

## Dell PowerVault DL2100 with CommVault Simpana 8.0 remote office/branch office data replication and deduplication analysis

### Executive summary

Dell Inc. (Dell) commissioned Principled Technologies (PT) to determine the relative performance of various remote replication and backup technologies for remote office/branch office (ROBO) data protection to a central office across a wide area network (WAN). We used the Microsoft® File Server Capacity Tool (FSCT) with the HomeFolders workload to simulate typical ROBO data change rates.<sup>1</sup> Microsoft created the FSCT benchmark tool after analyzing the workload of production file servers. The tool can simulate typical file server workload (and potentially other types of workloads) in a lab environment. Microsoft compiled the HomeFolders workload by capturing data from real, heavily accessed file servers and their clients. It includes activities such as deleting, navigating, and moving files in Windows Explorer, as well as editing, saving, closing, and opening files with Microsoft Office® applications, such as Microsoft Word®, Microsoft Excel®, or Microsoft PowerPoint®, thus simulating data set changes in a heavily used file server.

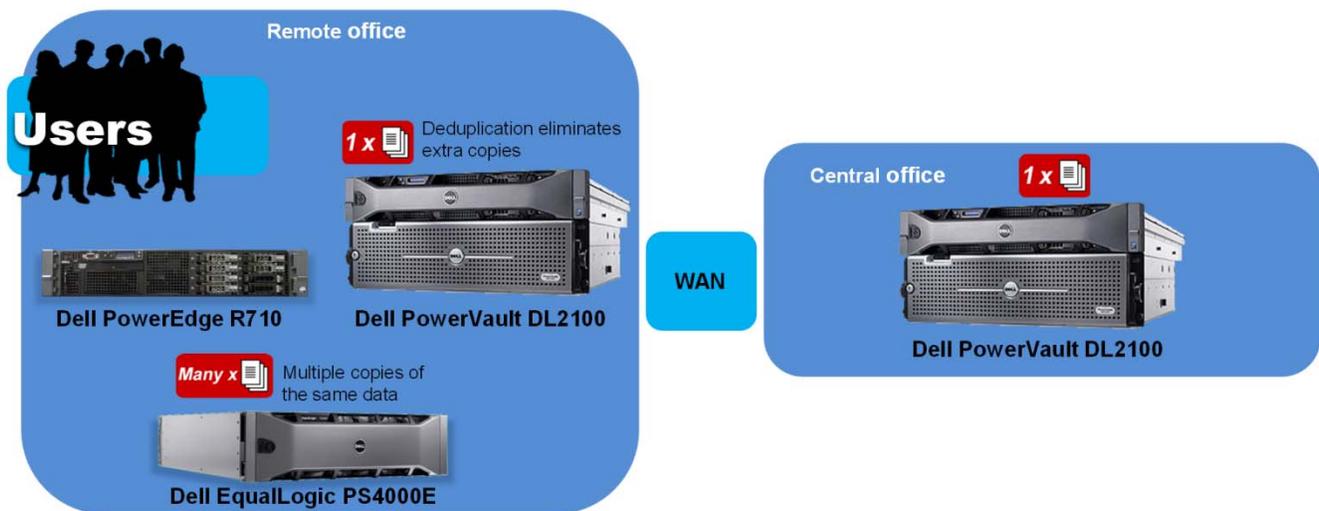


Figure 1: The remote office to central office deduplicated backup/replication scenario we tested.

### KEY FINDINGS

- The solution comprising the Dell EqualLogic PS4000E and Dell PowerVault DL2100 **without deduplication** at the remote office, and Dell PowerVault DL2100 at the central management site was able to remotely protect an hourly change rate of up to an estimated **6.27 GB** across the WAN, providing a 1-hour RPO to 700 users' home folders on a heavily accessed file server.
- The solution comprising the Dell EqualLogic PS4000E and Dell PowerVault DL2100 **using deduplication** at the remote office, and Dell PowerVault DL2100 at the central management site was able to remotely protect an hourly change rate of up to an estimated **18.52 GB** across the WAN, providing a 1-hour RPO to 2,100 users' home folders on a heavily accessed file server.

As we show in Figure 1, we created the data replication/backup test bed by running the HomeFolders workload on a Dell™ PowerEdge™ R710 file server with a Dell EqualLogic™ PS4000E SAN array. A pair of Dell PowerVault™ DL2100 backup appliances powered by CommVault connected over a WAN protect the changed data at the file server. We set our WAN emulator to use a T3 bandwidth with 15ms latency. This scenario resembles a typical company with a ROBO that is seeking to control data sprawl and reduce backup costs by

<sup>1</sup> A detailed description of the Microsoft FSCT benchmark tool and HomeFolders workload can be found at <http://blogs.technet.com/josebda/archive/2008/10/06/fsct-a-cifs-smb-smb2-file-server-tool-for-capacity-planning-and-performance-troubleshooting.aspx>

centralizing ROBO backup and by implementing disk-to-disk (or disk-to-disk-to-tape) backup over the WAN. For instance, this could be a global manufacturer with several branch offices. The company is using the appliances to automate and simplify the backup process to ensure consistent and reliable data backup. The company is also sensitive to the high cost of WAN connections. The solution uses deduplication and compression to overcome these WAN bandwidth constraints and to enable efficient and automated data protection back to the central office.

The remote office Dell PowerVault DL2100 first creates a backup of the file server data and optionally deduplicates that data. It then replicates the backup data set across the WAN to a second “central office” Dell PowerVault DL2100 using built-in compression and replication technology from CommVault. The compression and deduplication features of the Dell PowerVault DL2100 can significantly reduce the size of the backup data set by allowing the central and remote office Dell PowerVault DL2100 to store only one copy of any duplicate data. This deduplication technology allows the Dell PowerVault DL2100 solution to support a significantly greater change rate by reducing the size of the backup data set transmitted across the WAN.

Note: In addition to data change rates and available WAN bandwidth, managers should analyze the restore process and RTO (recovery time objective) when selecting the most effective solution for a specific enterprise. For instance, the Dell PowerVault DL2100 backup technologies require a restoration of the backup set before users or applications can access the files. This results in a longer RTO, which may be acceptable. If the RTO is the primary driver in the decision making process, a Dell EqualLogic PS4000E paired with another Dell EqualLogic array in the central office may be sufficient to fulfill corporate replication needs. The Dell EqualLogic PS4000E array-to-array Auto-Replication feature benefits from a significantly shorter RTO (users or applications can almost immediately access the data at the recovery site).<sup>2</sup>

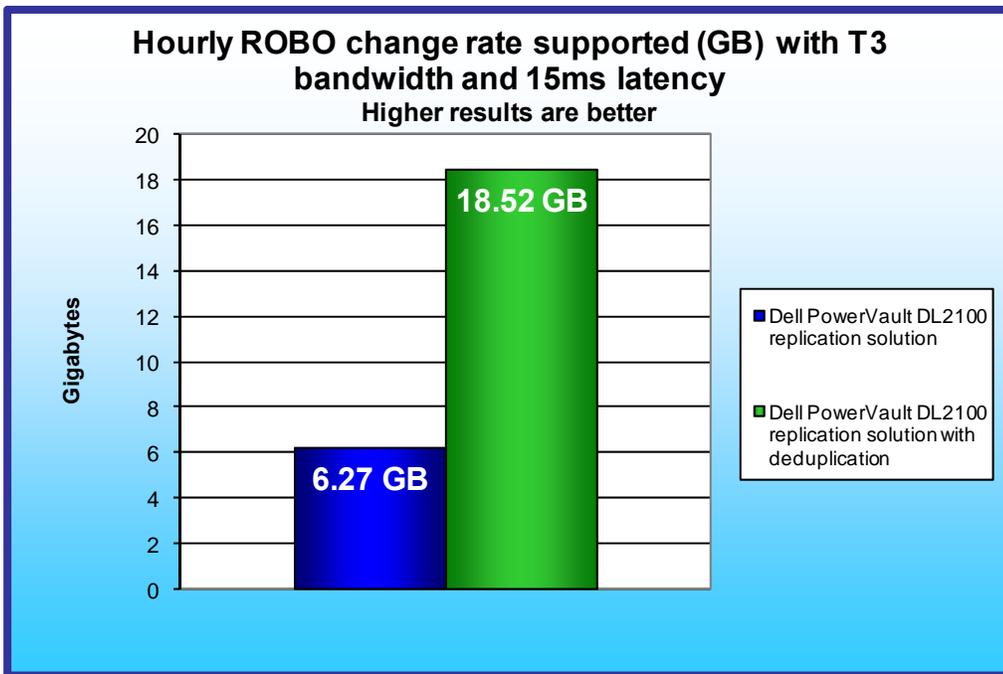


Figure 2: Hourly change rate supported by the Dell PowerVault DL2100 backup/replication solution with and without deduplication with the FSCT HomeFolders workload.

Figure 2 shows the hourly change rate supported by the Dell PowerVault DL2100 in a ROBO replication scenario with a T3 bandwidth and 15ms latency (This equates to the approximate round-trip latency of a 750 mile link.) Based on our workload, the Dell PowerVault DL2100 without deduplication can support up to 6.27 GB of user changes in less than 1 hour (700 FSCT HomeFolders users) and the Dell PowerVault DL2100 using deduplication can support up to an estimated 18.52 GB of user changes in less than 1 hour (2,100 FSCT HomeFolders users).

<sup>2</sup> Assuming T3 bandwidth and 15ms latency, an hourly data change rate of up to 4 GB per hour can be achieved using PS Series Auto-Replication. Environments requiring higher hourly rates can benefit from WAN acceleration solutions and/or higher bandwidth WAN infrastructure.

Figure 3 shows the time required to back up 1 hour of changes for 600, 700, 800, 900, and 1,000 users. As the graph shows, the Dell PowerVault DL2100 using deduplication significantly reduced the time required to transmit data across the WAN by utilizing deduplication to remove duplicate copies of data.

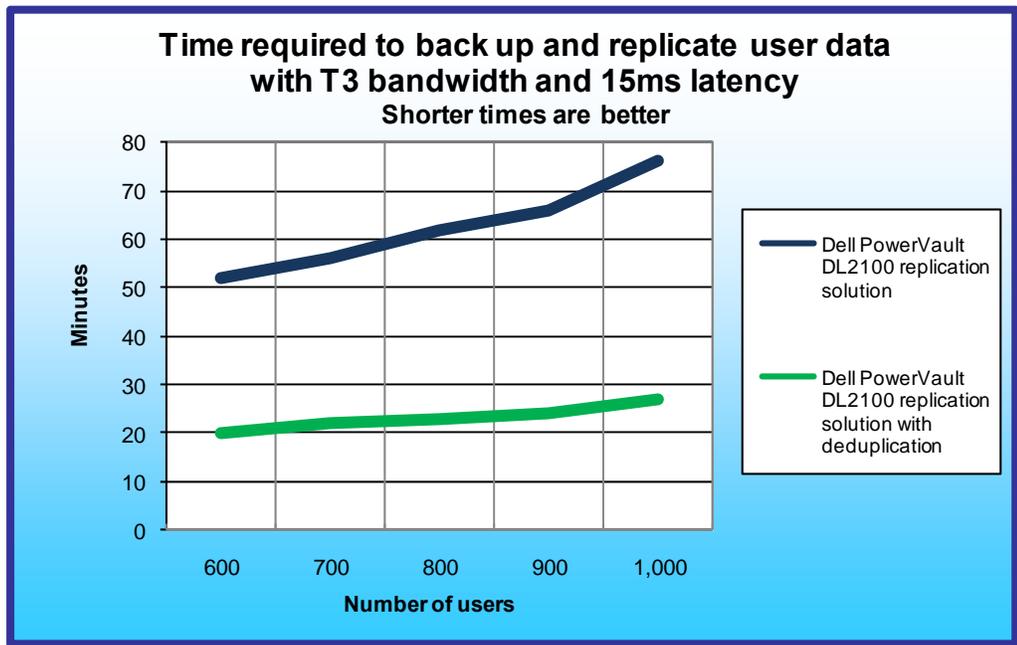


Figure 3: Time required to back up and replicate user data with and without deduplication across the T3 WAN connection (15ms latency). Each FSCT user's home folder has 75 MB of data and changes approximately 9 MB per hour.

## Test results

We used the Microsoft File Server Capacity Tool (FSCT) to test a remote office/branch office scenario with and without deduplication. Although FSCT is currently a file system performance benchmark, we used it for remote replication assessment as it captures change rates for a heavily used file system. (For more information about FSCT, see the Workload section.) We first ran FSCT with 1,000 users at the remote office for 4 hours to create a baseline data set on the Dell EqualLogic PS4000E. In the ROBO data replication solution without deduplication, we backed up this baseline data on the remote office Dell PowerVault DL2100 and replicated to the central office Dell PowerVault DL2100 using CommVault Simpana backup software with Continuous Data Replication (CDR). To capture ROBO data protection performance in this scenario, we then restarted FSCT for a specified user count and ran backups at 1-hour increments; increasing the user count by 100 users every other hour. Thus, the amount of data this solution replicated in 1 hour was equal to the amount of data a given number of users changed in the hour preceding the backup and replication.

We repeated the test for the ROBO data replication with deduplication solution. In this scenario, instead of storing multiple copies of identical backed up data blocks, the CommVault Simpana backup software in the local Dell PowerVault DL2100 stored only one copy of duplicate data blocks. We then transmitted this reduced backup set across the WAN to the central office Dell PowerVault DL2100 for remote protection. As a result, this solution greatly reduced the backup storage space and bandwidth needs. In the rest of this section, we report the user and change rate results from our backup tests. We want to emphasize that the FSCT benchmark with the HomeFolders workload simulates user activity in a heavily used File Server and that the FSCT benchmark results reported here may or may not reflect actual user activity at any given installation.

The ROBO data replication solutions with and without deduplication simulated the following scenario:

- a Dell PowerEdge R710 at the remote office for file sharing service
- a Dell EqualLogic PS4000E with RAID 10 at the remote office for primary storage

- a Dell PowerVault DL2100 at the remote office for local backup and deduplication
- a Dell PowerVault DL2100 at the central office for off-site data protection

We tested this scenario with deduplication enabled as well as disabled with user counts ranging from 600 to 1,000. Figures 4 and 5 show the complete results. We determined that the solution without deduplication can support approximately 700 FSCT HomeFolders users or it can back up and remotely replicate approximately 6.27 GB of changes every hour. For the same scenario, we again measured the change rate for 600 to 1,000 users – this time with deduplication enabled. We then assumed a linear progression and used the 1,000-user test results (27:31 minute replication time/8.82GB user change rate) to extrapolate the amount of users supported in less than 1 hour. Using the extrapolated numbers, we determined the maximum number of users supported to be approximately 2,100 with 18.52 GB of changed data.

<b>Dell EqualLogic PS4000E and Dell PowerVault DL2100 <i>without deduplication</i></b>			
<b>Number of users</b>	<b>Replication time (MM:SS)</b>	<b>User change rate (GB)</b>	<b>Data transmitted over WAN (GB)</b>
600	51:32	5.31	5.40
<b>700</b>	<b>56:14</b>	<b>6.27</b>	<b>6.38</b>
800	61:39	6.95	7.06
900	65:41	7.49	7.61
1,000	77:45	9.14	9.28

Figure 4: Microsoft FSCT results for varying user counts in the data replication scenario.

<b>Dell EqualLogic PS4000E and Dell PowerVault DL2100 <i>using deduplication</i></b>			
<b>Number of users</b>	<b>Replication time (MM:SS)</b>	<b>User change rate (GB)</b>	<b>Data transmitted over WAN (GB)</b>
600	19:47	5.23	0.63
700	22:02	6.36	0.68
800	23:03	7.18	0.74
900	24:00	7.69	0.83
1,000	27:31	8.82	0.92
...	...	...	...
<b>2,100*</b>	<b>57:47*</b>	<b>18.52*</b>	<b>1.93*</b>
2,200*	60:32*	19.40*	2.02*

Figure 5: Microsoft FSCT results for varying user counts in the data deduplication scenario. *\*We extrapolated these entries based on test bed behavior and results from lower user counts.*

## Workload

### File Server Capacity Tool (FSCT)

FSCT tests file server capacity and helps identify performance bottlenecks. Microsoft is currently developing FSCT and has released version 1.0.

FSCT simulates different file-service workloads in the following ways:

- By focusing on native application and OS behavior, with an emphasis on Microsoft applications (e.g., Microsoft Office applications, Windows Explorer) and Win32 applications (e.g., command line operations)
- By using pre-configured workload test scenarios, which simulate multiple requests from multiple users for server files
- By running multiple sessions per physical client, which allows a single client computer to perform the workload of multiple simulated clients

FSCT primarily reports the throughput and total number of users the server under test supported without reaching an overload condition. To ensure that the proper amount of changes occurred during each test, we monitored the

overload reported by FSCT to make sure that it was less than 1 percent at all times. FSCT also provides performance information such as latency; OS performance counters, including server CPU utilization; and network capacity. FSCT reports the errors the test client received, and provides such tracing information as Event Tracing for Windows.

FSCT comes with a standard workload, the HomeFolders workload. We ran that workload to simulate typical ROBO data change rates on a file server the user has assigned to store his or her home directory. The HomeFolders workload simulates 12 user scenarios that exercise common Microsoft applications. The initial data set created by the HomeFolders workload contains approximately 75 MB of randomly generated data per user. During the test run, this data changes approximately 9 MB per hour. The workload divides the data set into three main folders: static, new, and volatile. The new folder contains files FSCT uploaded to the user’s home folder directory during the test run. The volatile folder contains files FSCT deleted or edited and the static folder contains files that are either unchanged or only copied from the server to the client.

Figure 6 shows the different operations performed by the HomeFolders workload and each operation’s hourly frequency on a per-user basis.

Microsoft FSCT HomeFolders workload operations		
Scenario	Runs per user per hour	File set
CmdLineNavigate	15	static_dirs.xml
CmdLineFileDownload	150	static.xml
CmdLineFileUpload	40	new.xml
CmdLineFileDelete	7	volatile.xml
ExplorerNavigate	15	static_dirs.xml
ExplorerDragDropFileDownload	50	static.xml
ExplorerDragDropFileUpload	15	new.xml
ExplorerFileDelete	5	volatile.xml
ExplorerSelect	15	static.xml
WordFileOpen	7	static.xml
WordFileClose	7	static.xml
WordEditAndSave	5	volatile.xml

Figure 6: The operations performed by each Microsoft FSCT user in 1 hour.

FSCT requires a minimum of three computers to perform the roles of server, clients, and controller. The server machine is the system under test; the client machine(s) simulate multiple users who are running the HomeFolders workload on the server; and the controller machine coordinates the client work, captures performance counters, and gathers the workload results.

You can find more information about FSCT at the blog of Jose Barreto, Principal Program Manager with the Microsoft File Server Foundation team: <http://blogs.technet.com/filecab/archive/2009/09/16/file-server-capacity-tool-fsct-1-0-available-for-download.aspx>.

The End User License Agreement for Microsoft’s FSCT tool requires that the following text accompany all results: “These test results were generated by Principled Technologies, Inc. using the Microsoft File Server Capacity Tool. Test results generated with this software tool may not be accurate or appropriate for your needs and should not be relied upon as your sole reference. Microsoft makes no warranties of any kind, express or implied, about this tool, or any information or materials provided with this tool, including any results generated by this tool.”

## Test configuration

### Storage settings

- One Dell EqualLogic PS4000E array
- RAID 10 (with two spares)
- One 1TB volume

### Storage network settings

- One Dell PowerConnect™ 6248 network switch
- Jumbo frames enabled (on NICs and all ports on the switch)
- Flow control enabled
- IP routing enabled
- Spanning tree set to rapid spanning tree protocol (RSTP)
- Link layer discovery protocol (LLDP) disabled

### SAN and client network connections

- Dell EqualLogic PS4000E array
  - Two 1Gb iSCSI connections to the Dell PowerConnect 6248
  - Dell PowerConnect 6248 used for the remote office storage network
- Dell PowerVault DL2100 at remote office
  - Two 1Gb connections to local storage network
- Dell PowerVault D2100 at central office
  - One 1Gb connection to remote office through WAN emulator (constrained to T3 bandwidth with 15ms latency)
- Test servers (load-generating systems)
  - Two 1Gb connections per server (16 total) connected to the Dell PowerConnect 5448
  - Dell PowerConnect 5448 used for client-server network
  - Dell PowerConnect 5448 used for client-controller network

### WAN emulator

- Dell PowerEdge 2950
  - FreeBSD 8.0
  - Compiled with ipfw and dumynet
  - Use the following command line settings to restrict the bandwidth and add delay:
    - `ipfw add 1000 pipe 1 ip from any to any`
    - `ipfw pipe 1 config delay 3ms bw 45813Kbit`
      - Note: ipfw 3ms delay results in 15ms actual latency.

### FSCT load-generating clients

- Eight Dell PowerEdge servers
  - Windows Server 2008 R2 Enterprise x64
  - Total of 96 physical cores (Intel Xeon)
  - 1 x Dual Port Broadcom BCM5708C integrated network adapter
    - One port for client-server traffic
    - One port for client-controller traffic

Figure 7 illustrates our Dell PowerVault DL2100 WAN test bed.

## Dell PowerVault DL2100 WAN test bed

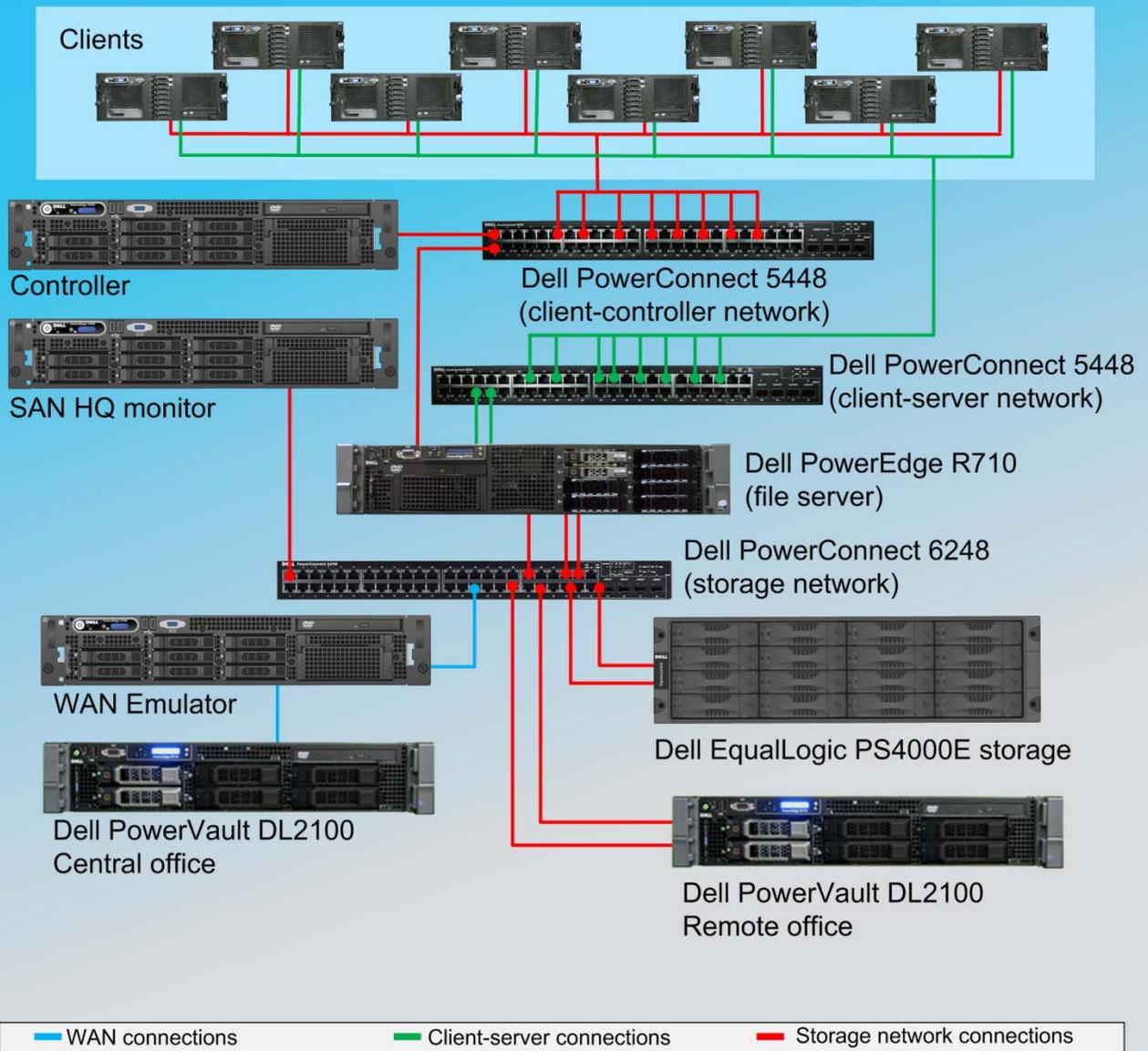


Figure 7: Dell PowerVault DL2100 WAN test bed.

## Test methodology

### Setting up and configuring the Dell PowerVault DL2100 and the Dell EqualLogic PS4000E storage

The Dell EqualLogic PS4000E array contained sixteen 500GB 7,200RPM SATA drives. We connected the Dell EqualLogic PS4000E array to a Dell PowerConnect 6248 storage switch via its two available data ports and we connected the Dell PowerEdge R710 to the switch via two Broadcom BCM5709C NIC ports. We configured the Dell EqualLogic PS4000E array in RAID 10 mode. We used the Microsoft iSCSI initiator with the Dell EqualLogic DSM and the Dell EqualLogic Host Integration Toolkit v3.2.0 to connect to the Dell EqualLogic PS4000E to the file server.

#### Setting up the external storage

1. Using the command line, set up a storage group with the following RAID policy:
  - PS4000E-1: RAID-10
2. Create a storage pool that you name `PS4000-1` with the following members:
  - PS4000E-1
3. Enable all network connections on the Dell EqualLogic PS4000E using the following IP address scheme:
  - IP Address: `192.168.1.##` (## being any number between 10 and 40)
  - Subnet Mask: `255.255.248.0`
4. Create a 1024GB volume
5. Enable shared access to the iSCSI target from multiple initiators on the volumes.
6. Create an access control record for the volumes without specifying any limitations.
7. Create a read-only SNMP community name to use for group monitoring.

### Installing and configuring the server

To set up this server, we installed several software components. The following subsections detail the necessary installation processes.

#### Setting up the operating system

1. Boot up the Dell PowerEdge R710 server.
2. Log in using the proper username and password.
3. Click Start, Control Panel, and double-click System.
4. Click Change Settings.
5. Click Change.
6. Enter a new computer name, and click OK.
7. Click OK, click Close, and click Restart Now.
8. Right-click the desktop, and select Personalize.
9. Click the Screen Saver link.
10. Click the Screen saver drop-down menu, and select (None).
11. Click Apply.
12. Click Change power settings.
13. Under Balanced plan, click Change plan settings.
14. From the Turn off monitor drop-down menu, select Never.
15. Click Save changes, and close the Power Options, Screen Saver Settings, and Personalization windows.
16. Open the Start menu, type `regedit` in the search field, and press Enter.
17. To allow the server to automatically log into the OS after a system reboot, change the following Registry key to have the values shown here:

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon]
DefaultPassword=Password1
AutoAdminLogon=1
```

18. Restart the server.

### **Installing the EqualLogic Host Integration Toolkit**

1. Download the EqualLogic Host Integration Toolkit v3.2.0 from the EqualLogic support Web site.
2. Run Setup64.exe.
3. Click Next.
4. Accept the license agreement, and click Next.
5. Click Next.
6. Click Yes.
7. Click Yes.
8. Click Yes.
9. Click OK.
10. Click OK.
11. Click OK.
12. Click Install.
13. Click OK.
14. Uncheck Launch Remote Setup Wizard, and click Finish.
15. Click OK.

### **Setting up the network adapters**

1. Click Start→Control Panel.
2. Double-click Network and Sharing Center.
3. Click Manage Network Connections.
4. Right-click the NIC connected to your Server-Controller network, and select Properties.
5. Click Internet Protocol Version 4 (TCP/IPv4), and select Properties.
6. Select Use the following IP address.
7. Type 192.168.10.200 for the IP address.
8. Type 255.255.255.0 for the Subnet mask.
9. Click OK.
10. Click Close.
11. Right-click the first NIC connected to your SAN, and select Properties.
12. Click Internet Protocol Version 4 (TCP/IPv4), and select Properties.
13. Select Use the following IP address.
14. Type 192.168.2.5 for the IP address.
15. Type 255.255.255.0 for the Subnet mask.
16. Click OK.
17. Click Close.
18. Right-click the second NIC connected to your SAN, and select Properties.
19. Click Internet Protocol Version 4 (TCP/IPv4), and select Properties.
20. Select Use the following IP address.
21. Type 192.168.2.6 for the IP address.
22. Type 255.255.255.0 for the Subnet mask.
23. Click OK.
24. Click Close.
25. Right-click the first NIC connected to your Client-Server Network, and select Properties.
26. Click Internet Protocol Version 4 (TCP/IPv4), and select Properties.
27. Select Use the following IP address.
28. Type 192.168.20.201 for the IP address.
29. Type 255.255.255.0 for the Subnet mask.
30. Click OK.

31. Click Close.
32. Right-click the second NIC connected to your Client-Server Network, and select Properties.
33. Click Internet Protocol Version 4 (TCP/IPv4), and select Properties.
34. Select Use the following IP address.
35. Type 192.168.20.202 for the IP address.
36. Type 255.255.255.0 for the Subnet mask.
37. Click OK.
38. Click Close.

### **Connecting the storage to the server**

1. Click Start→Control Panel.
2. Double-click Device Manager.
3. Expand Network Adapters.
4. Double-click the first NIC connected to your SAN.
5. Select the Advanced tab.
6. Click Flow Control.
7. Set the value to Rx and Tx Enabled.
8. Click Jumbo Packet.
9. Set the Value to 9,014 bytes.
10. Click OK.
11. Repeat steps 4 through 10 for the second NIC.
12. Click Start→Administrative Tools→iSCSI Initiator.
13. Select the Discovery tab.
14. Click Add Portal...
15. Type 192.168.2.200 and click OK.
16. Select the Targets tab.
17. Select the first inactive target, and click Log On...
18. Check the Automatically restore this connection when the computer starts checkbox.
19. Click OK.
20. Repeat Steps 18 through 20 three more times, for a total of four times.
21. Click Start→Administrative Tools→Server Manager.
22. Expand the Storage menu option.
23. Click Disk Management.
24. Click OK.
25. Right-click the first Unallocated partition, and select New Simple Volume.
26. Click Next.
27. Enter half of the volume size in MB, and click Next.
28. Click Next.
29. Check Perform a quick format, and click Next.
30. Click Finish.
31. Repeat steps 25 through 30 once.

### **Installing FSCT 1.0**

1. Copy the x64 FSCT ZIP file to the desktop of the server.
2. Unzip the FSCT ZIP file into C:\FSCT. Create the folder if it does not already exist.
3. Delete the ZIP file from the desktop, and empty the recycle bin.

## Installing and configuring CommVault Simpana 8.0

We configured the CommVault Simpana backup software by following the documentation available online from CommVault. For detailed setup instructions and best practices, please refer to CommVault's online documentation at [http://documentation.commvault.com/commvault/release\\_8\\_0\\_0/books\\_online\\_1/default.htm](http://documentation.commvault.com/commvault/release_8_0_0/books_online_1/default.htm).

We performed the following steps to create our ROBO data replication scenario:

1. Perform the initial setup on the Dell PowerVault DL2100s using the default settings (RAID 5).
2. Using the installation CDs provided with the Dell PowerVault DL2100, install the following software on the systems:
  - Dell PowerVault DL2100-1 (central office): Continuous Data Replicator and CommServe Master Server
  - Dell PowerVault DL2100-2 (branch office): Continuous Data Replicator and File System iDataAgent
  - Dell PowerEdge R710 (file server): File System iDataAgent
3. Create a Replica Magnetic Library on the DL2100-2 with replication enabled.
4. Create a storage policy with deduplication enabled. Set DL2100-2 as the MediaAgent, and set the Replica Magnetic Library as the Primary Storage Library. For the best deduplication performance, follow the best practices provided online by Dell at <http://www.dell.com/downloads/global/products/pvaul/en/storage-dl2100-commvault-dedupe.pdf>.
5. Create an identical storage policy as the deduplication storage policy but with deduplication disabled.
6. Create a replication set with the DL2100-2 Replica Magnetic Library as the source and the DL2100-1 as the destination host. Note: We used the CDR "remote backup" option in order to be able to have the ability to start and stop the replication to more accurately measure the time taken to perform the replication.

## Installing and configuring the clients

We cabled the Dell PowerEdge R710 to the client network switch via two Broadcom BCM5709C NIC ports.

### Installing the operating system

1. Insert the installation DVD for Windows Server 2008 R2 Enterprise x64 into the DVD drive.
2. Choose the language, time and currency, and keyboard input. Click Next.
3. Click Install Now.
4. Choose Windows Server 2008 R2 Enterprise (Full Installation). Click Next.
5. Accept the license terms, and click Next.
6. Click Custom.
7. Click the disk, and click Drive options (advanced).
8. Click New, Apply, Format, and click Next.
9. Let the installation process continue. The server will reboot several times.
10. After the installation completes, click OK to set the Administrator password.
11. Enter the administrator password twice, and click OK.
12. Click Start, Control Panel, and double-click System.
13. Click Change Settings.
14. Click Change.
15. Enter the new computer name, and click OK.
16. Click OK to restart, click Close, and click Restart Now.
17. Right-click the desktop, and select Personalize.
18. Click the Screen Saver link.
19. Click the Screen saver drop-down menu, and select (None).
20. Click Apply.
21. Click Change power settings.
22. Under Balanced plan, click Change plan settings.
23. From the Turn off monitor drop-down menu, select Never.
24. Click Save changes, and close the Power Options, Screen Saver Settings, and Personalization windows.
25. Open the Start menu, type `regedit` in the search field, and press Enter.

26. To allow the server to automatically log into the OS after a system reboot, change the following Registry key to have the values shown here:

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon]
DefaultPassword=Password1
AutoAdminLogon=1
```

27. Restart the server.

### Setting up the network adapters

1. Click Start→Control Panel.
2. Double-click Network and Sharing Center.
3. Click Manage Network Connections.
4. Right-click the NIC connected to your Client-Controller network, and select Properties.
5. Click Internet Protocol Version 4 (TCP/IPv4), and select Properties.
6. Select Use the following IP address.
7. Type 192.168.10.10# for the IP address (# is the Client number).
8. Type 255.255.255.0 for the Subnet mask.
9. Click OK.
10. Click Close.
11. Right-click the NIC connected to your Client-Server network, and select Properties.
12. Click Internet Protocol Version 4 (TCP/IPv4), and select Properties.
13. Select Use the following IP address.
14. Type 192.168.20.10# for the IP address (# is the Client number).
15. Type 255.255.255.0 for the Subnet mask.
16. Click OK.
17. Click Close.

### Installing FSCT

1. Copy the x64 FSCT ZIP file to the desktop of the server.
2. Unzip the FSCT ZIP file into C:\FSCT. Create the folder if it does not already exist.
3. Delete the ZIP file from the desktop, and empty the recycle bin.

### Installing and configuring the controller

#### Installing Windows Server 2008 R2 Enterprise x64

1. Insert the installation DVD for Windows Server 2008 R2 x64 into the DVD drive.
2. Choose the language, time and currency, and keyboard input. Click Next.
3. Click Install Now.
4. Choose Windows Server 2008 Enterprise R2 (Full Installation). Click Next.
5. Accept the license terms, and click Next.
6. Click Custom.
7. Click the disk, and click Drive options (advanced).
8. Click New, Apply, Format, and click Next.
9. Let the installation process continue. The server will reboot several times.
10. After the installation completes, click OK to set the Administrator password.
11. Enter the administrator password twice, and click OK.
12. Click Start, Control Panel, and double-click System.
13. Click Change Settings.
14. Click Change.
15. Enter the new computer name, and click OK.
16. Click OK to restart, click Close, and click Restart Now.
17. Right-click the desktop, and select Personalize.
18. Click the Screen Saver link.

19. Click the Screen saver drop-down menu, and select (None).
20. Click Apply.
21. Click Change power settings.
22. Under Balanced plan, click Change plan settings.
23. From the Turn off monitor drop-down menu, select Never.
24. Click Save changes, and close the Power Options, Screen Saver Settings, and Personalization windows.
25. Open the Start menu, type `regedit` in the search field, and press Enter.
26. To allow the server to automatically log into the OS after a system reboot, change the following Registry key to have the values shown here:

```
[HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon]
DefaultPassword=Password1
AutoAdminLogon=1
```

27. Restart the server.

### Setting up the network adapters

1. Click Start→Control Panel.
2. Double-click Network and Sharing Center.
3. Click Manage Network Connections.
4. Right-click the NIC connected to your Client-Controller network, and select Properties.
5. Click Internet Protocol Version 4 (TCP/IPv4), and select Properties.
6. Select Use the following IP address.
7. Type `192.168.10.60` for the IP address (# is the Client number).
8. Type `255.255.255.0` for the Subnet mask.
9. Click OK.
10. Click Close.

### Installing FSCT

1. Copy the x64 FSCT ZIP file to the desktop of the controller.
2. Unzip the FSCT ZIP file into `C:\FSCT`. Create the folder if it does not already exist.
3. Delete the ZIP file from the desktop, and empty the recycle bin.

## Preparing the systems for testing

### Preparing the server

1. Open an elevated command prompt on the server.
2. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
3. Type the following command line, replacing the variables with the relevant information for your test:  

```
prepare server /clients
client1,client2,client3,client4,client5,client6,client7,client8 /password
Password1 /users 125 /volumes E:,F: /workload HomeFolders
```

 Note: We used the HomeFolders workload for all tests.
4. When the server has finished the preparation, it is ready to begin the test.

### Preparing the clients

1. Open an elevated command prompt on each client.
2. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
3. Type the following command line, replacing the variables with the relevant information for your test:  

```
fsct
prepare client /server file-server /password Password1 /users 125 /server_ip
<server IP address> /workload HomeFolders
```
4. When the clients are finished with their user creation, they are ready to begin the test.

### Preparing the controller

1. Open an elevated command prompt.
2. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.

3. Type the following command line, replacing the variables with the relevant information for your test: `fsct prepare controller`
4. When the controller is finished and has closed the network, it is ready to begin.

### Preparing the Dell PowerVault D2100

1. Log into the CommVault Cell using the CommVault Explorer. Expand Client Computers→FSCT-file-server→File System and right-click defaultBackupSet.
2. Select All Tasks→New Subclient.
3. Name the Subclient `FSCT Data`.
4. Select the Content tab.
5. Enter `F:\` and press Enter.
6. Enter `G:\` and click OK.
7. Select the Storage Device tab.
8. For the Storage Policy, select DL2100-2 Replication Dedupe or DL2100-2 Replication non-Dedupe depending on the solution tested.
9. Click OK.
10. Select Do Not Schedule, and click OK.
11. Expand Client Computers→DL2100-2, and right-click Continuous Data Replicator.
12. Select Replication Set Creation Wizard, and click Next.
13. Select DL2100-2 as the source machine, and click Next.
14. Select DL2100-1 as the destination machine, and click Next.
15. Type `ROBO Replication` as the Replication Set name, and click Next.
16. Type `C:\DiskStorage\3\Replica` as the path to add and click Add.
17. Click Next.
18. Type `C:\DiskStorage\2` as the Common Base Folder and Destination Path.
19. Click Next.
20. Click Finish
21. Right-click ROBO Replication, and select Remote Backup.
22. Click OK.
23. Click OK.

### Creating the initial FSCT user data

1. Open an elevated command prompt on each of the clients.
2. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
3. Type the following command line, replacing the variables with the relevant information for your test: `fsct run client /controller controller /server file-server /password Password1`
4. The test will begin when the controller starts.
5. Open an elevated command prompt on the controller.
6. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
7. Type the following in the command line to run all 1,000 users for 4 hours: `fsct run controller /server file-server /password Password1 /volumes E:,F: /clients client1,client2,client3,client4,client5,client6,client7,client8 /min_users 1000 /max_users 1000 /step 0 /duration 14400 /workload HomeFolders`
8. After the run has finished, log into the CommVault Cell using the CommVault Explorer. Expand Client Computers→FSCT-file-server→File System, and click defaultBackupSet.
9. Right-click the FSCT Data subclient, and select Backup.
10. Select Full backup, and select Run Immediately.
11. Click OK.
12. After the full backup is complete, log into the CommVault Cell, expand Client Computers > DL2100-2, and right-click Continuous Data Replicator.
13. Select Replication Set Creation Wizard, and click Next.
14. Select DL2100-2 as the source machine, and click Next.
15. Select DL2100-1 as the destination machine and click Next.
16. Type `ROBO Replication` as the Replication Set name, and click Next.
17. Type `C:\DiskStorage\3\Replica` as the path to add, and click Add.

18. Click Next.
19. Type `C:\DiskStorage\2` as the Common Base Folder and Destination Path.
20. Click Next.
21. Click Finish.
22. Right-click ROBO Replication, and select Remote Backup.
23. Click OK.
24. Click OK.
25. Right-click ROBO Replication, and select All Tasks→Backup.
26. Select Full backup type, and click OK.

## Running the test

1. After the full backups are finished, open an elevated command prompt on each of the clients.
2. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
3. Type the following command line, replacing the variables with the relevant information for your run: `fsct run client /controller controller /server file-server /password Password1`
4. The test will begin when the controller starts.
5. Open an elevated command prompt on the controller.
6. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
7. Type the following in the command line to 600 users for 1 hour: `fsct run controller /server file-server /password Password1 /volumes E:,F: /clients client1,client2,client3,client4,client5,client6,client7,client8 /min_users 600 /max_users 600 /step 0 /duration 3600 /workload HomeFolders`
8. After the run has finished, log into the CommVault Cell using the CommVault Explorer. Expand Client Computers→FSCT-file-server→File System, and click defaultBackupSet.
9. Right-click the FSCT Data Subclient, and select Backup.
10. On the controller, run the previous `fsct` command to start 600 users for 1 hour again.
11. Select incremental backup, and select Run Immediately.
12. Simultaneously click OK and start the timer.
13. Stop the timer when the status of the backup job is Completed.
14. Right-click ROBO Replication, and select All Tasks→Backup.
15. Select Incremental backup type, click OK, and start the timer.
16. Stop the timer when the status of the backup job is Completed.
17. After the 600 users have finished running, create an incremental backup of FSCT Data.
18. After the backup has finished, start the replication.
19. Repeat steps 1 through 18 and increase the number of users in increments of 100 by setting the `min_users` and `max_users` on the controller to 700, 800, 900, and 1,000.

## Running the FSCT cleanup scripts

When the test is finished, you will need to run the FSCT cleanup scripts before beginning the next test to delete the users, files, and directories from the machines.

### Cleaning up the clients

1. Open an elevated command prompt.
2. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
3. Type the following command line, replacing the variables with the relevant information for your run: `fsct cleanup client /users 125`
4. When the cleanup is finished, restart the client.

### Cleaning up the controller

1. Open an elevated command prompt.
2. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
3. Type the following command line replacing the variables with the relevant information for your run: `fsct cleanup controller /backup c:\results`
4. When the cleanup is finished, restart the client.

### **Cleaning up the server**

1. Open an elevated command prompt.
2. Navigate to the FSCT folder by typing `cd c:\FSCT` and pressing Enter.
3. Type the following command line replacing the variables with the relevant information for your run:  

```
fsc  
cleanup server /clients  
client1,client2,client3,client4,client5,client6,client7,client8 /users 125  
/volumes E:,F:
```
4. When the cleanup is finished, restart the server.

## Appendix A –Test client information

### Client 1

- Dell PowerEdge 2950
- 2 x Intel Xeon E5405 (2.00 GHz)
- 8 x 2,048 MB Samsung PC2-5300 FB-DDR2 (16,384 MB), 1,333 FSB
- Dell BIOS 2.5.0 (09/12/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- ipmi 1.06, Driver- Broadcom 3.7.19.0 (1/19/2008)
- 1 x SATA Western Digital WD800AAJS, 80 GB, 7.2K, 3 Gb/s, Firmware- SM04, Intel 6321ESB Control Device driver- Microsoft 6.0.6001.18000 (6/21/2006)
- Microsoft Windows Server 2008 R2 x64

### Client 2

- Dell PowerEdge 2950
- 2 x Intel Xeon E5405 (2.00 GHz)
- 8 x 2,048 MB Samsung PC2-5300 FB-DDR2 (16,384 MB), 1,333 FSB
- Dell BIOS 2.5.0 (09/12/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- ipmi 1.06, Driver- Broadcom 3.7.19.0 (1/19/2008)
- 1 x SATA Western Digital WD800AAJS, 80 GB, 7.2K, 3 Gb/s, Firmware- SM04, Intel 6321ESB Control Device driver- Microsoft 6.0.6001.18000 (6/21/2006)
- Microsoft Windows Server 2008 R2 x64

### Client 3

- Dell PowerEdge 2950
- 2 x Intel Xeon E5405 (2.00 GHz)
- 8 x 2,048 MB Samsung PC2-5300 FB-DDR2 (16,384 MB), 1,333 FSB
- Dell BIOS 2.5.0 (09/12/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- ipmi 1.06, Driver- Broadcom 3.7.19.0 (1/19/2008)
- 1 x SATA Western Digital WD800AAJS, 80 GB, 7.2K, 3 Gb/s, Firmware- SM04, Intel 6321ESB Control Device driver- Microsoft 6.0.6001.18000 (6/21/2006)
- Microsoft Windows Server 2008 R2 x64

### Client 4

- Dell PowerEdge 2950
- 2 x Intel Xeon E5405 (2.00 GHz)
- 8 x 2,048 MB Samsung PC2-5300 FB-DDR2 (16,384 MB), 1,333 FSB
- Dell BIOS 2.5.0 (09/12/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- ipmi 1.06, Driver- Broadcom 3.7.19.0 (1/19/2008)
- 1 x SATA Western Digital WD800AAJS, 80 GB, 7.2K, 3Gb/s, Firmware- SM04, Intel 6321ESB Control Device driver- Microsoft 6.0.6001.18000 (6/21/2006)
- Microsoft Windows Server 2008 R2 x64

### Client 5

- Dell PowerEdge R900
- 4 x Intel Quad-Core Xeon E7340 (2.40 GHz)
- 16 x 4,096 MB FB-DDR2 (65530 MB), 1,066 FSB
- Dell BIOS 1.1.10 (11/14/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- UMP 1.1.9, Driver- Broadcom 3.7.19.0 (1/19/2008)

- 2 x SAS Seagate Savvio ST973451SS, 73 GB, 15K, 3 Gb/s, Firmware- SM04, Dell PERC 6/i Integrated RAID Control Device driver- LSI 2.13.0.64 (5/11/2007)
- Microsoft Windows Server 2008 R2 x64

#### Client 6

- Dell PowerEdge R900
- 4 x Intel Xeon E7450 6-Core (2.40 GHz)
- 32 x 2,048 MB FB-DDR2 (65,530 MB), 1,066 FSB
- Dell BIOS 1.1.9 (8/1/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- UMP 1.1.9, Driver- Broadcom 3.7.19.0 (1/19/2008)
- 2 x SAS Seagate Savvio ST973451SS, 73 GB, 15K, 3,Gb/s, Firmware- SM04, Dell PERC 6/i Integrated RAID Control Device driver- LSI 2.13.0.64 (5/11/2007)
- Microsoft Windows Server 2008 R2 x64

#### Client 7

- Dell PowerEdge R900
- 4 x Intel Quad-Core Xeon E7340 (2.40 GHz)
- 16 x 4,096 MB FB-DDR2 (65530 MB), 1,066 FSB
- Dell BIOS 1.1.10 (11/14/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- ipmi 1.06, Driver- Broadcom 3.7.19.0 (1/19/2008)
- 2 x SAS Seagate Savvio ST973451SS, 73 GB, 15K, 3 Gb/s, Firmware- SM04, Dell PERC 6/i Integrated RAID Control Device driver- LSI 2.13.0.64 (5/11/2007)
- Microsoft Windows Server 2008 R2 x64

#### Client 8

- Dell PowerEdge 2950
- 2 x Intel Quad-Core Xeon E5440 (2.83 GHz)
- 8 x 4,096 MB FB-DDR2 (32,768 MB), 1,333 FSB
- Dell BIOS 2.2.6 (2/5/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- ipmi 1.06, Driver- Broadcom 3.7.19.0 (1/19/2008)
- 2 x SAS 73 GB, 15K, 3 Gb/s, Firmware- SM04, Dell PERC 6/i Integrated RAID Control Device driver- LSI 2.13.0.64 (5/11/2007)
- Microsoft Windows Server 2008 R2 x64

#### Controller

- Dell PowerEdge 2950
- 2 x Intel Quad-Core Xeon E5440 (2.83 GHz)
- 8 x 4,096 MB FB-DDR2 (32,768 MB), 1,333 FSB
- Dell BIOS 2.2.6 (2/5/2008)
- 1 x BCM5708C - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- ipmi 1.06, Driver- Broadcom 3.7.19.0 (1/19/2008)
- 2 x SAS 73 GB, 15K, 3 Gb/s, Firmware- SM04, Dell PERC 6/i Integrated RAID Control Device driver- LSI 2.13.0.64 (5/11/2007)
- Microsoft Windows Server 2008 R2 x64

## Appendix B – Test server information

Figure 8 presents detailed information for the test servers we used in this report.

Servers	Dell PowerEdge R710	Two Dell PowerVault DL2100
<b>General dimension information</b>		
Height (inches)	3.50	3.50
Width (inches)	17.50	17.50
Depth (inches)	27.00	27.00
U size in server rack (U)	2	2
<b>Power supplies</b>		
Total number	1	2
Brand and model	Dell OPT164	Dell A870P-00
Wattage (W)	870	870
<b>Cooling fans</b>		
Total number	5	5
Dimensions (h x w)	2.5" x 2.5"	2.5" x 2.5"
Voltage (V)	12	12
Amps (A)	1.50	1.68
<b>General processor setup</b>		
Number of processor packages	2	2
Number of cores per processor package	4	4
Number of hardware threads per core	2	2
System power management policy	Balanced	Balanced
<b>CPU</b>		
Vendor	Intel	Intel
Name	Xeon X5570	Xeon E5520
Stepping	D0	D0
Socket type	LGA1366	LGA1366
Core frequency (GHz)	2.93	2.27
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	1 MB (4 x 256 KB)	1 MB (4 x 256 KB)
L3 cache (MB)	8	8
<b>Platform</b>		
Vendor and model number	Dell PowerEdge R710	Dell PowerVault DL2100
Motherboard model number	0M233H	0YDJK3
Motherboard revision number	13	13
BIOS name and version	Dell 1.2.6 (07/17/2009)	Dell 1.2.6 (07/17/2009)
<b>Memory modules</b>		
<b>Memory type 1</b>		
Total RAM in system (GB)	48	24

<b>Servers</b>	<b>Dell PowerEdge R710</b>	<b>Two Dell PowerVault DL2100</b>
Vendor and model number	Samsung M393B5170DZ1-CH9 Micron MT36JSZF51272PY-1G4D1AB	Samsung M391B5673EH1-CH9
Type	PC3-10600 DDR3	PC3-8500 DDR3
Speed (MHz)	1,333	1,066
Speed in the system currently running @ (MHz)	1,333	1,066
Timing/latency (tCL-tRCD-iRP-tRASmin)	9-9-9-24	7-7-7-20
Size (GB)	24	24
Number of RAM modules	6 x 4 GB	12 x 2 GB
Chip organization	Double-sided	Double-sided
<b>Memory type 2</b>		
Vendor and model number	Micron MT36JSZF51272PY-1G4D1AB	N/A
Type	PC3-10600 DDR3	N/A
Speed (MHz)	1,333	N/A
Speed in the system currently running @ (MHz)	1,333	N/A
Timing/latency (tCL-tRCD-iRP-tRASmin)	9-9-9-24	N/A
Size (GB)	24	N/A
Number of RAM modules	6 x 4 GB	N/A
Chip organization	Double-sided	N/A
<b>Hard disk</b>		
Vendor and model number	Fujitsu MBC2073RC	Western Digital WD2502ABYS-18B7A0
Number of disks in system	2	2
Size (GB)	73	250
Buffer size (MB)	16	16
RPM	15,000	7,200
Type	SAS	SATA
Controller	Dell PERC 6/i Integrated RAID Controller	Dell PERC 6/e Integrated RAID Controller Dell 6/iR Integrated Controller
Driver version	LSI 4.5.0.64 (02/06/2009)	Dell 2.24.0.64 (01/19/2009) Dell 1.28.3.1 (07/29/2008)
<b>Operating system</b>		
Name	Windows Server 2008 R2 Enterprise	Windows Server 2008 SP2 Enterprise
Build number	7600	6002
File system	NTFS	NTFS
Language	English	English

<b>Servers</b>	<b>Dell PowerEdge R710</b>	<b>Two Dell PowerVault DL2100</b>
<b>Network card/subsystem</b>		
Vendor and model number	Broadcom BCM5709C NetXtreme II Intel PRO1000	Broadcom BCM5709C NetXtreme II Intel PRO1000 ET Quad Port LP Server Adapter
Type	Integrated/PCI-E	Integrated/PCI-E
Driver version	Broadcom 5.0.13.0 (07/30/2009) Intel 11.1.6.0 (07/13/2009)	Broadcom 5.0.13.0 (07/30/2009) Intel 11.1.6.0 (07/13/2009)
<b>Optical drive</b>		
Vendor and model number	TEAC DV28SV DVD-ROM	PLDS DVD+-RW DS-8A3S
<b>USB ports</b>		
Number	4	4
Type	2.0	2.0
<b>External storage</b>		
Vendor and model number	Dell EqualLogic PS4000E	Dell PowerVault MD1000
Hard disk Vendor and model number	Seagate ST3500320NS	Western Digital WD5002ABYS
Number of disks in storage	16	8
Size (GB)	500	500
Buffer size (MB)	16	16
RPM	7,200	7,200
Type	SATA	SATA

Figure 8: Detailed system configuration information for the two test servers.

## Appendix C –Test storage information

Figure 9 provides detailed configuration information about the storage array system.

Storage array	Dell EqualLogic iSCSI SAN
Arrays	One Dell EqualLogic PS4000E array
Disks	16 x 7,200RPM SATA disks
Active storage cache (GB)	2
Firmware revision	v4.2.1
Switch type/model/firmware revision	One Dell PowerConnect 6248 v2.2.0.1
Disk vendor and model number	Seagate ST3500320NS
Disk size (GB)	500
Disk buffer size (MB)	16

Figure 9: Detailed configuration information for the storage array system.

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