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Enterprise Backup Study for the EMD to EEB Bridge Contract

Technical Paper

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Abstract

This white paper identifies the current data enterprise backup systems in the PVC, at the DAAC sites, the EDF and the VATC with the intent of determining a replacement backup system. One common backup system for all environment was the target but site specific configurations had to be taken into consideration. There are three backup solutions evaluated in this study; two vendor solutions using virtual tape libraries and one solution using the EMC/Legato NetWorker DiskBackup Option. All three solutions include physical tape libraries for data cloning and off-site archiving to tape. The study is conducted by installing each solution in a test environment, performing backups, restores and tape cloning tests then collecting statistics on the various component operations. The output of this study will be used as input for the planning and procurement of replacement backup system hardware and software in the Task 03 SDPS Refresh Proposal.

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Abstract

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1. Introduction

1.1 Purpose

The purpose of this study is to determine a suitable replacement for the current backup systems. These backup systems include the Pathlight VX in the Performance and Verification Center (PVC) and the DAACs, the Quantum DX30 in the EDF and the STK Timberwolf 9714 in the VATC. One goal is to replace these backup systems before they reach End of Service Life (EOSL) with a backup system that takes advantage of the latest technologies, such as disk-to-disk-to-tape (D2D2T) and de-duplication to reduce backup storage capacity. Another goal is to increase disk storage capacity so the DAACs can retain up to 3 months of full and incremental backups.

1.2 Background and Scope

The current network backup systems, Pathlight VX (PVX), were initially deployed in the PVC and at the DAAC sites, LP DAAC, NSIDC, LaRC and GSFC between April and July 2006 (actual dates shown below). After the GSFC DAAC was decommissioned, their Pathlight VX backup system was de-installed and returned to the Riverdale Data Center as a spare/test unit.

- 5/15/06 - 5/17/06 LARC (10msp20, HP ProLiant DL360)
- 6/5/06 - 6/8/06 EDC (e4msl20, IBM HS20 Blade)
- 6/19/06 - 6/22/06 NSIDC (n4msl20, IBM HS20 Blade)
- 7/20/06 – 7/22/06 GSFC (g0msp20, HP ProLiant DL360)

The Pathlight VX system hardware includes an ADIC Virtual Tape Library (VTL) or disk backup appliance using EMC RAID and an ADIC Scalar 100 Tape Library with 2 physical LTO 3 tape drives. The backup server OS is Red Hat Enterprise Linux 3 (RHEL3) Update 9 running on an IBM HS20 Blade at all sites except LaRC. LaRC's (and formerly GSFC's) backup server is a rack-mount HP ProLiant DL360 because sites not originally participating in EMD Evolution were not slated to receive an IBM BladeCenter. EMC/Legato NetWorker backup software controls and administrates the backup, restore and archive configurations, policies and schedules.

EMD's Development environment uses a Quantum DX30 for disk backup (VTL) and a Quantum M2500 Tape Library with 4 physical SDLT600 tape drives. The backup server OS is Solaris 5.8 running on a SunFire 280R server. A unique configuration exists for this system to backup high capacity Network Appliance (NetApp) NFS servers. To eliminate additional network traffic from backups, two dedicated tape drives are direct fibre attached to the NetApp and use NDMP for NetWorker to control backing up the NetApp directly to tape.

The VATC STK Timberwolf 9714 tape library has already reached EOSL along with the Sun Enterprise 3000 backup server running Solaris 5.8. While the total data capacity of the clients in the VATC is much less than the other environments mentioned above, it is still desirable to have a hardware supported backup system in the VATC.

The Pathlight VX backup system is not slated to get any future firmware upgrades or support for running RHEL5 on the backup server. Quantum support does not currently maintain a hardware configuration in-house to test or troubleshoot our current PathLight hardware environment running on RHEL5. Another issue is the current Pathlight VX backup system server is running EMC NetWorker v7.4.2-1 on RHEL3 U9 which is going End of Life and does not meet EMD requirements for Linux OS security patches. The OS needs to be upgraded to RHEL5 but Quantum has not certified our existing hardware configuration with RHEL4 or RHEL5.

Two primary options will be assessed; using a Virtual Tape Library (VTL) or appliance from one of several vendors or using EMC/Legato NetWorker DiskBackup Option (DBO) with generic RAID storage for backup-to-disk. All solutions considered will include a physical tape library for tape archiving and off-site storage capability.

1.3 Organization

This paper is organized as follows:

Section 1 provides the introduction, the purpose, background and the scope of the study.

Section 2 discusses the study approach and methodology.

Section 3 presents the requirements for the study.

Section 4 presents the results of the study.

Section 5 provides the conclusions of the study.

1.4 Contacts

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2. Study Approach

2.1 Existing Backup Hardware

This section identifies the current hardware backup configurations with the Pathlight VX, the Quantum DX30 and the STK 9714 then addresses the study approach and methodology for evaluating potential backup system replacements.

The current PVC and DAAC backup system is the ADIC Pathlight VX 650, a scalable enterprise backup and restore solution that integrates disk and tape in a single, unified system. Pathlight VX 650 leverages SATA disk arrays, a Virtual Tape Library (VTL) to increase users' backup performance and give it RAID reliability. Then it integrates the capacity and value of physical tape (LTO 3) to deliver enterprise level scalability, archiving and disaster recovery support.

Pathlight VX Hardware

The PVC and DAACs NetWorker backup server, Pathlight VX and physical tape library hardware specifications are shown in Figure 2-1 and listed below. LaRC has a standalone backup server since their IBM BladeCenter was deployed after the Pathlight VX backup system.

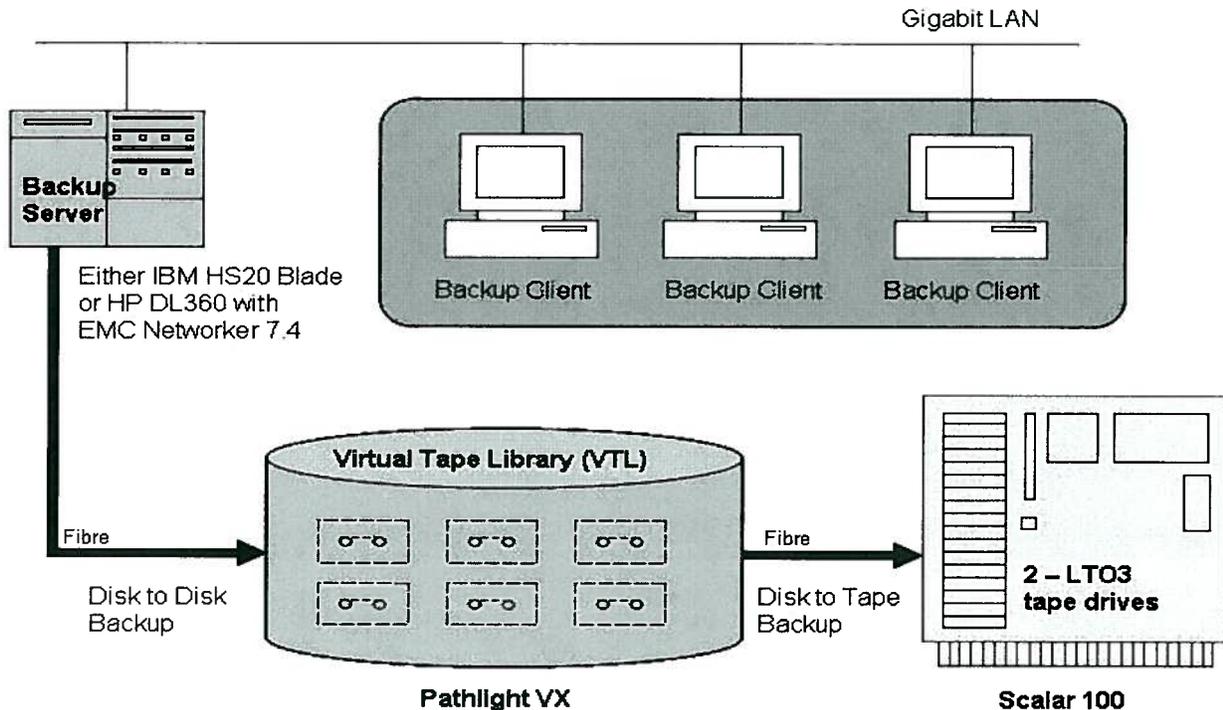


Figure 2-1. Current PVC and DAAC Backup Systems

Server (PVC, NSIDC, LP DAAC)

IBM Blade: HS20 (x4msl20)

4GB Memory

2 x 3.8GHz Intel Xeon CPUs

2 73GB Disk Drives (hardware mirrored by BIOS)

2 Integrated Gigabit Ethernet Interfaces

QLogic QLA2312 HBA (2-Gbps)

OS: Red Hat Enterprise Linux 3 Update 9

Legato NetWorker v7.2.1 Build 311

Server (LaRC)

HP ProLiant DL360 G4 (10msp20)

2GB Memory

2 x 3.4GHz Intel Xeon CPUs

2 73GB Disk Drives (hardware mirrored by BIOS)

2 Integrated Gigabit Ethernet Interfaces

Qlogic QLA2462 HBA (4-Gbps)

OS: Red Hat Enterprise Linux 3 Update 9

ADIC Pathlight VX 650

ADIC Appliance – EMC CX300 RAID

Shelf #1: 6 x 73GB, 10K rpm disks (438GB, RAID vault array configuration on disks 0-4 with 1 hot spare)

Shelf #2: 15 x 320GB, 5.4K rpm disks, 4.8TB Raw, 3.7TB usable VTL

Shelf #3 (LP DAAC only): 15 x 320GB, 5.4K rpm disk 4.8TB Raw, 3.7TB usable VTL

ADIC Scalar 100 Tape Library

6 Virtual Tape Drives – IBM ULT3580-TD3

2 Physical IBM LTO 3 tape drives

2.1.2 Quantum DX30 Hardware

The EDF NetWorker backup server, Quantum DX30 and physical tape library hardware specifications are shown in Figure 2-2 and listed below.

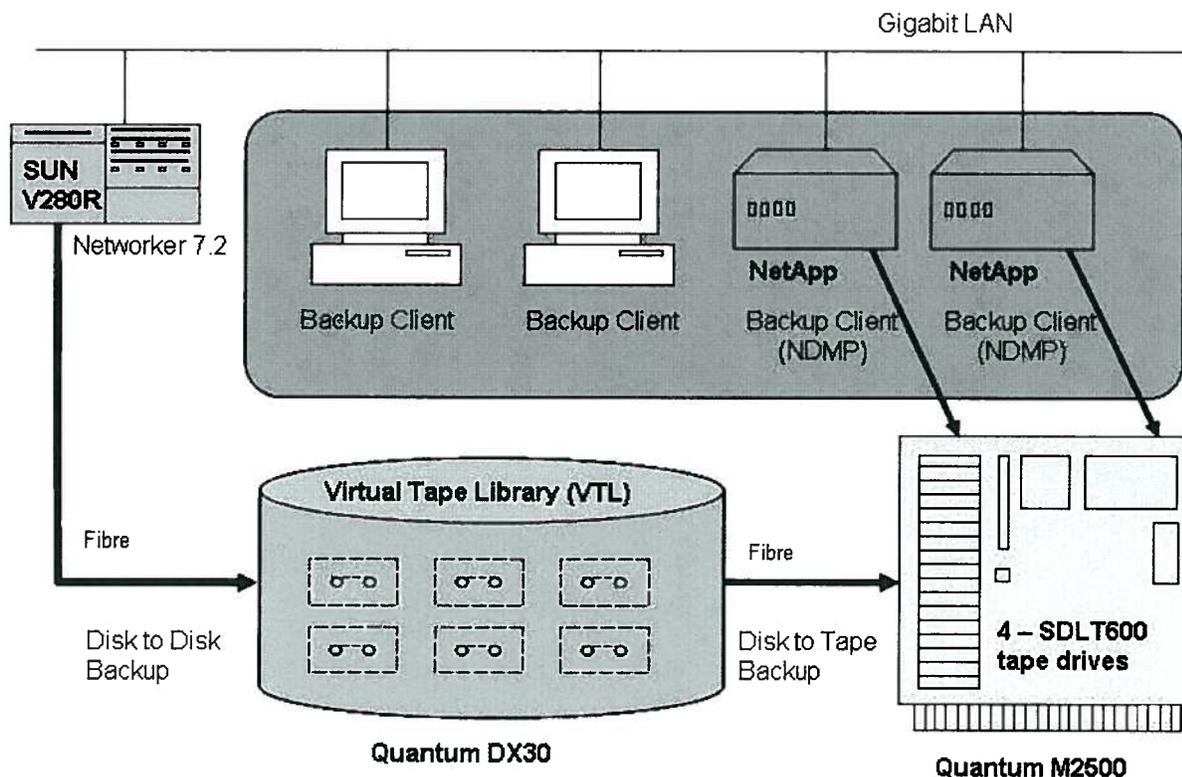


Figure 2-2. Current EDF Backup System

Server (EDF)

- SunFire 280R (platinum)
- 2GB Memory
- 2 x UltraSPARC-III+ CPUs
- 2 36GB Disk Drives
- 1 Integrated Gigabit Ethernet Interface
- Qlogic QLA2462 HBA (4-Gbps)
- OS: Solaris 8 (2/04)
- Legato NetWorker v7.2.1 Build 311

Quantum DX30

- Quantum RAID Array
- 2 Shelves: 32 x 250GB, 6TB usable
- Quantum ATL M2500 Tape Library
- 6 Virtual Tape Drives
- 2 Physical SDLT600 tape drives for NetWorker backups
- 2 Physical SDLT600 tape drives direct attached to NetApps (seattle and fury)

2.1.3 STK 9714 Hardware

The VATC NetWorker backup server and STK Timberwolf 9714 physical tape library hardware specifications are shown in Figure 2-3 and listed below.

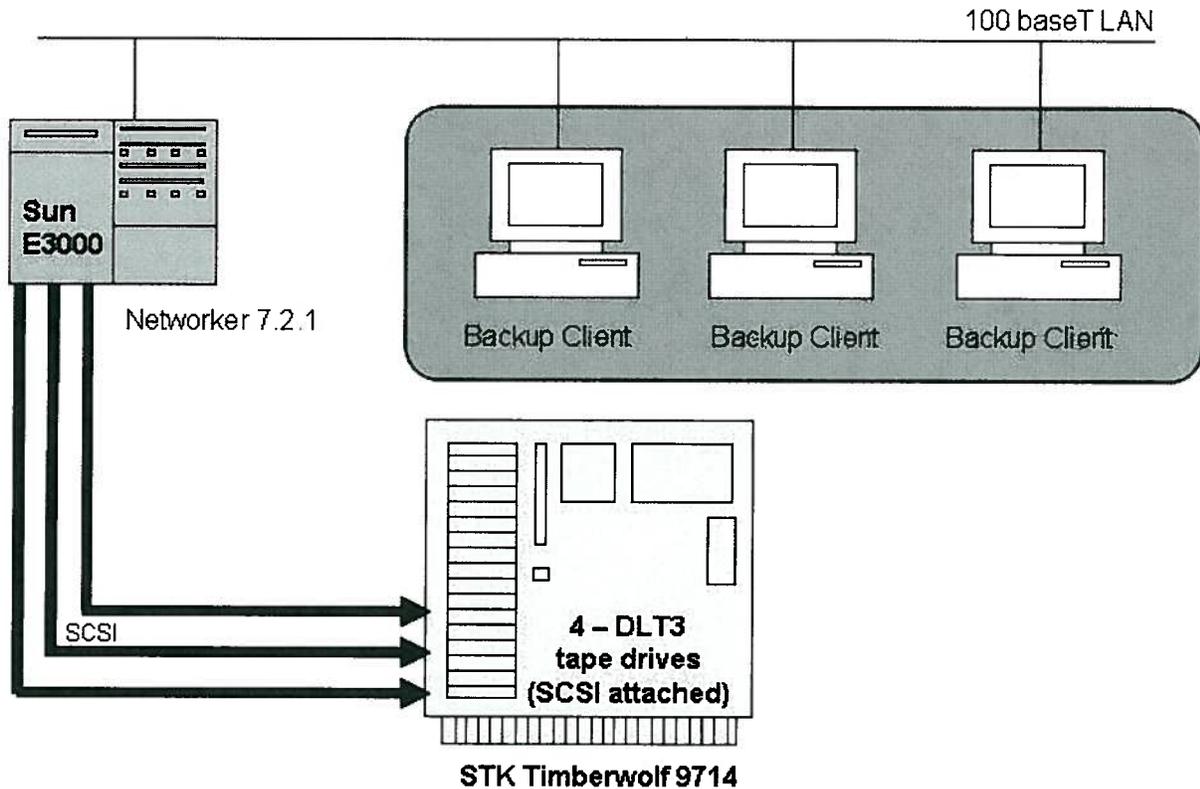


Figure 2-3. Current VATC Backup System

Server (VATC)

- Sun Enterprise 3000 (t1mss02)
- 1GB Memory
- 2 x 168MHz UltraSPARC CPUs
- 3 9GB Disk Drives
- 1 100Base-T Ethernet Interface
- Differential SCSI
- OS: Solaris 8 (2/04)
- Legato NetWorker v7.2.1 Build 314

STK Timberwolf 9714

- StorageTek 9714 SCSI-Attached Tape Library
- 4 Physical DLT3 tape drives

2.2 Study Approach

This section provides the technical approach for conducting the study. The search for a replacement solution was narrowed down to three configurations; HP and Quantum's options use Virtual Tape Libraries for primary backup storage with physical tape libraries for secondary and archive storage. The third option uses the NetWorker DiskBackup Option (DBO) with generic RAID storage for primary backup storage and a physical tape library for archiving. All options were tested using EMC/Legato NetWorker as the backup management software running on Red Hat Enterprise Linux 5 (RHEL5) operating system servers. Test hardware and network specifics are captured in Appendix A.

Create the test environments:

- Install server and backup system hardware (appliance, RAID, tape library)
- Connect Ethernet and fibre interfaces
- Configure NetWorker application (devices, pools, groups, clients, etc.)
- Configure client(s) to backup to test backup server

Perform test backups:

- Execute full backup from single client
- Execute repeat full backup, observe de-duplication benefits, if applicable
- Execute full backups of multiple clients
- Clone backup data to archive tape, measure I/O
- Delete disk backup copy and restore data from archive tape

Collecting backup statistics:

- Capture NetWorker backup stats
 - Start/stop time of backup
 - Actual size of volumes backed up
 - Representative NetWorker compressed size of backed up volumes
 - Space used on VTL or DBO storage disk
- Check NetWorker client disk I/O system activity reports (sar) during backups
- Check NetWorker server CPU, memory and disk I/O sar during backups

2.3 Study Methodology

The steps to create the test environments and are detailed in this section.

NetWorker DBO Solution

1. Load the HP ProLiant DL360 from the former GSFC Pathlight configuration with RHEL5 via Linux Kickstart in the PVC and perform Yum update to install updated packages per 914-TDA-430 Rev02 Release Notes. Install CIS Benchmarks per 914-TDA-448 Release Notes.
2. Rename server to t1msl20.vatc.ecs.nasa.gov and change site specific settings in configuration files for relocation of t1msl20 to the VATC. Reconnect t1msl20 to VATC production network via gigabit Ethernet port on Cisco switch.

3. Connect two fibre channel (FC) cables to SGI TP9700 RAID controller and one FC cable to ADIC Scalar 100 LTO 3 tape library. Configure SGI TP9700 RAID by binding 4 LUNs, 1.089 TB each. Create one 4.2 TB volume group named “DBO” and an lvm named “backup”. Create ext4 file system and mount as /dbo_backup.
4. Install EMC/Legato NetWorker v7.5.1-1 server software on t1msl20 and configure to use DBO feature (using 30 day evaluation licenses) with TP9700 RAID as “disk” device. NetWorker deduplication feature not available without integrating with an EMC Avamar server.
5. Perform full backup of t1acl04 using current NetWorker server t1mss02 then upgrade NetWorker client on t1acl04 from v7.4.2-1 to v7.5.1-1. Change NetWorker server access on t1acl04 from t1mss02 to t1msl20.
6. Ensure t1acl04 has at least 500GB of data on local storage then perform another full backup of t1acl04 to t1msl20. Verify space used for first full backup on NetWorker DBO device then perform a second full backup to determine spaced saved (if any) on subsequent backup(s) of same data.
7. Collect NetWorker backup stats along with sar data from backup server and client.
8. Install 2 retired SGI servers, t1acg05 and t1spg07, back into VATC and perform full backups with multiple clients. Collect backup stats again.
9. Perform test data recovery. Archive (tape copy) save sets from DBO disk backups to tape then remove DBO disk copy and recover data from archive tape.

HP Solution

1. Connect the HP ProLiant DL180 primary Ethernet interface (eth0) to PVC production network. Load the server with RHEL5 via Linux Kickstart in the PVC as p4tel03 and perform Yum update to install updated packages per 914-TDA-430 Rev02 Release Notes. Install CIS Benchmarks per 914-TDA-448 Release Notes.
2. Configure second Ethernet interface with private address (10.1.1.100) and connect to Cisco 2900 switch port #1 installed inside HP demo equipment rack. Verify ports 7-12 on 2900 switch are enabled for network connections from HP backup equipment.
3. Install HP evaluation equipment in data center. Connect D2D4112 and MSL4048 Ethernet and fibre channel cables and configure equipment with HP field engineer.
4. Create virtual tape devices on HP D2D4112 for NetWorker to “discover”, a virtual MSL4048 hardware emulator and a generic D2D device.
5. Install EMC/Legato NetWorker v7.5.1-1 server software on p4tel03 and “discover” HP hardware devices. NetWorker v7.4.2-1 client on not upgraded on p4tel01 since it was an operational server still being backed up by p4msl20. Add NetWorker server access on p4tel01 for test backup server p4tel03 to operation backup server p4msl20.
6. Populate p4tel01 with at least 400GTB of data then perform full backups of t1acl04 to p4tel03 using virtual MSL4048 and generic D2D devices. Collect stats and compare performance between virtual devices. HP best practices guide recommends using generic D2DBS device.
7. Verify space used for first full backup with both HP VTLs and then perform a second full backup to determine spaced saved by deduplication. Execute additional full backups using best performing virtual devices and collect stats.
8. Copy (clone) data from virtual tape(s) to physical tapes, measure performance.

9. Perform test data recovery from VTL. Delete VTL copy then recover data from cloned physical tape.

Quantum Solution

Due to time constraints for acquiring a Quantum hardware evaluation unit, configure/test the DXi7500 at the Quantum Forbes Blvd test facility. Performed the following tasks to demonstrate backup, deduplication and recovery operations from disk:

1. Create a virtual disk backup device on the Dxi7500.
2. Perform an initial backup of a specific data set.
3. Perform a second backup with of the same data set to show de-duplication (metadata only should be written).
4. Restore a de-duplicated file from disk make sure changes show up correctly.
5. Restore a selected file or directory from tape.
6. Demonstrate of unit performance to both tape and disk.
7. Copy (clone) data from virtual tape(s) to physical tapes, measure performance.

2.4 Assumptions

The following assumptions were made for this study.

- VATC client disk I/O for t1acl04 limited by internal 6TB RAID6 (6+2 1TB disks). All I/O for local file systems reading from same LUN/disks.
- Use of LTO 3 tape drives in VATC backup/archive step will not perform as well as LTO 4 tape drives.
- Backup tests will be performed during non-operational backup periods to avoid adding to existing heavy network loads.
- Network traffic between NetWorker backup servers and client will be the same regardless of what backup solution is deployed.
- The network bandwidth (~11MB/sec on 100Base-T network) at Quantum test lab would be the limiting factor for backup client-to-server I/O.

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3. Requirements

The hardware and software requirements listed in this section provide the weighted selection criteria used to form an assessment value for the backup solution recommendation.

3.1 Hardware Requirements

- (10) Increased storage capacity, at least 10TB, for minimum retention of 3 months of full and incremental backups online.
- (10) Support LTO 4 tapes.
- (10) Ease of operation, minimal user intervention.
- (8) Rack-mountable, self contained system including backup server, disk storage and tape library. Direct fibre connections between devices, not using Brocade SAN fabric.
- (4) Disk storage and tape library supported by single vendor.

3.2 Software Requirements

- (10) Support Network Data Management Protocol (NDMP) to back up Network Appliance servers in the EDF.
- (10) Support multiple client operating systems, Linux, Solaris, Irix, HP-UX, Windows, Mac OSX
- (10) Tape archiving and data cloning capability.
- (4) Use EMC/Legato NetWorker as the backup management software.
- (4) Support data de-duplication.

3.3 Current Backup Volumes

The amount of data (NetWorker compressed size) from the full and incremental backups from August 2008 to June 2009 for all hosts at the DAACs and EDF are shown in Table 3-1. The EDF includes 2 Network Appliance NFS filers that write directly to dedicated tape drives in the M2500 Tape Library. EDF backup totals include only full backups (no incrementals) other than the month of June 2009.

The numbers for NSIDC monthly backups (Table 3-1 in red) retrieved from NetWorker's reporting utility are much lower than expected and shall not be used for sizing of their replacement system. LaRC statistics only date back to May 2009 because they shutdown the operations NetWorker Backup Server (10msp20) around April 2009 and consolidated their backups onto their M&O network backup server. LaRC is still using the Quantum Scalar 100 physical tape library but writes initial data to TP9700 RAID using NetWorker DBO. LP DAAC currently backs up nightly Sybase dump files and keeps several copies on disk/tape, which may skew the LP DAAC totals below.

Table 3-1. Monthly Full and Incremental Backup Volumes

Month	Amount of Data Backed Up in Terabytes				
	LaRC	LP DAAC	NSIDC	PVC	EDF
Aug-2008		3.306	0.247	4.511	0.851
Sep-2008		4.760	0.252	4.855	0.834
Oct-2008		3.104	0.146	6.823	0.842
Nov-2008		3.098	0.234	5.455	2.036
Dec-2008		3.129	0.069	9.712	2.175
Jan-2009		4.365	0.176	5.465	1.574
Feb-2009		3.086	0.202	5.441	3.216
Mar-2009		3.060	0.150	6.130	2.333
Apr-2009		3.137	0.095	4.991	2.352
May-2009	2.366	3.288	0.117	4.591	2.127
Jun-2009	2.487	3.385	0.286	4.034	3.741
Total	4.853	37.718	1.974	62.008	22.081
Average	2.427	3.429	0.179	5.637	2.007
3 Mo Average	7.280	10.287	0.538	16.911	6.022

4. Results

4.1 HP D2D4112 Data Collection Results

Data collection and analysis results from the different backup hardware solutions, the NetWorker backup server and client(s) during the full backups and for cloning data to physical tape in the various environments is presented in this section.

4.1.1 PVC NetWorker Performance with HP D2D4112 Backup System

The statistics collected from the NetWorker backup logs when storing backup data on the HP D2D4112 evaluation unit are displayed in Table 4-1. The table shows for approximately 432GB of data saved with full backups from PVC backup client p4tel01 on 3 separate occasions, NetWorker consistently achieved a compression ratio of 1.3 to 1. This reduced the actual data capacity from backup client p4tel01's local file systems from 432GB to 334GB. The total time to back up 432GB averaged 2 hours for the 3 full backups performed which equates to 61MB/second.

Table 4-1. PVC NetWorker Backup Stats – Compression Ratio 1.3:1 (1 of 2)

						MSL4048 VTL		
p4tel01 file systems (Sept 1)						Backup #2 - August 28th		
Filesystem	Size	Used	Avail	Use%	Mounted on	Backed Up	Time	Files
LogVol00	992M	349M	593M	38%	/	110M	0:00:51	5645
LogVol07	9.7G	365M	8.9G	4%	/cots	108M	0:01:00	4686
LogVol08	7.8G	147M	7.3G	2%	/custom	7K	0:00:04	26
LogVol06	2.0G	68M	1.8G	4%	/data	3K	0:00:02	6
LogVol05	2.0G	135M	1.8G	8%	/opt	30M	0:00:32	1654
LogVol03	992M	191M	751M	21%	/tmp	2K	0:00:20	2
LogVol02	7.8G	3.3G	4.1G	45%	/usr	1495M	0:05:00	146804
LogVol01	3.9G	551M	3.2G	15%	/var	165M	0:00:56	1406
c0d0p1	487M	17M	445M	4%	/boot	5433K	0:00:21	25
userpull	418G	262G	195G	58%	/user_pull	257G	2:02:20	1828
hammerdata	345G	165G	164G	51%	/hammerdata	70G	1:50:12	256045
Total		~432G				~334G	2hr 3m	418127
						D2DBS Generic VTL		
p4tel01 file systems (Sept 1)						Backup #3 - Sept 1st		
Filesystem	Size	Used	Avail	Use%	Mounted on	Backed Up	Time	Files
LogVol00	992M	349M	593M	38%	/	110M	0:00:51	5645

Table 4-1. PVC NetWorker Backup Stats – Compression Ratio 1.3:1 (2 of 2)

LogVol07	9.7G	365M	8.9G	4%	/cots		108M	0:01:02	4683
LogVol08	7.8G	147M	7.3G	2%	/custom		7K	0:00:02	26
LogVol06	2.0G	68M	1.8G	4%	/data		3K	0:00:03	9
LogVol05	2.0G	135M	1.8G	8%	/opt		30M	0:00:33	1654
LogVol03	992M	191M	751M	21%	/tmp		2K	0:00:20	2
LogVol02	7.8G	3.3G	4.1G	45%	/usr		1495M	0:05:41	146804
LogVol01	3.9G	551M	3.2G	15%	/var		170M	0:00:54	1406
c0d0p1	487M	17M	445M	4%	/boot		5433K	0:00:21	25
userpull	418G	262G	195G	58%	/user_pull		257G	2:00:08	1828
hammerdata	345G	165G	164G	51%	/hammerdata		70G	1:46:22	256045
Total		~432G					334G	2hr 0m	418127
							D2DBS Generic VTL		
	p4tel01 file systems (Sept 3)						Backup #4 – Sept 3rd 11:56		
Filesystem	Size	Used	Avail	Use%	Mounted on		Backed Up	Time	Files
LogVol00	992M	349M	593M	38%	/		110M	0:00:46	5646
LogVol07	9.7G	365M	8.9G	4%	/cots		108M	0:00:54	4689
LogVol08	7.8G	147M	7.3G	2%	/custom		7K	0:00:05	26
LogVol06	2.0G	68M	1.8G	4%	/data		3K	0:00:06	9
LogVol05	2.0G	135M	1.8G	8%	/opt		30M	0:00:18	1654
LogVol03	992M	170M	772M	18%	/tmp		2K	0:00:09	2
LogVol02	7.8G	3.3G	4.1G	45%	/usr		1495M	0:05:35	146804
LogVol01	3.9G	688M	3.1G	19%	/var		194M	0:00:43	1390
c0d0p1	487M	17M	445M	4%	/boot		5433K	0:00:19	25
userpull	418G	262G	195G	58%	/user_pull		257G	1:56:27	1828
hammerdata	345G	165G	164G	51%	/hammerdata		70G	1:43:54	256045
Total		~432G					~334G	1hr 57m	418118

4.1.2 PVC HP D2D4112 Backup System

The D2D4112 storage space used during the 3 full backups is captured in Table 4-2. An initial test full backup of p4tel01 was performed but statistics were not captured. However, the second full backup of p4eil01 indicates the D2d4112 User Data Stored capacity is 678GB, roughly double the 334GB of compressed data written in the August 28 full backup #2. The D2D4112 Disk Space Used capacity is 273GB, representing a deduplication ratio of 2.5 to 1 with 2 backup written to the MSL4048 VTL device.

Full backups #3 and #4, both NetWorker compressed to 334GB, were written to the D2D4112 generic D2DBS VTL device. Backup #3 actually resulted in a Disk Space Used increase of 232GB and a decrease in deduplication ratio to 2.0 to 1 because the data was written to a virtual tape library device with no previous save sets. Backup #4 clearly shows the optimal deduplication scenario when the same 334GB of save sets is written to the generic D2DBS VTL

device with existing copies of those save sets. Although the D2D4112 User Data Stored capacity increased by approximately 410GB, the actual Disk Space Used only increased by 26GB and the disk used percentage remained at 2%.

Table 4-2. PVC D2D4112 Disk Space Used after Full Backups

D2D4112 Backup Stats (Date & VTL Device)	Aug 28 #2 MSL4048	Sept 1 #3 D2DBS	Sept 3 #4 D2DBS
Disk Space Used (GB)	273.0	505.0	531.0
Disk Space Allocated (GB)	554.0	783.0	806.0
User Data Stored (GB)	678.1	1024.0	1433.6
DeDup Ratio:	2.5:1	2.0:1	2.6:1
Disk Percentage Used	1%	2%	2%
Disk Percentage Allocated	3%	4%	4%

A data recovery test was conducted by renaming a directory containing 11GB of data then recovering the data from NetWorker via the D2D4112. Shown in the screen output below, 9797 files were restored to the p4tel01:/hammerdata/OPS/HammerData/MYD29- directory from a D2D4112 virtual tape in just over 5 minutes. The file recovery read rate from the D2D4112 was approximately 38MB/second.

```

root@p4tel01:/hammerdata/OPS/HammerData> du -hs MYD29-
11G  MYD29-
root@p4tel01:/hammerdata/OPS/HammerData> mv MYD29- MYD29-.orig
root@p4tel01:/hammerdata/OPS/HammerData> recover -s p4tel03
Current working directory is /hammerdata/OPS/HammerData/
recover> add MYD29-
/hammerdata/OPS/HammerData/MYD29-
9797 file(s) marked for recovery
Recovering 9797 files into their original locations
Volumes needed (all on-line):
    34EE13D3 at /dev/nst6
Total estimated disk space needed for recover is 11 GB.
Requesting 9797 file(s), this may take a while...
./MYD29-/set1.MYD29P1N.A2004065.h14v11.004.2004068002527.hdf
./MYD29-/
Received 9797 file(s) from NSR server `p4tel03'
Recover completion time: Wed 09 Sep 2009 11:13:18 AM EDT
(Start time Wed 09 Sep approx 11:08am)

```

4.1.3 PVC HP MSL4048 Tape Library

To copy (clone) one D2D4112 virtual tape with 268GB of data to a MSL4048 physical tape took 2 hours to complete, only writing approx 38MB/sec. This tape write rate would result in 6 hours to clone a full (native capacity 800GB) LTO 4 virtual tape. LTO 4 write speed should be much faster, capable of data transfer rates up to 240 MB/sec. Possible the un-deduplication of virtual tape data before copying to physical tape caused the slow I/O throughput. It was also discovered during this test that the MSL4048 can only copy or clone one physical tape at a time, eliminating all benefits to having multiple tape drives.

4.1.4 PVC SAR Data from NetWorker Server and Client

System activity reports captured during the August 28th full backup that started at 12:57 and ended at 15:00 indicate minimal use of system resources on the NetWorker server, p4tel03. Server CPU usage averaged 80% idle, percent of memory used increase minimally and disk I/O was commensurate with the volume of data saved in the NetWorker backup logs.

Statistics for the NetWorker client p4tel01 were captured simply to analyze whether any system resources prevented the NetWorker server from performing as expected. For instance, if client disk I/O only averaged 40MB/second, the server will be limited to that average at best. The NetWorker client performance will not change regardless of the backup configuration deployed. On p4tel01 during the 2 hour backup period, CPU resources decreased from 99.9% idle to 82% idle with no significant increase in memory use.

4.2 NetWorker DBO Data Collection Results

4.2.1 VATC NetWorker Performance with DBO

With NetWorker DBO storing data in t1msl20:/dbo_backup, a 4.2TB mounted file system on SGI TP9700 RAID, statistics from the NetWorker backup logs are displayed in Table 4-3. Two full backups of t1acl04 on August 28th and August 31st produced nearly identical results; approximately 678GB of data saved with a compression ratio of 1.97:1. The actual data capacity saved to the NetWorker DBO device compressed down to 345GB in roughly 4 hours and 30 minutes, an average of 42MB/second.

Another full backup was performed, adding two NetWorker clients, t1acg05 and t1spg07, to t1acl04. Total data backed up on these three clients, shown in Table 4-4, was 1.65TB in 12 hours and 38 minutes, averaging 37MB/second. Compression ratio for this backup could not be determined since some of the data was deleted from t1acl04's /LO_buffer and /science file systems after the start and prior to the end of the full backups.

Table 4-3. VATC NetWorker Client Backup Stats – Compression Ratio 1.97:1

t1acl04 file systems						Backup #2 – August 28 th			
Filesystem	Size	Used	Avail	Use%	Mounted on	Backed Up	Time	Files	
LogVol00	992M	323M	619M	35%	/	96M	0:01	5503	
LogVol07	9.7G	172M	9.1G	2%	/cots	12M	0:00:32	957	
LogVol08	7.8G	3.6G	3.9G	49%	/custom	1157M	0:05	41618	
LogVol06	2.0G	339M	1.6G	18%	/data	47M	0:00:29	14	
LogVol05	2.0G	174M	1.7G	10%	/opt	83M	0:00:29	1655	
LogVol03	992M	58M	884M	7%	/tmp	2K	0:00:01	2	
LogVol02	7.8G	3.3G	4.1G	45%	/usr	1477M	0:07	144633	
LogVol01	3.9G	2.1G	1.7G	56%	/var	651M	1:36	1536	
c0d0p1	487M	17M	445M	4%	/boot	5733K	0:00:02	25	
LogVol10	296G	15G	267G	6%	/user_pull	2470M	0:14	7248	
LogVol09	9.9G	1.6G	7.8G	17%	/COTS	1294M	0:03	15	
LogVol11	197G	91G	97G	49%	/science	83G	1:45	78117	
LogVol12	4.9T	561G	4.1T	12%	/L0_buffer	255G	4:33	315616	
Total		~678G				~345G	4hr 33m	596939	

t1acl04 file systems						Backup #3 – August 31 st			
Filesystem	Size	Used	Avail	Use%	Mounted on	Backed Up	Time	Files	
LogVol00	992M	323M	619M	35%	/	96M	1:03	5503	
LogVol07	9.7G	172M	9.1G	2%	/cots	12M	0:00:12	981	
LogVol08	7.8G	3.6G	3.9G	49%	/custom	1157M	0:05	41618	
LogVol06	2.0G	339M	1.6G	18%	/data	47M	0:00:32	14	
LogVol05	2.0G	174M	1.7G	10%	/opt	83M	0:00:33	1655	
LogVol03	992M	58M	884M	7%	/tmp	2K	0:00:12	2	
LogVol02	7.8G	3.3G	4.1G	45%	/usr	1477M	0:07	144633	
LogVol01	3.9G	2.1G	1.7G	56%	/var	638M	1:44	1538	
c0d0p1	487M	17M	445M	4%	/boot	5733K	0:00:02	25	
LogVol10	296G	15G	267G	6%	/user_pull	2470M	0:14	7248	
LogVol09	9.9G	1.6G	7.8G	17%	/COTS	1294M	0:03	15	
LogVol11	197G	91G	97G	49%	/science	83G	1:45	78117	
LogVol12	4.9T	561G	4.1T	12%	/L0_buffer	255G	4:26	315688	
Total		~678G				~343G	4hr 26m	597037	

Table 4-4. VATC NetWorker Backup Stats for 3 Concurrent Clients

t1acl04 file systems						Backup #5 – Sept 16 th		
Filesystem	Size	Used	Avail	Use%	Mounted on	Backed Up	Time	Files
LogVol00	992M	323M	619M	35%	/	96M	0:00:33	5503
LogVol07	9.7G	174M	9.1G	2%	/cots	14M	0:00:16	1161
LogVol08	7.8G	3.6G	3.9G	49%	/custom	1161	0:02:45	46894
LogVol06	2.0G	339M	1.6G	18%	/data	47M	0:00:10	14
LogVol05	2.0G	174M	1.7G	10%	/opt	83M	0:00:29	1655
LogVol03	992M	71M	871M	8%	/tmp	2K	0:30:02	2
LogVol02	7.8G	3.3G	4.1G	45%	/usr	1479M	0:35:04	144633
LogVol01	3.9G	2.2G	1.6G	58%	/var	730M	0:31:10	1538
c0d0p1	487M	17M	445M	4%	/boot	5M	0:30:03	25
LogVol10	296G	15G	267G	6%	/user_pull	4191M	0:44:03	7248
LogVol09	9.9G	1.6G	7.8G	17%	/COTS	1.2G	0:00:42	15
LogVol11	197G	91G	97G	49%	/science	4113M	3:21:40	78117
LogVol12	4.9T	561G	4.1T	12%	/L0_buffer	3448M	12:38:10	516939
Subtotal		~678G				~16GB	12:38:10	803744
t1acg05 file systems								
Filesystem	Size	Used	Avail	Use%	Mounted on	Backed Up	Time	Files
root	3.9G	3.2G	717M	83%	/	1.6G	0:14:36	62445
hammerdata	544G	164G	109G	61%	/hammerdata	70G	3:17:56	256050
ftppull	1.0T	260G	284G	48%	/user_pull	257G	3:07:05	1856
dks0d1s7	17.3G	4.6G	4.0G	54%	/data1	2.2G	0:42:54	25681
Subtotal		~432GB				~330.8GB	3:17:56	346032
t1spg07 file systems								
Filesystem	Size	Used	Avail	Use%	Mounted on	Backed Up	Time	Files
/dev/root	13G	5.2G	7.9G	40%	/	2519M	0:35:56	48204
dks0d2s7	17G	512K	17G	1%	/data1	2K	0:30:03	2
raid2_tp9700	545G	48G	497G	9%	/raid2	18G	3:58:14	5299209
raid1_tp9700	1.1T	72G	1018G	7%	/raid1	33G	1:41:11	575249
97_mogdata2	1.1T	412G	678G	38%	/mog_data2	316G	4:10:23	15179
Subtotal		~537GB				~369GB	4:10:23	5937843
Total		~1.65TB					12:38:10	

Using NetWorker DBO allows backup to disk but the application does not natively support de-duplication. Therefore each full backup increases the amount of disk space used on the DBO device. If 3 full backups are performed without any change to the source data on the NetWorker clients, 3x the original full backup space is used on the DBO storage device. Table 4-5 shows the linear growth in Disk Percentage Used with the NetWorker DBO without de-duplication.

Table 4-5. VATC DBO Disk Space Used after Full Backups

DBO Backup Stats (Date)	Aug 20 #1	Aug 28 #2	Aug 31 #3
Disk Space Used (GB)	343	679	1013
DeDup Ratio:	N/A	N/A	N/A
Disk Percentage Used	8%	16%	24%

4.2.2 VATC Scalar 100 Tape Library Performance

To create archive or clone tapes, since the NetWorker DBO does not utilize virtual tapes, individual save sets must be identified for copy to tape. The Scalar 100 with LTO 3 tape drives was used to clone approximately 2TB in 2 hours 42 minutes, to 2 tapes, averaging 107MB/second written to tape.

4.2.3 VATC SAR Data from NetWorker Server

SAR data captured on the VATC NetWorker server, t1msl20, during the August 31st full backup that started at 18:48 and ended at 23:14 show CPU resources decreasing from 99.8% idle to 83% idle. The NetWorker DBO configuration does generate significant disk I/O, graphed in Figure 4-1, while writing data to the backup device file system.

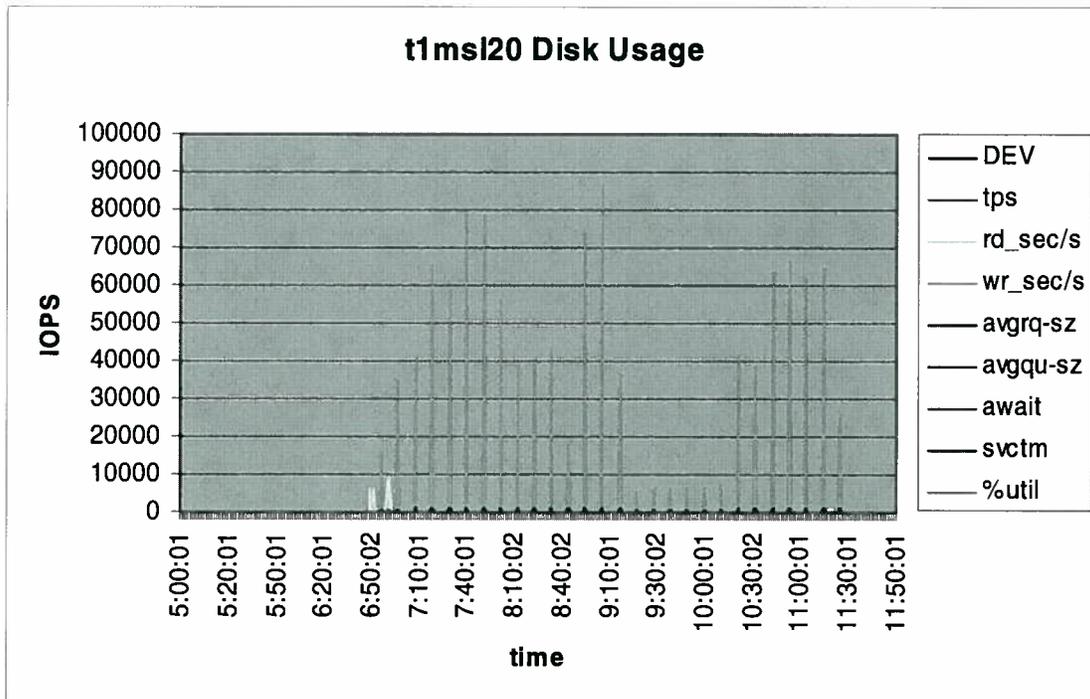


Figure 4-1. Graph of t1msl20 writes/second during DBO backups

Figure 4-2 shows the memory cache used on t1msl20 during full backups increasing slightly during the full backup then returning to normal. Red Hat Linux allocates all the memory available during system startup so the memory used graph line always reflects the total memory on the system, in this case, 2GB.

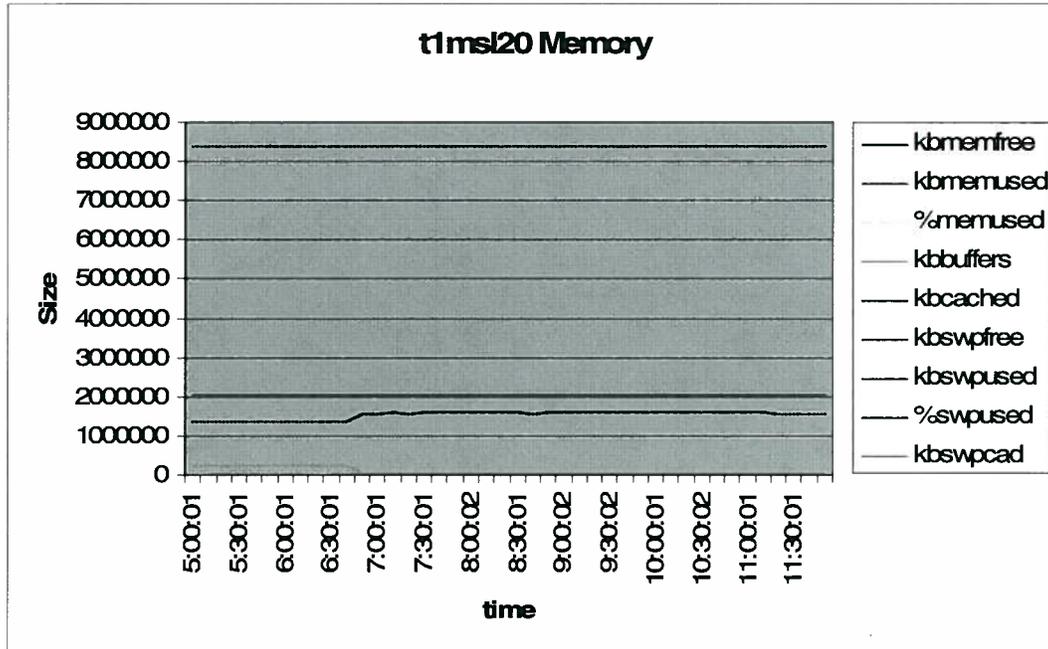


Figure 4-2. Graph of t1msl20 memory cached during DBO backups

4.3 Quantum DXi7500 Data Collection Results

4.3.1 Quantum Test Lab NetWorker Performance with DXi7500

The Dxi7500 system was evaluated by visiting the Quantum facility and observing the configuration and performance of the Dxi7500 and the software configuration of Legato NetWorker to work with the Dxi7500. 30GB of data was copied from the NetWorker server accessing files on a Dxi5500 NAS share to virtual tapes created on the Dxi7500. The same data set was copied a second time to the Dxi7500 to observe the effects of de-duplication. Data was cloned from a virtual tape to a physical tape to measure path-to-tape performance. The performance data is shown below.

- 30GB of random, file data
- Average of 20-40MB/second written to Dxi7500
- **27MB of disk space used** on second backup of 30GB (NetWorker metadata)
- Path-to-Tape performed at 30-60MB/sec

5. Conclusions

The brief evaluations below discuss technical observations that are not necessarily quantifiable but factored into the final recommendation.

5.1 HP D2D4112 and MSL4048 Evaluation

The HP solution using the D2D4112 backup system performed sufficiently when backing up and restoring data with no discernable difference using an MSL4048 emulation VTL or generic D2DBS VTL. Subsequent backups of the same data resulted in very good de-duplication ratios. To copy data from VTL to physical tape underperformed and required 2 hours to complete a copy of 268GB, approximately 33% of a full LTO 4 tape. It also was discovered during this testing that only one SAS tape drive can be accessed at a time, meaning only one tape copy operation could be performed at a time, regardless of how many physical tape drives were installed. This configuration absolutely does not support the EDF configuration which requires 2 tape drives be direct fibre attached to Network Appliance servers and an additional 2 drives be available for NetWorker tape clone and archive operations.

From the hardware perspective, starting with the initial equipment setup thru the evaluation of the demo equipment, HP failed to demonstrate adequate knowledge of the D2D4112 hardware and its operations. Numerous configuration questions could not be answered by the vendor and administration of the D2D4112 and MSL4048 was not well integrated. Separate web interfaces from the D2D4112 and the MSL4048 must be accessed to accomplish the complete task of copying data to physical tape and removing the tape from the tape library. This system is not deemed a suitable replacement to the current backup system.

5.2 EMC/Legato NetWorker DBO Evaluation

Since evaluation of each solution utilizes NetWorker as the backup management software, this solution only evaluates the DiskBackup Option performance and storage capacity used. Our test environment used TP9700 RAID for the DBO storage device and performed sufficiently, writing over 40MB/second. Without de-duplication, which requires integration with an EMC Avamar server, no space savings are gained when backing up duplicate data. This would mandate the procurement of additional disk space to maintain a 3 month data retention policy.

Copying or cloning data to tape also performed well but requires manual selection of specific NetWorker save sets as opposed to creating a one-to-one copy or clone from a virtual tape to a physical tape. There are additional license impacts based on the capacity of the DBO device. This configuration was tested with the Quantum Scalar 100 with LTO 3 drives. With the potential of having multiple vendor support for the DBO disk storage device and physical tape library, as well as an escalating storage capacity requirement for maintaining multiple months of full backup, this solution is not recommended for the PVC, DAACs or EDF. With the reuse of an existing NetWorker server, tape hardware and procuring minimal RAID space, this configuration

can provide an relatively low cost replacement for the STK Timberwolf 9714 in the VATC that has already surpassed EOSL.

5.3 Quantum DXi7500 Evaluation

The Quantum Dxi7500 backup system was demonstrated at the Quantum test facility and performed as expected with the NetWorker backup server and client connected to a 100Mbps LAN. The screen captures displayed in Appendix B show this backup system provides the visibility and direct access to the tape library that is missing in the current Pathlight VX system. It also uses NDMP for direct tape drive communication that is also required to support the EDF direct backup of Network Appliance servers to tape. The vendor knowledge demonstrated with this hardware coupled with the necessary knowledge to integrate and configure NetWorker to take advantage of the features was impressive.

Connectivity from the backup server to the tape library can be direct fibre attached or pass-thru via the Dxi7500. Data de-duplication will allow longer backup retention periods without significantly increasing the storage capacity of the Dxi7500 storage disk. The recommendation is to deploy a Dxi7500 Express with 11TB of disk space and the Quantum Scalar i500 tape library.

5.4 Replacement Backup Server

It is recommended that the option chosen have a replacement, standalone server deployed with the new backup hardware. The current IBM HS20 Blade backup servers have several limitations that will deter future enhancements to the backup system.

- Limited to 2Gbps due to IBM chassis optical pass-thru modules, regardless of HBA speed
- Maximum of 1 dual port HBA supported
- Dependent on stability of IBM Blade chassis
- Maximum local disk capacity 146GB, 2 x 73GB internal disks

Testing the different options has proven the NetWorker server uses minimal system resources. EMC/Legato’s system requirements for a NetWorker server are shown Table 5-1.

Table 5-1. System Configuration Requirements for NetWorker Server

	Minimum Recommended Configuration	Preferred Configuration
CPU	Dual Core, 1.5GHz speed	Two Dual Core
RAM	2 GB	4 GB
Swap Space	4 GB or Ram x 2	8 GB

5.5 Final Recommendation

The final recommendation of this study to use the Quantum DXi7500 backup solution is further supported by the total score achieved by each solution in the weighted selection criteria matrix in Table 5-2.

Table 5-2. Weighted Selection Criteria Matrix

Selection Criteria	Weight Scale	HP D2D4112	NetWorker DBO	Quantum DXi7500
Increased storage capacity, at least 10TB, minimum retention of 3 months online	10	10	10	10
Support LTO 4 tapes	10	10	10	10
Ease of operation, minimal user intervention	10	0	10	10
Rack-mountable, self contained system including backup server, disk storage and tape library	8	8	8	8
Disk storage and tape library supported by single vendor	4	4	0	4
NDMP Support for NetApp	10	0	10	10
Support multiple client operating systems, Windows, Linux, Solaris, Irix, HP-UX, Mac	10	10	10	10
Tape archiving and data cloning capability	10	10	10	10
Use EMC/Legato NetWorker as the backup management software	4	4	4	4
Support data de-duplication	4	4	0	4
Total Score	80	60	72	80

The Quantum backup solution recommended for the PVC and DAACs is pictured in Figure 5-1. The EDF configuration adds two additional LTO 4 tape drives for direct fibre attachment to the NetApps, seattle and fury. It is also the recommendation of this study to deliver all components of this backup solution, the DXi7500, tape library, backup server and power distribution units (PDUs) as a self-contained system in a standard 19" equipment rack. The i500 tape library and HP DL380 backup server are shown in Figure 5-1 for completeness but not guaranteed to be the exact hardware delivered in the final backup solution.

QUANTUM BACKUP SOLUTION DAACs and PVC

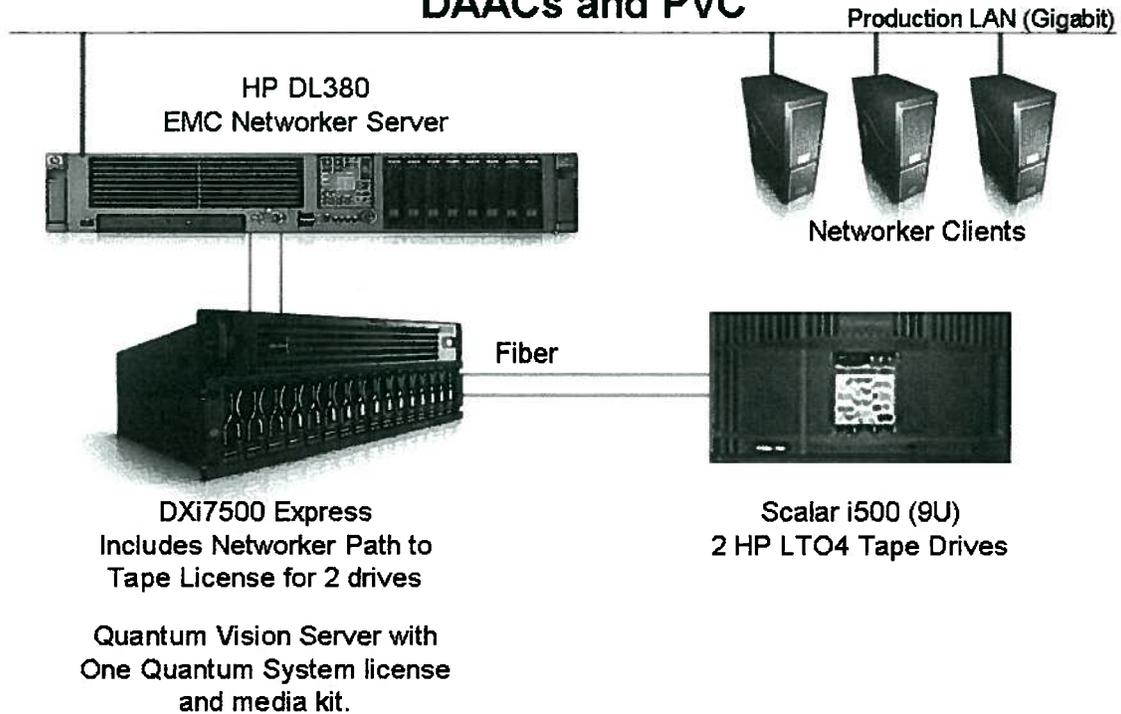


Figure 5-1. Quantum Backup Solution – PVC and DAACs

Appendix A. Test Environment Configurations

The following lists the hardware, software, network and SAN configurations used in the test environments.

Test Hardware Configurations

HP Solution – Installed in PVC

- Server - HP ProLiant DL180 G6
- Client - HP ProLiant DL180 G6
- VTL - HP D2D4112 with 18TB of storage (2 shelves)
 - RAID5 – 10+1 stripe groups, 1TB disks
- Tape Library - HP MSL4048 with 2 LTO 4 tape drives

NetWorker DBO Solution – Installed in VATC

- Server - HP ProLiant DL360 G4 (from GSFC Pathlight)
- Client #1 - HP ProLiant DL185 G5
- Client #2 - SGI Origin 300
- Client #3 - SGI Origin 2000
- VTL - None
- RAID - SGI TP9700, 4.2TB
 - RAID5 – 8+1 stripe groups, 4 LUNs, 146GB disks
- Tape Library – ADIC Scalar 100 with 2 LTO 3 tape drives

Quantum Solution – Installed at vendor facility

- Server - SunFire 280R
- Client - NAS share off of a DXi5500 (approx. 100GB)
- VTL - Quantum DXi7500 Enterprise with 22TB of storage (2 shelves)
 - RAID5 – 1TB FC disks
- Tape Library - Quantum Scalar i500

Software Configurations

HP and NetWorker DBO Solutions

- OS – RHEL5, Yum updates and CIS Benchmark changes
 - HP solution server – p4tel03 (PVC) RHEL v5.3
 - NetWorker DBO solution server – t1msl20 (VATC) RHEL v5.2
- Backup Software - EMC/Legato NetWorker v7.5.1-1

Quantum Solution

- OS – Solaris10
- Backup Software - EMC/Legato NetWorker v7.5.1

Network Configurations

HP and NetWorker DBO Solutions

- Backup server and clients - Gigabit Ethernet connection to production network

Quantum Solution

- Backup server and clients - 100Mb test lab network

HP VTL connections - connected to local Cisco 2900 100Mb switch

- Backup server second Ethernet interface (eth1) connected to switch port 1
- Ethernet ports on D2D4112 and MSL4048 connected to Cisco 2900 switch ports 7-12
- Management port on D2D4112 connected to Cisco 2900 switch

Quantum VTL connections?

- Legato server and DXi connected via 2Gb FC Brocade switch

NetWorker DBO connections

- SGI RAID management - 2 100Mb connections to management network

SAN Configurations

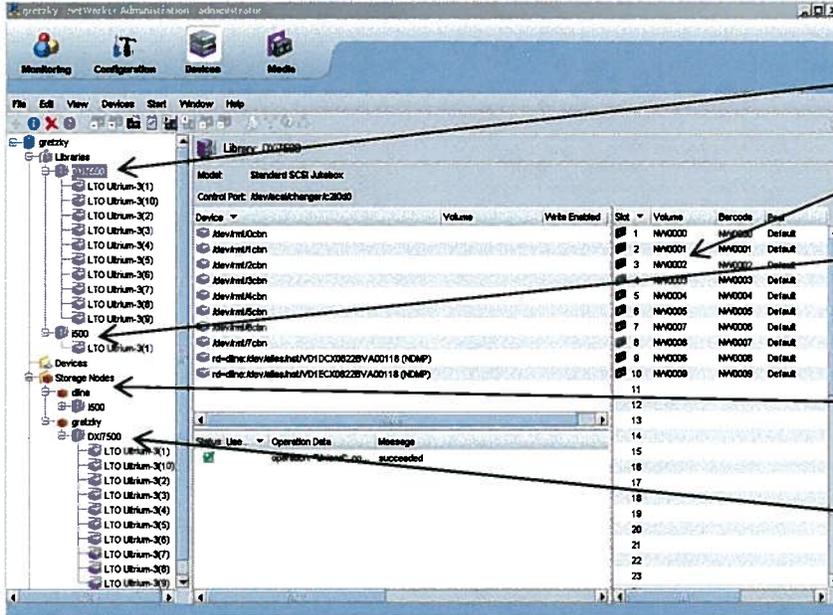
HP and Quantum Solutions

- NetWorker backup server – 2 direct connected fibre cables to VTL

NetWorker DBO connections

- NetWorker backup server – 1 direct connected fibre cable to tape library

Appendix B. Quantum DXi7500 Screen Shots



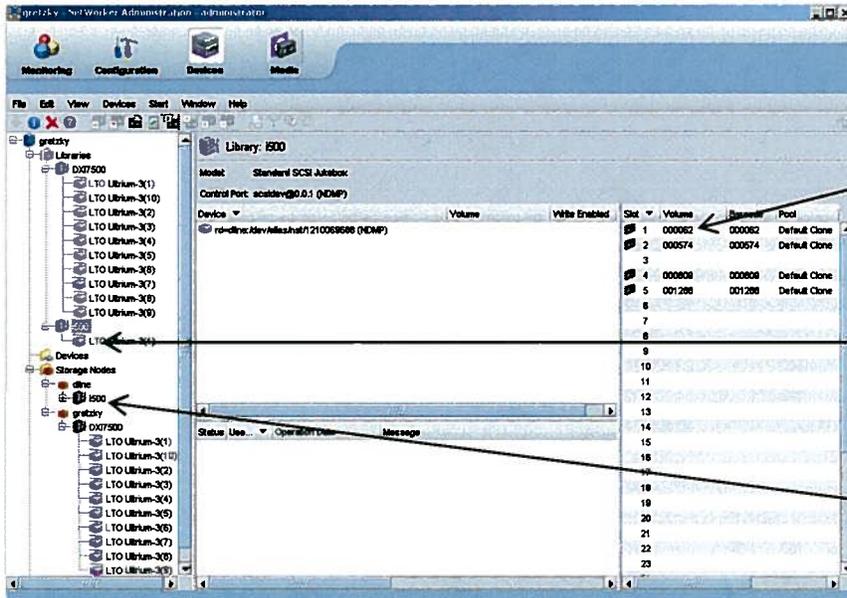
DXi7500 VTL with 10 drives

Virtual Media - NW series of tapes

I500 TLU with 1 drive

DXi7500 (dline) added as storage node with i500 directly attached to DXi

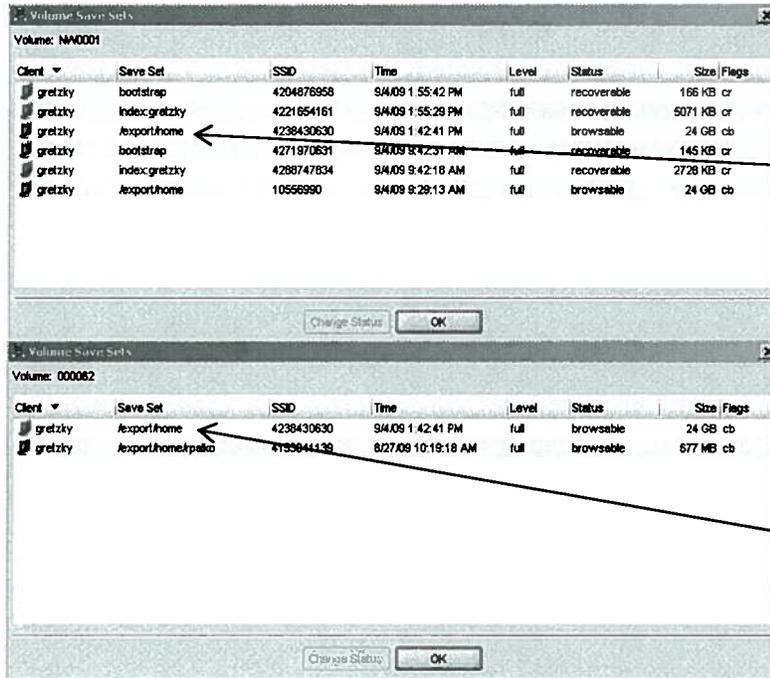
DXi7500 attached to NetWorker server



Physical Media - 0000 series of tapes

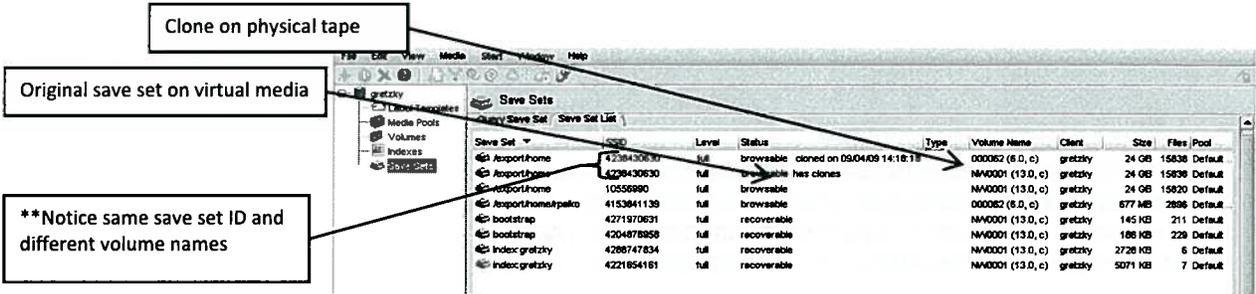
I500 TLU with 1 drive

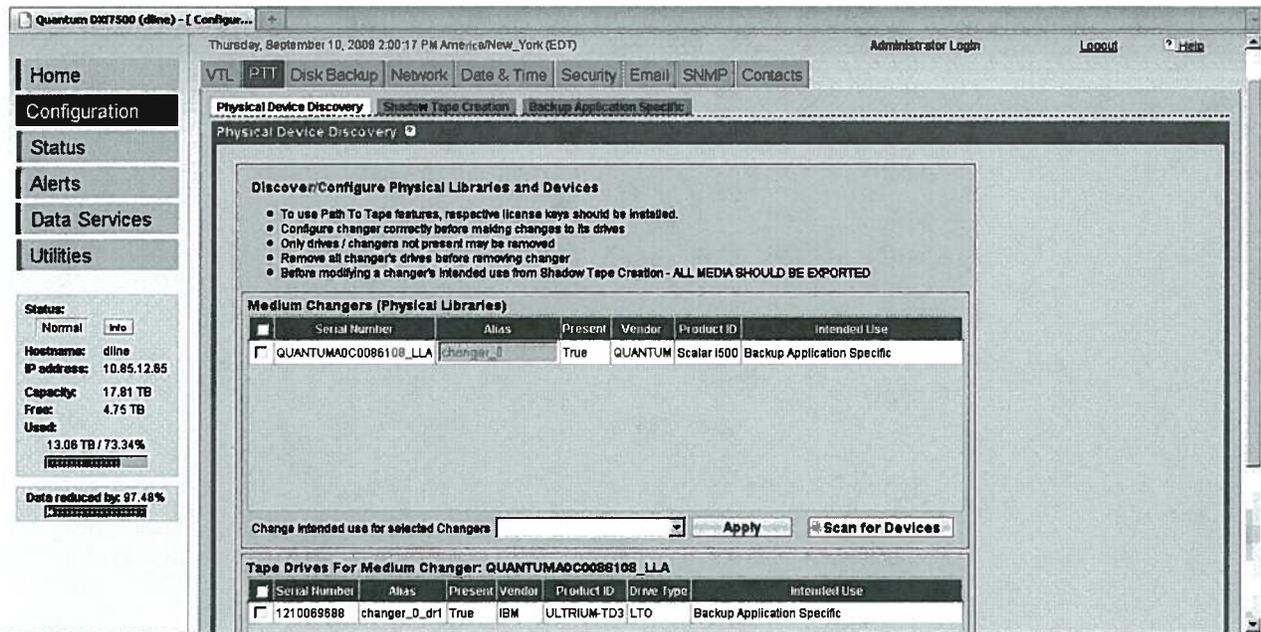
I500 only connected through DXi7500



Save set on virtual media
NW0001

Cloned Save set on physical media
000062





Dxi7500 Screen shot showing i500 visibility and connection with 1 LTO 3 tape drive

Status

Alerts

Data Services

Utilities

Status:
 Normal

Hostname: dline
IP address: 10.85.12.65

Capacity: 17.81 TB
Free: 4.75 TB
Used: 13.06 TB / 73.34%

Data reduced by: 97.48%

Lanham_NW

Tape Drives

0 Empty

1 Empty

2 Empty

3 Empty

4 Empty

Storage Slots

Slot	Barcode	WP	Capacity	Used	Raw Data Size	Compression Ratio	Used Percent
000	NW0000		400.00 GB	0.10 MB	0.07 MB	0.67x	0.00
001	NW0001		400.00 GB	31.70 GB	49.40 GB	1.56x	7.92
002	NW0002		400.00 GB	0.10 MB	0.07 MB	0.67x	0.00
003	NW0003		400.00 GB	0.10 MB	0.07 MB	0.67x	0.00
004	NW0004		400.00 GB	0.10 MB	0.07 MB	0.67x	0.00
005	NW0005		400.00 GB	0.10 MB	0.07 MB	0.67x	0.00
006	NW0006		400.00 GB	0.10 MB	0.07 MB	0.67x	0.00
007	NW0007		400.00 GB	0.10 MB	0.07 MB	0.67x	0.00
008	NW0008		400.00 GB	0.03 MB	0.07 MB	2.00x	0.00
009	NW0009		400.00 GB	0.10 MB	0.07 MB	0.67x	0.00
010							
011							
012							
013							
014							
015							
016							
017							
018							
019							

DXI 7500 view showing virtual tape drives and virtual tape cartridges

Home
 Configuration
 Status
 Alerts
 Data Services
 Utilities

Hardware System **VTL**

Physical View Logical View **Performance View**

Partition Throughput ?

The table below shows a partitions avg write speed
 Click on a partition to show its drive(s) performance.

Partition	Performance (write)
ATTVTL	0.00 MB / S
Lanham_NW	0.00 MB / S
lanham_NB	0.00 MB / S

Lanham_NW Drive(s) Performance

0 Empty ---
 1 Empty ---
 2 Empty ---
 3 Empty ---
 4 Empty ---
 5 Empty ---
 6 Empty ---
 7 Empty ---
 8
 9

Status:
 Normal **Info**
Hostname: dline
IP address: 10.85.12.65
Capacity: 17.81 TB
Free: 4.75 TB
Used: 13.06 TB / 73.34%
 Data reduced by: 97.48%

Performance view of DXi VTL

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