Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization

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) using the Blue Coat® WAN Optimization solution. We selected Blue Coat ProxySG Hardware Appliances for the high data change rate remote offices and the Blue Coat ProxySG Virtual Appliances for the low data change rate offices. The results for a 1-hour RPO scenario are as follows:

- **A Blue Coat ProxySG 510 Hardware Appliance can enhance Dell™ PowerVault™ DL2100 data replication performance up to 5 times.**
- **A Blue Coat ProxySG Virtual Appliance can enhance Dell EqualLogic™ SAN data replication performance up to 3 times.**

We used the Microsoft® File Server Capacity Tool (FSCT) with the HomeFolders workload to simulate typical ROBO data change rates of heavy users in two independent test cases: high change rate scenario and low change rate scenario.

Case 1: High change rate scenario. In the high change rate scenario (SAN-to-SAN backup with Dell PowerVault DL2100 and Blue Coat Appliances-based Acceleration Solution), intended for remote offices with medium to large data change rate, we used a combination of Dell PowerVault DL2100s and Dell EqualLogic SANs, with and without Blue Coat's appliance-based WAN acceleration solution. We installed ProxySG appliances inline, which enhance the performance of the data replication between the two Dell PowerVault DL2100s over the WAN.

5x more data change rate supported!

Dell PowerEdge R710

Dell EqualLogic PS4000   Dell PowerVault DL2100   Blue Coat ProxySG 510   Blue Coat ProxySG 510   Dell PowerVault DL2100

Figure 1: The high change rate scenario we tested. We used a 5Mbps effective WAN bandwidth with a 40ms round-trip latency.

KEY FINDINGS

- The high change rate solution comprising the Dell EqualLogic PS4000 and Dell PowerVault DL2100 at the remote office, and the Dell PowerVault DL2100 at the central management site, remotely protected an hourly change rate of up to *1.75 GB natively* and *9.19 GB with the Blue Coat ProxySG 510 Hardware Appliance* across the WAN, providing a 1-hour RPO to a heavily accessed file server.

- The low change rate solution comprising the Dell EqualLogic PS4000 at the remote office and Dell EqualLogic PS6000 at the central office remotely protected an hourly change rate of up to *1.85 GB natively* and *6.07 GB with the Blue Coat ProxySG Virtual Appliance* across the WAN, providing a 1-hour recovery point objective (RPO) to a heavily accessed file server.

Case 2: Low change rate scenario. In the low change rate scenario (SAN-to-SAN direct backup with Blue Coat Virtual Appliances-based Acceleration Solution), intended for remote offices with small to medium data change rates, we used Dell EqualLogic SANs, one each in the datacenter and remote office, with and without Blue Coat's Virtualized WAN acceleration solution.

Figure 2: The low change rate scenario (block transfer) we tested. We used a 5Mbps effective WAN bandwidth with a 40ms round-trip latency.

Dell PowerVault DL2100 replication solution for high change rates

As Figure 1 shows, we created the data replication/backup test bed by running the HomeFolders workload against a Dell PowerEdge™ R710 file server with a Dell EqualLogic PS4000 SAN array. A pair of Dell PowerVault DL2100 backup appliances powered by CommVault connected over a WAN protected the changed data at the file server. We set our WAN emulator to allow an effective 5Mbps bandwidth with 40ms round-trip latency. This scenario resembles a small- to medium-sized business with a ROBO with a high change rate that is seeking to control data sprawl and reduce backup costs by centralizing ROBO backup and implementing disk-to-disk (or disk-to-disk-to-tape) backup over the WAN. The company is using the appliances to automate and simplify the backup process to ensure consistent and reliable data backup. They are also sensitive to the high cost of WAN connections and only have limited bandwidth available. The solution uses the Blue Coat ProxySG WAN Optimization to overcome these WAN bandwidth limitations 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 using the CommVault Simpana® 8.0 File System iDataAgent, which creates a backup of the specified volumes' file system. It then replicates the backup data set across the WAN to a second "central office" Dell PowerVault DL2100 using the CommVault Simpana 8.0 Continuous Data Replication (CDR). The WAN Optimization feature of the Blue Coat ProxySG Hardware Appliance compresses the data inline to effectively increase the available throughput and significantly decrease the data transfer time over the WAN. The WAN Optimization technology allows the Blue Coat appliance, combined with the Dell PowerVault DL2100, to support a significantly greater change rate by reducing the size of the backup data set as it travels across the WAN; in this case, the solution with the Blue Coat Hardware Appliance supports over five times more data change rate than it does without the appliance.

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 their specific enterprise. The Dell PowerVault DL2100 solution requires 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 your company has a short RTO for your remote office backups, you have the option of scheduling local snapshots of your data using the Dell EqualLogic PS4000 Auto-Snapshot Manager/Microsoft Edition in tandem with the backup and replication provided by the Dell PowerVault DL2100 appliances. Alternatively, if RTO is the primary driver in the decision-making process, a Dell EqualLogic PS4000 paired with another Dell EqualLogic PS Series array in the central office may be sufficient to fulfill corporate needs.

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch
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Hourly ROBO data transfer over WAN supported (GB)
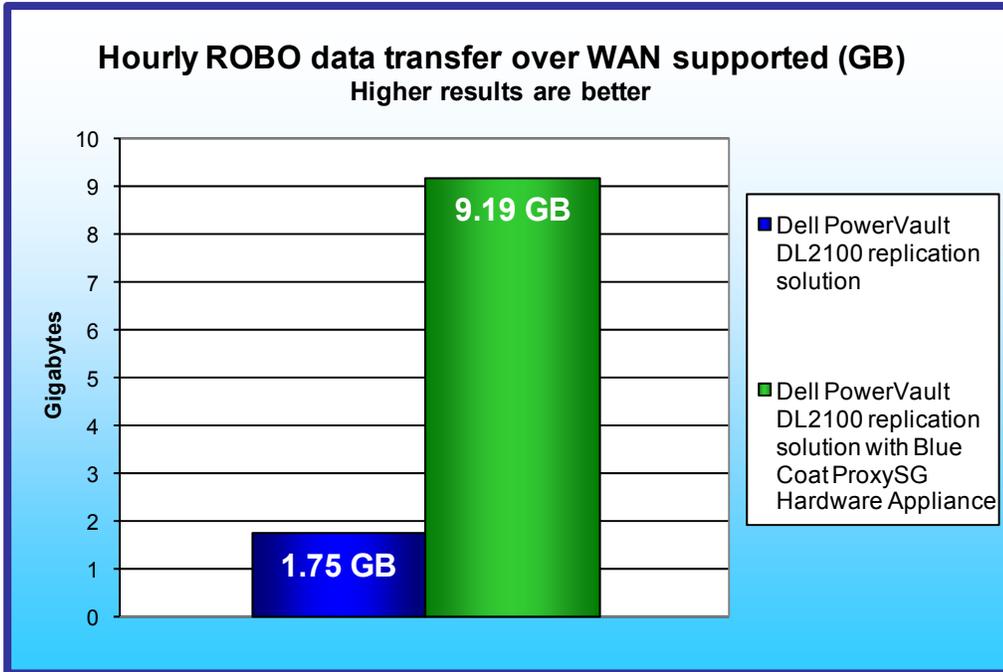### Higher results are better

Figure 3: Hourly ROBO data transfer over WAN supported by the Dell PowerVault DL2100 backup/replication solution with and without the Blue Coat ProxySG 510 WAN Optimization using the FSCT HomeFolders workload.

Time required to do full backup (40 GB)
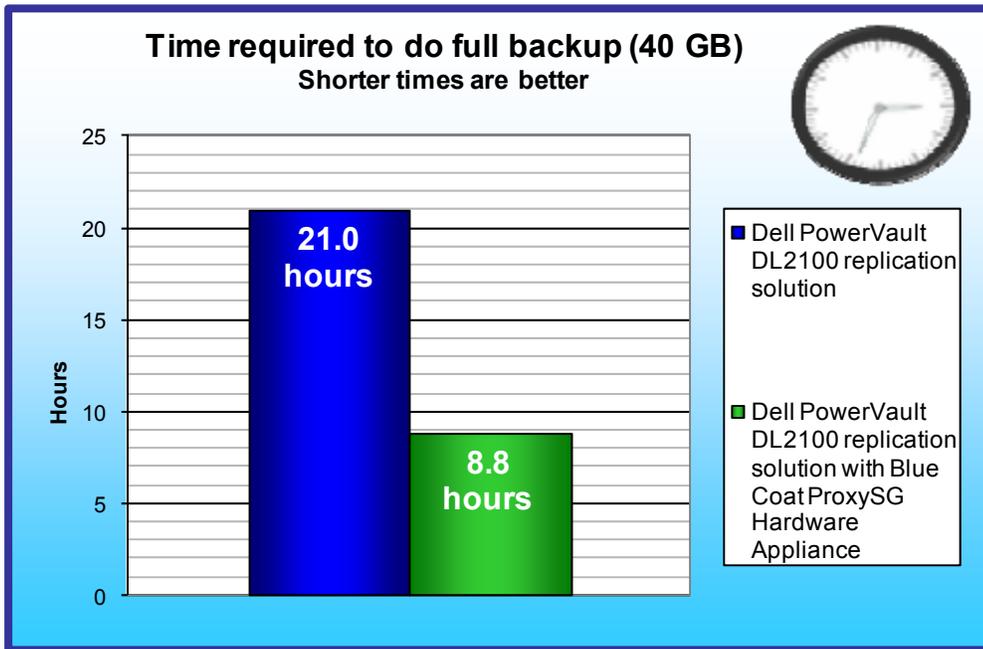### Shorter times are better

Figure 4: Time required to do the first full backup of 41 GB of data (500 FSCT Users) and replicate user data with and without the Blue Coat ProxySG 510 Hardware Appliance across the 5Mbps WAN connection (40ms latency). Each FSCT user's home folder has 75 MB of data.

Figure 3 shows the hourly change rate supported by the Dell PowerVault DL2100 in a ROBO replication scenario with a 5Mbps bandwidth and 40ms round-trip latency. Based on our workload, the Dell PowerVault DL2100 without WAN Optimization can support up to 1.75 GB of user changes in less than 1 hour and the Dell PowerVault DL2100 with the Blue Coat ProxySG 510 Hardware Appliance can support up to 9.19 GB of user changes in less than 1 hour.

The Blue Coat WAN Optimization technologies also reduced the time to complete the first full backup of the user data across the WAN. Figure 4 shows the time required to perform the full backup of 41 GB of data. The Dell PowerVault DL2100 using the Blue Coat ProxySG WAN Optimization significantly reduced the time required to transmit data across the WAN by utilizing WAN compression to reduce the size of the data sent over the WAN.

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization

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Dell EqualLogic PS Series replication solution for low change rates

As we show in Figure 2, we created the data replication/backup test bed by running the HomeFolders workload against a Dell PowerEdge R710 file server with a Dell EqualLogic PS4000 SAN array at the remote office. We also used a Dell EqualLogic PS6000 at the central office for off-site data protection. This scenario is typical of a medium-sized business with a ROBO with a low change rate. The company is using the SAN arrays to automate and simplify the backup process. The solution also uses the Blue Coat ProxySG Virtual Appliance WAN Optimization to overcome the WAN bandwidth constraints.

To start the replication process, the remote office Dell EqualLogic PS4000 creates a local snapshot of the storage volume, which is an instantaneous block-level copy of the company's specified volumes' data. It then replicates that snapshot across the WAN to the central office Dell EqualLogic PS6000. The WAN Optimization feature of the Blue Coat ProxySG compresses the data inline to effectively increase the available throughput and significantly decrease the transfer time over the WAN. The WAN Optimization technology allows the Blue Coat ProxySG Virtual Appliance, combined with the Dell EqualLogic PS series arrays, to support three times greater change rate by reducing the size of the data set as it travels across the WAN.

Note: With the Dell EqualLogic PS Series replication solution, your backup recovery time is nearly instantaneous as you can restore a snapshot or even mount a snapshot and access individual files needed at both the remote and central offices in a matter of seconds.

Figure 5 shows the hourly change rate supported by the Dell EqualLogic PS Series replication in a ROBO replication scenario with a 5Mbps bandwidth and 40ms round-trip latency. Based on our workload, the Dell EqualLogic PS replication without WAN Optimization can support up to 1.85 GB of user changes in less than 1 hour and the Dell EqualLogic PS Series replication with the Blue Coat ProxySG Virtual Appliance can support up to 6.07 GB of user changes in less than 1 hour.
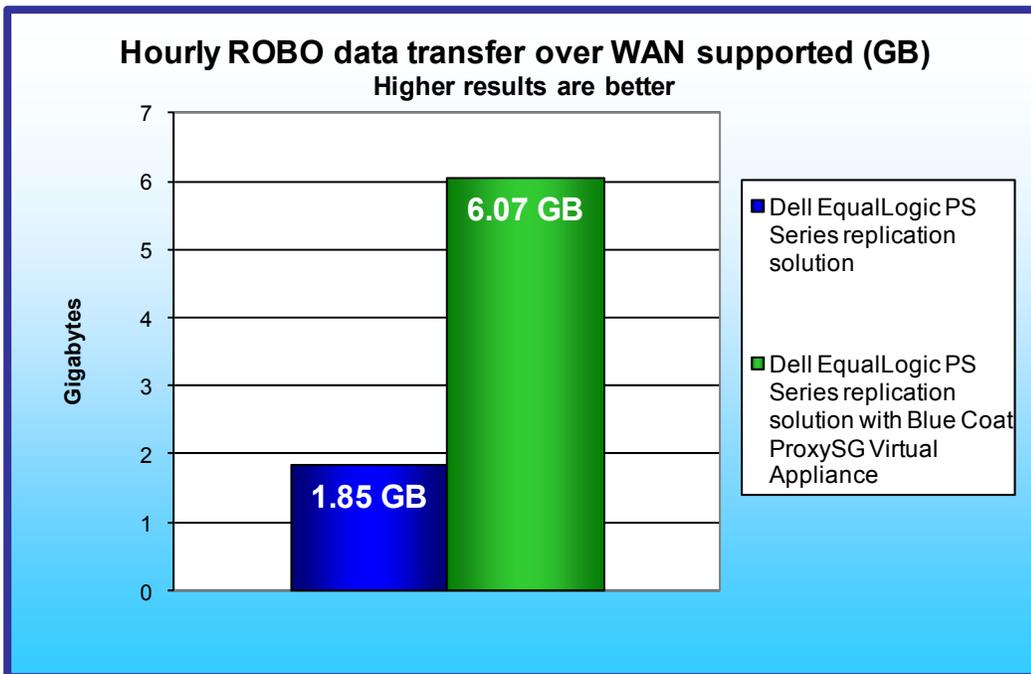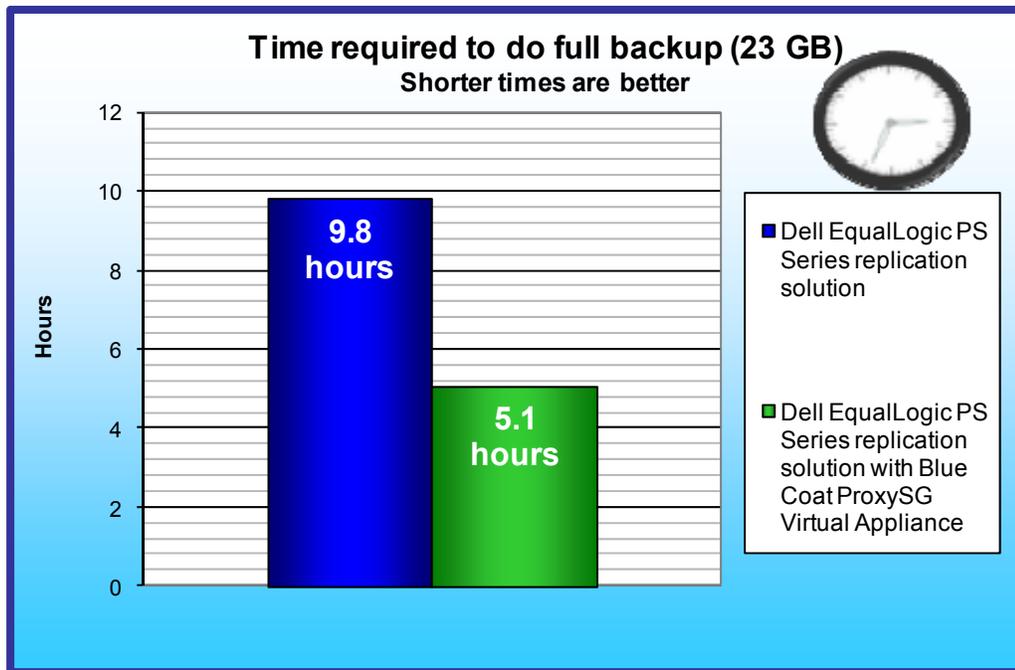
Figure 5: Hourly ROBO data transfer over WAN supported by the Dell EqualLogic PS Series replication solution with and without the Blue Coat ProxySG Virtual Appliance WAN Optimization with the FSCT HomeFolders workload.

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization

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Time required to do full backup (23 GB)
Shorter times are better

- Dell EqualLogic PS Series replication solution: 9.8 hours
- Dell EqualLogic PS Series replication solution with Blue Coat ProxySG Virtual Appliance: 5.1 hours

Figure 6: Time required to do the first full backup of 23 GB of data and replicate user data with and without the Blue Coat Proxy SG Virtual Appliance across the 5Mbps WAN connection (40ms latency). Each FSCT user's home folder has 75 MB of data.

Figure 6 shows the time required to perform the first full backup of 23 GB of data. The Dell EqualLogic PS Series replication solution using the Blue Coat ProxySG WAN Optimization significantly reduced the time required to transmit data across the WAN by utilizing WAN compression to reduce the size of the data sent over the WAN.

Test results

We used the Microsoft File Server Capacity Tool (FSCT) to test a remote office/branch office scenario with and without Blue Coat WAN Optimization. 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.)

Dell PowerVault DL2100 replication solution

We first ran FSCT with 500 users at the remote office for 4 hours to create a baseline data set on the Dell EqualLogic PS4000. In the ROBO data replication solution without WAN Optimization, 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. See Appendix B for the specifications of the Dell PowerVault DL2100 backup appliances.

To capture ROBO data protection performance in this scenario, we restarted FSCT for a specified user count and ran backups at 1-hour increments; increasing the user count 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 WAN Optimization enabled. In this scenario, Blue Coat ProxySG uses WAN Compression to reduce the size of the data as it travels across the WAN, which allows more total data to be transmitted in less time. We then transmitted this backup set across the WAN to the central office Dell PowerVault DL2100 for remote protection. As a result of the Blue Coat ProxySG WAN Optimization, this solution greatly reduced the backup time and bandwidth needs. In the rest of this section, we report the user and change rate results from our backup tests. Note that the FSCT benchmark with the HomeFolders workload simulates user activity in a heavily used file server and that the FSCT benchmark results we report here may or may not reflect actual user activity at any given installation.

The ROBO data replication solutions with and without Blue Coat WAN Optimization simulated six scenarios:

- a Dell PowerEdge R710 at the remote office for file sharing service
- a Dell EqualLogic PS4000 at the remote office for primary storage
- a Dell PowerVault DL2100 at the remote office for local backup

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization

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- a Dell PowerVault DL2100 at the central office for off-site data protection
- a Blue Coat ProxySG 510 at the remote office
- a Blue Coat ProxySG 510 at the central office

We tested this scenario with and without Blue Coat WAN Optimization with user counts ranging from 30 to 500. Figures 7 and 8 show the complete results. The solution without WAN Optimization could support approximately 80 FSCT HomeFolders users, as it can back up and remotely replicate approximately 1.75 GB of changes every hour. We determined that the solution with WAN Optimization could support approximately 400 FSCT HomeFolders users, as it can back up and remotely replicate approximately 9.19 GB of data every hour. Note: For all calculations, we represent 1 GB as 1,024 MB.

Dell EqualLogic PS4000 and Dell PowerVault DL2100 *without Blue Coat ProxySG WAN Optimization*			
Backup type	**Number of users**	**Replication time* (HH:MM:SS)**	**Data transmitted over WAN (GB)**
Full	500	20:18:20	40.47
Incremental	30	0:32:01	1.00
Incremental	**80**	**0:55:34**	**1.75**
Incremental	300	3:38:57	7.07
Incremental	400	4:36:25	9.90
Incremental	500	5:08:46	9.92

Figure 7: Microsoft FSCT results for varying user counts in the Dell PowerVault DL2100 data replication scenario. *Note: The replication time is the time to back up the data to the local Dell PowerVault DL2100 plus the time to replicate that data across the WAN.

Dell EqualLogic PS4000 and Dell PowerVault DL2100 *with Blue Coat ProxySG WAN Optimization*			
Backup type	**Number of users**	**Replication time (HH:MM:SS)**	**Data transmitted over WAN (GB)**
Full	500	8:48:29	40.47
Incremental	30	0:06:33	0.80
Incremental	80	0:11:27	1.99
Incremental	300	0:41:08	7.03
Incremental	**400**	**0:53:52**	**9.19**
Incremental	500	1:09:47	11.23

Figure 8: Microsoft FSCT results for varying user counts in the Dell PowerVault DL2100 with Blue Coat WAN Optimization scenario. *Note: The replication time is the time to back up the data to the local Dell PowerVault DL2100 plus the time to replicate that data across the WAN.

Dell EqualLogic PS Series replication solution

We first ran FSCT with 150 users at the remote office for 4 hours to create a baseline data set on the Dell EqualLogic PS4000. We then used the Dell EqualLogic PS series replication feature to replicate a snapshot of the data set. See Appendix C for specifications of the Dell EqualLogic storage arrays.

To capture ROBO data protection performance in this scenario, we restarted FSCT for a specified user count and ran backups at 1-hour increments, increasing the user count 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 WAN Optimization enabled. In this scenario, the Blue Coat ProxySG Virtual Appliance uses WAN Compression to reduce the size of the data as it travels across the WAN, which allows more data to be transmitted in less time. As a result of the Blue Coat ProxySG Virtual Appliance WAN Optimization, this solution greatly reduced the backup time and bandwidth needs. In the rest of this section, we report the user and change rate results from our backup tests.

The ROBO data replication solutions with and without Blue Coat WAN Optimization simulated scenario:

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization

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- a Dell PowerEdge R710 at the remote office for file sharing service
- a Dell EqualLogic PS4000 at the remote office for primary storage and local backup
- a Dell EqualLogic PS6000 at the remote office for off-site data protection
- a Blue Coat ProxySG Virtual Appliance at the remote office
- a Blue Coat ProxySG 510 at the central office

We tested this scenario with and without Blue Coat WAN Optimization with user counts ranging from 10 to 150. Figures 9 and 10 show the complete results. We determined that the solution without WAN Optimization could support approximately 30 FSCT HomeFolders users, as it can back up and remotely replicate approximately 1.85 GB of changes every hour. We determined that the solution with WAN Optimization could support approximately 100 FSCT HomeFolders users as it can back up and remotely replicate approximately 6.07 GB of data every hour. Note: For all calculations, we represent 1 GB as 1,024 MB.

Dell EqualLogic PS Series replication *without Blue Coat ProxySG WAN Optimization*			
Backup type	Number of users	Replication time (HH:MM:SS)	Data transmitted over WAN (GB)
Full	150	9:49:27	23.13
Incremental	10	0:20:35	0.73
Incremental	**30**	**0:50:52**	**1.85**
Incremental	50	1:20:52	2.93
Incremental	100	2:35:11	5.74
Incremental	150	3:42:10	8.42

Figure 9: Microsoft FSCT results for varying user counts in the Dell EqualLogic PS Series data replication scenario.

Dell EqualLogic PS Series replication *with Blue Coat ProxySG WAN Optimization*			
Backup type	Number of users	Replication time (HH:MM:SS)	Data transmitted over WAN (GB)
Full	150	5:05:12	22.97
Incremental	10	0:08:20	0.78
Incremental	30	0:19:36	2.05
Incremental	50	0:31:06	3.17
Incremental	**100**	**0:59:23**	**6.07**
Incremental	150	1:27:54	8.74

Figure 10: Microsoft FSCT results for varying user counts in the Dell EqualLogic PS Series replication with Blue Coat WAN Optimization scenario.

Workload
File Server Capacity Tool (FSCT)
Microsoft is currently developing FSCT and has released version 1.0. The tool tests file server capacity and helps identify performance bottlenecks.

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

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Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization

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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 work set called 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 11 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 11: The operations performed by each Microsoft FSCT user in 1 hour.

FSCT requires a minimum of three computers to perform the roles of server, client(s), 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. See Appendix A for specifications of the FSCT clients and controller.

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."

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization

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Test configuration
Dell PowerVault DL2100 replication solution
Storage settings
- One Dell EqualLogic PS4000 array
- RAID 50 (with two spares)
- One 1TB volume

Storage network settings
- Two Dell PowerConnect™ 6248 network switches
- Jumbo frames disabled (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 PS4000 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 DL2100 at central office
  - One 1Gb connection to remote office through WAN emulator (constrained to 5Mbps bandwidth with 40ms round-trip latency)
- Test servers (load-generating systems)
  - Two 1Gb connections per server (16 total) connected to a Dell PowerConnect 5448
  - Dell PowerConnect 5448 used for client-server network
  - Dell PowerConnect 5448 used for client-controller network
- Blue Coat Proxy SG 510 Appliance at the central office
  - Connected inline between the WAN emulator and the Dell PowerConnect 6248 at the central office
- Blue Coat Proxy SG 510 Appliance at the remote office
  - Connected inline between the WAN Emulator and the Dell PowerConnect 6248 at the remote office

WAN emulator
- Soekris Engineering net4801
  - FreeBSD 6.0
  - Compiled with ipfw and dummynet
  - 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 20ms bw 6192Kbit`
      - Note: As per Blue Coat Technologies, 6,192 Kbps results in approximately 5 Mbps of effective bandwidth, and ipfw 20ms delay results in 40ms actual round-trip latency.

FSCT load-generating clients
- Eight Dell PowerEdge M600 servers
  - Windows Server 2008 R2 Enterprise x64
  - Total of 64 physical cores (Intel® Xeon® Processor)
  - 1 x Dual Port Broadcom BCM5708C integrated network adapter per server
    - One port for client-server traffic
    - One port for client-controller traffic

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization
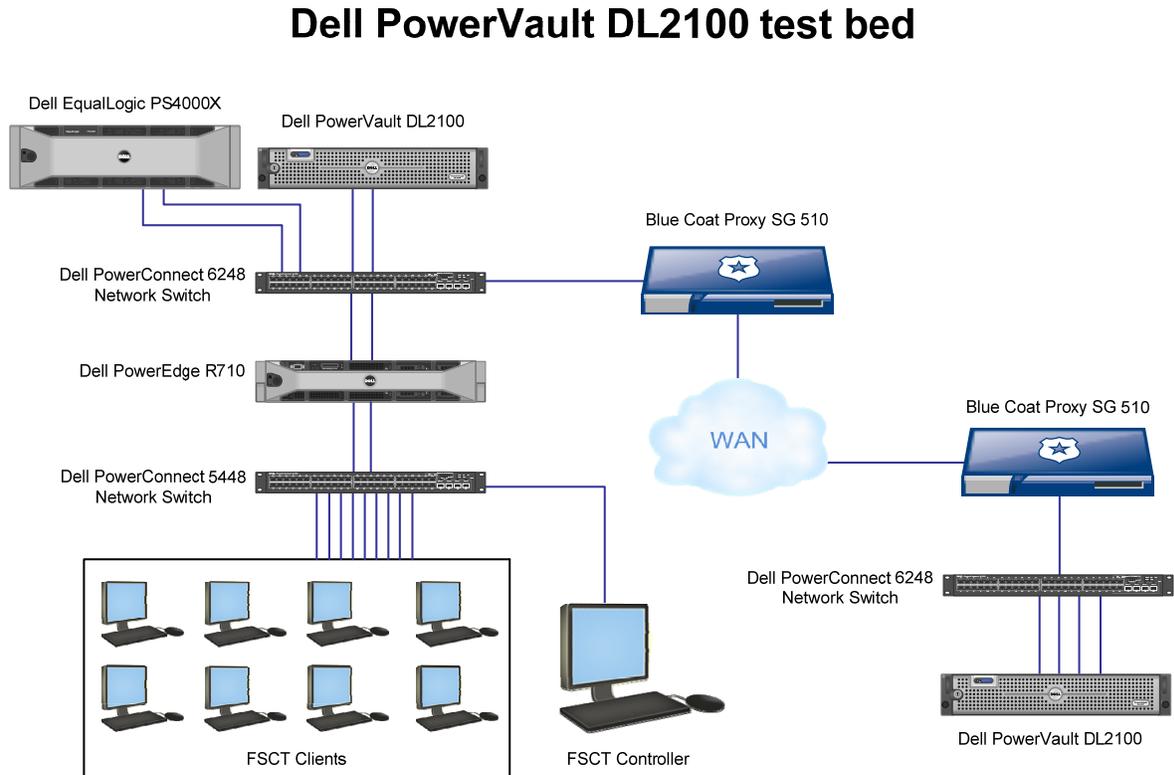
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Figure 12 illustrates our Dell PowerVault DL2100 WAN test bed.

Dell PowerVault DL2100 test bed

Dell EqualLogic PS Series replication solution
Storage settings
- One Dell EqualLogic PS4000 array
- One Dell EqualLogic PS6000 array
- RAID 50 (with two spares)
- One 1TB volume

Storage network settings
- Two Dell PowerConnect 6248 network switches
- Jumbo frames disabled (on NICs and all ports on the switch)
- Flow control enabled
- IP routing enabled
- Spanning tree set to RSTP
- LLDP disabled

SAN and client network connections
- Dell EqualLogic PS4000 array
  - Two 1Gb iSCSI connections to the Dell PowerConnect 6248
  - Dell PowerConnect 6248 used for the remote office storage network
- Dell EqualLogic PS6000 array
  - Four 1Gb iSCSI connections to the Dell PowerConnect 6248
  - Dell PowerConnect 6248 used for the central office storage network

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch office data replication with Blue Coat ProxySG WAN Optimization

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- 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
- Blue Coat ProxySG 510 Appliance at the central office
  - Connected inline between the WAN emulator and the Dell PowerConnect 6248 at the central office
- Blue Coat ProxySG Virtual Appliance at the remote office
  - Installed on a Dell PowerEdge 2950
  - ESX vSphere 4.0 Update 1
  - Connected using WCCP redirection on a Cisco Catalyst 3560 series switch

WAN emulator
- Soekris Engineering net4801
  - FreeBSD 6.0
  - Compiled with ipfw and dummynet
  - 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 20ms bw 6192Kbit`
      - Note: As per Blue Coat Technologies, 6,192 Kbps results in approximately 5 Mbps of effective bandwidth, and ipfw 20ms delay results in 40ms actual round-trip latency.

FSCT load-generating clients
- Eight Dell PowerEdge M600 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 13 illustrates our Dell EqualLogic PS Series WAN test bed.

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch
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Dell EqualLogic PS Series test bed

Dell EqualLogic PS4000X

Blue Coat Proxy SG
Virtual Appliance

Dell PowerConnect 6248
Network Switch

Cisco
Catalyst
3560
Switch

Dell PowerEdge R710

WAN

Blue Coat Proxy SG 510

Dell PowerConnect 5448
Network Switch

Dell PowerConnect 6248
Network Switch

FSCT Clients

FSCT Controller
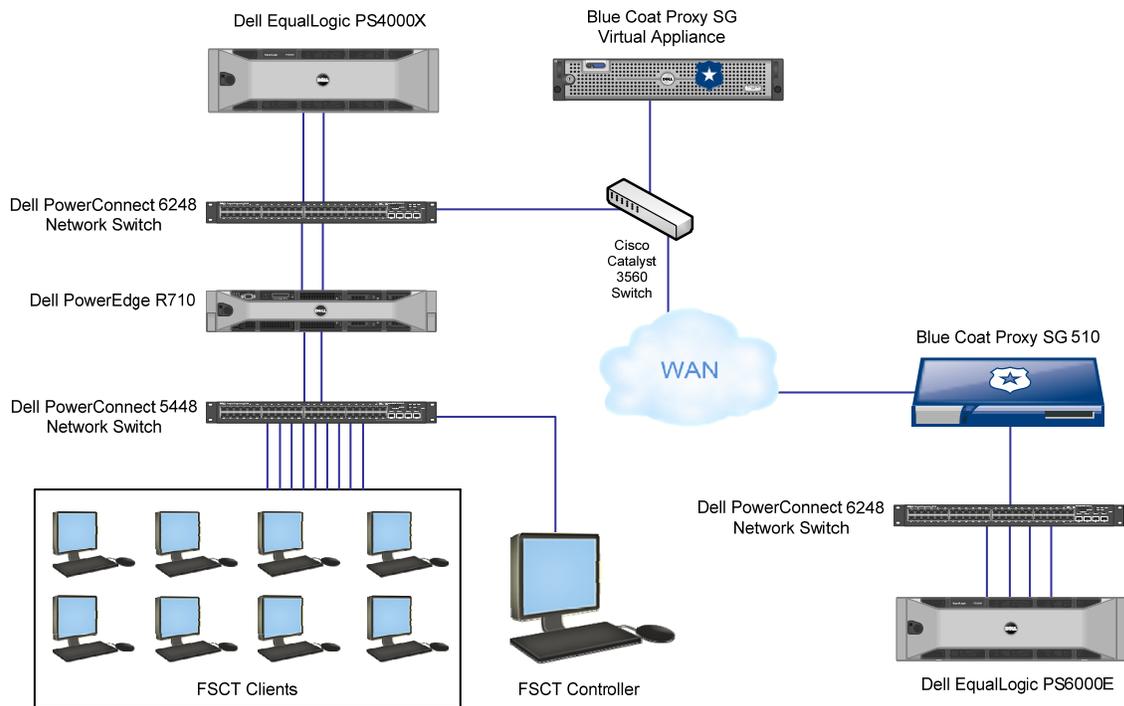
Dell EqualLogic PS6000E

Figure 13: Dell EqualLogic PS series WAN test bed.

Test methodology
Setting up and configuring the Dell PowerVault DL2100, Dell EqualLogic PS4000 storage, and Dell EqualLogic PS6000

The Dell EqualLogic PS4000 array contained 16 600GB 10,000 RPM SAS drives. We connected the Dell EqualLogic PS4000 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 PS4000 array in RAID 50 mode. The Dell EqualLogic PS6000 array contained 16 1TB 7,200RPM SATA drives. We connected the Dell EqualLogic PS6000 array to a Dell PowerConnect 6248 storage switch via its four available data ports. 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 PS4000 to the file server. We connected the remote office Dell PowerVault DL2100 to the remote office Dell PowerConnect 6248 via two Broadcom BCM5709C ports and the central office Dell PowerVault DL2100 to the central office Dell PowerConnect 6248.

Setting up the external storage
1. Using the command line or GUI, set up a storage group with the following RAID policy:
    - PS4000-1: RAID-50
2. Create a storage pool that you name `PS4000-1` with the following members:
    - PS4000-1
3. Enable all iSCSI network connections on the Dell EqualLogic PS4000 using the following IP address scheme:
    - IP Address: `192.168.1.##` (## being any number between 10 and 40)
    - Subnet Mask: `255.255.255.0`

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4. Create a 1,024GB volume.
5. Enable shared access to the iSCSI target from multiple initiators on the volume.
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.
8. Using the command line or GUI, set up a second storage group with the following RAID policy:
   - PS6000-1: RAID-50
9. Create a storage pool that you name `PS6000-1` with the following members:
   - PS6000-1
10. Enable all iSCSI network connections on the Dell EqualLogic PS6000 using the following IP address scheme:
    - IP Address: `192.168.3.##` (## being any number between 10 and 40)
    - Subnet Mask: `255.255.255.0`
11. Create a 1,024GB volume.
12. Enable shared access to the iSCSI target from multiple initiators on the volume.
13. Create an access control record for the volumes without specifying any limitations.
14. 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 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.

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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.

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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.

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.

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 and compression disabled. Set DL2100-2 as the MediaAgent, and set the Replica Magnetic Library as the Primary Storage Library.
5. 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.

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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), and 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.

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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) , and 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.

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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 ### /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 ### /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. Type `F:\` and press Enter.
6. Type `G:\` and click OK.
7. Select the Storage Device tab.
8. For the Storage Policy, select DL2100-2.
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.

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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 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 ### /max_users ### /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 run ### number of 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 ### /max_users ### /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.

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

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Appendix A —Test client information

Clients 1 through 8 and controller

- Dell PowerEdge M600 Blade Server
- 2 x Intel Xeon Processor E5345 (2.33 GHz)
- 4 x 2,048 MB Samsung PC2-5300 FB-DDR2 (16,384 MB), 1,333 FSB
- Dell BIOS 2.2.3 (09/12/2008)
- 2 x BCM5708S - 10/100/1000BASE-T TOE PCI Express Ethernet Controller, 1,000 Mbps, Firmware- ipmi 1.06, Driver- Broadcom 4.8.4.1 (12/23/2008)
- 2x SATA Fujitsu MAY2073RC, 73 GB, 10K
- Microsoft Windows Server 2008 R2 x64

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Appendix B – Test server information

Figure 14 presents detailed information for the test servers we used in this report.

Servers	Dell PowerEdge R710	Two Dell PowerVault DL2100
General dimension information		
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
Power supplies		
Total number	1	2
Brand and model	Dell 0PT164	Dell A870P-00
Wattage (W)	870	870
Cooling fans		
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
General processor setup		
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
CPU		
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
Platform		
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)
Memory modules		
Memory type 1		
Total RAM in system (GB)	48	24

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Servers	Dell PowerEdge R710	Two Dell PowerVault DL2100
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
Memory type 2		
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
Hard disk		
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)
Operating system		
Name	Windows Server 2008 R2 Enterprise	Windows Server 2008 SP2 Enterprise
Build number	7600	6002
File system	NTFS	NTFS
Language	English	English

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Servers	Dell PowerEdge R710	Two Dell PowerVault DL2100
Network card/subsystem		
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)
Optical drive		
Vendor and model number	TEAC DV28SV DVD-ROM	PLDS DVD+-RW DS-8A3S
USB ports		
Number	4	4
Type	2.0	2.0
External storage		
Vendor and model number	Dell EqualLogic PS4000X	Dell PowerVault MD1000
Hard disk Vendor and model number	Seagate ST3600002SS	Western Digital WD5002ABYS
Number of disks in storage	16	8
Size (GB)	600	500
Buffer size (MB)	16	16
RPM	10,000	7,200
Type	SAS	SATA

Figure 14: Detailed system configuration information for the test servers.

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Appendix C –Test storage information

Figure 15 and 16 provide detailed configuration information about the storage array system.

Storage array	Dell EqualLogic remote office SAN
Arrays	One Dell EqualLogic PS4000X array
Disks	16 x 10,000RPM SAS disks
Active storage cache (GB)	2
Firmware revision	v4.3.2
Switch type/model/firmware revision	One Dell PowerConnect 6248 v2.2.0.1
Disk vendor and model number	Seagate ST3600002SS
Disk size	600 GB
Disk buffer size (MB)	16

Figure 15: Detailed configuration information for the storage array system.

Storage array	Dell EqualLogic central office SAN
Arrays	One Dell EqualLogic PS6000E array
Disks	16 x 7,200RPM SATA disks
Active storage cache (GB)	4
Firmware revision	v4.3.2
Switch type/model/firmware revision	One Dell PowerConnect 6248 v2.2.0.1
Disk vendor and model number	Seagate ST31000340NS
Disk size	1 TB
Disk buffer size (MB)	16

Figure 16: Detailed configuration information for the storage array system.

Dell PowerVault DL2100 and Dell EqualLogic PS Series remote office/branch
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About Principled Technologies

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 you assess how it will fare against its competition, its performance, whether it's ready to go to market, 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.

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