

Network Appliance™ NearStore® VTL600 and EMC CLARiiON DL710 Performance Comparison

Test report prepared under contract from Network Appliance

Executive summary

Network Appliance™ commissioned VeriTest, a division of Lionbridge Technologies Inc., to compare the performance of the Network Appliance NearStore® VTL600 to the EMC CLARiiON DL710 in a variety of scenarios that can be encountered when using virtual tape library technology in typical backup and recovery environments.

The tests performed included a characterization of the throughput of the products under a variety of stream counts and real-world workloads, a comparison of published throughput specifications against the actual throughput observed during testing, system performance following a simulated disk failure, and the ability of the products to optimize the utilization of physical tape media when the VTL was used to create backup tapes under the control of a backup software application.

Key findings

- ❑ The Network Appliance NearStore VTL600 consistently performed at or above 95% of its published throughput rate in twenty separate test runs in which backup data was randomized to simulate the variability of real world workloads.
- ❑ The EMC CLARiiON DL710 performance ranged from 50% to 80% of its published throughput rate in twenty separate test runs in which backup data was randomized to simulate the variability of real world workloads.
- ❑ The Network Appliance NearStore VTL600 automatically balanced disk I/O and achieved a maximum throughput of 495 MB/sec using three disk shelves during tests in which disk shelves and backup streams were steadily increased.
- ❑ The EMC CLARiiON DL710 achieved a maximum throughput of 311MB/sec using four disk shelves during tests in which disk shelves and backup streams were steadily increased.
- ❑ In our tests, we found that the Network Appliance NearStore VTL600 was able to automatically optimize physical tape media utilization by adapting to the compression capabilities of a physical tape drive in a SAN attached tape library.
- ❑ In our tests, we found that the EMC CLARiiON DL710 was unable to automatically adapt to the compression capabilities of a physical tape drive in a SAN attached tape library, which resulted in the use of twice as many physical tape cartridges to store the test data.

The EMC CLARiiON DL710 configuration used in this test contained four disk trays with 320 GB SATA drives. The EMC CLARiiON DL710 used a total of four Fibre Channel connections to the Brocade Silkworm 3800 switch during the testing.

The Network Appliance NearStore VTL600 configurations used in this test contained four disk trays with 320GB SATA drives. The NearStore VTL600 used a total of three Fibre Channel connections to the Brocade during the testing.

Please refer to the Testing Methodology section of this report for complete details on how we conducted the performance testing on the NearStore VTL600 and CLARiiON DL 710.

Complete details on the specifications for these devices can be found at

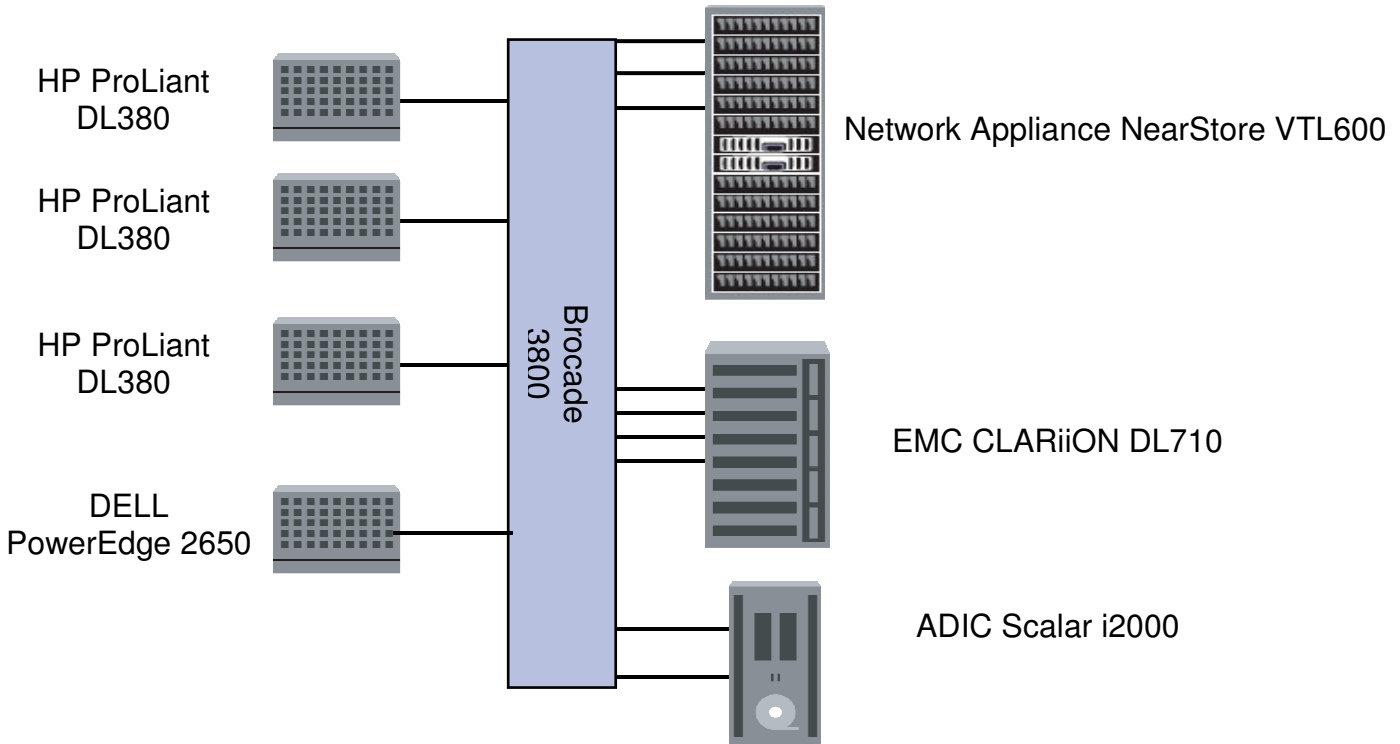
NearStore VTL600 specification sheet from Network Appliance.

<http://www.netapp.com/products/nearstore/nearstore-vtl-tech-specs.html>

CLARiiON DL710 specification sheet from EMC

http://www.emc.com/products/systems/clariion_disk/compare/index.jsp

Test Bed Configuration



Test Results

Observed Throughput vs. Product Specifications

Figures 1 and 2 below shows the results of the testing to compare the throughput in MB/second of both devices under best case conditions (see Appendix A). The maximum throughput observed was compared against the throughput claims published on the manufacturers' respective websites listed in the previous section of this document.

We found that the NearStore VTL600 performed at 512 MB/sec under best case conditions and exceeded the advertised throughput claim of 500 MB/sec.

We found that the CLARiiON DL710 performed at 517 MB/sec under best case conditions, equal to approximately 86% of its advertised throughput claim of 600 MB/sec.

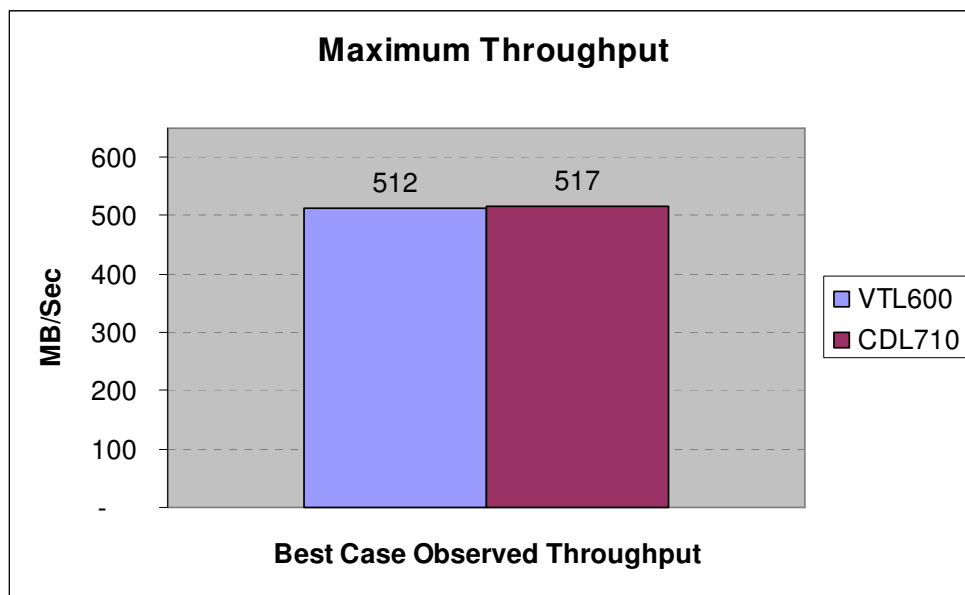


Figure 1 Maximum Observed Throughput Under Best Case Conditions

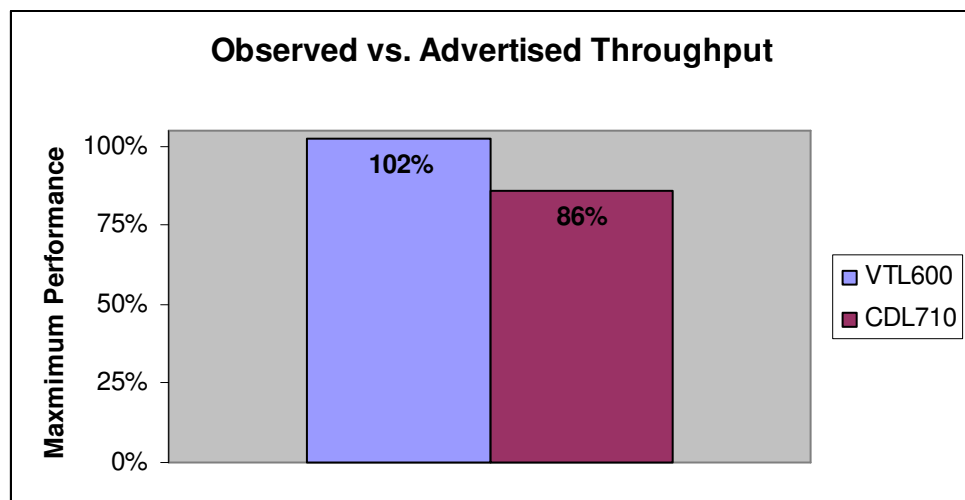


Figure 2 Observed Throughput vs. Published Specifications

Self Tuning: Automatic Utilization of Available Disk Resources

The NearStore VTL600 balances backups across available disk resources without manual intervention. Throughout our testing, we observed that backup streams were automatically directed to the most available RAID groups. The performance benefit of this type of design can be demonstrated using a scenario that introduces new disk resources to an existing test configuration. As the new disks become available, it is possible to observe the ability of the test system to automatically use those resources.

The following tests measured the throughput of both products as disk shelves were added to a base configuration. An initial test utilized a single disk shelf and ten streams of data, and then the test was repeated successively using an additional shelf along with an additional ten streams of data, up to a maximum test configuration that consisted of four shelves and forty streams of data.

Because the CLARiiON DL710 statically allocates virtual tapes to a LUN, it would not utilize the new disk shelves unless additional virtual tapes were created for each test. In order to allow the DL710 to use the new disk shelves, 10 new virtual tapes were created as each shelf was added.

The observed results are listed below. Note that there was no operator intervention between the test runs to aid in the performance of either product.

One disk shelf and ten data streams:

The NearStore VTL600 and the CLARiiON DL710 were both measured at 205 MB/Second of throughput.

Two shelves and twenty streams:

In this configuration the NearStore VTL600 throughput was measured at 410 MB/second and the CLARiiON DL710 throughput was measured at 221 MB/Second. The NearStore VTL600 was 85% faster.

Three shelves and thirty streams:

In this configuration the NearStore VTL600 throughput was measured at 495 MB/second and the CLARiiON DL710 throughput was measured at 289 MB/Second. The NearStore VTL600 was 71% faster.

Four shelves and forty streams:

In this configuration the NearStore VTL600 throughput was measured at 492 MB/second and the CLARiiON DL710 throughput was measured at 311 MB/Second. The NearStore VTL600 was 58% faster.

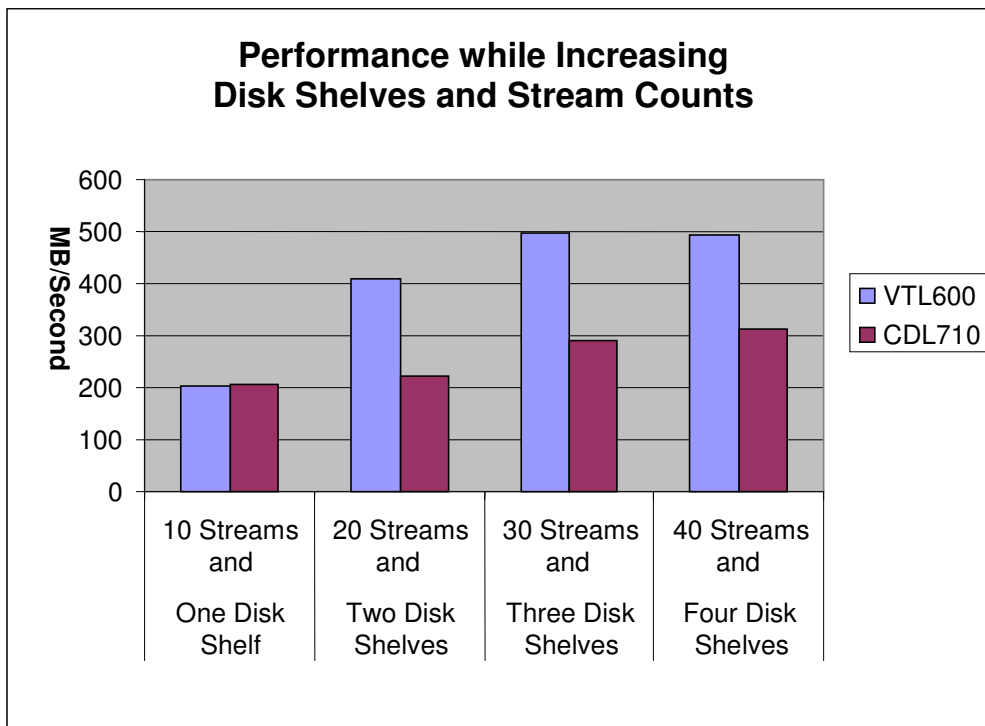


Figure 3 Incremented Shelves and Stream Counts

Self Tuning: Automatic Optimization of Available Disk Resources

The purpose of these tests was to measure the ability of each product to adapt to a dynamic environment where workloads can vary. We attempted to simulate the variability of real world backup loads using two tests that wrote data at varying rates, one using 20 streams of backup data and another that used 40 streams of data. Each test was repeated 10 times for each product, yielding the results displayed in Figures 4 and 5, below.

For the twenty stream test we found that the NearStore VTL600 throughput ranged from 476 MB/second to 490 MB/sec and the CLARiiON DL710 throughput ranged from 302 MB/second to 368 MB/sec.

For the forty stream test we found that the NearStore VTL600 throughput ranged from 490 to 495 MB/sec and the CLARiiON DL710 throughput ranged from 435 to 483MB/sec.

Multiple Backups at Varying Rates – 20 Streams

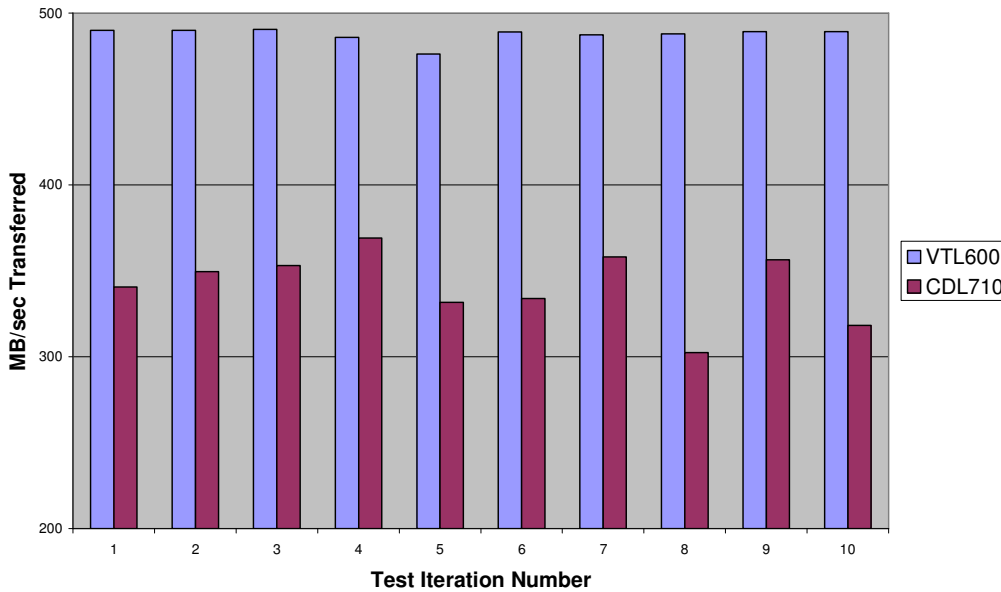


Figure 4 Twenty Streams

Multiple Backups at Varying Rates – 40 Streams

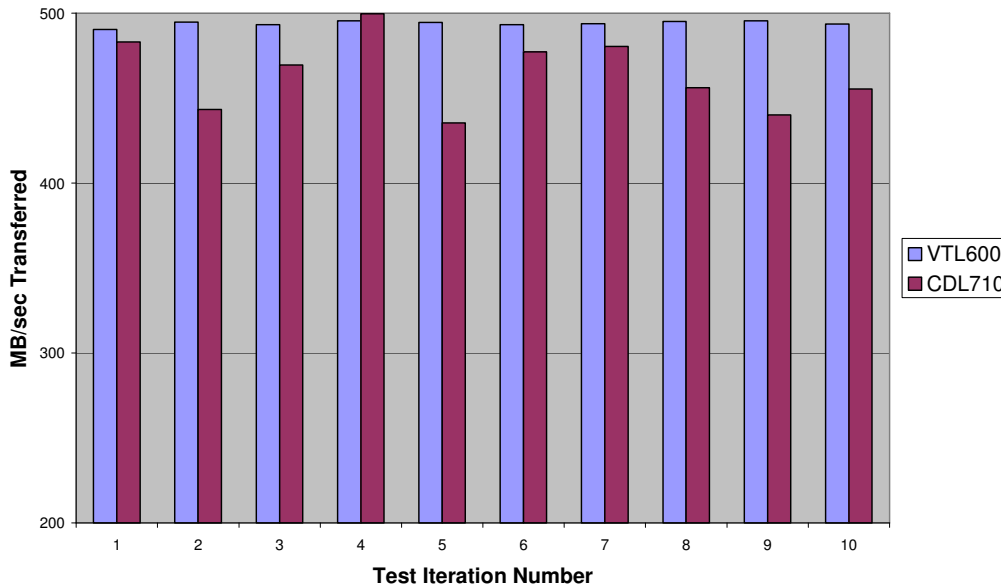


Figure 5 Forty Streams

VTL Tape Creation and Physical Tape Utilization

The purpose of this test was to measure the utilization of physical tape media when both VTL systems were used to create physical tapes in an ADIC Scalar i2000. In this scenario, test data was first backed up to the VTL, and then physical tapes were created by each test system under the control of a backup application software program.

The data on each virtual tape was required to fit onto a corresponding physical tape so that there would be a one-to-one mapping between the barcodes cataloged by the backup application and those written on the physical tape cartridges. We used publicly available software from Hewlett Packard called HPCreateData.exe to generate a data set that allowed for a specific compression ratio. This utility is freely available from the Hewlett Packard website at this URL:

http://h20000.www2.hp.com/bizsupport/TechSupport/SoftwareDescription.jsp?lang=en&cc=us&wItem=co-9515-2&jumpid=reg_R1002_USEN

The test used 100GB physical tapes in a SAN attached tape library, Symantec's NetBackup 6.0 to perform the backup test, and 175 GB of test data that could be compressed at a 2 to 1 ratio. The physical tape drive target (IBM Ultrium T400F LTO-1) was able to compress the data at a ratio of 2:1.

The NearStore VTL600 dynamically adjusted the size of the virtual tape so that it was able to fit onto a single corresponding physical tape *after compression by the physical tape drive target*. NearStore VTL Smart Sizing tracks the degree of compression that is possible for data as it is being backed up, and it also takes into account the compression ratio that can be achieved by the physical tape drive. In this test, the VTL600 automatically sized the virtual tape so that it could use one LTO-1 (100 GB Native) physical tape to store 175 GB of backup data by taking into account the compression capability of the physical tape drive.

When used to create physical tapes, the CLARiiON DL710 limits the capacity of the virtual tapes to the *uncompressed capacity* of the physical tape. This allows the DL710 to ensure that the data on each virtual tape will fit onto a physical tape during an export operation (refer to the EMC CLARiiON DL710, Version 2.1 Administrator's Guide, P/N 300-001-098, REV A05, Page 4-6). In

this test the CLARiiON DL710 used two LTO-1 (100 GB Native) physical tapes to store the 175 GB of backup data because it did not take into account the compression capability of the physical tape drive.

Figure 6 below illustrates the test results (in this chart, the smaller the number the better).

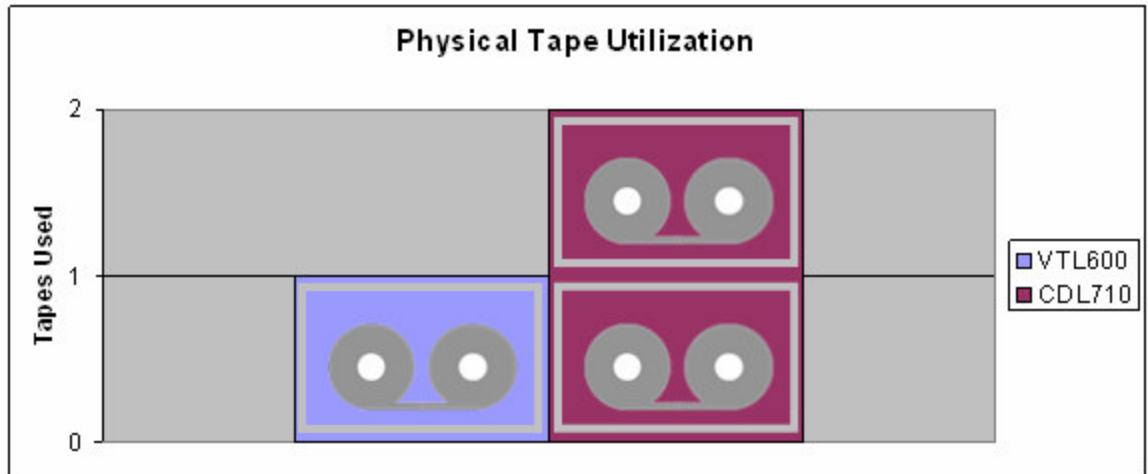


Figure 6 Physical Tapes Used for Backup

RAID Group Rebuild Comparison

The purpose of this test was to document the time required by each product to rebuild a RAID group in the event of a drive failure. On the NearStore VTL600, only the data that has been written to a RAID group needs to be rebuilt in the event of a disk failure. This capability can minimize the impact of a RAID group rebuild to overall backup performance.

For this test, each product had one RAID group and a single LUN present on the system. The NearStore VTL600 RAID group and the CLARiiON DL710 LUN had the same number of underlying disks to ensure an even comparison.

A total of 175 GB of test data was sent to each product for this test. Once the data was present on both systems a single disk in each product was pulled and the total time to rebuild the RAID group was measured and recorded. The results are show below.

The NearStore VTL600 took 40 minutes and 42 seconds to rebuild the RAID group.

The CLARiiON DL710 took 19 hours and 23 minutes to rebuild the RAID group.

Figure 7 shows the amount of time need to rebuild the RAID group. In this graph, the smaller the number the better.

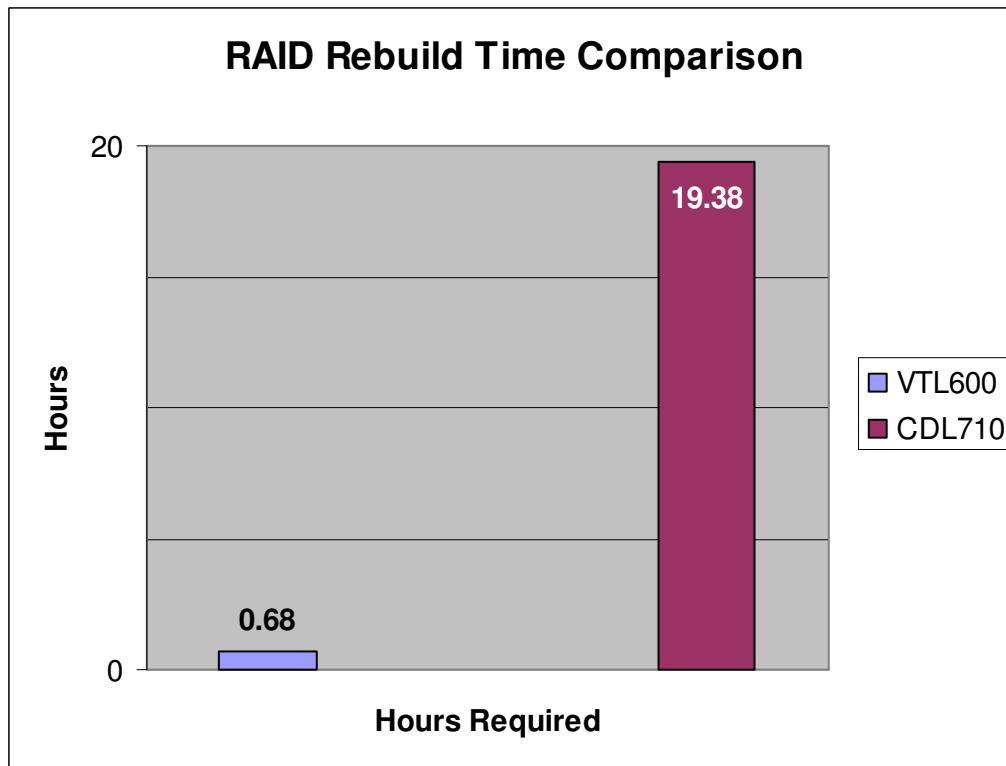


Figure 7 RAID Group Rebuild Time

A subsequent test was run on the NearStore VTL600 to characterize the RAID group rebuild time for a single LUN when using a total of 1.9TB of test data to simulate a RAID group that was completely filled with backup data. In this test, the NearStore VTL600 took 4 hours and 30 minutes to rebuild the entire RAID group. Because the VTL600 is configured using 2TB LUNs, the result from this test approximates the maximum rebuild time that could be expected for a VTL600 RAID group when completely filled with data.

Backup Performance in Degraded Mode

The purpose of this test was to demonstrate the performance of both products when performing a backup to a virtual tape drive while simultaneously rebuilding a RAID group that had experienced a physical disk failure.

Each system initially had one RAID group and a single LUN added to the system, and a single virtual tape drive was created on both products in the original RAID group. The NearStore VTL600 RAID group and the CLARiiON DL710 LUN had the same number of underlying disks to ensure an even comparison.

After the first backup was completed on both products, a second RAID group was created and a physical drive from the first RAID group on each product was pulled to force a RAID group rebuild.

The second backup was initiated to the same virtual tape drive and it revealed that when the original RAID group is rebuilding on the NearStore VTL600, all write activity to the virtual tape drive is dynamically moved to the second RAID group.

The second backup revealed that when a RAID group is rebuilding on the CLARiiON DL710, all write activity remains directed to the first RAID group that was in degraded mode due to the rebuild operation.

The ability to switch the workload to an alternative RAID group is an automatic feature of the NearStore VTL600 while the CLARiiON DL710 will continue writing data to a degraded LUN in the event of a drive failure.

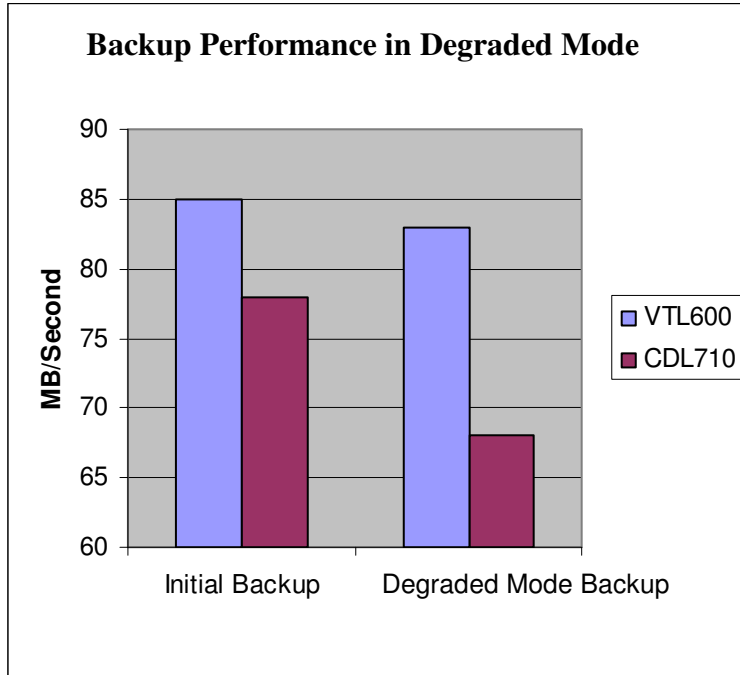


Figure 8 Backup Performance in Degraded Mode

Conclusions:

1. In our test configurations, we found that the Network Appliance NearStore VTL600 best case throughput was 512 MB/sec, which is 102% of the published throughput rate stated on the Network Appliance website.
2. In our test configurations, we found that the EMC CLARiiON DL710 best case throughput was 517 MB/sec, which is 86% of the published throughput rate of 600 MB/sec stated on the EMC website.
3. The Network Appliance NearStore VTL600 was able to self tune when the number of disk trays increased from one to four while the data stream count increased from ten to forty, resulting in a 240 percent increase in throughput, from 205 MB/sec to 492 MB/sec.
4. The CLARiiON DL710 throughput increased by 150 percent in the same incremented test bed as (3) above, from 205 MB/sec to 311 MB/sec.
5. The Network Appliance NearStore VTL600 was able to consistently perform at or above 95% of its published throughput rate in twenty separate test runs in which backup data was randomized to simulate the variability of real world workloads.
6. The CLARiiON DL710 performance ranged from 50% to 80% of its published throughput rate in twenty separate test runs in which backup data was randomized to simulate the variability of real world workloads.
7. In our tests, we found that the Network Appliance NearStore VTL600 was able to automatically adjust the size of a virtual tape in order to optimize the utilization of physical tape media in a SAN attached physical tape library.
8. In our tests, we found that the EMC CLARiiON DL710 did not automatically adjust virtual tapes to optimize the utilization of physical tape media in a SAN attached physical tape library which resulted in twice the number of physical tapes being used.
9. During our rebuild test of a partially filled LUN, the NearStore VTL600 took 40 *minutes* and 42 seconds to rebuild the RAID group.
10. The same rebuild test of a partially filled LUN using the EMC CLARiiON DL710 19 *hours* and 23 minutes to rebuild the RAID group.
11. A test to measure the rebuild time for a RAID group fully filled with data on the NearStore VTL600 took 4 hours and 30 minutes.
12. The NearStore VTL600 was able to automatically switch a workload to an alternative RAID group when the initial RAID group was in degraded mode, providing 97% of the throughput measured before the simulated disk failure.
13. In the same test on the EMC CLARiiON DL710, all write activity remained directed to the initial RAID group that was in degraded mode due to the rebuild operation, providing 86% of the throughput measured before the simulated disk failure.

Appendix A: Block Sizes, Stream Counts and Virtual Tapes used for Baseline Maximum Performance

We conducted initial testing against both products to determine the baseline maximum available throughput using a variety of data transfer scenarios. This testing was conducted under best case conditions using dedicated I/O generators to eliminate bottlenecks external to the storage system. In order to achieve maximum performance, software compression was disabled for both products throughout the testing.

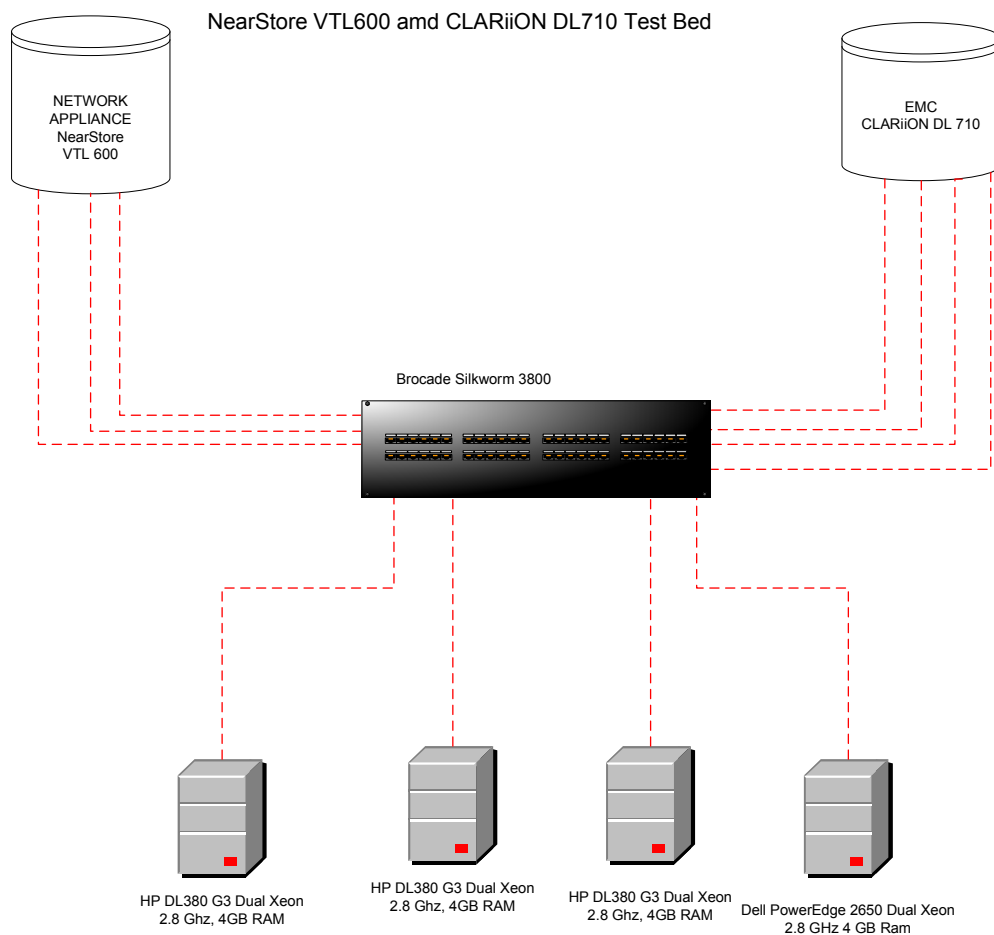
We used a publicly available data generation tool for dd called xdd6.4 in our testing. Xdd is a tool for measuring and characterizing disk subsystem I/O and is designed to provide consistent and reproducible performance measurements of disk I/O traffic. It can be downloaded at: <http://www.ioperformance.com/products.htm>

We observed that in a four disk shelf test configuration, the NearStore VTL600 achieved a maximum throughput of 512.27 MB/sec by using a 512KB block size and 20 I/O streams. This test used three Linux I/O initiators, each with a dedicated virtual tape library, with a total of 40 virtual tapes spread across the virtual libraries.

We observed that in a four disk shelf test configuration, the CLARiiON DL710 achieved a maximum throughput of 517.04 MB/sec by using a 256KB block size and 40 I/O streams. This test used four Linux I/O initiators, each with a dedicated virtual tape library, with a total of 40 virtual tapes spread across the virtual libraries.

Although the NearStore VTL600 achieved maximum throughput using a 512KB block size, it was agreed that a 256KB block size would be used throughout the remaining tests in order to provide results that would *not disadvantage* the CDL710 system, thus allowing a fair comparison.

Appendix B: Test Bed Configuration



NearStore VTL600 Setup:

1. Three ProLiant DL380 Linux servers, one each directly connected to FC ports 0a, 0c and pci4b on NearStore VTL600.
2. NearStore VTL600 Virtual tape devices were /dev/st16 through /dev/st31 on these hosts
3. A maximum of four disk shelves were used in the testing.
4. A virtual library was created for each Linux initiator (16 virtual drives each).

CLARiiON DL710 Setup:

1. Three ProLiant DL380 Linux servers and one Dell PowerEdge 2650 Linux server, each one connected to one FE port on EMC CLARiiON DL710.
2. CLARiiON DL710 Virtual tape devices were /dev/st0 through /dev/st15 on these hosts
3. A maximum of four disk shelves were used in the testing. All available LUNs on the CLARiiON DL710 were added to the system except where noted
4. A virtual library was created for each Linux initiator (16 virtual drives each).

Test Procedure Used to Achieve Maximum Write Throughput

1. SSH to host dl3801 (All tests were run from this host).
2. The following command was run for the performance runs to the NearStore VTL600.
3. `./measure_xdd VTL 512 20 20stream_VTL_log`
4. The above command started 6 xdd write streams of 512KB blocks from dl3801, 7 streams from dl3802, and 7 streams from dl3803.
5. The same script was run for the EMC CLARiiON DL710
6. `./measure_xdd CDL 256 40 40stream_CDL_log`
7. The above command started 10 xdd write streams of 256KB blocks from dl3801, 10 streams from dl3802, 10 streams from dl3803, and 10 streams from dell5
8. Total throughput values for each run were sent to STDOUT as well as saved in the log directory. The results file was saved on dl3801. The test output files (xdd output) were saved on each machine in the specified log directory.
9. `measure_xdd` command usage
10. `measure_xdd <VTL/CDL> <Blocksize> <Number of Streams> <Log dir>`

Test Procedure for Measuring Throughput as Disk Shelves and Stream Counts are Increased

NearStore VTL600 Setup:

1. Three ProLiant DL380 Linux servers, one each directly connected to FC ports 0a, 0c, pci4b on NearStore VTL600 (dl3801, dl3802, dl3803)
2. NearStore VTL600 Virtual tape devices are /dev/st16 through /dev/st31 on these hosts
3. One disk shelf has been added to the system (Shelf ID 1 through ports 0b/0d)
4. A total of 10 virtual tapes have been created
 - a. 3 for dl3801
 - b. 3 for dl3802
 - c. 4 for dl3803

EMC CLARiiON DL710 Setup:

1. Four ProLiant DL380 Linux servers, one each directly connected to one FE port on EMC CDL710 (dell5, dl3801, dl3802, dl3803)
2. EMC CLARiiON CDL710 Virtual tape devices are /dev/st0 through /dev/st15 on these hosts
3. LUNs 0:0:0:14, 6:0:0:15, 4:0:0:16 have been added to the system (Bus 0 Enclosure 1)
4. A total of 10 virtual tapes have been created
 - a. 3 for dell5
 - b. 2 for dl3801
 - c. 2 for dl3802
 - d. 3 for dl3803

Test Procedure:

1. SSH to host dl3801
2. The following commands shall be executed for the 10 stream test to the NearStore VTL600 with one disk shelf

```
cd /root/scripts
./measure_xdd VTL 256 10 1shelf_VTL_log
```
3. The same commands shall be executed for the 10 stream test to the EMC CLARiiON DL710 with one disk shelf

```
cd /root/scripts
./measure_xdd CDL 10 1shelf_CD_L_log
```
4. Total throughput for each run shall be saved in the results file
5. Add a disk shelf for each system
 - NearStore VTL600: Add shelf 1 (ports PCI4a/PCI2b)
 - EMC CLARiiON DL710: Add LUNs 2:0:0:11, 6:0:0:12, and 2:0:0:13 (Bus 3 Enclosure 0).
6. Create a total of 10 additional virtual tapes for each system:
 - NearStore VTL600:
 - 3 tapes for dl3801
 - 4 tapes for dl3802
 - 3 tapes for dl3803
 - EMC CLARiiON DL710
 - 2 tapes for dell5
 - 3 tapes for dl3801
 - 3 tapes for dl3802
 - 2 tapes for dl3803
7. The following commands shall be executed for the 20 stream test to the NearStore VTL600 using two disk shelves

```
cd /root/scripts
./measure_xdd VTL 256 20 2shelf_VTL_log
```
8. The same commands shall be executed for the 20 stream test to the EMC CLARiiON DL710 using two disk shelves

```
cd /root/scripts
```

- ./measure_xdd CDL 20 2shelf_CDLog_log
- 9. Total throughput for each run shall be saved in the results file
- 10. Add a disk shelf for each system
 - NearStore VTL600: Add shelf 2 (ports 0b/0d)
 - EMC CLARiiON DL710: Add LUNs 2:0:0:12, 0:0:0:19, and 6:0:0:19 (Bus 2 Enclosure 1).
- 11. Create a total of 10 additional virtual tapes for each system:
 - NearStore VTL600:
 - 4 tapes for dl3801
 - 3 tapes for dl3802
 - 3 tapes for dl3803
 - EMC CLARiiON DL710
 - 3 tapes for dell5
 - 2 tapes for dl3801
 - 2 tapes for dl3802
 - 3 tapes for dl3803
- 12. The following commands shall be executed for the 30 stream test to the NearStore VTL600 using three disk shelves
 - cd /root/scripts
 - ./measure_xdd VTL 256 30 3shelf_VTL_log
- 13. The same commands shall be executed for the 30 stream test to the EMC CLARiiON DL710 using three disk shelves
 - cd /root/scripts
 - ./measure_xdd CDL 30 3shelf_CDLog_log
- 14. Total throughput for each run shall be saved in the results file
- 15. Add a disk shelf for each system
 - NearStore VTL600: Add shelf 2 (ports PCI4b/PCI2a)
 - EMC CLARiiON DL710: Add LUNs 4:0:0:20, 2:0:0:21, and 0:0:0:22 (Bus 3 Enclosure 1).
- 16. Create a total of 10 additional virtual tapes for each system:
 - NearStore VTL600:
 - 3 tapes for dl3801
 - 3 tapes for dl3802
 - 4 tapes for dl3803
 - EMC CLARiiON DL710
 - 3 tapes for dell5
 - 2 tapes for dl3801
 - 2 tapes for dl3802
 - 3 tapes for dl3803
- 17. The following commands shall be executed for the 40 stream test to the NearStore VTL600 using four disk shelves
 - cd /root/scripts
 - ./measure_xdd VTL 256 40 4shelf_VTL_log
- 18. The same commands shall be executed for the 40 stream test to the EMC CLARiiON DL710 with four disk shelves
 - cd /root/scripts
 - ./measure_xdd CDL 40 4shelf_CDLog_log
- 19. Total throughput for each run shall be saved in the results file

Test Procedure to Simulate the Variability of Real World Backup Loads

In general, backup servers will send data to tape devices at varying rates, some slower and some faster depending on many factors, including network load, system load, and the ability of the backup server disk system to deliver I/O over the storage network.

Test Bed Setup:

1. This test writes 20 and 40 streams of data at varying rates.
2. The rate and number of each stream listed below shall be sent in a random order from each initiator for each run.

NearStore VTL600 Setup:

1. Three ProLiant DL380 Linux servers, one each directly connected to FC ports 0a, 0c, pci4b on NearStore VTL600 (dl3801, dl3802, dl3803)
2. NearStore VTL600 Virtual tape devices are /dev/st16 through /dev/st31 on these hosts.
3. Four disk shelves shall be used for both systems.
4. Create a virtual library for each Linux initiator (16 virtual drives each).
5. A total of 40 virtual tapes shall be created in the virtual libraries

20 stream test: Rates on each initiator:					
Host	Number of each stream rate to be used				
	5 MB/s	10 MB/s	25 MB/s	50 MB/s	Unthrottled
dl3801	2	1	1	1	1
dl3802	1	2	1	2	1
dl3803	1	1	2	1	2
TOTAL	4	4	4	4	4

40 stream test : Rates on each initiator:					
Host	Number of each stream rate to be used				
	5 MB/s	10 MB/s	15 MB/s	30 MB/s	Unthrottled
dl3801	5	4	1	2	1
dl3802	5	4	1	1	2
dl3803	6	4	2	1	1
TOTAL	16	12	4	4	4

EMC CLARiiON DL710 Setup:

1. Four ProLiant DL380 Linux servers and one Dell PowerEdge 2650 Linux server, each one connected to one FE port on EMC CDL (dl3801, dl3802, dl3803, dell5).
2. CLARiiON DL710 Virtual tape devices are /dev/st0 through /dev/st15 on these hosts.
3. LUNs corresponding to the 4 disk shelves on the CLARiiON DL710 shall be added to the system:

Bus #	Enclosure #	LUN
B0E1		0:0:0:14, 6:0:0:15, 4:0:0:16
B3E0		2:0:0:11, 6:0:0:12, 2:0:0:13
B2E1		2:0:0:17, 0:0:0:18, 6:0:0:19
B2E0		0:0:0:4, 6:0:0:9 0:0:0:10

4. A virtual library shall be created for each Linux initiator (16 virtual drives each)
5. A total of 40 virtual tapes shall be created in the virtual libraries

20 stream test: Rates on each initiator:					
Host	Number of each stream rate to be used				
	5 MB/s	10 MB/s	25 MB/s	50 MB/s	Unthrottled
dl3801	1	1	1	1	1
dl3802	1	1	1	1	1
dl3803	1	1	1	1	1
dell5	1	1	1	1	1
TOTAL	4	4	4	4	4

40 stream test: Rates on each initiator:					
Host	Number of each stream rate to be used				
	5 MB/s	10 MB/s	15 MB/s	30 MB/s	Unthrottled
DELL5	4	3	1	1	1
DI3801	4	3	1	1	1
DI3802	4	3	1	1	1
DI3803	4	3	1	1	1
TOTAL	16	12	4	4	4

1. SSH to host dl3801
2. The following commands shall be executed for the 20 streams test to the NearStore VTL600:
3. cd /root/scripts
4. ./rand_test vtltest_20streams 20varied_VTL_log 10
5. This will start a test that runs 20 streams of data at varying rates 10 times, as per the table above
6. Each time the test runs, it will send the above streams in a random order.
7. Each of the 10 randomized runs will be save to logs in a separate directory:/root/scripts/20varied_VTL_log-x
8. Where x = 1to 10
9. The same command shall be executed for the 20 streams test to the CLARiiON DL710
10. ./rand_test cdltest_20streams 20varied_CD_L_log 10
11. Each of the 10 randomized runs will be saved to logs in a separate directory:/root/scripts/20varied_CD_L_log-x
12. Where x = 1to 10
13. Total throughput for each run will be sent to STDOUT as well as saved in the log directory
14. The order in which the throttle values were sent will be available from the logs.
15. The following commands shall be run for the 40 streams test to the NearStore VTL600:
16. cd /root/scripts
17. ./rand_test cdltest_40streams 40varied_VTL_log 10
18. Run the same command for the 40 streams test to the CLARiiON DL710
19. ./rand_test cdltest_40streams 40varied_CD_L_log 10
20. Each of the 10 randomized runs will be saved to logs in a separate directory:/root/scripts/20varied_CD_L_log-x
21. Where x = 1to 10
22. Total throughput for each run will be sent to STDOUT as well as saved in the log directory.

Test Procedure for VTL Tape Creation and Physical Tape Utilization

The purpose of this test is to measure the utilization of physical tape media when both VTL systems are used to create physical tapes in an ADIC Scalar i2000. In this scenario, test data is first backed up to the VTL, and then physical tapes are created by each test system under the control of a backup application software program.

Test Bed Setup:

1. Four disk shelves shall be used for each system.
2. Target mode for FC 5 in CLARiiON DL710 console shall be disabled
3. One NetBackup server shall be directly connected to FC port 0a on NearStore VTL600
4. The same NetBackup server shall be connected to CLARiiON DL710
5. The virtual libraries shall be configured into NetBackup.
6. NearStore VTL600 library: TLD(0)
7. EMC CLARiiON DL710 library: TLD(1)
8. A physical tape library shall be connected to both systems
9. A NearStore VTL600 virtual library shall be created with the following options enabled:
 - a. Tape Smart Sizing
 - b. Automatically move Tape from EEP to slot
 - c. Over-allocation (system-wide setting)
10. 175GB of 2:1 Compressible Data shall be created in F:\2_to_1_data using HPCreateData.exe found at:
11. http://h20000.www2.hp.com/bizsupport/TechSupport/SoftwareDescription.jsp?lang=en&c=us&swItem=co-9515-2&jumpid=reg_R1002_USEN

Test Procedure:

1. Remote Desktop todell6
2. Create one Virtual Tape in the NearStore VTL600 GUI that matches a barcode in the physical tape library:
3. Under "Daily Tasks" -> click Virtual Tapes
4. Click on "Create Virtual Tapes Using Barcodes"
5. Uncheck "Verify volume is empty before exporting volume"
6. Select Barcode "A00002" (LTO1 Tape)
7. Click Apply
8. Create Virtual Tapes in the CLARiiON DL710 console that are the same capacity as the raw physical tape (100GB in this case). Refer to EMC CLARiiON DL710 Administrator Guide.
9. Expand Virtual Tape Library System -> Virtual Libraries
10. Right click ADIC-Scalar i2000-dell6 and select New Tapes
11. Check "Create virtual tape(s) that match the physical tape(s) in the physical tape library"
12. Click Next
13. Select tape 000071 and 000072 (LTO1 tapes)
14. Click Next
15. Inventory the robots in NetBackup
16. Select the predefined NetBackup policy *2-1_to_NearStoreVTL* and perform a manual backup
17. After the backup is done, eject the tapes that are written to in the library from the NetBackup Administration Console
18. Select the predefined NetBackup policy *2-1_to_EMCCDL* and perform a manual backup
19. After the backup is done, eject the tapes that are written to in the library from the NetBackup Administrator Console

Test Procedure for RAID Group Rebuild Comparison

The purpose of this test is to measure the rebuild time for a RAID group that has been partially filled with data.

Test Bed Setup:

1. Each system shall use only one RAID group with the corresponding LUN added to the system.
2. The NearStore VTL600 RAID group and the EMC CLARiiON DL710 LUN shall use the same number of underlying disks for an even comparison.

NearStore VTL600 Setup:

3. Delete all virtual tapes
4. Drop all RAID groups
5. Add one RAID group in shelf 1 (connected via ports 0b/0d) - fourth shelf from top by selecting disks 1 through 6.
6. Create two tapes in the Library dell6

EMC CLARiiON DL710 Setup:

7. Delete all tapes
8. Unassign all LUNs
9. Assign only LUN 0:0:0:14.
10. Create two tapes in the Library ADIC-Scalar i2000-dell6

Test Procedure:

11. Inventory the Robots in NetBackup
12. Select the predefined NetBackup policy *2-1_to_NearStoreVTL* and perform a manual backup
13. Select the predefined NetBackup *2-1_to_EMCDL* and perform a manual backup.
14. Unplug Disk 2 from the NearStore VTL shelf #1 (this is the shelf that was directly connected to ports 0b and 0d from the controller)
15. Unplug the Bus 0 Enclosure 1 Disk 1 on the CLARiiON CDL710.
16. Record how much time it takes to rebuild the RAID group in the NearStore VTL600
17. Record how much time it takes to rebuild the LUN in the CLARiiON CDL710

Test Procedure for NearStore VTL600 Full RAID Group Rebuild

The purpose of this test is to measure the rebuild performance of a full RAID group using the NearStore VTL600. In this test, dd commands will be used to fill up the virtual tapes in the RAID group.

Test Bed Setup using 1.9TBGB Data Set:

1. Host dl3801 is connected to the NearStore VTL600
2. The virtual tape devices are discovered from /dev/st0 through /dev/st16.
3. Add one RAID group in shelf 1 (connected via ports 0b/0d) - third shelf from the top by selecting disks 1 through 7.
4. Add a hot spare in that shelf:
 - a. Configuration Tasks -> RAID Groups -> Hot Spare Disks
 - b. Click Add Hot Spare Disk
 - c. Add the disk with Port Name: 0d, Shelf: 1, Bay: 0.
5. Create 16 tapes in library DL3801 (Smart Sizing turned on)

Test Procedure

6. ssh to host dl3801 and do the following:
 - a. cd /root/scripts
 - b. perl move.pl /dev/sg0 load 16 (will instruct robot device on /dev/sg0 to load 16 tapes)
 - c. sh run_dd 0 15 (will start dd commands to drives /dev/nst0 through /dev/nst15)
7. After the dd commands exit, confirm that LD0001 is full:
 - a. Navigate to Daily Tasks -> Monitoring -> Statistics and scroll down to RAID Group I/O Load
8. Pull the disk in bay 2 from shelf 1.
9. Check the Event Log to find out how long it took to rebuild the RAID group.

Test Procedure for Measuring Backup Performance in Degraded Mode

The purpose of this test is to measure the throughput of a single stream backup directed to a RAID group before and after it was put into a degraded mode and to observe whether or not the backup load is automatically redirected to an alternate RAID group.

Test Bed Setup:

1. Each system initially had TWO RAID groups and associated LUNs added to the system
2. The NearStore VTL600 RAID group and the EMC CLARiiON DL710 LUN had the same number of underlying disks for an even comparison.

NearStore VTL600 Setup:

3. Delete all tapes
4. Drop all RAID groups
5. Add one RAID group in shelf 1 (connected via ports 0b/0d) - fourth shelf from top by selecting disks 1 through 6.
6. Create ONE tape in Library dell6

EMC CLARiiON DL710 Setup:

7. Delete all tapes
8. Unassign all LUNs
9. Assign LUN 0:0:0:14
10. Create ONE tape in Library ADIC-Scalar i2000-dell6

Test Procedure:

11. Load the one virtual tape into a virtual drive using the GUI of the NearStore VTL600 as well as the EMC CLARiiON DL710
12. ssh to dl3801 and run the following command to simulate a backup to the virtual tape in the NearStore VTL600
13. `time dd if=/dev/zero of=/dev/nst16 bs=256k count=20000` (calculate MB/s)
14. Run the following command to simulate a backup to the virtual tape in the EMC CLARiiON DL710
15. `time dd if=/dev/zero of=/dev/nst0 bs=256k count=20000` (calculate MB/s)
16. Observe which LUN is being written to by looking at the disk activity lights.
17. After the dd has completed, add a RAID group for the NearStore VTL600 in shelf 1 (connected via ports 0b/0d) – fourth shelf from the top by selecting disks 7 through 11
18. Assign LUN 6:0:0:15 for the EMC CLARiiON DL710
19. unplug a disk from each of the systems (one disk from the ones that were used in steps #13 and #15).
20. Wait for each system to detect the disk failure and start the RAID rebuild
21. Run the following commands to simulate an appending of data to the NearStore VTL600
22. `mt -f /dev/nst16 rewind`
23. `mt -f /dev/nst16 eod`
24. `time dd if=/dev/zero of=/dev/nst16 bs=256k count=10000` (calculate MB/s)
25. **For NearStore VTL600:** Observe and record where the new backup is being written by looking at the statistic page.
26. Run the following commands to simulate an appending of data to the EMC CLARiiON DL710
27. `mt -f /dev/nst0 rewind`
28. `mt -f /dev/nst0 eod`
29. `time dd if=/dev/zero of=/dev/nst0 bs=256k count=10000` (calculate MB/s)
30. **For EMC CLARiiON DL710:** Observe and record where the new backup is being written to by looking at the Layout of the virtual tape:
31. Expand Virtual Tape System -> Virtual Tape Libraries -> ADIC-Scalar i2000-dell6 -> Drives -> Drive with tape in it
32. Select the Tape that was in the drive
33. On the right frame, select the “Layout” tab to see which LUN it was on

Appendix C: System disclosures

Network Appliance NearStore VTL600	
Storage Unit	Network Appliance NearStore VTL600
Disk Drives	62 – 7200 RPM 320 GB SATA (2 Spares)
Base software version	Network Appliance VTL OS Version 4.1

Table 1: Network Appliance NearStore VTL600

EMC CLARiiON DL710	
Storage Unit	EMC CLARiiON DL710
Disk Drives	60 7200 RPM 320GB SATA (4 Spares)
Base software version	Release 19 Flare-OS (2.19.700.5.027)
Disk Library Server Version	EMC Disk Library Server v2.1 (Build 1165)
Disk Library Console Version	Disk Library Console v2.1 (Build 1165)

Table 2: EMC CDL 710

Hewlett Packard ProLiant DL380 G3 Load Servers (Red Hat AS Release 4 Update 2)	
Processor / Speed / # of CPUs	Dual Intel 2.8Ghz Xeon, 400 MHz
System RAM / Type	4 GB PC 2100 DDR
Network Adapter	Dual HP NC7781 PCI-X Gigabit server adapters (embedded)
OS	Red Hat AS Release 4 Update 2

Table 3: HP ProLiant DL380 G3 Servers used for Linux load generation

Networking Equipment	
Fibre Channel Switch	Brocade Silkworm 3800 Firmware v3.1.3 ^a

Table 4: Networking Equipment Used

ADIC Scalar i2000	
Storage Unit	ADIC Scalar i2000
Tape Drive(s)	Two LTO2 IBM Ultrium T400F Firmware: 4APO
Base software version	Product Version : 400A-TS01201
Tape(s)	100 GB LTO-1 Tapes

Table 5: Physical Tape Drive Equipment Used

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