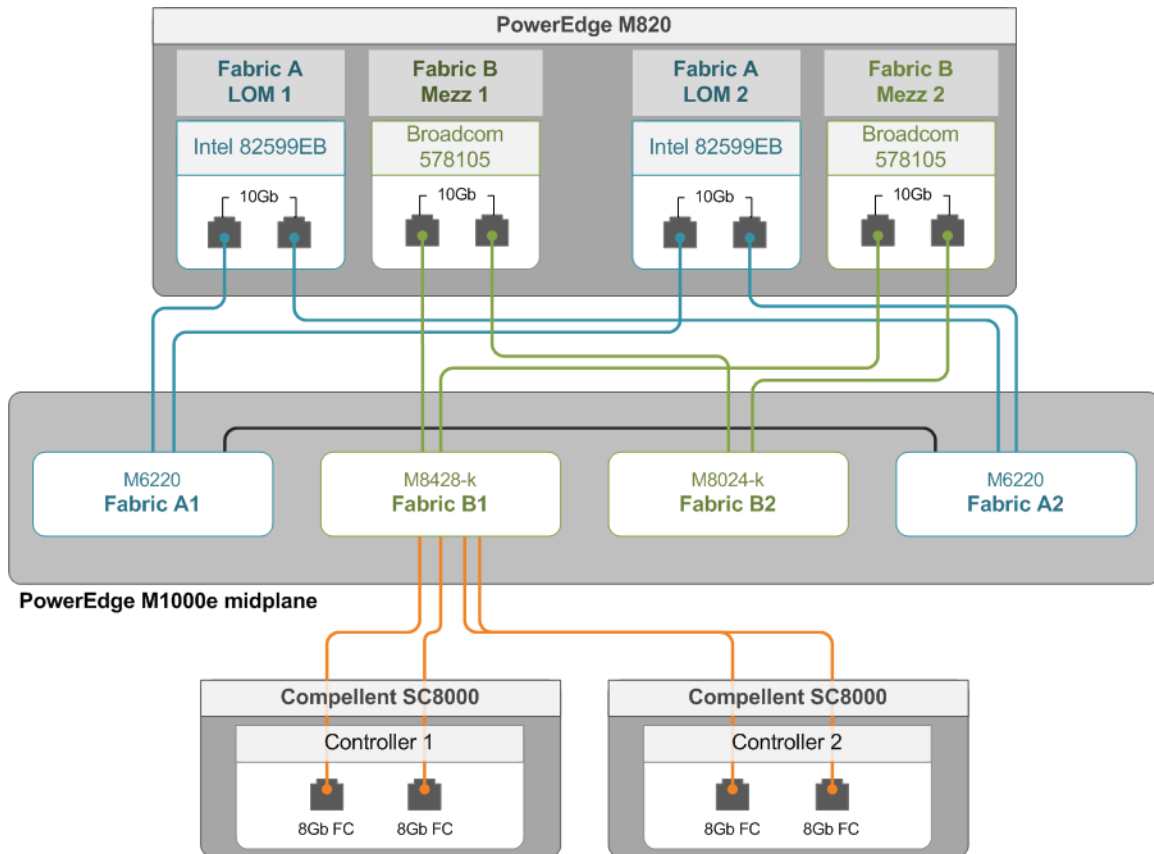


Figure 7: Our network setup for the Dell PowerEdge M820 server solution.

Our complete Dell storage infrastructure consisted of two 10Gb Fiber Channel over Ethernet (FCoE) HBA ports dedicated to fiber traffic, a Dell PowerConnect 8428-k switch dedicated to fiber traffic, and two Dell Compellent SC8000 storage controllers.

The Dell Compellent SC8000 contained 29 drives: twenty 200GB SSDs and nine 300 GB 15K SAS drives. We assigned storage profiles to each LUN to set the preferred disk tier and RAID type.

For volumes, we created the following:

- Four 400GB volumes to hold ASM database files on tier 1 storage.
- Four 100GB volumes to hold ASM log files tier 2 storage.

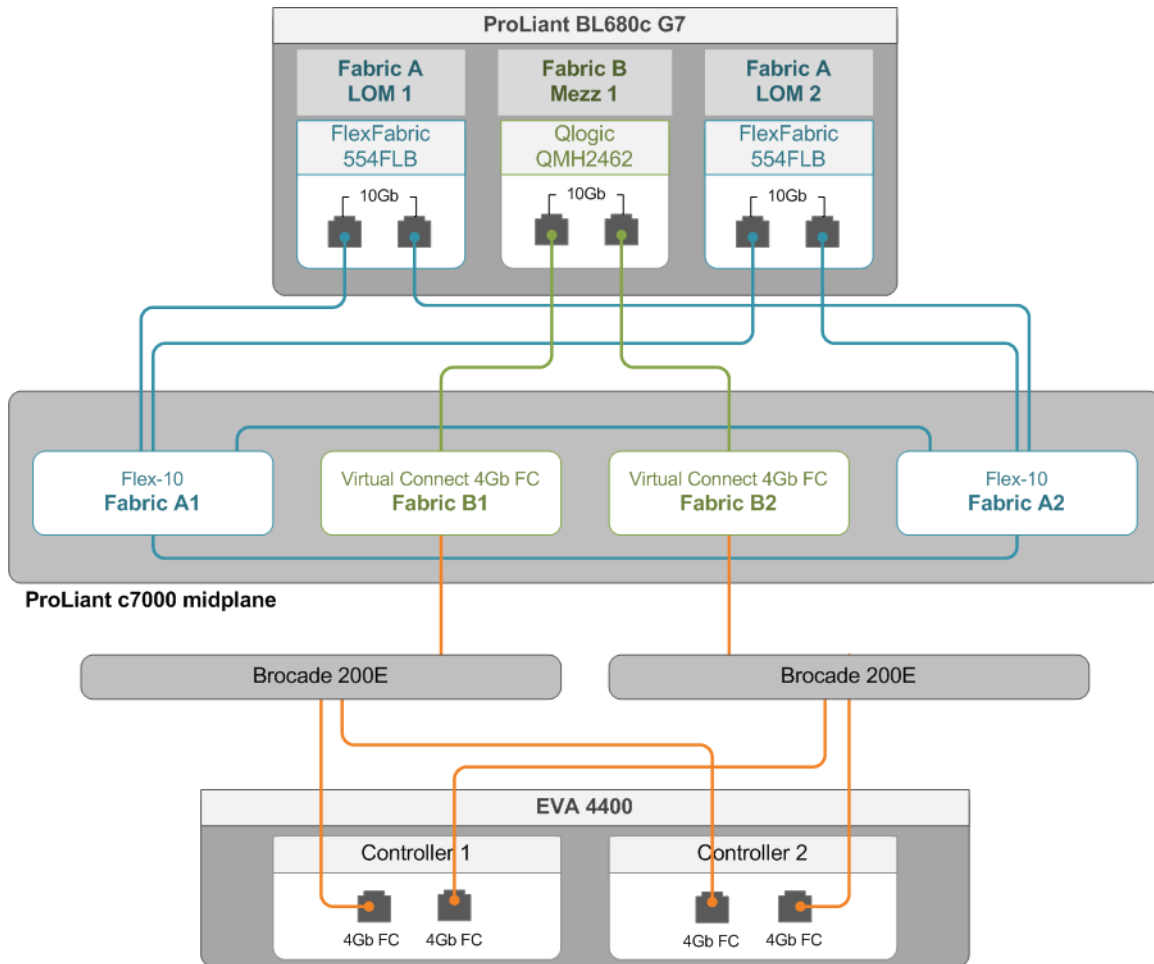


Figure 8: Our network setup for the HP ProLiant BL680c G7 server solution.

Our complete HP storage infrastructure consisted of two 10Gb Fiber Channel (FC) HBA ports connected to two Virtual Connect 4Gb FC switches. These FC switches were then connected to two Brocade 200E FC switches, and then to the two EVA 4400 storage controllers.

The EVA 4400 contained 58 15K RPM FC drives. We combined them into one 58 disk database and log disk group. All LUNs were configured in RAID 10.

For volumes, we created the following:

- Four 400GB volumes to hold ASM database files.
- Four 100GB volumes to hold ASM log files.

Setting up the system under test

Installing Oracle Linux 6.2

Many of the steps we took in this methodology originate from suggestions in [Oracle Database 11g Release 2 on Red Hat Enterprise Linux 6](#).

1. Insert the Oracle Linux 6.2 DVD into the server and boot to it.
2. Select Install or upgrade an existing system.
3. If you are unsure of the fidelity of your installation disk, select OK to test the installation media; otherwise, select Skip.

4. In the opening splash screen, select Next.
5. Choose the language you wish to use, and click Next.
6. Select Basic Storage Devices, and click Next.
7. Select Fresh Installation, and click Next.
8. Insert your hostname, and select Configure Network.
9. In the Network Connections menu, configure two network connections:
 - a. The first connection for external (Internet) traffic
 - b. The second connection for internal (test) traffic
10. After configuring your network connections, click Close.
11. Click Next.
12. Select the nearest city in your time zone, and click Next.
13. Enter your root password, and click Next.
14. Select Use All Space, and click Next.
15. When the installation prompts you to confirm that you are writing changes to the disk, select Write changes to disk.
16. Select Software Development Workstation, and click Next. Oracle Linux installation begins.
17. When the installation completes, select Reboot to restart the server.
18. After rebooting, a Welcome splash screen appears. Click Forward.
19. In the License Information screen, agree to the License Agreement, and click Forward.
20. In the Set Up Software Updates screen, select No, I prefer to register at a later time.
21. You may receive a warning. Select No thanks, I'll connect later.
22. In the Finish Updates Setup screen, click Forward.
23. In the Create User screen, create a username and password, and click Forward.
24. In the Date and Time screen, verify your date and time, and click Forward.
25. In the Kdump screen, make sure that kdump is not enabled, and click Finish.

Initial configuration tasks

Complete the following steps to provide the base functionality that Oracle Database requires. We performed all of these tasks as root.

1. Edit `/etc/grub.conf` and make sure that the server is booting into the Red Hat Linux kernel (in our case, that meant changing `default=0` to `default=1`), and reboot.
2. Disable firewall services. In the command line (as root), type:


```
service iptables stop
chkconfig iptables off
service ip6tables stop
chkconfig ip6tables off
```
3. Configure yum to use the Oracle public yum server:


```
cd /etc/yum.repos.d
wget http://public-yum.oracle.com/public-yum-ol6.repo
```
4. Install automatic system tuning for database storage through yum:


```
yum install tuned
chkconfig tuned on
tuned-adm profile enterprise-storage
```
5. Using yum, install the following prerequisite packages for Oracle Database:
 - `binutils`
 - `compat-libcap1`
 - `compat-libstdc++-33`
 - `compat-libstdc++-33 (32-bit)`

- elfutils-libelf
- elfutils-libelf-devel
- gcc
- gcc-c++
- glibc
- glibc (32-bit)
- glibc-common
- glibc-devel
- glibc-devel (32-bit)
- glibc-headers
- ksh
- libaio
- libaio (32-bit)
- libaio-devel
- libaio-devel (32-bit)
- libgcc
- libgcc (32-bit)
- libstdc++
- libstdc++ (32-bit)
- libstdc++-devel
- make
- sysstat
- unixODBC
- unixODBC (32-bit)
- unixODBC-devel

6. Modify your /etc/hosts file to include the IP address of your internal IP and your hostname.

7. Add the following lines to /etc/sysctl.conf to:

- a. Create a huge-page pool of 1 GB:
`vm.nr_hugepages=512`
- b. Control the rate at which virtual memory is reclaimed:
`vm.swappiness=0`
`vm.dirty_background_ratio=3`
`vm.dirty_ratio=15`
`vm.dirty_expire_centisecs=500`
`vm.dirty_writeback_centisecs=100`
- c. Modify shared memory sizes:
`kernel.shmall=25165824`
`kernel.shmmax=51539607552`
`kernel.shmmni=4096`
- d. Provide sufficient resources for semaphores:
`kernel.sem = 250 32000 100 128`
- e. Allow automatically assigned client source-ports:
`net.ipv4.ip_local_port_range = 9000 65500`
- f. Tune TCP/IP-socket buffer sizes and application-socket buffer sizes:
`net.core.rmem_default = 262144`
`net.core.rmem_max = 4194304`
`net.core.wmem_default = 262144`
`net.core.wmem_max = 1048576`

8. Add the following lines to `/etc/security/limits.conf` to:
 - a. Allow the oracle user account to lock huge pages in memory:


```
oracle hard memlock 1048576
oracle soft memlock 1048576
```
 - b. Increase the resources available to the oracle user account:


```
oracle - nproc 16384
oracle - nofile 65536
oracle soft stack 10240
```
9. Create the oracle user account and groups:


```
groupadd -g 1001 oinstall
groupadd -g 1002 dba
groupadd -g 1003 oper
groupadd -g 1004 asmadmin
groupadd -g 1005 asmdba
groupadd -g 1006 asmoper
useradd -u 1002 -g oinstall -G dba,oper,asmadmin,asmdba,asmoper oracle
passwd oracle
```
10. Create the `/u01` directory for Oracle inventory and software and give it to the oracle user:


```
mkdir -p /u01/app/oracle
chown -R oracle:oinstall /u01
chmod -R 775 /u01
```
11. Create a file in `/etc/udev/rules.d/99-asm.rules` to grant ownership of your database and log LUNs to the oracle user (for ASM purposes). For more details, see section 5.1.3 in the guide [Oracle Database 11g Release 2 on Red Hat Enterprise Linux 6](#).
12. Create a file in `/etc/init/ohasd.conf` with these contents:


```
start on runlevel [35]
stop on runlevel [016]

respawn
exec /etc/init.d/init.ohasd run >/dev/null 2>&1 </dev/null
```

Installing Oracle Database 11g Release 2

We downloaded Oracle Database and Oracle Grid Infrastructure from

<http://www.oracle.com/technetwork/database/enterprise-edition/downloads/112010-linx8664soft-100572.html>. The following tasks were performed by the oracle user.

Installing Oracle Grid Infrastructure 11g Release 2

1. Unzip `linux.x64_11gR2_grid.zip`
2. Open a terminal in the unzipped Grid directory.
3. Set the Oracle hostname and Oracle base values by entering the following commands (Note: Replace `hostname` with your actual hostname):


```
ORACLE_HOSTNAME=hostname
ORACLE_BASE=/u01/app/oracle
```
4. To start the installer, type `./runInstaller`
5. In the Select Installation Option screen, select Install and Configure Grid Infrastructure for a Standalone Server, and click Next.
6. Choose your language, and click Next.
7. In the Create ASM Disk Group screen, choose your Disk Group Name, change redundancy to External, and change your discovery path to the directory you set in your ASM udev rules file.

8. After you've changed the discovery path, select only those LUNs that you are planning to use for your database, and click Next.
9. In the Specify ASM Password screen, write the passwords for the ASM users, and click Next.
10. In the Privileged Operating System Groups screen, leave the defaults, and click Next.
11. Leave the default installation, and click Next.
12. Leave the default inventory location, and click Next.
13. In the Prerequisite Checks screen, make sure that there are no errors outside of missing packages. If there are any errors, click Fix & Check Again.
14. There will be errors with the Packages, as Oracle Database checks for i386 libraries instead of the backwards-compatible i686 libraries. Verify that the only missing libraries are i386 libraries, click the Ignore All checkbox, and click Next.
15. In the Summary screen, verify that everything is correct, and click Finish to install Oracle Grid Infrastructure.
16. At one point during the installation, the installation prompts you to execute two configuration scripts as root. Follow the instructions to run the scripts.
NOTE: If the second script (root.sh) hangs at Adding daemon to inittab, run `initctl start ohasd` in a second command window as root to kickstart the script.
17. After you have run the root scripts, go back to the Execute Configuration Scripts window, and click OK to finish the installation.
18. At the Finish screen, click Close.
19. In the command console, navigate to `/u01/app/oracle/product/11.2.0/grid/bin` and run the ASM Configuration Assistant by typing `./asmca`
20. In the ASM Configuration Assistant, click Create.
21. In the Create Disk Group window, name your new disk group `log` choose redundancy External (None), select your log LUNs, and click OK.
22. Exit the ASM Configuration Assistant.

Installing Oracle Database 11g Release 2

1. Unzip `linux.x64_11gR2_database_1_of_2.zip` and `linux.x64_11gR2_database_2_of_2.zip`.
2. Open a terminal to the unzipped database directory.
3. Set the Oracle hostname and Oracle base values by entering the following commands (NOTE: Replace `hostname` with your actual hostname):
`ORACLE_HOSTNAME=hostname`
`ORACLE_BASE=/u01/app/oracle`
4. To start the installer, type `./runInstaller`
5. In the Configure Security Updates screen, uncheck I wish to receive security updates via My Oracle Support, and click Next.
6. If you receive a warning about your email address not being specified, click Yes to continue.
7. In the Select Installation Option screen, select Create and configure a database, and click Next.
8. In the System Class screen, select Server Class, and click Next.
9. In the Node Selection screen, select Single instance database installation, and click Next.
10. In the Select Install Type screen, select Advanced install, and click Next.
11. Select your language, and click Next.
12. In the Select Database Edition screen, select Enterprise Edition, and click Next.
13. In the Specify Installation Location screen, accept the defaults, and click Next.
14. In the Select Configuration Type screen, select General Purpose / Transaction Processing, and click Next.
15. Name your global database and SID, and click Next.
16. In the Specify Configuration Options screen, uncheck Enable Automatic Memory Management, and click Next.

17. In the Specify Management Options screen, select Use Database Control for database management, and click Next.
18. In the Specify Database Storage Options screen select Automatic Storage Management, type the password for the ASMSNMP user, and click Next.
19. In the Specify recovery Options screen, select Do not enable automated backups, and click Next.
20. In the Select ASM Disk Group screen, select your database Disk Group, and click Next.
21. In the Specify Schema Passwords screen, type the passwords for your accounts, and click Next.
22. In the Privileged Operating System Groups screen, accept the default groups, and click Next.
23. In the Prerequisite Checks screen, make sure that there are no errors outside of missing packages. If there are any errors, click Fix & Check Again.
24. There will be errors with the Packages, as Oracle Database checks for i386 libraries instead of the backwards-compatible i686 libraries. Verify that the only missing libraries are i386 libraries, click the Ignore All checkbox, and click Next.
25. In the Summary screen, verify that everything is correct, and click Finish.
26. When the database has been created, the Database Configuration Assistant will alert you. Click OK to continue.
27. At the end of the installation, the installation prompts you to execute a configuration script as root. Follow the instructions to run the script.
28. After the installation, to grant the SYSASM role to the SYS user, open a command prompt, and type:

```
export ORACLE_HOME=/u01/app/oracle/product/11.2.0/grid
export ORACLE_SID=+ASM
cd /u01/app/oracle/product/11.2.0/grid/bin
./sqlplus / as sysasm
grant SYSASM to SYS;
Exit
```

Configuring the database (DVD Store)

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 1TB database size and the database platform on which we ran: Oracle Database 11g Release 2. We ran the Install.pl script on a utility system running Linux. The database schema was also generated by the Install.pl script.

After processing the data generation, we transferred the data files and schema creation files to an Oracle Linux-based system running Oracle Database 11g Release 2. We built the 1TB database in Oracle Database 11g Release 2, and then performed a full backup, storing the backup file on a mapped LUN for quick access. We used that backup file to restore on both servers between test runs. We performed this procedure once, and used the same backup file for all Oracle Linux machines.

We made a few modifications to the schema creation. We created additional indexes to improve lookup performance and reduce table scans. We configured the tablespaces to use ASM and created 16-24 files per tablespace to improve parallelism and allow for potential database file expansion. Additionally, we modified the login stored procedure to bypass using the temporary tablespace. Finally, we also modified the data generation scripts (see DVD store modifications section below). Specifically, we followed the steps below:

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our 1TB database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Linux system running Oracle Database.
3. We created database tables, stored procedures, and objects using the provided DVD Store scripts.

4. We loaded the data we generated into the database using sqlldr and the provided DVD Store load scripts.
5. We created indices, full-text catalogs, primary keys, and foreign keys using our modified database-creation scripts.
6. We updated statistics on each table according to database-creation scripts, which sample 20 percent of the table data.
7. We created a database user, and mapped this user to the Oracle Database login.
8. We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

DVD Store modifications

We made a few modifications to the database creation scripts and the client driver source code for DVD store to allow the benchmark to scale up to 1000GB. The files we modified and their changes are list below:

1. **ds2_data.h**
 - a. Increased the number of actor first and last names from 200 each to 500 each.
2. **ds2_create_prod.c**
 - a. Increased the random number selection range for actor names from 200 to 500.
3. **ds2xdriver.cs**
 - a. Increased the number of actor first and last names from 200 each to 500 each.
 - b. Increased the random number selection range for actor names from 200 to 500.
4. **oracleds2_create_ind.sql**
 - a. Created a new index on the CUST_HIST table that included the CUSTOMERID and PROD_ID columns.
 - b. Changed the PK_ORDERS index to a reverse index.
 - c. Created a new index on the ORDERS table that included the CUSTOMERID column.
 - d. Changed the PK_ORDERLINES index to a reverse index.
 - e. Created a new index on the PRODUCTS table that included the PROD_ID and COMMON_PROD_ID columns.
 - f. Created a new index on the PRODUCTS table that included the SPECIAL, CATEGORY, and PROD_ID columns.
 - g. Changed the IX_INV_PROD_ID index to a unique index and made it the primary key.
 - h. Created a new index on the REORDER table that included the PROD_ID column.
5. **oracleds2_analyze_all.sql**
 - a. Modified to include all new indexes.
 - b. The “estimate_percent” properties were changed from 18 to 20.
6. **oracleds2_create_sp.sql**
 - a. Removed the “derivedtable” global temporary table creation.
 - b. Modified the LOGIN procedure to not use the “derivedtable” global temporary table.
7. **oracleds2_create_tablespace_1000GB_asm.sql**
 - a. Modified to use ASM datastore.
 - b. Used 24 datafiles for the CUSTTBS tablespace.
 - c. Used 24 datafiles for the INDXTBS tablespace.
 - d. Used 16 datafiles for the ORDERTBS tablespace.
 - e. Used one BIGFILE datafile for the DS_MISC tablespace.
 - f. Modified TEMP and UNDOTBS default global tablespaces to use a single BIGFILE datafile with unlimited MAXSIZE.

Running the DVD Store tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. DVD Store outputs an orders-per-minute metric, which is a running average calculated through the test. In this report, we use the last OPM reported by each client/target pair to calculate the advantage of the new solution. We downloaded the latest Oracle Data Provider for .NET 2.x (version 2.112.3.0). We used eight client systems with 32 threads running on each for a total 256 threads to generate a high load rate.

Each complete test cycle consisted of the general steps listed below. For each scenario, we ran three test cycles, and chose the median outcome.

1. Clean up prior outputs from the host system and all client driver systems.
2. Drop all databases from the system under test (SUT).
3. Restore all databases on the SUT.
4. Reboot the SUT and all client systems.
5. Wait for a ping response from the SUT and all client systems.
6. Let the test server idle for one hour.
7. Start the DVD Store driver on all respective clients.

We used the following DVD Store parameters for testing the virtual machines in this study:

```
ds2oracledriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --  
n_threads=32 --db_size=1000GB--think_time=0 --detailed_view=Y --  
warmup_time=10
```

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