HP Data Protector software performance white paper

Executive summary

This white paper provides performance-related information for HP Data Protector software 6.0 together with some typical examples. The emphasis is on backup servers and two common backup and restore performance questions:

- Why are backups so slow?
- Why are restores so slow?

The first step toward exactly estimating backup requirements and performance is a complete understanding of the environment. Many performance issues can be traced to hardware or environmental issues. A basic understanding of the complete backup data path is essential in determining the maximum performance that can be expected from the installation. Every backup environment has a bottleneck. It may be a fast bottleneck, but it will determine the maximum performance obtainable in the system.

There are many configuration options and procedures available that can help IT professionals to improve the performance of their backup environment. This white paper focuses on server running HP-UX 11.11 (11iv1) and Microsoft® Windows® Server 2003, which are backing up file server and Microsoft Exchange Server 2003 in local area network (LAN) and storage area network (SAN) environments. All data was located on an HP StorageWorks 6000 Enterprise Virtual Array (EVA6000) and backed up or restored with an HP StorageWorks Ultrium960 tape drive.

The following hardware and software was installed and configured:

- HP9000 rp3440 with HP-UX 11.11 (11iv1)
- HP ProLiant DL380 G5 server with Microsoft Windows Server 2003 SP2 and Exchange Server 2003
- HP ProLiant DL380 G4 server with Microsoft Windows Server 2003 SP2 and HP Data Protector software 6.0
- HP ProCurve LAN switch 20 10/100/1000-ports
- HP ProCurve SAN Switch 4/16
- EVA6000
- Two Ultrium 960 tape drives

The HP-UX test environment showed good performance results across all tests. The NULL device backup performance was 386 MB/s or 1,359 GB/h and the Ultrium 960 tape backup performance 156 MB/s or 548 GB/h.

The Windows test environment also showed good performance results except for the test with millions of small files. In such environments, the Windows NTFS file system responds very slowly if a file is restored and its attributes recovered. The restore performance from the Ultrium 960 tape drive was just 3.38 MB/s. See Local restore of small files.

As a result of these tests, several recommendations and rules of thumb have emerged:

1. HP Data Protector software tuning can help to improve the performance, for example, for file systems with millions of small files whereas the first tree walk is disabled and the backup concurrency increased. See Tuning Recommendations.
2. Data Protector's default configuration parameters are well sized for most use cases.
3. Some changes of configuration parameters have almost no performance impact, for example, the Disk Agent buffers. See Disk Agent buffers.
4. Software compression causes high CPU loads and less backup performance than the Ultrium 960 built-in compression. See Software compression.

Overview

HP servers, storage, and software can help to provide a seamless enterprise backup and recovery solution. The solution starts with understanding what server and storage components work best for the required workload. Being able to determine performance baselines and uncovering potential bottlenecks in the solution can help to focus on areas that may need improvement, and can also provide information that helps with planning for data growth. Understanding the backup and recovery requirements for a data center can also help to maintain a consistent process and set expectations for data backup and recovery. Many times these business expectations are documented in a Service Level Agreement (SLA).

HP has conducted testing in typical solution configurations for backup and recovery. While solution design can be done by directly attaching storage devices, by way of SCSI or Fibre Channel, attaching to backup servers on the LAN, attaching to devices over a Fibre Channel SAN, or offloading backup processes to a dedicated backup server for a non-disruptive backup solution, or Zero Downtime Backup, this paper focuses only on SCSI-attached tape devices in LAN and SAN configurations.

Objectives and target audience

The objective of this white paper is to educate and inform users of the HP Data Protector software about what levels of performance are achievable in typical backup scenarios.

The emphasis is in showing mid-size environments and not very large installations with academic performance. This white paper highlights where the performance bottlenecks are and how these might be overcome. User loads are disregarded on the assumption that backups and restores are executed in idle environments, for example, executing backups at night when nobody is online.

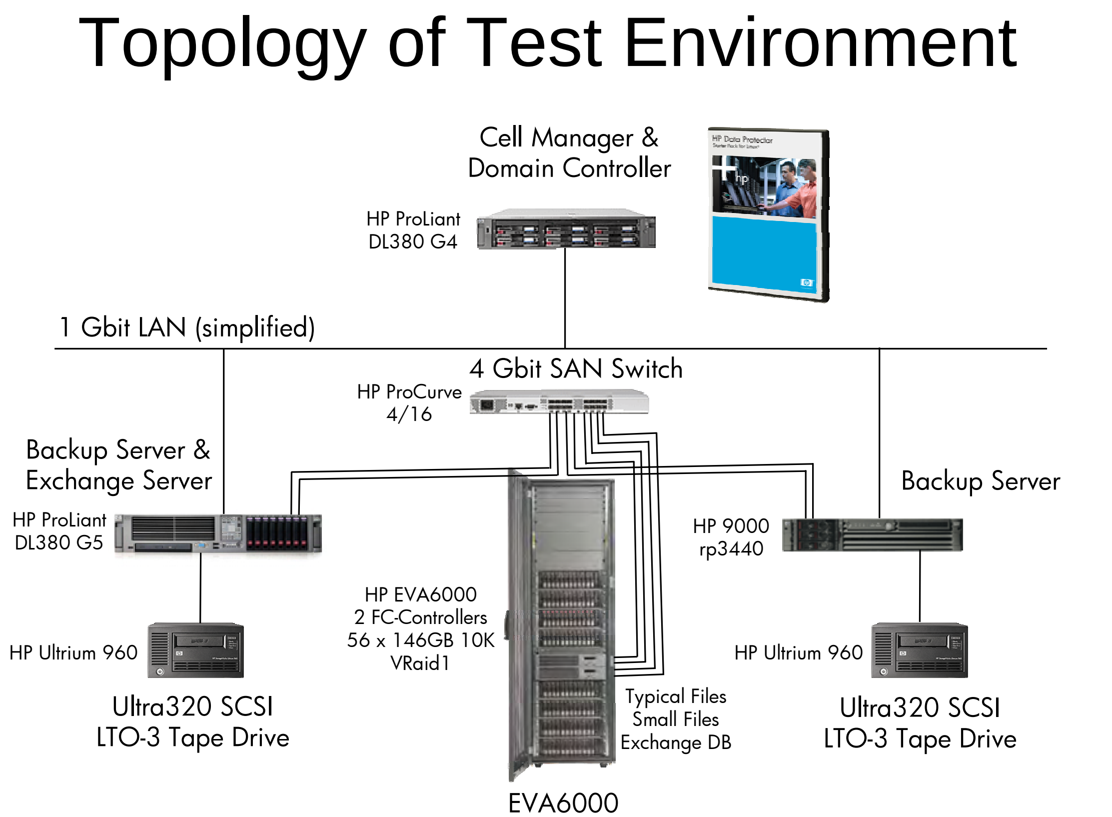
The target audience is system integrators and solution architects and indeed anyone involved in getting the best backup performance out of their HP infrastructure investments.

Introduction and review of test configuration

Testing was conducted in a Microsoft Windows Server 2003 and HP-UX 11.11 environment utilizing an HP StorageWorks 6000 Enterprise Virtual Array for file server and Microsoft Exchange Server 2003 data. The HP StorageWorks Ultrium 960 tape drive was utilized for backups and restores by way of LAN and SAN. The configuration details are described in the following sections.

Figure 1 illustrates the topology layout of the test environment.

Figure 1. Topology layout of test environment



Storage array

The HP StorageWorks 6000 Enterprise Virtual Array is an enterprise class, high-performance, high-capacity, and high-availability "virtual" array storage solution. The EVA6000 is designed to meet the needs of the data center to support critical application demands for consistently high transaction I/O.

This document assumes that the reader has previous knowledge of the EVA family of storage arrays. However, there are several terms that are exclusive to the EVA and referenced throughout the document. These terms are defined to provide a knowledge baseline. For further information on the EVA6000, visit http://www.hp.com/go/eva6000.

The EVA6000 storage array was set up in a 2C4D configuration (2 controller and 4 disk shelves) with a total of 56 x 146-GB 10K Fibre Channel disk drives.

EVAs perform excellent when all the disks are in a single disk group, so in this example the disk group consists of all 56 disks. A total of 15 x 100-GB LUNs (Vdisks) were created on the array and presented to the two client servers. The RAID level applied to these LUNs was VRaid 1 to get the best read performance out of the available drives.

The firmware version was XCS 6.000.

Storage management

The HP StorageWorks Command View general purpose server running on an HP ProLiant DL580 G2 server was configured with Microsoft Windows Server 2003 Enterprise Edition. HP StorageWorks Command View EVA V5.0 was used to manage the EVA6000.

LAN infrastructure

The LAN consisted of one HP ProCurve switch with 20 x 10/100/1000-ports. All network links were configured with1 Gb.

SAN infrastructure

The fabrics consisted of one HP ProCurve SAN switch 4/16. All links between servers and storage devices were 4 Gb.

The HP-UX and Windows server were equipped with one dual channel host bus adapter (HBA) each and connected to the SAN switch for optimal performance.

The EVA6000 was equipped with two Fibre Channel controllers and four host ports total (two per controller).

HP StorageWorks Ultrium 960 tape drive

The backup devices consisted of two HP StorageWorks Ultrium 960 tape drives, each connected to one backup server by way of an Ultra320 SCSI interface.

Management server

The HP ProLiant DL380 G4 management server was configured as a Windows domain controller and installed with:

- Windows Server 2003 SP1, 32-bit Enterprise Edition
- Data Protector 6.0 Cell Manager including patches DPWIN_00243, DPWIN_00244, DPWIN_00245, DPWIN_00246, and DPWIN_00260

HP ProLiant DL380 G4 server

The HP ProLiant DL380 G4 management server was equipped with one Intel® Xeon™ 3.60-GHz dual-core processor (hyper-threaded to two) and 1-GB RAM.

Both internal 146-GB disks were configured with RAID 1, which gave the Data Protector Internal Database (IDB) an excellent performance. For the LAN connection, only one adapter of the integrated dual port NC7782 Gigabit Server Adapter was configured.

Windows backup and Exchange Server 2003

The HP ProLiant DL380 G5 Windows backup and Exchange server was installed with:

- Windows Server 2003 SP2, 32-bit Enterprise Edition
- Microsoft Exchange Server 2003 SP2

HP ProLiant DL 380 G5 server

The HP ProLiant DL380 G5 Windows backup and Exchange Server 2003 was equipped with two Intel Xeon 3.00-GHz dual-core processors (hyper-threaded to four) and 16-GB RAM.

Both network adapters of the dual embedded NC373i Multifunction Gigabit Server Adapter were configured for teaming with failover functionality. The total network performance was 1 Gb/sec. Fibre connectivity was provided by way of one Emulex PLUS 4-Gb PCIe dual channel HBA with the native Windows MPIO driver used for host connectivity for a total of eight physical paths to the fabric (two HBAs, one switch, four EVA controller ports). Ultra320 SCSI connectivity to the tape drive was provided by the HP SC11Xe PCIe HBA.

HP-UX backup server

The HP9000 rp3440 backup server was installed with HP-UX 11.11.

HP 9000 rp3440 server

The HP9000 rp3440 backup server was equipped with two 1.0-GHz dual-core PA-8900 processors and 8-GB RAM. Fibre connectivity was provided by way of one 4-Gb dual port host HBA.

Configuration guidelines

For general information, refer to the HP StorageWorks Enterprise Backup Solutions (EBS) design guide at http://www.hp.com/go/ebs.

Backup environment

The backup manager is the core of any backup environment that must be checked for requirements and compatibility. Visit http://www.hp.com/go/dataprotector for the following documents:

- Data Protector concepts guide
- Data Protector installation and licensing guide
- Data Protector product announcements, software notes, and references
- Data Protector support matrices

Note
Carefully check the Data Protector support matrices and install the latest patches.

Backup server

The following components of a backup server environment must be additionally checked for compatibility:

- HBA
- OS/HBA drivers
- HBA BIOS
- Tape drive firmware

For detailed information, refer to the EBS compatibility matrix at http://www.hp.com/go/ebs.

For fast tape devices, the PCI bus performance should be checked. Use separate PCI busses for disks and tape if possible. The total PCI bandwidth needs to be more than double the backup rate.

Windows 2000/2003 tape drive polling

The Windows Removable Storage Manager service (RSM) polls tape drives on a frequent basis (every three seconds in Microsoft Windows 2000, and every second in Windows Server 2003). This polling, which involves sending a Test Unit Ready (TUR) command to each tape or library device with a loaded driver, is enabled by way of the AUTORUN feature of Windows Plug and Play. Windows built-in backup software (NTBACKUP) relies on the device polling to detect media changes in the tape drive.

Note
In SAN configurations, this polling can have a significant negative impact on tape drive performance. For SAN configurations, HP strongly recommends disabling RSM polling.

For additional information, refer to the Microsoft Knowledge Base article number 842411.

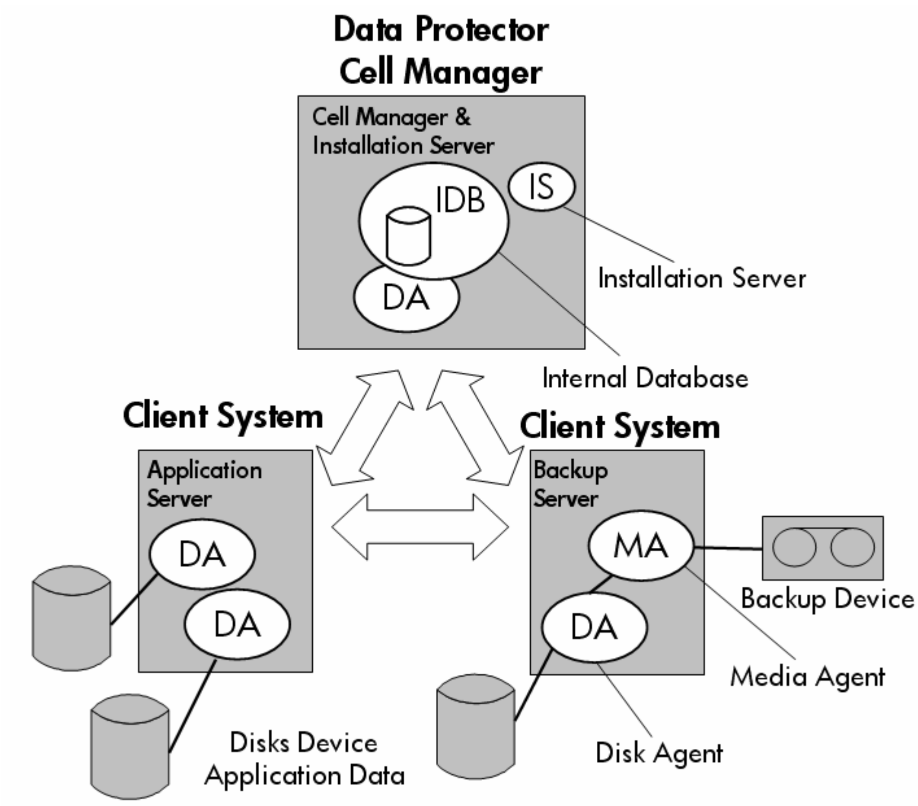
Data Protector overview and architecture

HP Data Protector software automates high-performance backup and recovery, from disk or tape, over unlimited distances, to ensure 24x7 business continuity and maximize IT resource utilization. Data Protector offers acquisition and deployment costs which are 30–70 % less than competition, responding to the pressure for lower IT costs and greater operational efficiency. The license model is very simple and easy to understand, helping to reduce complexity. Data Protector lowers data protection costs while ensuring backup/recovery flexibility, scalability, and performance. Data Protector is a key member of the fast-growing HP storage software portfolio, which includes storage resource management, archiving, replication, and device management software. No software can integrate better with the HP market-leading line of StorageWorks disk and tape products, as well as with other heterogeneous storage infrastructures, than Data Protector.

Data Protector can be used in environments ranging from a single system to thousands of systems on several sites. The basic management unit is the Data Protector cell.

The Data Protector cell, as shown in Figure 2, is a network environment consisting of a Cell Manager, one or more Installation Servers, Clients Systems, Backup and Disk Devices. The Cell Manager and Installation Server can be on the same system, which is the default option, or on separate systems.

Figure 2. Data Protector architecture



Cell Manager

The Cell Manager is the main system that controls the Data Protector cell from a central point, where the Data Protector core software with the Internal Database (IDB) is installed. The Cell Manager runs Session Managers that control backup and restore sessions and write session information to the IDB. The IDB keeps track of the backed up files as well as of the configuration of the Data Protector cell.

Installation Server

The Installation Server is the computer where the software repository of Data Protector is stored. There is at least one Installation Server for UNIX® and one for the Windows environment required so that remote installations through the network can be executed and the software components to the client systems in the cell be distributed.

Client Systems

After installing the Cell Manager and the Installation Server of Data Protector, components can be installed on every system in the cell. These systems become Data Protector clients. The role of a client depends on the Data Protector software being installed on this system.

Systems to be backed up

Client systems (application server) to be backed up must have the Data Protector Disk Agent installed. The Disk Agent reads or writes data from/to disks on the system and sends or receives data from/to a Media Agent.

The Disk Agent is installed on the Cell Manager as well, allowing the administrator to back up data on the Cell Manager, the Data Protector configuration, and the IDB.

Systems with backup devices

Client systems with connected backup devices must have a Data Protector Media Agent installed. A Media Agent reads or writes data from/to media in the device and sends or receives data from/to the Disk Agent. A backup device can be connected to any system and not only to the Cell Manager. Client systems with backup devices are also called Backup Servers.

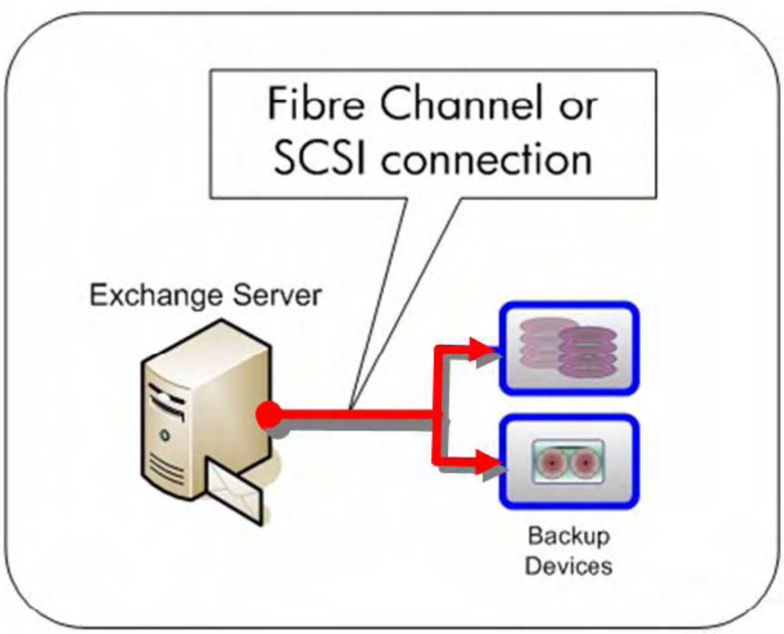
Backup and restore designs

Design of the backup environment can be performed using a variety of configurations. The following list describes three designs typically used in a backup and restore solution.

Direct attached storage (DAS)

Direct attached storage (DAS) implies that the storage you are backing up to and restoring from is directly attached to the server through a SCSI or Fibre Channel bus. This can be a good solution for smaller data centers with only a few servers that do not require the sharing of a large tape or disk resource. While this solution can provide for good performance, it cannot be leveraged across multiple servers as illustrated in Figure 3.

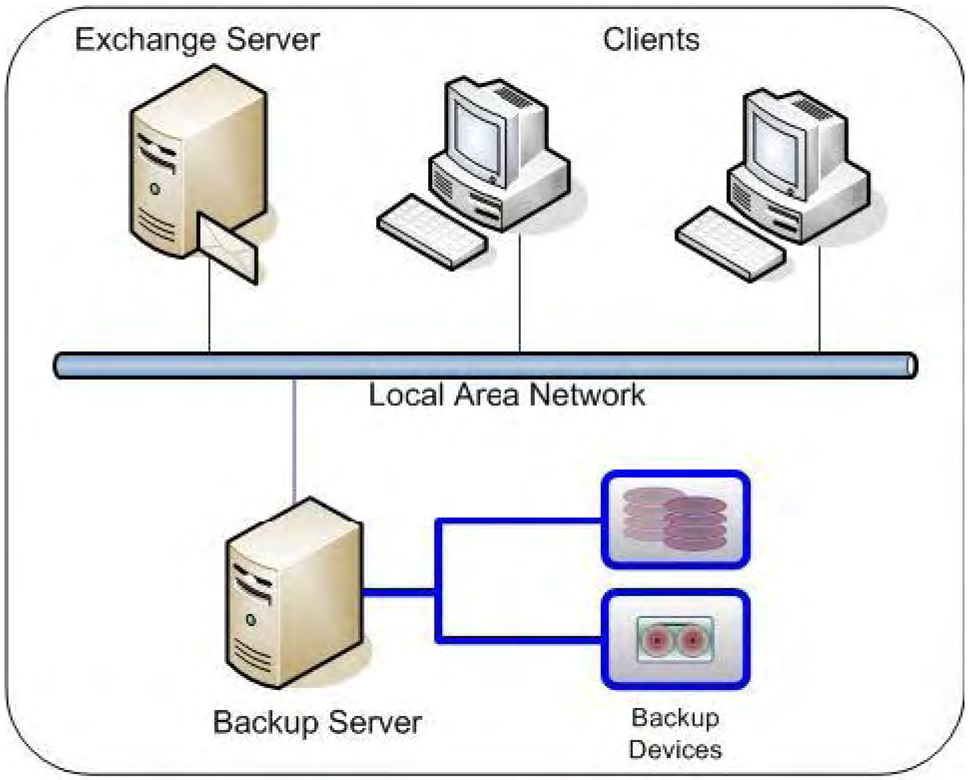
Figure 3. DAS



Local area network (LAN)

When combined with a server that has a DAS design, this solution allows for servers and clients to back up and restore over the LAN to the machine with the DAS tape library or disk array. Now, this is the traditional method that is employed throughout most data centers. This method allows for the sharing of backup devices by other servers on the network. However, all backup data must be passed over the public LAN, or a dedicated backup LAN, which can reduce the overall performance (see Figure 4).

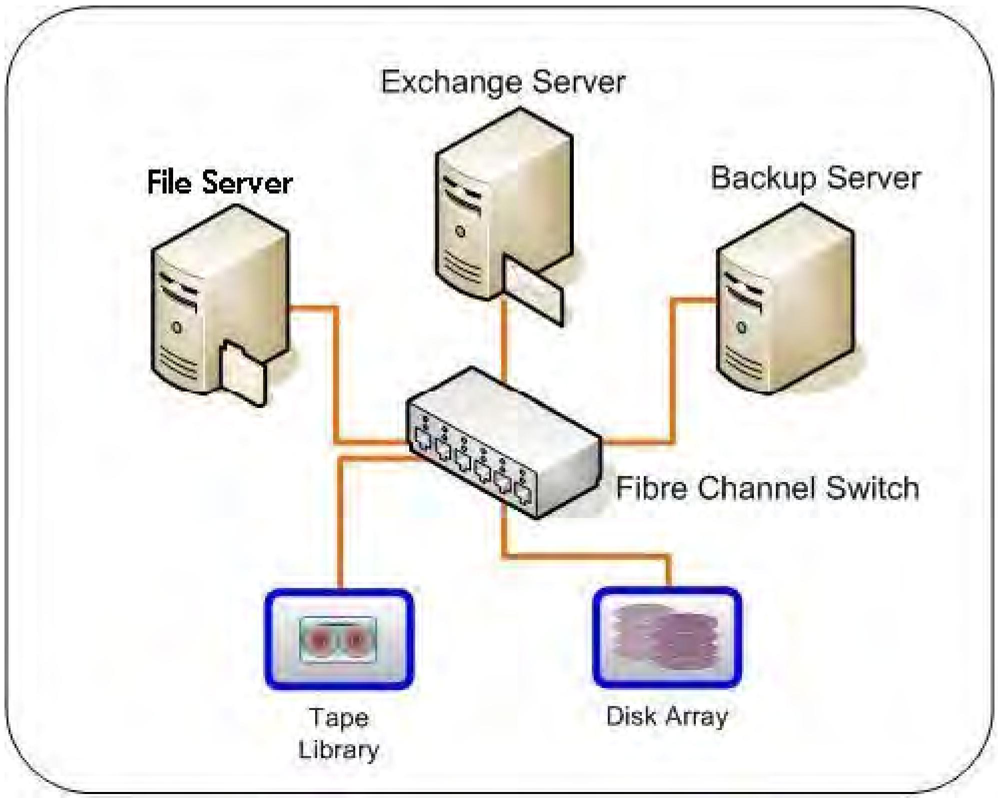
Figure 4. LAN



Storage area network (SAN)

SANs are very similar to DAS solutions. However, the storage on the SAN may be shared between multiple servers. This shared storage can be both disk arrays and tape libraries. To the server it will appear as if it owns the storage device, but the shared Fibre Channel bus and the controllers for the disk and tape devices allow the devices to be shared. This configuration is very advantageous for both resource sharing and performance (see Figure 5).

Figure 5. SAN



Others

The following technologies go beyond the scope of this white paper:

- Direct backup (sever-less backup solution for SAN environments)
- Disk backup
- Split mirror backup
- Snapshot backup
- Microsoft Volume Shadow Copy Service (VSS)

For further information, see the HP Data Protector Software Zero Downtime Concepts Guide at http://www.hp.com/go/dataprotector.

Performance bottlenecks

The goal is that a tape drive becomes a performance bottleneck. In that case, backup and restore times are predictable.

Backup performance

Backup performance will always be limited by one or more bottlenecks in the system, of which the tape drive is just one part. That way it affects the backup time more than the restore time.

The flow of data throughout the system must be fast enough to provide the tape drive with data at its desired rates. High-speed tape drives, such as the HP StorageWorks Ultrium 960 tape drive, are so fast that making them the bottleneck can be very challenging.

All components must be considered and analyzed for getting the best backup performance. Standard configurations with default values are mostly not sufficient. In enterprise environments, performance estimations are very difficult to provide without benchmarks.

Restore performance

Many backup environments are tuned for backup performance because frequent backups require most resources. Large restores are less common and runtimes less predictable. Backup runtimes cannot be used for calculating exact restore runtimes. Therefore, runtimes can only be proved by restore tests.

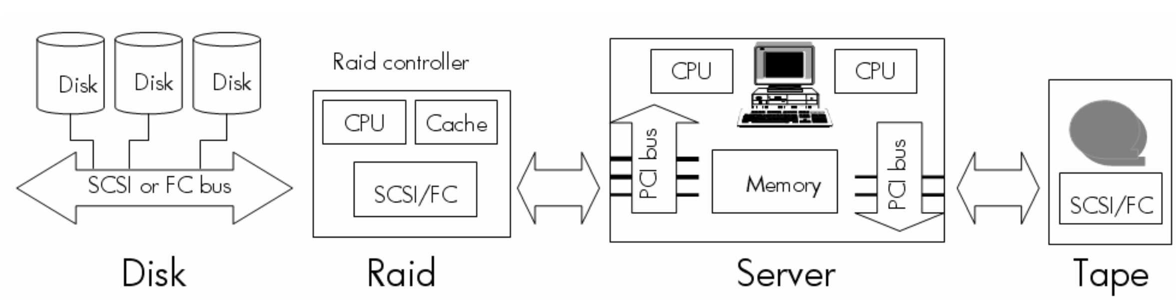
Backup and restore data path

The limiting component of the overall backup and restore performance is of course the slowest component in the backup environment. For example, a fast tape drive combined with an overloaded server results in poor performance. Similarly, a fast tape drive on a slow network also results in poor performance.

The backup and restore performance depends on the complete data transfer path.

Figure 6 shows that the backup path usually starts at the data on the disk and ends with a copy on tape. The restore path is vice versa. The tape drive should be the bottleneck in the data path. All other components should process data faster than the tape drive so the tape drive has never to wait for data.

Figure 6. Backup and restore data path



Manager server (Data Protector Cell Manager)

The backup manager server should be sized according to its installation requirements.

Note
Additional applications or backups on the manager server would increase the installation requirements. Carefully check any application installation requirements. In larger backup environments, it is not recommended to share this server with other applications or to utilize it as a backup server.

The server should be clustered for having no single point of failure (SPOF) in the backup environment. The network connections to each client are essential and should be protected against single link failures.

Backup and application server (Data Protector Client System)

Backup and application servers should be sized according to the installation requirements.

During backup, these servers should not be under heavy load by additional applications that run I/O and CPU-intensive operations, for example, virus scans or a large amount of database transactions.

Backup servers demand special attention for proper sizing because they are central to the backup process as they run the required agents. The data is passed into and out of the server's main memory as it is read from disk subsystem or network and written to tape. The server memory should be sized accordingly, for example, in case of an online database backup whereas the database utilizes a large amount of memory. Backup servers that receive data from networks rely also on fast connections. If the connection is too slow, a dedicated backup LAN or moving to SAN architecture could improve the performance.

Application servers without any backup devices depend basically on a good performance of connected networks and disks. In some cases, file systems with millions of small files (for example, Windows NTFS) could be an issue.

Backup application

For database applications (for example, Oracle®, Microsoft SQL and Exchange), use the backup integration provided by those applications as they are tuned to make best use of their data structures.

Use concurrency (multi-threading) if possible—this allows multiple backups to be interleaved to the tape, thus reducing the effect of slow APIs and disk seeks for each one. Note that this can have an impact on restore times as a particular file set is interleaved among other data.

File system

There is a significant difference between the raw read data rate of a disk and the file system read rate. This is because traversing a file system requires multiple, random disk accesses whereas a continuous read is limited only by the optimized data rates of the disk.

The difference between these two modes becomes more significant as file size reduces. For file systems where the files are typically smaller than 64 KB, sequential backups (for example, from raw disk) could be considered to achieve the required data rates for high-speed tape drives.

File system fragmentation could be also an issue. It causes additional seeks and slower throughput.

Disk

If the system performing the backup has a single hard disk drive, the major factor restricting the backup performance is most likely to be the maximum transfer rate of the single disk. In a typical environment, the maximum disk throughputs for a single spindle can be as low as 8 MB.

High-capacity disk

One high-capacity disk is still one spindle with its own physical limitations. Vendors have the tendency to sell them with the arguments "best price per MB."

This is just one side of the reality. The cons are really important for high-performance environments that can cause serious problems.

Two smaller spindles provide double performance than one large spindle. The backup performance of large disks may be acceptable without any application load. But if an application writes in parallel to that disk, the total disk performance can go below 5 MB/s and the hit ratio of a disk array read cache below 60%.

Disk array

Benchmarks have shown that the theoretical disk array performance cannot be achieved with standard backup tools. The problem is the concurrency with the belonging read processes that cannot be distributed equally among all I/O channels and disk drives. The disk array can be seen as a bunch of disks, which internal organization and configuration is hidden for the backup software. High-capacity disks can cause additional problems at which intelligent disk array caches do not improve the situation. They are not able to provide reasonable throughput for backup and restore tasks—the number of sequential reads and writes are just too high.

The 50% backup performance rule became a standard for the disk array sizing.

RAID

The use of RAID for a disk backup should be carefully considered. There are three main levels of RAID, each with its own strengths. The raw I/O speed of the disk backup device significantly affects the overall backup performance.

There are five main levels of RAID that are commonly referred to. These are:

- RAID 0 (Striping)

  Data is striped across the available disks, using at least two disk drives. This method offers increased performance, but there is no protection against disk failure. It will allow you to use the maximum performance the disks have to offer, but without redundancy.

- RAID 1+0 (Disk Drive Mirroring and Striping)

  The disks are mirrored in pairs and data blocks are striped across the mirrored pairs, using at least four disk drives. In each mirrored pair, the physical disk that is not busy answering other requests answers any read request sent to the array; this behavior is called load balancing. If a physical disk fails, the remaining disk in the mirrored pair can still provide all the necessary data. Several disks in the array can fail without incurring data loss, as long as no two failed disks belong to the same mirrored pair. This fault-tolerance method is useful when high performance and data protection are more important than the cost of physical disks. The major advantage of RAID 1+0 is the highest read and write performance of any fault-tolerant configuration.

- RAID 1 (Mirroring)

  Data is written to two or more disks simultaneously, providing a spare "mirror copy" in case one disk fails. This implementation offers high assurance of the disk transfers completing successfully, but adds no performance benefit. It also adds cost, as you do not benefit from the additional disk capacity.

- RAID 3 (Striping and Dedicated Parity)

  This type of array uses a separate data protection disk to store encoded data. RAID 3 is designed to provide a high transfer rate. RAID 3 organizes data by segmenting a user data record into either bit- or byte-sized chunks and evenly spreading the data across N drives in parallel. One of the drives acts as a parity drive. In this manner, every record that is accessed is delivered at the full media rate of the N drives that comprise the stripe group. The drawback is that every record I/O stripe accesses every drive in the group. RAID 3 architecture should only be chosen in a case where the user is virtually guaranteed that there will be only a single, long process accessing sequential data. A video server and a graphics server would be good examples of proper RAID 3 applications. RAID 3 architecture is also beneficial for backups but becomes a poor choice in most other cases due to its limitations.

- RAID 5 (Striping and Distributed Parity)

  Mode data is striped across all available drives, with parity information distributed across all of them. This method provides high performance, combined with failure protection, but requires at least three disk drives. If one disk fails, all data will be recoverable from the remaining disks due to the parity bit, which allows data recovery. The disk write performance on RAID 5 will be slower than RAID 0 because the parity has to be generated and written to disk.

Tape drive

The mechanical impact on tape drives of "not-feeding-enough" is principally underestimated and customers suffer from slow performance and broken-down tape drives.

The tape drive should be operating at or above its lowest streaming data rate to achieve the best life for the head, mechanism, and tape media. If the data is not sent fast enough, the internal buffer will empty and the drive will not write a continuous stream of data. At that point, the drive will start exhibiting what is called head repositioning. Head repositioning is also known as shoe shining and it causes excessive wear on the tape media, on the tape drive heads, and on the mechanical tape drive components. Tape drives have buffers in the data path that are large enough to prevent head repositioning from explicitly slowing the backup down further. However, the increased error rate from worn heads/media causes more tape to be used and additional retries to be performed. This will slow the backup down and it will get worse over time.

Storage area network (SAN)

The standard topology for a mid-size and large environment is SAN-based. The SAN has its own components and data paths. Each of them could become a bottleneck:

- Any HBA (of server, disk, tape and tape library bridge)
- SAN switch (total and single port bandwidth)
- Cabling (each cable type has unique performance and distance specifications)

Finding bottlenecks

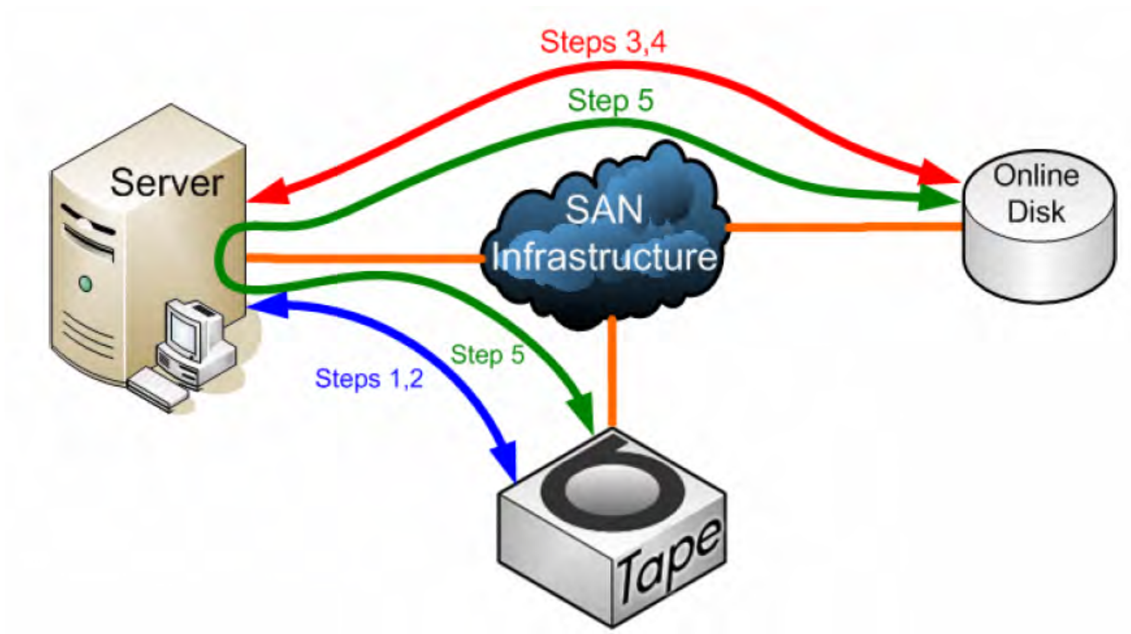
Process for identifying bottlenecks

To get the maximum performance of a backup and restore environment, it is important to understand that many elements influence backup and restore throughput.

A process is needed that even breaks down a complex SAN infrastructure into simple parts, that can then be analyzed, measured, and compared. The results can then be used to plan a backup strategy that maximizes performance.

Figure 7 illustrates an example for identifying bottlenecks in SAN environments.

Figure 7. Example for identifying bottlenecks



The following steps are used to evaluate the throughput of a complex SAN infrastructure:

1. Tape subsystem's WRITE performance
2. Tape subsystem's READ performance
3. Disk subsystem's WRITE performance
4. Disk subsystem's READ performance
5. Backup and restore application's effect on disk and tape performance

Details of each of the steps are demonstrated in the test environment. See the Evaluating tape and disk drive performance section.

With the test and subsequent analysis on a component level, it is possible to identify bottlenecks in the SAN.

Performance tools

Understanding the performance of a server, its HBAs, CPU, memory, and storage can be vital in determining the expected performance of a backup solution. Much of the theoretical performance information may be known when sizing the server and its components, but the true performance may not be known until baseline testing is conducted on the system. HP offers tools that help in determining the raw performance of each component involved in the backup and restore solution.

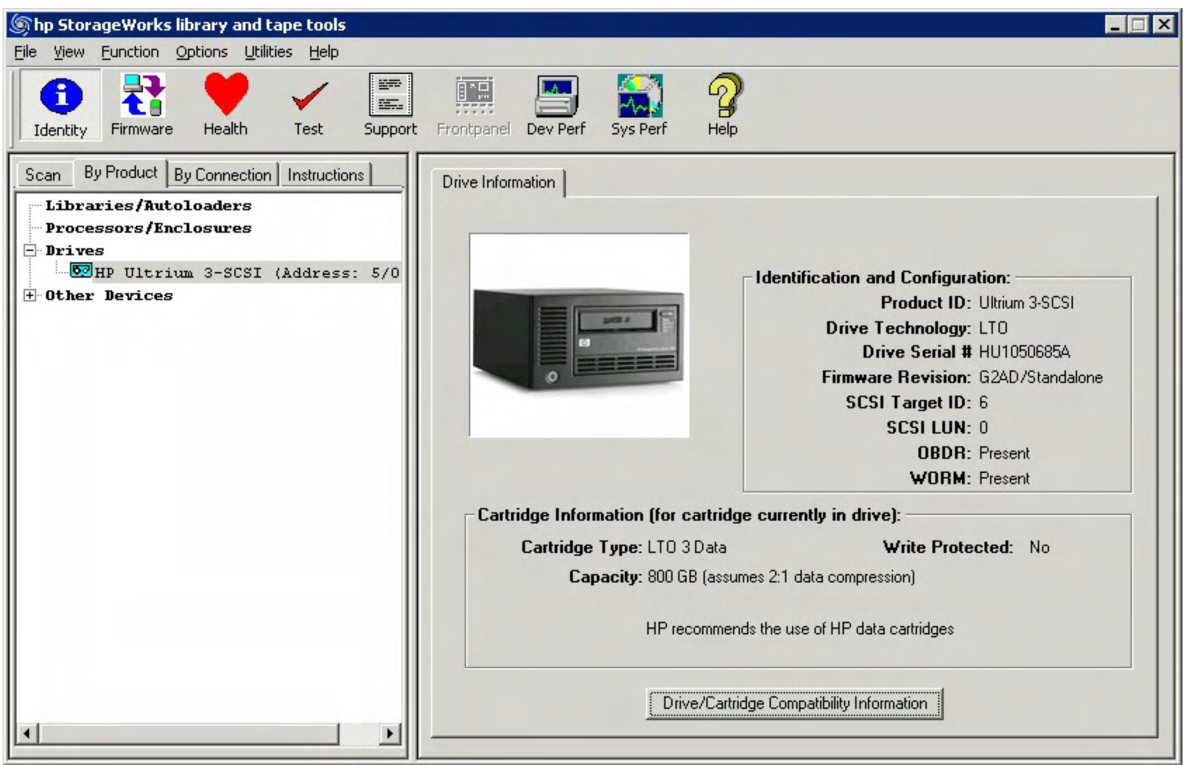
The following performance tools were utilized:

- HP StorageWorks Library and Tape Tools diagnostics (L&TT)
- HPCreateData
- HPReadData
- LoadSim 2003

HP StorageWorks Library and Tape Tools diagnostics (L&TT)

The HP industry-leading Library and Tape Tools diagnostics assist in troubleshooting backup and restore issues in the overall system. It includes tools that help identify where bottlenecks exist in a system and valuable tools for HP tape drive performance and diagnostics needs. The Windows version of L&TT uses a graphical user interface (GUI) as shown in Figure 8. All other versions of the program use a command screen interface (CSI), for example, HP-UX.

Figure 8. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) GUI—Drive information

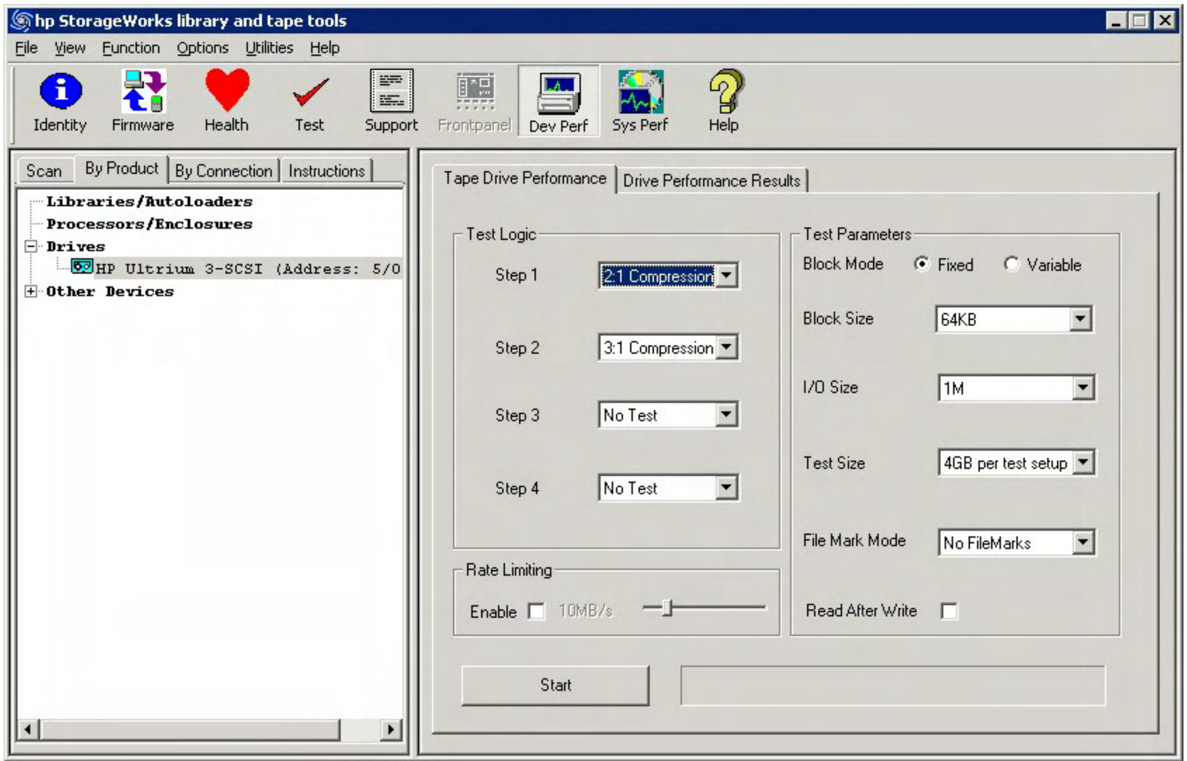


L&TT version 4.2 SR1 was used in this white paper for:

- Determining the rate at which the tape drive reads and writes data
- Determining the rate at which the disk subsystem can write and supply data

The belonging features can be found in the Tape Drive Performance GUI as shown in Figure 9. The embedded tools behind that are HPCreateData and HPReadData.

Figure 9. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) GUI—Tape drive performance



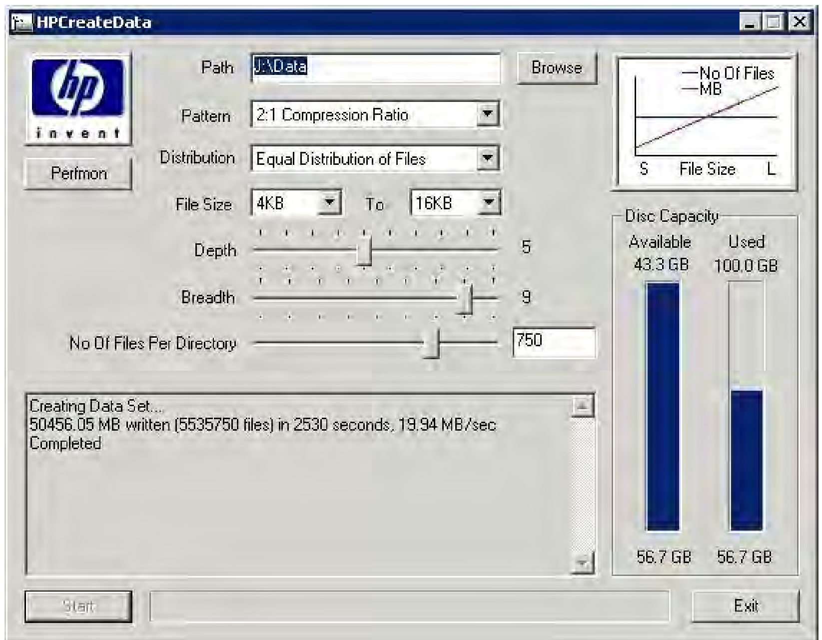
L&TT can be downloaded free from http://www.hp.com/support/tapetools.

HPCreateData

The HPCreateData PAT utility is a file system generator for restore performance measurements. It is useful in assessing the rate at which your disk subsystem can write data, and this is ultimately what will limit the restore performance. To write more than one stream, initiate multiple instances of HPCreateData.

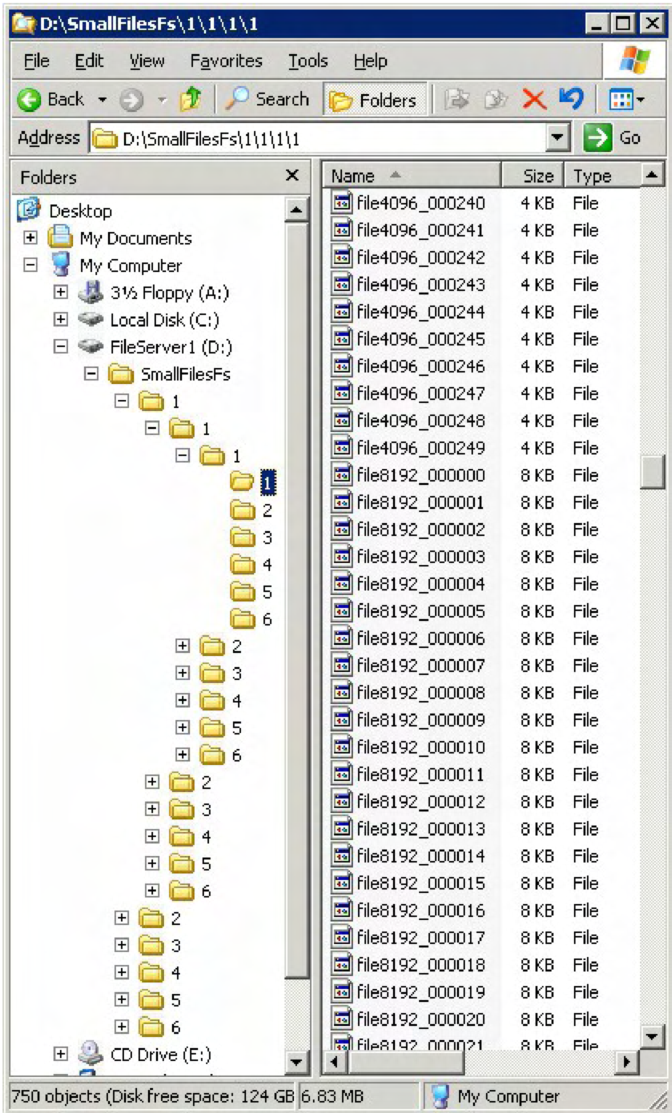
HPCreateData version 1.2.3 was used for testing. Figure 10 shows an example for creating Windows test data.

Figure 10. HPCreateData for Windows example



Executing HPCreateData results in a directory and file structure similar to that shown in Figure 11. In each directory, 750 files were created with a depth of 5 and breadth of 6.

Figure 11. Executing HPCreateData for Windows—Directory and file structure



HPCreateData can be downloaded free from http://www.hp.com/support/pat.

HPReadData

The HPReadData PAT utility is useful in assessing the rate at which your disk subsystem can supply data, and this is ultimately what will limit the backup performance. It simulates the way Data Protector reads files. A single instance of HPReadData can read eight streams simultaneously from your array. To read more than eight streams, initiate multiple instances of HPReadData. HPReadData is available for Windows, HP-UX, Solaris, and Linux.

HPReadData version 1.2.4 was used for testing. Figure 12 shows an example for reading Windows test data.

Figure 12. HPReadData for Windows example

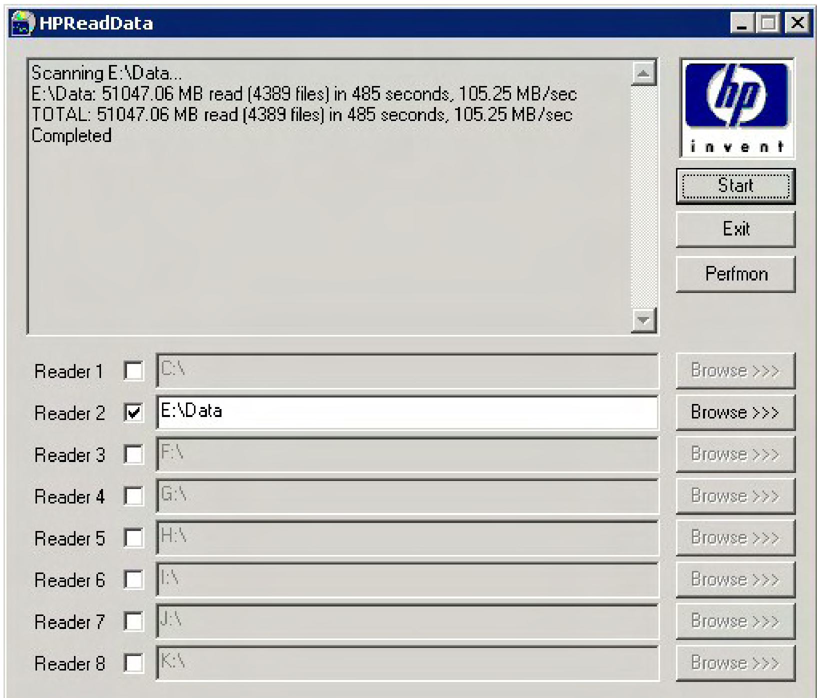


Figure 12 shows HPReadData reading one LUN from a file system in a manner similar to the way a backup application will read files. We can see that the maximum read rate from this configuration is 105.25 MB/s, so we cannot expect any higher backup transfer performance to tape than this figure.

Note
For simulating Data Protector disk read agents, start the equivalent number of HPReadData instances whereas each instance should only read from one file system.

HPReadData can be downloaded free from http://www.hp.com/support/pat.

LoadSim 2003

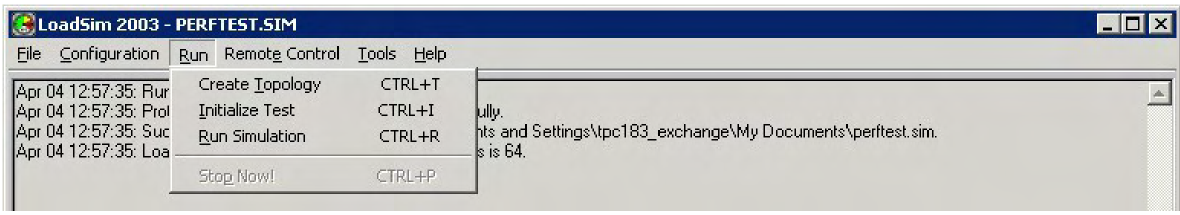
The Microsoft Exchange Server 2003 Load Simulator (LoadSim) is basically a benchmarking tool to simulate the performance load of MAPI clients.

For this white paper, it was very useful to use its additional features for data creation:

- Create Topology
- Initialize Test

Figure 13 shows the initial screen of LoadSim 2003.

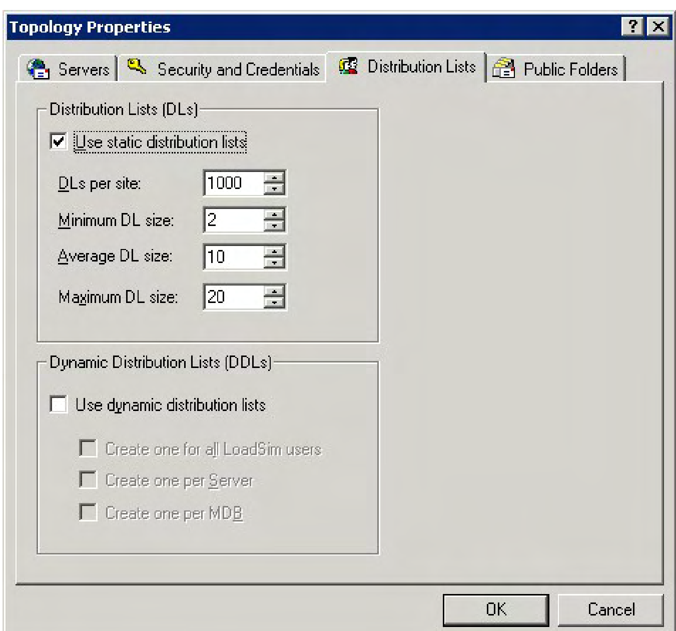
Figure 13. LoadSim 2003—Initial screen



LoadSim provides many configuration parameters for simulating customer's Microsoft Exchange Server environments. If 500 users are initialized with the default initialization values for either the MMB3, Heavy, or Cached Mode profile, the Exchange database will grow to approximately 54 GB.

Figure 14 illustrates the default LoadSim configuration parameters for distribution lists.

Figure 14. LoadSim—Distribution Lists screen of topology properties



LoadSim 2003 is downloadable from http://go.microsoft.com/fwlink/?LinkId=27882.

Test data

In the following proof points, two different types of file systems and one Microsoft Exchange Server 2003 were created, so that the results shown are realistically achievable in similar situations:

- Typical file server data with fewer files and a broad range of size (KB/MB)
- Problematic file server data with millions of small files
- Typical Microsoft Exchange Server 2003 data

Data creation tools

All test data was created using the following public tools:

- HP L&TT version 4.2 SR1a
- HP HPCreateData version 1.2.3
- Microsoft Exchange Server 2003 Load Simulator

HPCreateData and L&TT

The datasets were developed using the following utilities:

- HPCreateData for Windows
- L&TT for HP-UX

HPCreateData for HP-UX was not used because it is only available as a CLI and cannot create more than one directory—all files would be created in one single directory, which does not correspond to what actually occurs in real file server environments.

HPCreateData and L&TT generate different file sizes with different data contents (fixed, random, up to 4:1 compression ratio) and different distribution (file-based, MB-based). All created files had a name with maximal 16 characters for avoiding corner cases.

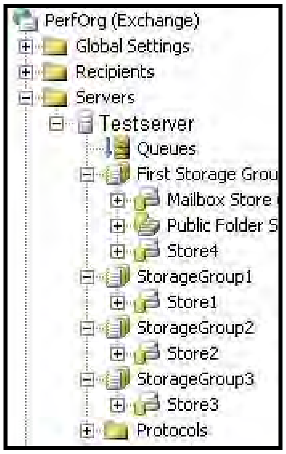
HPCreateData and L&TT are downloadable from http://www.hp.com/support/pat.

LoadSim 2003

LoadSim 2003 was used for creating the Exchange test data. But before it was used, the Exchange organization had be prepared with the Exchange System Manager. For optimal performance, all databases files were moved to separate disk volumes. When data is read or written, the storage system should not become a bottleneck for the test.

Figure 15 illustrates an example of an Exchange Server that is configured for LoadSim testing. In this example, the Exchange System Manager was used to add three additional storage groups named StorageGroup1–StorageGroup3. Also, one mailbox store was added to each storage group. These mailbox stores were named Store1–Store4.

Figure 15. Exchange System Manager with additional storage groups and additional mailbox stores



Two LoadSim features were utilized with their default initialization parameters:

- Create Topology

  After topology parameters were specified, the topology was created. This step creates the LoadSim users and distribution groups (also referred to as DLs or distribution lists), in Active Directory on the Exchange Server.

- Initialize Test

  When the test was initialized, LoadSim added or deleted messages in the Inbox and folders of each user in the test so that each mailbox has the number of messages specified in the Initialization tab of the Customize Tasks window. LoadSim created also new folders, smart folders, rules in Inbox, appointments, and contacts.

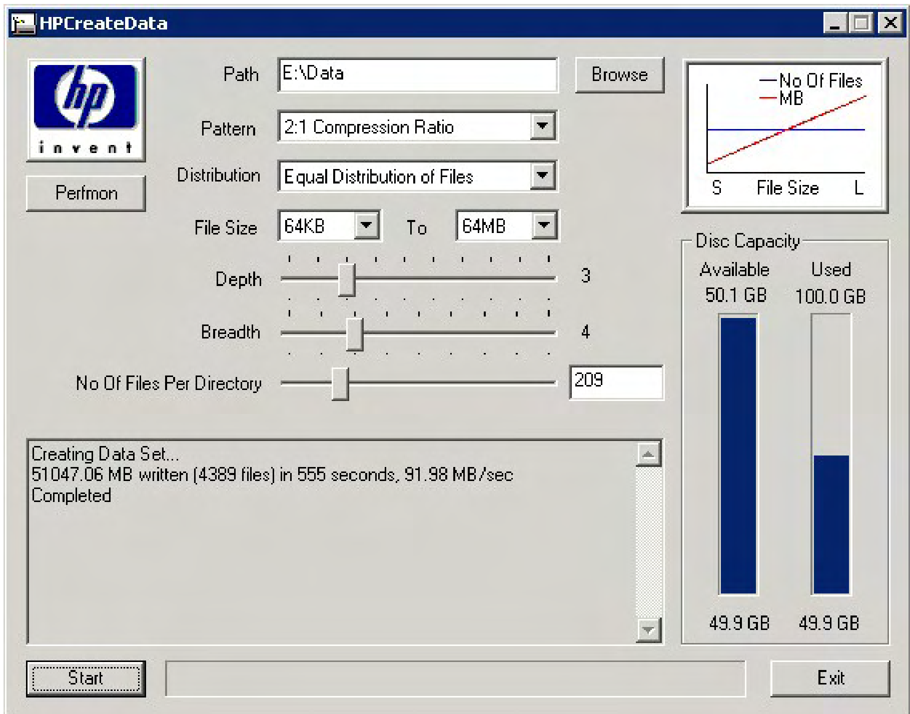
LoadSim 2003 is downloadable from http://go.microsoft.com/fwlink/?LinkId=27882.

Creating typical files for Windows NTFS

The typical file system was created with file sizes between 64 KB and 64 MB and the compressibility of the data 2:1. The utility created an equal distribution of files in each directory.

Figure 16 shows the HPCreateData input parameters and results.

Figure 16. HPCreateData for Windows—Creating typical files



Finally, the file system contained 49.85 GB with 4,389 files in 20 folders.

Creating typical files for HP-UX VxFS

The typical file system for HP-UX VxFS was created with file sizes between 64 KB and 64 MB and the compressibility of the data 2:1. The utility created an equal distribution of files in each directory.

Figure 17 illustrates the L&TT input parameters and Figure 18 the results.

Figure 17. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for HP-UX—Creating typical files—Input parameters

```
Main > System Performance Tools > Restore Pre-Test >
-----------------------------------------------------------------------------
The Performance of the disk subsystem can be measured using this tool. This
creates a directory structure based on file size, directory depth, blocksize
and compression ratio and measures the data rates it achieves. Type the
corresponding number to select/set each option.

  1.     Set minimum file size in bytes (min-filesize) - 65536
  2.     Set maximum file size in bytes (max-filesize) - 67108864
  3.     Set no. of files per directory (nofile) - 209
  4.     Set dir where to create dataset (dirpath) - /typical1/data
  5.     Set compressibility pattern to create files.1) Fixed Byte. 2) Incr...
  6.     Set file tree depth (file tree depth) - 3
  7.     Set file tree breadth (file tree breadth) - 4
```

Figure 18. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for HP-UX—Creating typical files—Results

```
Main > System Performance Tools > Restore Pre-Test > Viewer >
-------------------------------------------------------------
51047 MB written (4389 files) in 307 seconds at 166 MB/sec
Restore Pre-Test successfully created files.
166.28 MB/sec
```

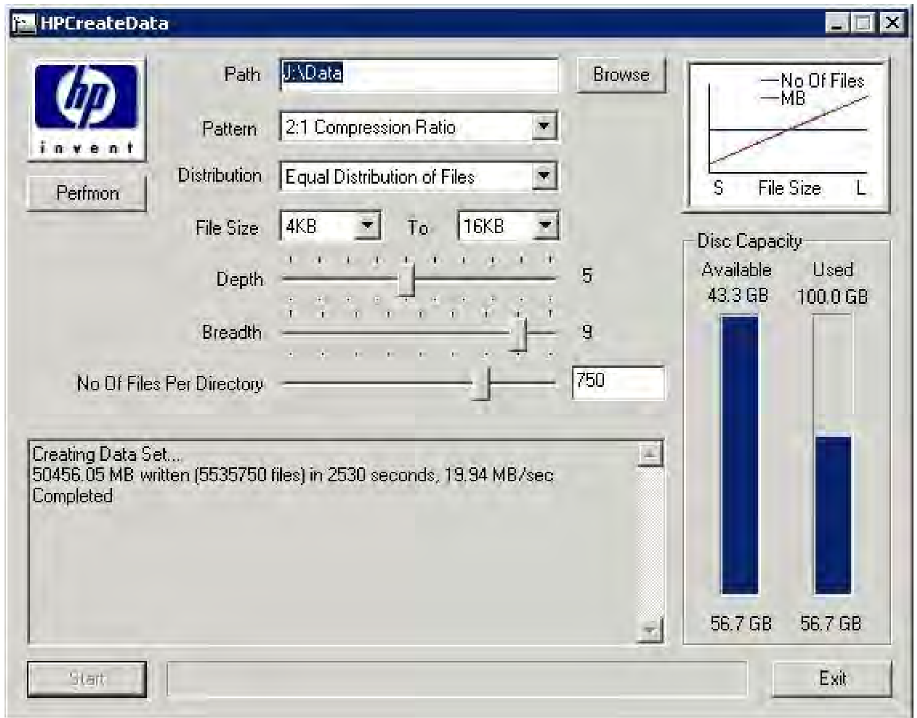
Finally, the file system contained 49.85 GB with 4,389 files in 20 folders.

Creating millions of small files for Windows NTFS

The file system with millions of small files for Windows NTFS was created with file sizes between 4 KB and 16 KB and the compressibility of the data 2:1. The utility created an equal distribution of files in each directory.

Figure 19 illustrates the HPCreateData input parameters and results.

Figure 19. HPCreateData for Windows—Creating small files



Finally, the file system contained 49.27 GB with 5,535,750 files in 7,380 folders.

Creating millions of small files for HP-UX VxFS

The file system with millions of small files for HP-UX VxFS was created similar to Windows. The file sizes were between 4 KB and 16 KB and the compressibility of the data 2:1. The utility created an equal distribution of files in each directory.

Note
The number of files per directory was set to 120 due to limitations of L&TT version 4.2 SR1a. The restore pre-test was executed six times for getting a HP-UX VxFS layout, which is similar the Windows NTFS layout as described in the previous section, Creating millions of small files for Windows NTFS. In later L&TT releases, the number of files should be increased to 750.

Figure 20 illustrates the L&TT input parameters and Figure 21 the results.

Figure 20. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for HP-UX—Creating small files—Input parameters

```
Main > System Performance Tools > Restore Pre-Test >
------------------------------------------------------------------------------
The Performance of the disk subsystem can be measured using this tool. This
creates a directory structure based on file size, directory depth, blocksize
and compression ratio and measures the data rates it achieves. Type the
corresponding number to select/set each option.

  1.     Set minimum file size in bytes (min-filesize) - 4096
  2.     Set maximum file size in bytes (max-filesize) - 16384
  3.     Set no. of files per directory (nofile) - 120
  4.     Set dir where to create dataset (dirpath) - /small1/data1
  5.     Set compressibility pattern to create files.1) Fixed Byte. 2) Incr...
  6.     Set file tree depth (file tree depth) - 5
  7.     Set file tree breadth (file tree breadth) - 9
```

Figure 21. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for HP-UX—Creating small files—Results

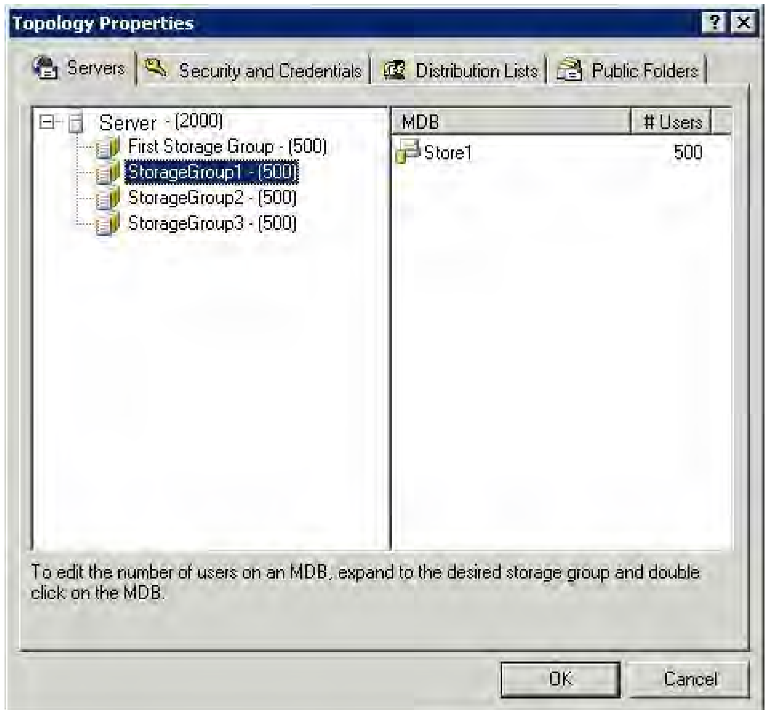
```
Main > System Performance Tools > Restore Pre-Test > Viewer >
--------------------------------------------------------------
8072 MB written (885720 files) in 161 seconds at 50 MB/sec
Restore Pre-Test successfully created files.
8072 MB written (885720 files) in 156 seconds at 51 MB/sec
Restore Pre-Test successfully created files.
8072 MB written (885720 files) in 157 seconds at 51 MB/sec
Restore Pre-Test successfully created files.
8072 MB written (885720 files) in 158 seconds at 51 MB/sec
Restore Pre-Test successfully created files.
8072 MB written (885720 files) in 156 seconds at 51 MB/sec
Restore Pre-Test successfully created files.
8072 MB written (885720 files) in 154 seconds at 52 MB/sec
Restore Pre-Test successfully created files.
```

Finally, the file system contained 47.29 GB with 5,314,320 files in 44,286 folders.

Creating data for Microsoft Exchange Server 2003

LoadSim was configured for simulating 2,000 users. Four equal storage groups were created with one store each as illustrated in Figure 22.

Figure 22. LoadSim Topology for simulating 2,000 users



The LoadSim initialization resulted in four storage groups with one 50-GB database each. The total size, which is relevant for backups and restores, was 200 GB.

Evaluating tape and disk drive performance

The performance test of tape and disk drives gives a good overview of what the source and target devices are able to provide. Backup applications cannot perform better than these basic tools.

Tape write and read performance

The tape drive performance was determined with the HP StorageWorks Library and Tape Tools Diagnostics (L&TT).

L&TT for Windows was configured for writing and reading:

- Zeros with fixed block mode, 256-KB block size, 1M I/O size, 32-GB test size and no file marks
- 2:1 compressible data with fixed block mode, 256-KB block size, 1M I/O size, 32-GB test size and no file marks

Figure 23 illustrates the L&TT for Windows input parameters and Figure 24 some test results.

Figure 23. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for Windows—Input parameters

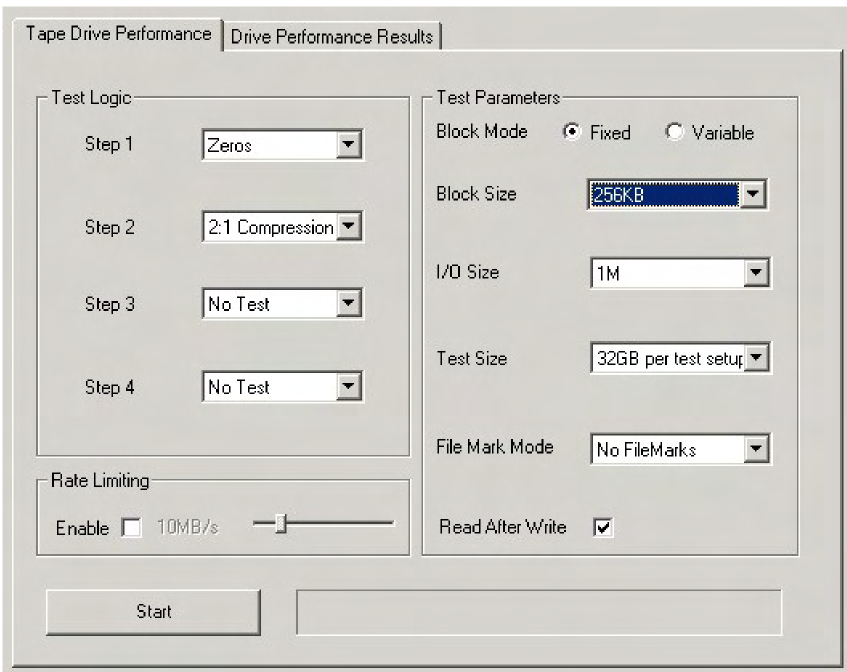


Figure 24. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for Windows—Test results

```
Clear Log
Reading 16GB of 32GB
Reading 17GB of 32GB
Reading 18GB of 32GB
Reading 19GB of 32GB
Reading 20GB of 32GB
Reading 21GB of 32GB
Reading 22GB of 32GB
Reading 23GB of 32GB
Reading 24GB of 32GB
Reading 25GB of 32GB
Reading 26GB of 32GB
Reading 27GB of 32GB
Reading 28GB of 32GB
Reading 29GB of 32GB
Reading 30GB of 32GB
Reading 31GB of 32GB
Reading 32GB of 32GB
32 GB read in 209 seconds at 156 MB/s
Rewinding Tape
Closing Tape Drive Tape0
```

L&TT for HP-UX was configured for writing and reading with the following parameters:

- 4.3/1 compressible data with 128-KB block size, 32768 repeats and 8 blocks
- 2:1 compressible data with 128-KB block size, 32768 repeats and 8 blocks

Note
L&TT for HP-UX does not offer zero patterns. Therefore, the highest available compression pattern of 4.3/1 was specified.

Figure 25 illustrates the L&TT for HP-UX input parameters and Figure 26 some test results.

Figure 25. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for HP-UX—Input parameters

```
Main > Drive Information > Device Performance Tool >
--------------------------------------------------------------------------------
The purpose of this tool is to measure the tape drive performance by checking
how fast the server can access the tape drive independent of the disk
subsystem. It works by transferring pre-loaded data with different compression
ratios directly from the memory of the server to the tape drive.

  1.     Set the blocksize to write to tape (blocksize) - 131072
  2.     Set the no. of writes/reads to perform (reps) - 32768
  3. [X] Enables the readback test after writing data to the device (readback)
  4.     Set the no. of blocks per read/write to tape (count) - 8
  5.     Pattern (1)-uncompressible (random), (2)-2/1 compressible, (3)-3/1...
```

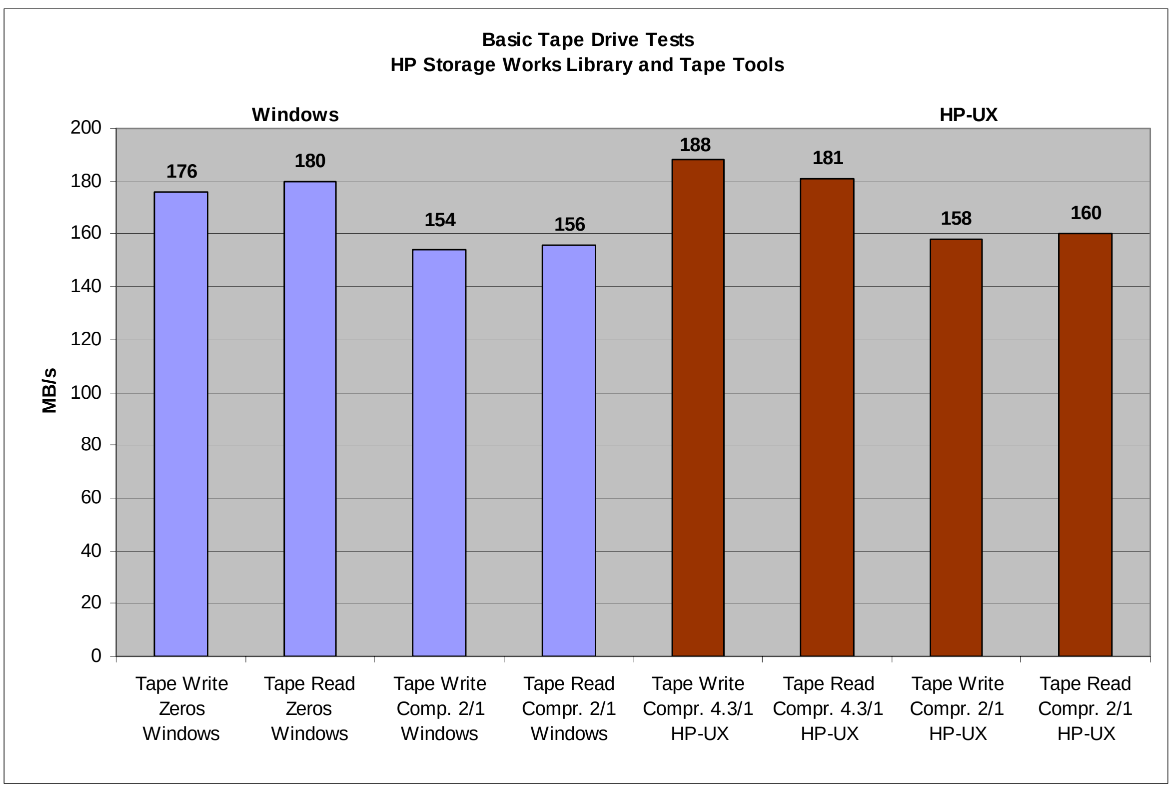
Figure 26. HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for HP-UX—Test results

```
Compression 4.3/1
Opening Tape Drive 2.5.0[0-20/0/2/1/0.5.0]
Successfully opened the Tape Drive /dev/rmt/Omnb
34359 MB written in 182.7644 seconds at 188.0002 MB/s
34359 MB read in 189.7036 seconds at 181.1233 MB/s
Device performance tool has successfully completed execution.

Compression 2/1
Opening Tape Drive 2.5.0[0-20/0/2/1/0.5.0]
Successfully opened the Tape Drive /dev/rmt/Omnb
34359 MB written in 216.7234 seconds at 158.5419 MB/s
34359 MB read in 213.7984 seconds at 160.7110 MB/s
Device performance tool has successfully completed execution.
```

The results of all L&TT tape drive test are illustrated in Figure 27, which shows the performance limits of a direct attached Ultrium 960 tape drive. This figure is a reference for any later Data Protector test. The tape drive cannot be faster as with L&TT. This applies to any backup application.

Figure 27. Library and Tape Tools—Results of tape drive tests



The tests had revealed that the Ultrium 960 tape drive performs slightly better in the HP-UX than in the Windows environment. But the difference is only marginal. Both environments demonstrated that they are fully able to utilize the Ultrium 960 tape drive.

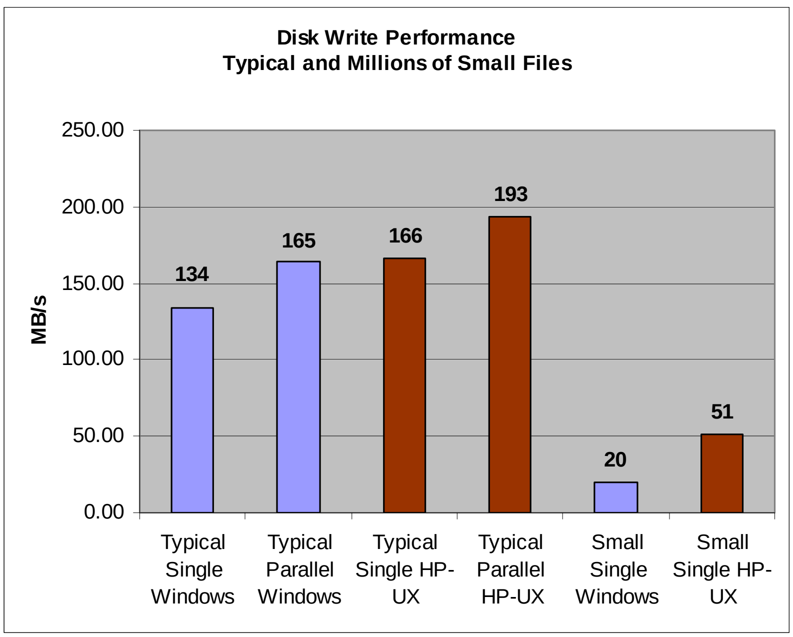
Disk write performance

The disk write performance was determined with the HP StorageWorks Library and Tape Tools Diagnostics (L&TT) for HP-UX and with the HPCreateData utility for Windows.

Note
The performance data of parallel writes is determined by the data volume divided by the time of the slowest write process. This approach simulates a backup application that does not finish before the last byte is written.

Figure 28 demonstrates that single writes of typical files (one stream to one disk volume) already perform good compared to multiple writes (five streams to five disk volumes). With Windows, single writes of small files (4–16 KB) are very slow because its NTFS file system overhead is much higher than with HP-UX VxFS.

Figure 28. Results of disk write tests



For Windows, parallel writes (five streams to five disk volumes) of small files failed due to problems with an overflow of the Windows system paged pool. This cannot be solved without Windows kernel tuning, which is not a focus of this white paper.

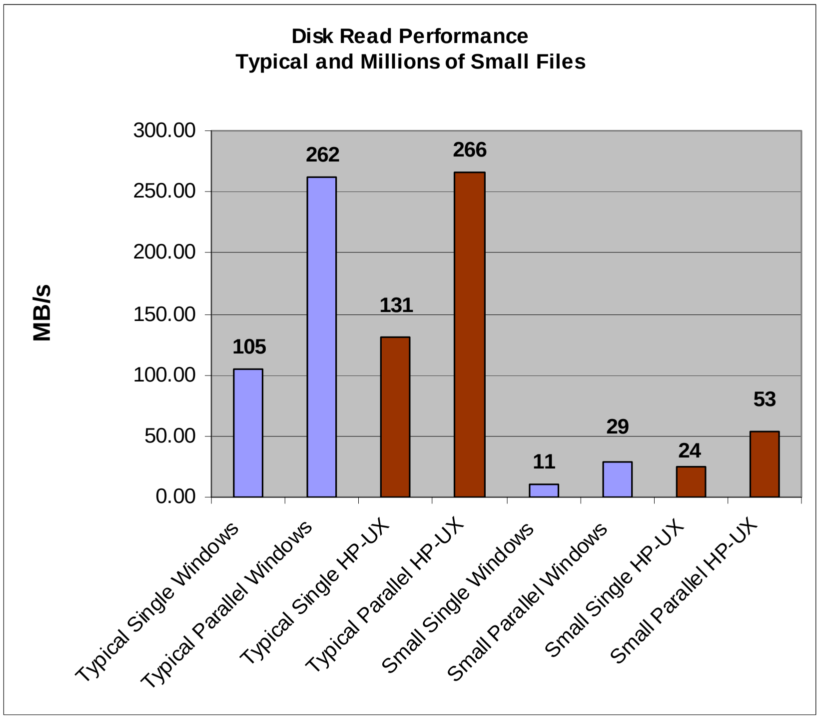
Note
For Windows, it is recommended that file systems with millions of small files are only restored single.

Disk read performance

The disk read performance was determined for HP-UX with the HP StorageWorks Library and Tape Tools Diagnostics (L&TT) and for Windows with the HPReadData utility.

Figure 29 demonstrates that multiple reads (five streams from five disk volumes) perform much better than single reads (one stream from one disk volume). With Windows, single reads of small files (4–16 KB) are very slow because its NTFS file system overhead is much higher than with HP-UX VxFS.

Figure 29. Results of disk read tests



Note
The performance data of parallel reads is determined by the data volume divided by the time of the slowest read process. This approach simulates a backup application, which does not finish before the last byte is read.

Evaluating Data Protector performance

This section highlights the Data Protector performance and uses the results of the previous sections for finding the bottleneck and giving recommendations. The procedures of this section should be transferable to many customer environments.

The Data Protector performance was tested and analyzed for two different types of file servers and a classic Microsoft Exchange Server 2003:

- Typical file server data with a common amount of files and a broad range of size (KB/MB)
- Problematic file server data with millions of small files (KB)
- Typical Microsoft Exchange Server 2003 data

The performance tests were executed by configuring single and multiple backup/restore streams—also named as concurrency or multiplexing. The results of single and multiple stream tests were compared and analyzed. In some cases, multiple streams could be slower than single streams.

The tests included the measurement of performance (MB/s), CPU load (%), and memory usage (MB) of the backup server and if applicable the client. Windows performance data was measured with the built-in tool Perfmon and HP-UX performance data with the built-in tool vmstat.

Note
The memory usage is **not** documented in the following sections because all tests had shown that the memory usage by Data Protector itself was very little and never exceeded 46 MB. For example, Data Protector did not utilize for the HP-UX local backup of typical files more than 19-MB memory and for the worst case with the Windows local backup of typical files not more than 46-MB memory. These days, 46-MB usage is not relevant for servers with gigabytes of memory.

Note
The Cell Manager performance was **not** logged because of not being a focus of this white paper. During testing, some quick Cell Manager performance checks confirmed that the Cell Manager was far away from getting a bottleneck. The CPU and IDB load was very little, even while saving and restoring the file server with millions of small files. The test scenarios of this paper were not sufficient to put the Cell Manager under pressure.

Data Protector configuration

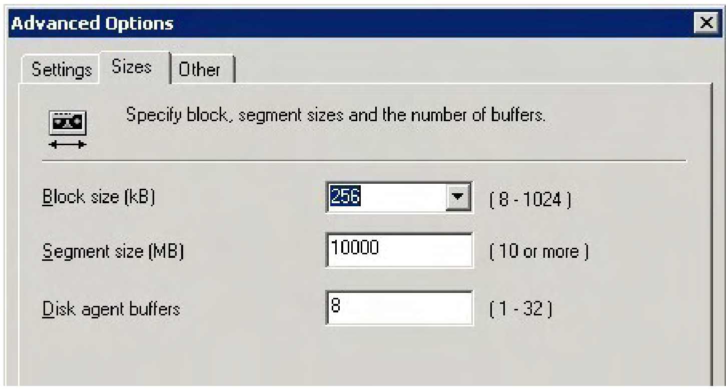
The backup and restore tests were executed with the following changes of Data Protector's default configuration:

- 256-KB tape drive block size as described in the HP StorageWorks Ultrium 960 tape drive configuration section
- Only one file system tree walk for Windows NTFS file systems with millions of small files as described in the File system tree walk section

HP StorageWorks Ultrium 960 tape drive configuration

For all tests with the HP StorageWorks Ultrium 960 tape drive, the block size was configured in Data Protector with 256 KB (64-KB default) as shown in Figure 30. For further details, see the "Getting the most performance from your HP StorageWorks Ultrium 960 tape drive white paper" (downloadable from http://h18006.www1.hp.com/storage/tapewhitepapers.html).

Figure 30. HP StorageWorks Ultrium 960 Configuration—drive block size 256 KB (64-KB default)



File system tree walk

File system tree walks are typically problematic in Windows NTFS file systems with millions of small files. UNIX file systems are less sensitive and respond much faster.

For each file system backup, Data Protector executes two tree walks by default:

- The **first** file system tree walk is required for:
  - Running backup statistics

    By default Data Protector creates backup statistics during runtime. The tree walk scans the files selected for the backup and calculates its size, so that the progress (percentage done) can be calculated and displayed in the Data Protector Monitor GUI.
  - Detecting Windows NTFS hard links

    NTFS hard links are detected if the advanced WINFS filesystem option Detect NTFS Hardlinks is selected (ON).
  - Detecting UNIX POSIX hard links

    POSIX hard links are detected and backed up as links if the advanced UNIX filesystem option Backup POSIX Hard Links as Files is not selected (OFF).

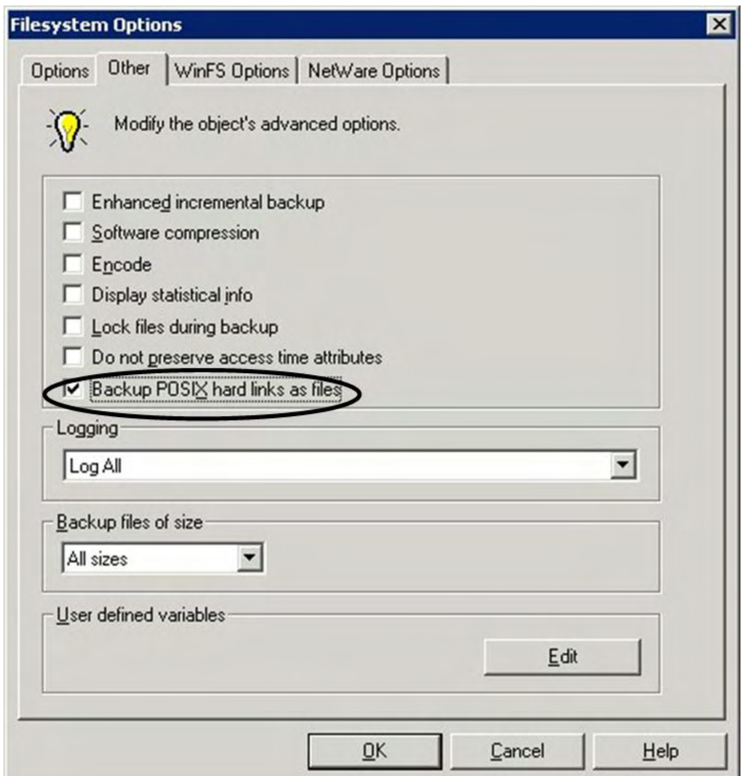
- The **second** file system tree walk is required for cataloging, indexing, and saving the selected files.

Note
Disabling the first file system tree walk is only recommended in the following scenarios:
• Running unattended backup sessions
• Backing up millions of small files from Windows NTFS or UNIX file systems with the requirement of an overall runtime decrease
• Having no NTFS or POSIX hard links, otherwise Data Protector would back up the entire file contents for each hard link, which would occupy more space on the backup media.

How to disable first tree walk for Windows NTFS: If the advanced WINFS file system option Detect NTFS Hardlinks is not set, the first tree walk of NTFS can be disabled by setting "NoTreeWalk=1" in the client's local "omnirc" file (<Data_Protector_home>\omnirc).

How to disable first tree walk for UNIX file systems: If the advanced UNIX file system option Backup POSIX Hard Links as Files is selected (ON), the first tree walk of UNIX file systems is disabled and POSIX hard links are backed up as files. Figure 31 illustrates the correct configuration for disabling the tree walk.

Figure 31. Disabling the first tree walk for UNIX file systems—Backup POSIX hard links as files



Data Protector IDB considerations

Note
The IDB logging level was not changed from its default value "Log All." This logging level is the worst case for the IDB while each file is tracked. For further details, see the IDB logging level section.

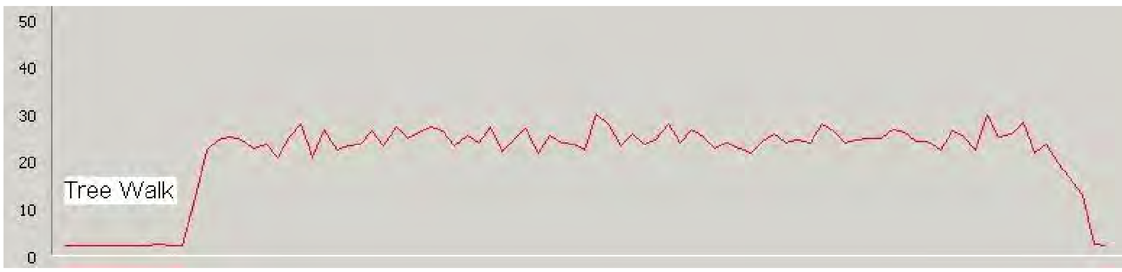
The following section tests had shown that more tape space was consumed for small files than for typical files. The backup of 5,535,750 small files and 249.36-GB total volume resulted in 267.32-GB tape space usage. The overhead was caused by the high number of small files and the required catalog information for each single file written to tape, for example, its file name and attributes.

Backup of typical and small files

This section covers the local and the network backup of typical and small files. For Windows NTFS file systems with millions of small files, the first tree walk was disabled as described in the File system tree walk section. For UNIX file systems, the first tree walk was always enabled (default) because it is less critical.

Figure 32 illustrates the effect of the first file system tree walk during the HP-UX network backup of small files. At the beginning, the Windows server loaded the tape and waited for data from the remote HP-UX server, which was busy with the execution of the HP-UX file system tree walk.

Figure 32. CPU Load of the Windows backup server during the HP-UX network backup of millions of small files



Local backup of typical files

The typical files were saved to the SCSI-attached Ultrium 960 tape drive.

For Windows, Test 1 of Table 1 shows that that the tape device wrote with 154.00 MB/s. This was sufficient for backing up a single file system as shown in Test 2 with 105.25 MB/s. But if backing up multiple file systems as shown in Test 3, the file systems were able to provide 262.24 MB/s, which was faster than the Ultrium 960 tape drive. Test 5 showed that the Data Protector performance of 151.69 MB/s was very close the to the tape drive performance of Test 1 with 154.00 MB/s. In this Test 5, the tape drive was able to stream with its highest performance and therefore it became the bottleneck. This is a very good example of a well-balanced environment for an Ultrium 960 tape drive.

For HP-UX, Test 1 of Table 1 shows that the results were much better than for Windows but that the same rules applied. The Ultrium 960 tape drive was the bottleneck.

The CPU load was low except the HP-UX NULL device backup of Test 4, which resulted in 43% and the excellent backup performance of 368.76 MB/s. Test 5 with the backup to the Ultrium 960 tape drive did not allocate much resources. The CPU load was just 13% for Windows and 16% for HP-UX.

Table 1. Local backup of typical files—bottleneck determination

Test	Performance (MB/s)	CPU Load	Bottleneck
1. Windows L&TT Tape Write[1]	154.00	-	**Yes (Tape)**
2. Windows HPReadData Single[1]	105.25	-	No
3. Windows HPReadData Parallel[1]	262.24	-	No
4. Windows DP NULL Parallel	197.15	18%	No
5. Windows DP Ultrium 960 Parallel	151.69	13%	No
1. HP-UX L&TT Tape Write[1]	158.54	-	**Yes (Tape)**
2. HP-UX HPReadData Single[1]	130.58	-	No
3. HP-UX HPReadData Parallel[1]	265.75	-	No
4. HP-UX DP NULL Parallel	368.76	43%	No
5. HP-UX DP Ultrium 960 Parallel	156.11	16%	No

Recommendation

If backing up typical files locally to the SCSI-attached Ultrium 960 tape drive, parallel backups (multiplexing/concurrency) are recommended because one single stream cannot fully utilize the tape drive.

[1] Tested in the Evaluating tape and disk drive performance section

Local backup of small files

The small files were saved to the SCSI-attached Ultrium 960 tape drive.

Table 2 shows that file systems with millions of small files were not able to fully utilize the Ultrium 960 tape drive. The file systems were the bottleneck for both operating systems. This had also some impact to Data Protector because the large amount of file information had to be written to tape and into Data Protector's IDB, which resulted in additional performance loss of 6.04 MB/s for Windows (Test 3 with 29.02 MB/s—Test 5 with 22.98 MB/s = 6.04 MB/s). For further details, see the Data Protector IDB considerations section.

The CPU load of Test 4 and Test 5 was higher for Windows (61%) than for HP-UX (25% and 16%). This is the result of the inefficient Windows NTFS file system if keeping millions of small files.

Note
For Windows Tests 4 and 5, the first file system tree walk was disabled, which improved the overall performance. Without this, the performance would have been even worse.

Table 2. Local backup of small files—bottleneck determination

Test	Performance (MB/s)	CPU Load	Bottleneck
1. Windows L&TT Tape Write[2]	154.00	-	No
2. Windows HPReadData Single[2]	10.59	-	**Yes (File System)**
3. Windows HPReadData Parallel[2]	29.02	-	**Yes (File System)**
4. Windows DP NULL Parallel	22.54	61%	No
5. Windows DP Ultrium 960 Parallel	22.98	61%	No
1. HP-UX L&TT Tape Write[2]	158.54	-	No
2. HP-UX HPReadData Single[2]	24.41	-	**Yes (File System)**
3. HP-UX HPReadData Parallel[2]	53.08	-	**Yes (File System)**
4. HP-UX DP NULL Parallel	50.50	25%	No
5. HP-UX DP Ultrium 960 Parallel	48.76	16%	No

Recommendation
If backing up file systems with millions of small files, parallel backups with a higher concurrency are recommended. These kinds of file systems are very slow and should be multiplexed. In case of the fast Ultrium 960 tape drive, a slower Ultrium tape drive or backup-to-disk technology could be considered.

[2] Tested in the Evaluating tape and disk drive performance section

Network backup of typical files

The typical files were saved from the client server by way of the network (Gigabit Ethernet) to the remote backup server and its SCSI-attached Ultrium 960 tape drive.

Table 3 shows that the tape device in Test 1 and the disk device in Test 3 were faster than Data Protector in Test 4 and Test 5. In this scenario, both operating systems showed the same backup performance by way of the network, which was the bottleneck. The Gigabit Ethernet itself has a 1,000-Mb/s or 120-MB/s limitation, which is very close to the results of Test 5 (Windows 108.29 MB/s and HP-UX 111.84 MB/s).

Table 3. Network backup of typical files—bottleneck determination

Test	Performance (MB/s)	CPU Load Client	CPU Load Backup Server	Bottleneck
1. Windows L&TT Tape Write[3]	154.00	-	-	No
2. Windows HPReadData Single[3]	105.25	-	-	No
3. Windows HPReadData Parallel[3]	262.24	-	-	No
4. Windows DP NULL Parallel	108.16	12%	12%	**Yes (Network)**
5. Windows DP Ultrium 960 Parallel	108.29	16%	15%	**Yes (Network)**
1. HP-UX L&TT Tape Write[3]	158.54	-	-	No
2. HP-UX HPReadData Single[3]	130.58	-	-	No
3. HP-UX HPReadData Parallel[3]	265.75	-	-	No
4. HP-UX DP NULL Parallel	112.83	26%	26%	**Yes (Network)**
5. HP-UX DP Ultrium 960 Parallel	111.84	24%	26%	**Yes (Network)**

Recommendation

If backing up typical files from a fast disk by way of Gigabit Ethernet to a remote Ultrium 960 tape drive, backups without multiplexing/concurrency could be considered. In this case, the network is the bottleneck.

[3] Tested in the Evaluating tape and disk drive performance section

Network backup of small files

The small files were saved by way of the network (Gigabit Ethernet) to the remote backup server and its SCSI-attached Ultrium 960 tape drive.

Table 4 shows that file systems with millions of small files were not able to fully utilize the remote Ultrium 960 tape drive with the network (Gigabit Ethernet) limit of 120 MB/s. The file systems were the bottleneck for both operating systems.

Note
For Windows Tests 4 and 5, the first file system tree walk was disabled, which improved the overall performance. Without this, the performance would have been even worse.

Table 4. Network backup of small files—bottleneck determination

Test	Performance (MB/s)	CPU Load Client	CPU Load Backup Server	Bottleneck
1. Windows L&TT Tape Write[4]	154.00	-	-	No
2. Windows HPReadData Single[4]	10.59	-	-	No
3. Windows HPReadData Parallel[4]	29.02	-	-	No
4. Windows DP NULL Parallel	22.02	3%	62%	**Yes (Network)**
5. Windows DP Ultrium 960 Parallel	22.25	3%	62%	**Yes (Network)**
1. HP-UX L&TT Tape Write[4]	158.54	-	-	No
2. HP-UX HPReadData Single[4]	24.41	-	-	No
3. HP-UX HPReadData Parallel[4]	53.08	-	-	No
4. HP-UX DP NULL Parallel	49.22	32%	21%	**Yes (Network)**
5. HP-UX DP Ultrium 960 Parallel	48.89	31%	21%	**Yes (Network)**

Recommendation
Parallel backups with a higher concurrency are recommended for file systems with millions of small files—also if backing up by way of the network (Gigabit Ethernet). These kinds of file systems are very slow and should be multiplexed. In case of the fast Ultrium 960 tape drive and the Gigabit Ethernet, a slower Ultrium tape drive or backup-to-disk technology could be considered.

[4] Tested in the Evaluating tape and disk drive performance section

Restore of typical and small files

This section covers the local- and network-based restore of typical and small files.

Local restore of typical files

The files were restored directly from the SCSI-attached Ultrium 960 tape drive.

For Windows, Test 1 of Table 5 shows that the tape device did not read faster than 156.00 MB/s. Test 3 shows that the disk device resulted in164.67-MB/s write performance and Test 4 in 145.07-MB/s restore performance for Data Protector. If the performance of two devices is so close, the tape has to wait sometimes for I/O, which explains the slightly slower Data Protector performance. Note that a disk device does not show 100% consistent performance from the operating system point of view. It will always have higher and lower values and monitoring tools just displaying the average value in a configured timeframe. This can be verified, for example, with the built-in performance tool Perfmon for Windows.

For HP-UX, Test 1 of Table 5 shows that the tape device result of Test 1 (160.71 MB/s) was less than the disk device result in Test 3 (193.07 MB/s). The tape device was the bottleneck.

Table 5. Local restore of typical files—bottleneck determination

Test	Performance (MB/s)	Bottleneck
1. Windows L&TT Tape Read[5]	156.00	**Yes (Tape)**
2. Windows HPCreateData Single[5]	133.98	No
3. Windows HPCreateData Parallel[5]	164.67	No
4. Windows DP Ultrium 960 Parallel	145.07	No
1. HP-UX L&TT Tape Read[5]	160.71	**Yes (Tape)**
2. HP-UX HPCreateData Single[5]	166.28	No
3. HP-UX HPCreateData Parallel[5]	193.07	No
4. HP-UX DP Ultrium 960 Parallel	153.30	No

[5] Tested in the Evaluating tape and disk drive performance section

Local restore of small files

The files were restored directly from the SCSI-attached Ultrium 960 tape drive.

For Windows, Test 1 of Table 6 shows that the tape device did not read faster than 156.00 MB/s. Test 2 shows that the disk device resulted in 19.94-MB/s single write performance. Test 3 resulted with Data Protector in just 3.38-MB/s single restore performance. The bottleneck was the file system, which was very busy during the recovery. Millions of small files were written back with their original names and file attributes. The tape device was always in the start/stop mode.

Note

With Windows, Test 4 with parallel writes to file systems was not possible due to problems with an overflow of the Windows system paged pool. For further details, see the Disk write performance section. Out of that reason HP-UX Test 4 was skipped.

For HP-UX, Test 2 of Table 6 shows a much better disk write performance (51.41 MB/s) than for Windows (19.94 MB/s). If the results of Test 3 are compared between Windows (3.38 MB/s) and HP-UX (20.76 MB/s), the difference is even bigger. This shows how efficient the HP-UX file system is.

Table 6. Local restore of small files—bottleneck determination

Test	Performance (MB/s)	Bottleneck
1. Windows L&TT Tape Read[6]	156.00	No
2. Windows HPCreateData Single[6]	19.94	**Yes (File System)**
3. Windows DP Ultrium 960 Single	3.38	**Yes (File System)**
4. Windows DP Ultrium 960 Parallel	-	-
1. HP-UX L&TT Tape Read[6]	160.71	No
2. HP-UX HPCreateData Single[6]	51.41	**Yes (File System)**
3. HP-UX DP Ultrium 960 Single	20.76	**Yes (File System)**
4. HP-UX DP Ultrium 960 Parallel	-	-

[6] Tested in the Evaluating tape and disk drive performance section

Network restore of typical files

The typical files were restored by way of the network (Gigabit Ethernet) from the remote backup server and its SCSI-attached Ultrium 960 tape drive.

Table 7 shows that the tape device of Test 1 and the disk device of Test 3 were faster than with Data Protector in Test 4. In this scenario, both operating systems showed the same performance for the tests by way of the network, which was the bottleneck. The Gigabit Ethernet itself has a 1,000-Mb/s or 120-MB/s limitation, which is very close to the results of Test 4 (Windows with 104.96 MB/s and HP-UX with 104.22 MB/s).

Table 7. Network restore of typical files—bottleneck determination

Test	Performance (MB/s)	Bottleneck
1. Windows L&TT Tape Read[7]	156.00	No
2. Windows HPCreateData Single[7]	133.98	No
3. Windows HPCreateData Parallel[7]	164.67	No
4. Windows DP Ultrium 960 Parallel	104.96	**Yes (Network)**
1. HP-UX L&TT Tape Read[7]	160.71	No
2. HP-UX HPCreateData Single[7]	130.58	No
3. HP-UX HPCreateData Parallel[7]	265.75	No
4. HP-UX DP Ultrium 960 Parallel	104.22	**Yes (Network)**

[7] Tested in the Evaluating tape and disk drive performance section

Network restore of small files

The small files were restored by way of the network (Gigabit Ethernet) from the remote backup server and its SCSI-attached Ultrium 960 tape drive.

For Windows, Table 8 shows that the tape device did not read faster than 156.00 MB/s and Test 2 shows that the disk device can write with 19.94 MB/s. But Test 3 resulted in just 3.66-MB/s restore performance for Data Protector. The bottleneck was the file system, which was very busy during the recovery. Millions of small files were written back with their original names and file attributes. The tape device was always in the start/stop mode.

Note
For Windows, Test 4 with parallel writes to file systems was not possible due to problems with an overflow of the Windows system paged pool. For further details, see the Disk write performance section. Out of that reason, HP-UX Test 4 was skipped.

Table 8. Network restore of small files—bottleneck determination

Test	Performance (MB/s)	Bottleneck
1. Windows L&TT Tape Read[8]	156.00	No
2. Windows HPCreateData Single[8]	19.94	**Yes (File System)**
3. Windows DP Ultrium 960 Single	3.66	**Yes (File System)**
4. Windows DP Ultrium 960 Parallel	-	-
1. HP-UX L&TT Tape Read[8]	160.71	No
2. HP-UX HPCreateData Single[8]	51.41	**Yes (File System)**
3. HP-UX DP Ultrium 960 Single	20.18	**Yes (File System)**
4. HP-UX DP Ultrium 960 Parallel	-	-

Backup and restore of Microsoft Exchange Server 2003

The Microsoft Exchange Server was principally tested for backup performance. Four storage groups with one 50-GB database each were saved to the SCSI-attached Ultrium 960 tape drive. Other scenarios were not tested, for example, with multiple databases per storage group, because it would not significantly change the performance results (MB/s). Multiple databases within one storage group are backed up one after the other.

Note
Multiple storage groups are backed up in parallel but multiple databases (stores) within a storage group only sequentially.

Basic Microsoft Exchange Server 2003 test tools for backup and restore were not available during the creation of this white paper. Therefore, only L&TT and Data Protector were used for testing.

[8] Tested in the Evaluating tape and disk drive performance section

Data Protector configuration parameters

The maximum device concurrency for backing up the Exchange Server data is two. A higher concurrency would utilize too much Exchange Server resources and finally not improve the backup performance.

Recommendation

The recommended device concurrency for backing up the Exchange Server data is two for devices connected directly to the server, and one for devices connected remotely.

The buffer size is based on the formula **buffer size = concurrency * 16 KB.** The minimum buffer size is 32 KB, which is the default buffer size as well.

Local backup of Microsoft Exchange Server 2003

All storage groups were saved to the SCSI-attached Ultrium 960 tape drive with the default configuration values for concurrency (2) and backup buffer size (32 KB).

The performance was only calculated based on the backup time of storage groups and its databases. The backup time for the subsequent transaction log backup was excluded.

Table 9 demonstrates with Test 2 (226.99 MB/s) and Test 3 (289.55 MB/s) that the Exchange Server integration of Data Protector was able to provide more performance than the Ultrium 960 tape drive can handle (154 MB/s). The Exchange Server backup of Test 4 (138.70 MB/s) did not completely reach the Ultrium tape drive performance of Test 1 (154 MB/s). This is because the data was not always streamed with the same performance. The performance ups were higher and if a database was switched—one database backup had finished and the next one started—the downs much lower.

Table 9. Local backup of Exchange Server 2003—bottleneck determination

Test	Performance (MB/s)	Bottleneck
1. Windows L&TT Tape Write[9]	154.00	No
2. DP Null Single (conc.=1)	226.99	No
3. DP Null Parallel (conc.=2)	289.55	No
4. DP Ultrium 960 Parallel	138.70	**Yes (Tape)**

[9] Tested in the Evaluating tape and disk drive performance section

Local restore of Microsoft Exchange Server 2003

All storage groups were restored from the SCSI-attached Ultrium 960 tape drive.

The performance was only calculated based on the restore time of the storage groups and its databases. The time for the subsequent transaction log restore and recovery was excluded.

As shown in Table 10, the Exchange Server restore of Test 2 (109.61 MB/s) was slower than the Ultrium tape drive performance of Test 1 (156 MB/s). This is because the data was not always streamed with the same performance. The performance ups were higher and, for example, if a storage group was initialized, the downs much lower.

Table 10. Local restore of Exchange Server 2003 – bottleneck determination

Test	Performance (MB/s)	Bottleneck?
1. Windows L&TT Tape Read[9]	156.00	No
2. DP Ultrium 960 Parallel	109.61	**Yes (Tape)**

Tuning Data Protector performance for typical files

Data Protector's backup and restore performance can be improved by modifying its configuration for backups, devices, and media.

Because most customers tune their environment for backup performance, restores are only discussed. The focus of this white paper is on the most important backup parameters, which are configurable in the GUI. The client-based parameter for the File system tree walk is not considered.

For simplicity, all tests of this section were executed on HP-UX with the typical files dataset as created in the Creating typical files for HP-UX VxFS section.

Note
In this section, all tests were based on HP-UX typical files with the compressibility of the data 4:1.

Backup options

Data Protector offers a comprehensive set of backup options for fine tuning. The most relevant options for performance are:

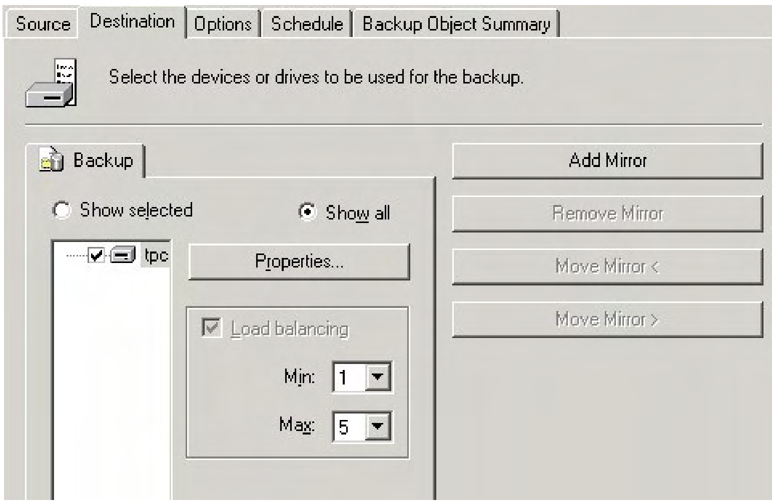
- Load balancing
- Software compression
- IDB logging level
- Detect Windows NTFS hardlinks

Load balancing

By default, Data Protector automatically balances the load (usage) of devices so that they are used evenly. Since load balancing is done automatically during backup time, it is not required to manage the assignment of objects to devices, so that all assigned devices stay busy during the backup session. If this option was selected in the Create New Backup dialog (the default), it cannot be deselected.

Figure 33 illustrates a backup configuration with the default load balancing switched ON.

Figure 33. Backup configuration—load balancing



If load balancing was not selected (OFF) in the Create New Backup dialog, single devices can be chosen, which will be used for each object in a backup specification. This could be very beneficial for bundling objects (for example, file systems) based on their speed and not based on their size. Data Protector does not track the backup speed of each object and therefore cannot automatically balance based on that. But the manual load balancing option provides an alternative solution for fine tuning the distribution of backup objects to devices.

Software compression

This option enables compressing the data, which is read by the Disk Agent. It is based on the Lempel-Ziv compression algorithm, which is compatible with the standard UNIX compress utility.

Software compression could be advantageous in network environments with small bandwidths when the network is the bottleneck. The Disk Agent would compress the data and subsequently send it across the network to the remote Media Agent. Sometimes this procedure improves the backup performance. The default compression value is OFF.

Note

Most modern backup devices provide built-in hardware compression that you can configure when adding a device to a client. In this case, do not use this option, since double compression only decreases performance without giving better compression results.

Figure 34 shows the default configuration parameters for file systems. The software compression is set to OFF by default.

Figure 34. Backup configuration—default file system options—software compression OFF

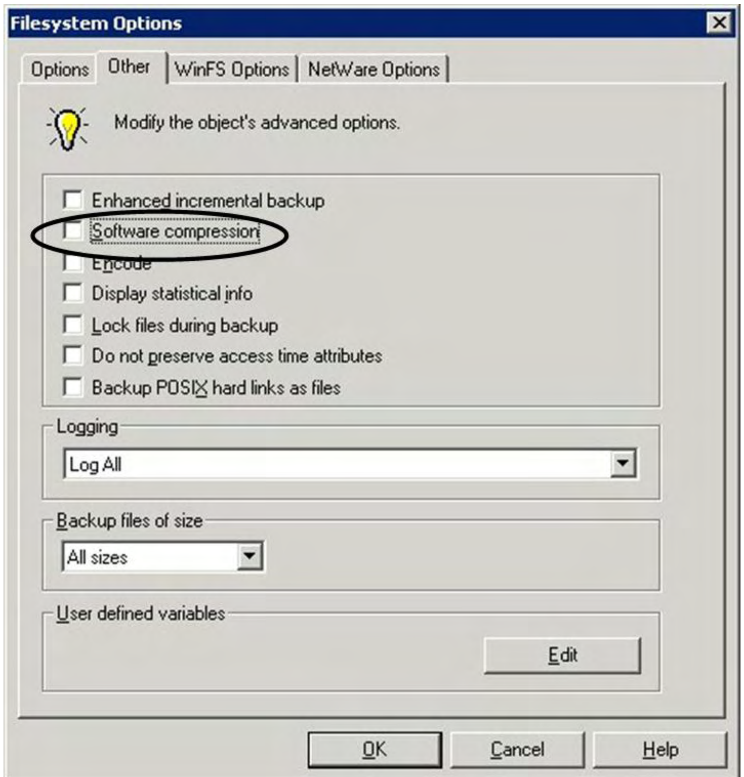


Figure 35 demonstrates how performance-efficient the Ultrium 960 tape drive compression is. With the software compression disabled (default), the backup performance was 156 MB/s. With the software compression enabled, the performance was just 46 MB/s.

Figure 35. Performance of HP-UX local backup to Ultrium 960 with software compression OFF/ON

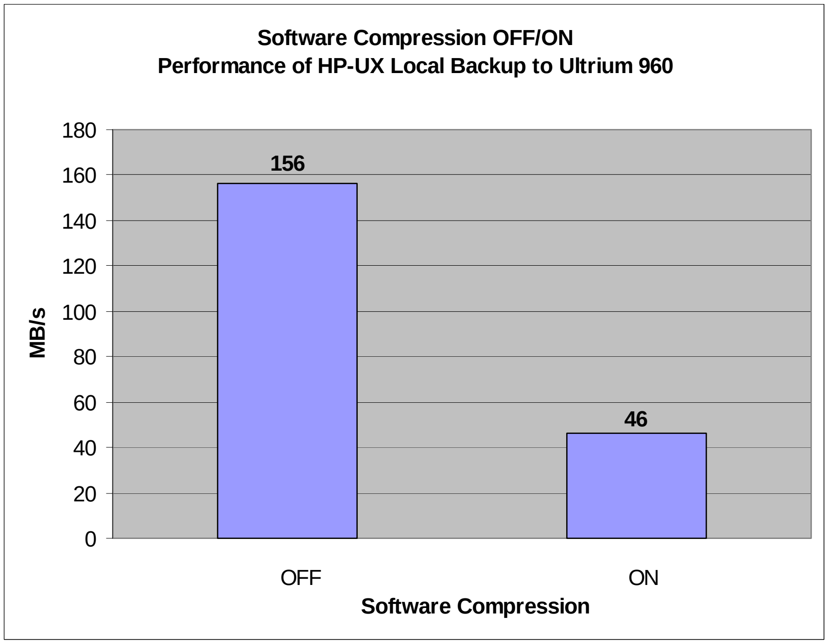
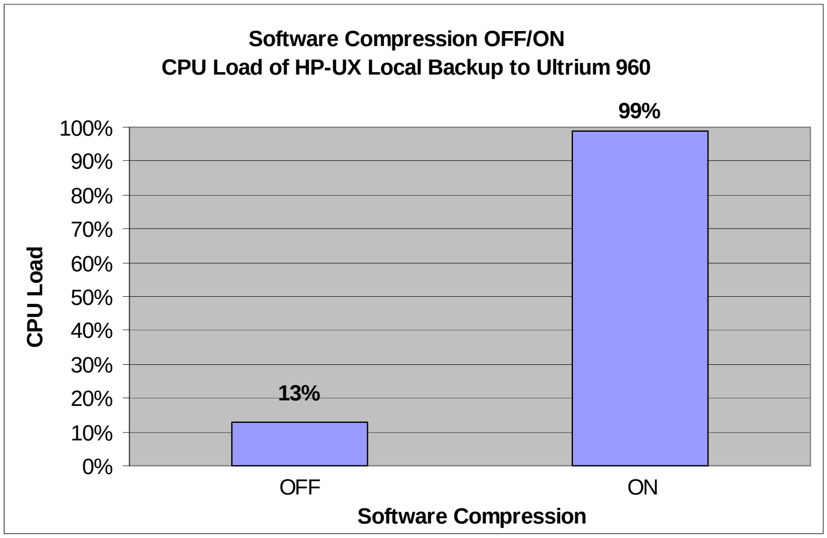


Figure 36 shows that enabling the software compression increased the CPU load from 13% to 99%. The CPU load was very high because Data Protector compressed five file systems in parallel.

Figure 36. CPU load of HP-UX local backup to Ultrium 960 with software compression OFF/ON

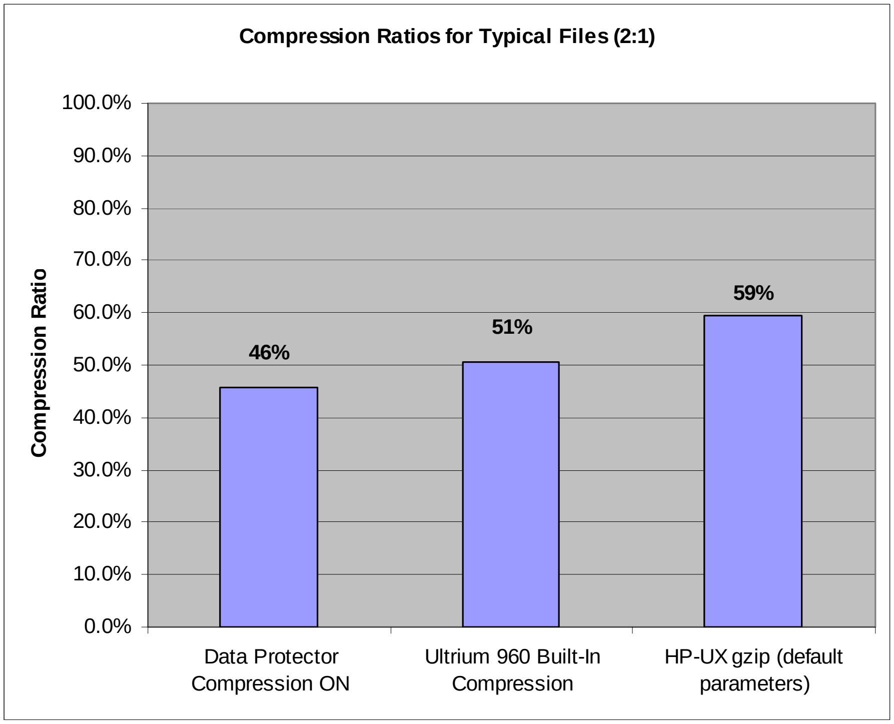


Note

As a rule of thumb, each software compression process takes all available resources of a single CPU. For instance, one Disk Agent would utilize only one out of four CPUs, which would result in an overall 25% CPU load.

Figure 37 shows that the ratios were different for software and hardware compression. HP-UX gzip was additionally tested because it is the current standard compression utility for UNIX and a good indicator for possible ratios. The compression ratio of HP-UX gzip resulted in 59%, the Ultrium 960 built-in compression in 50% and Data Protector software compression in 45%.

Figure 37. Compression ratios for HP-UX



Following are some reasons why Data Protector's software compression ratio was lower:

- The Data Protector compression is based on the Lempel-Ziv compression algorithm, which is less space-efficient than for instance the newer gzip (GNU zip) compression utility. On the other hand, better compression has its price in terms of speed.
- gzip offers different compression levels—between less and best compression. This test was executed with the default level, which is biased toward high compression at expense of speed.
- Ultrium tape drives use the Advanced Lossless Data Compression (ALDC) algorithm for data compression. ALDC is an implementation of the Lempel-Ziv method of compressing data and can be implemented very hardware-efficient. ALDC has the ability to switch into a non-compressed mode according to the structure of the data pattern. This means that highly random data does not actually expand when compressed. This way of compression is very fast and space-efficient simultaneously.

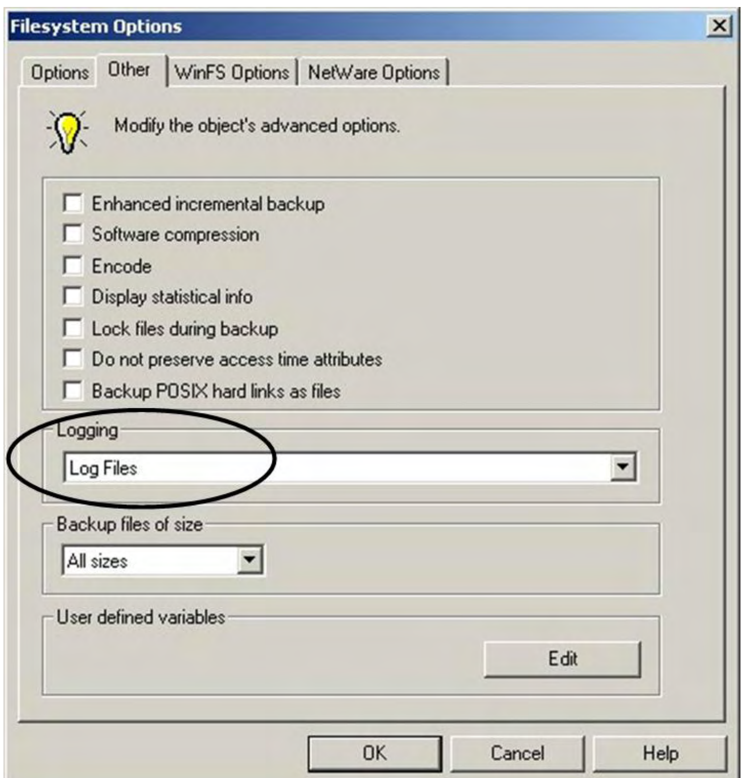
IDB logging level

The logging level determines the amount of details on files and directories, which are written to the IDB during backup, object copying, or object consolidation. Regardless of the logging level, the backed up data can always be restored. Data Protector provides four logging levels: Log All, Log Directories, Log Files, and No Log. The different logging level settings influence the IDB growth, backup speed, and the convenience of browsing data for restore. Since the impact is mostly relevant for the Cell Manager, which is not a focus of this white paper, it was not tested.

Note
Any Data Protector test was executed with the default configuration parameter Log All, which represents the worst case in terms of performance.

Figure 38 shows the default configuration parameters for file systems. The logging level is set to Log All.

Figure 38. Backup configuration—default file system options—logging level Log Files



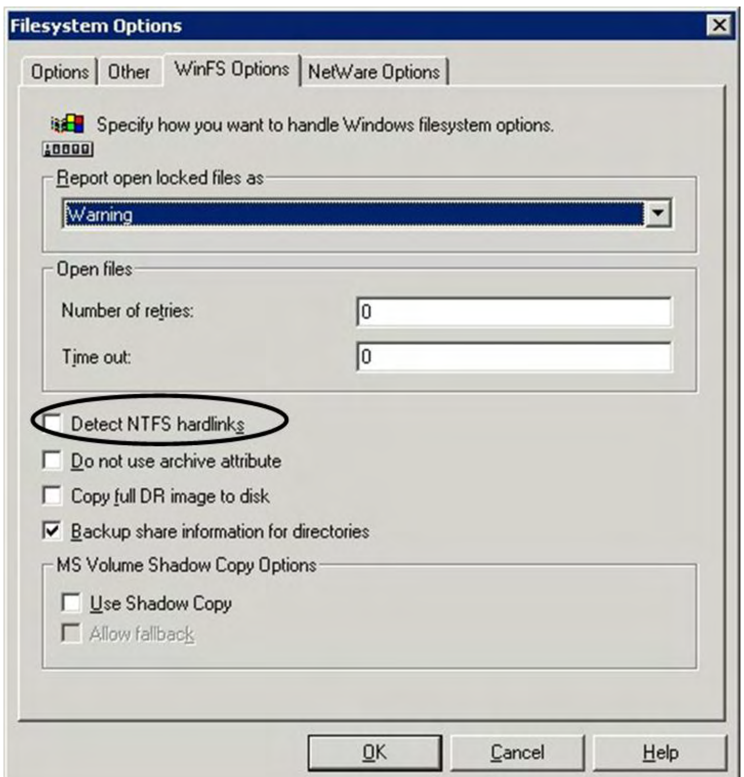
Detect Windows NTFS hardlinks

This option enables detection of NTFS hard links. By default, Data Protector does not detect NTFS hard links, and backs up hard links as files. This significantly improves backup performance, but the files occupy more space on the media. The original structure is not preserved and, at restore, hard links are restored as files.

Note
NTFS hard links are not commonly used in Windows environments. Therefore, it is not a focus of this white paper.

Figure 39 shows the default configuration parameters for Windows file systems. The default NTFS hardlinks detection is OFF.

Figure 39. Backup configuration—advanced WinFS filesystem options—detect NTFS hardlinks



Device and media options

Advanced options can be set for devices and media when configuring a new device, or when changing device properties. The availability of these options depends on the device type.

Some of these options can also be set when configuring a backup, for example, the concurrency. Device options set in a backup specification override options set for the device in general.

The most relevant options for performance are:

- Concurrency
- CRC check
- Block size
- Segment size
- Disk Agent buffers
- Hardware compression

Concurrency

The number of Disk Agents started for each Media Agent is called Disk Agent (backup) concurrency and can be modified using the advanced options for the device or when configuring a backup. The concurrency set in the backup specification takes precedence over the concurrency set in the device definition.

Data Protector provides a default number of Disk Agents that are sufficient for most cases. The fast HP StorageWorks Ultrium 960 device is configured with a default number of four.

For example, if you have a library with two Ultrium 960 devices, each controlled by a Media Agent and each Media Agent receives data from four Disk Agents concurrently, data from eight disks is backed up simultaneously.

Figure 40 shows the default configuration parameters for Ultrium tape drives. The concurrency is set to four. Note that other tape drives or backup devices could have different values.

Figure 40. HP StorageWorks Ultrium 960 advanced options—concurrency

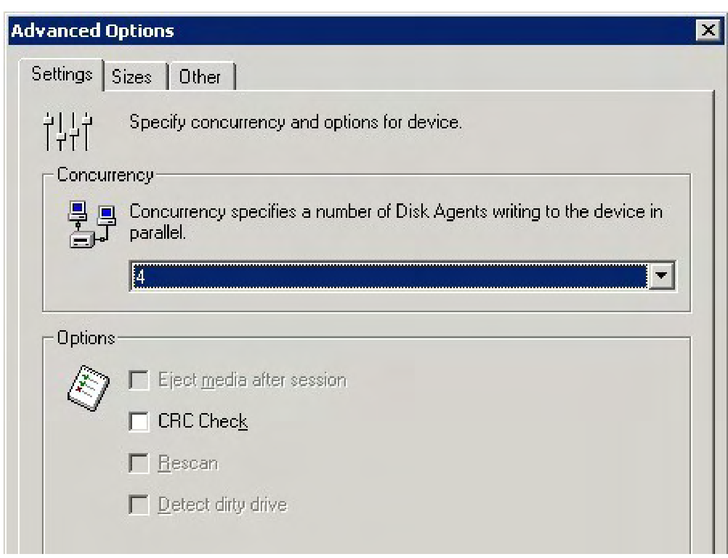


Figure 41 illustrates the performance of a local backup to the Ultrium 960 tape drive with different concurrencies. It shows that the Ultrium 960 concurrency value of three was sufficient for this test environment with the SAN-connected disk volumes. The default value of four or the higher value of five did not result in a higher performance but also did not result in a lower performance. Higher values for concurrency are useful for environments with slower disks and file systems.

Figure 41. Performance of HP-UX local backup to Ultrium 960 with concurrency 1–5

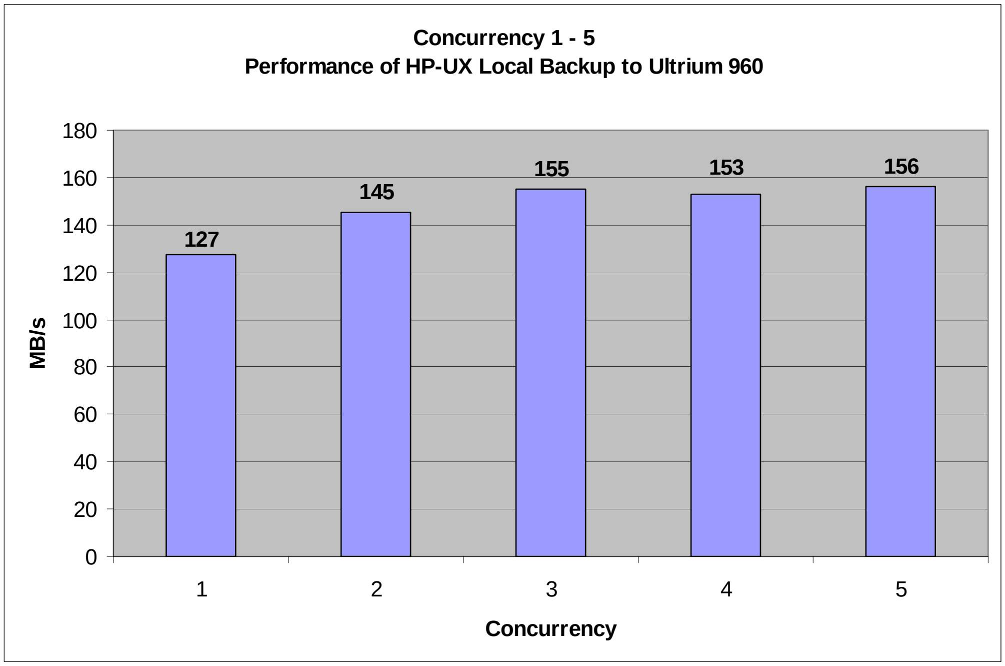
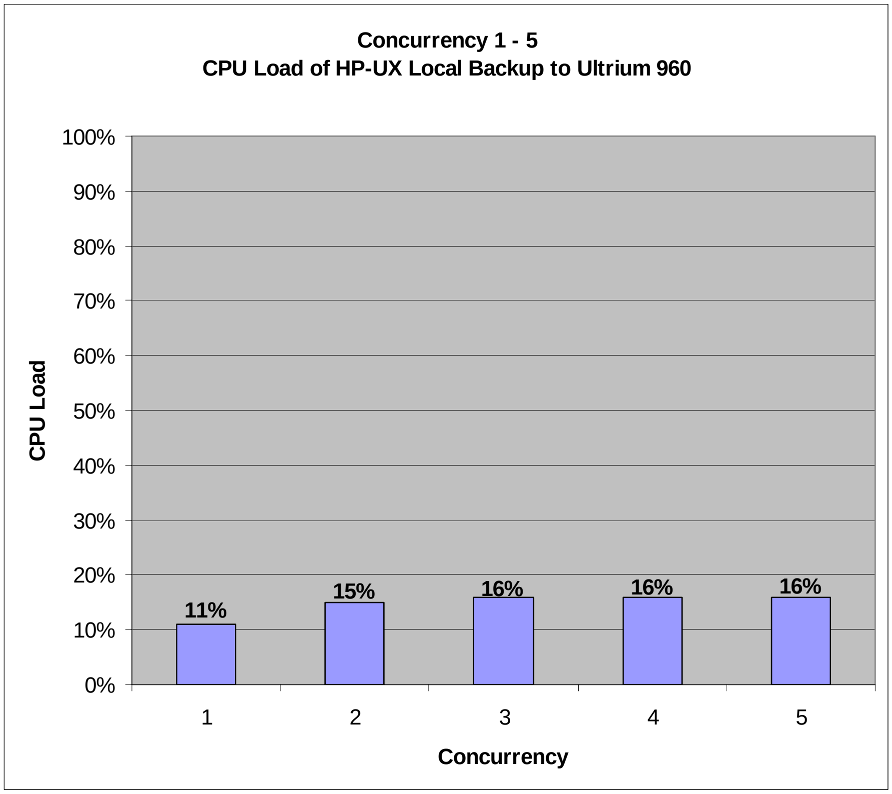


Figure 42 demonstrates that the CPU load was low during all backup tests. Concurrency values of three to five resulted in the same CPU load. This is like the backup performance as shown in Figure 41.

Figure 42. CPU load of HP-UX local backup to Ultrium 960 with concurrency 1–5



CRC check

The CRC check is an enhanced checksum function. When this option is selected, cyclic redundancy check sums (CRC) are written to the media during backup. The CRC checks allow you to verify the media after the backup. Data Protector re-calculates the CRC during a restore and compares it to the CRC on the medium. It is also used while verifying and copying the media. This option can be specified for backup, object copy, and object consolidation operations. The default value is OFF.

Figure 43 shows the default configuration parameters for Ultrium tape drives. The CRC check was OFF.

Figure 43. HP StorageWorks Ultrium 960 advanced options—CRC check OFF

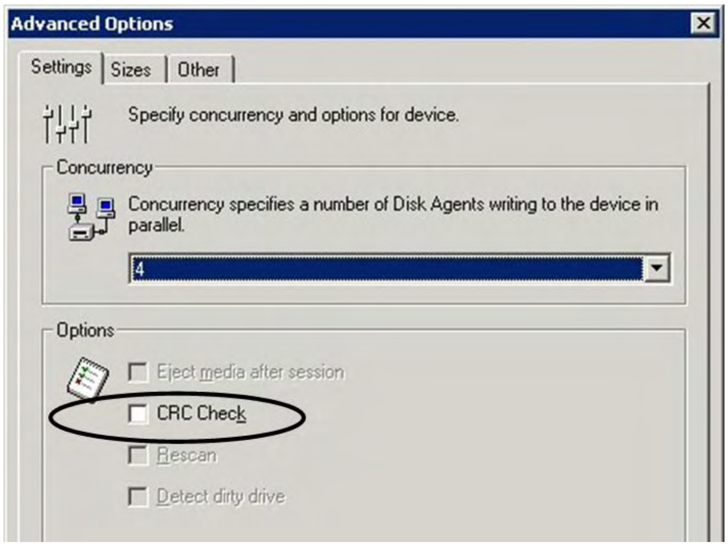


Figure 44 demonstrates that enabling the CRC check required additional system resources. The CRC ON test resulted in approximately 20% performance decrease.

Figure 44. Performance of HP-UX local backup to Ultrium 960 with CRC check OFF/ON

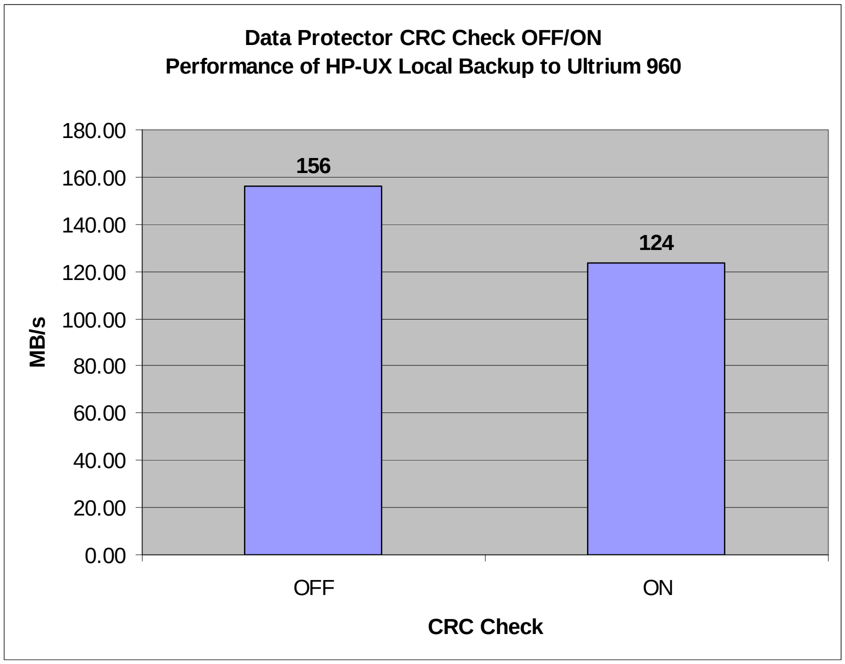
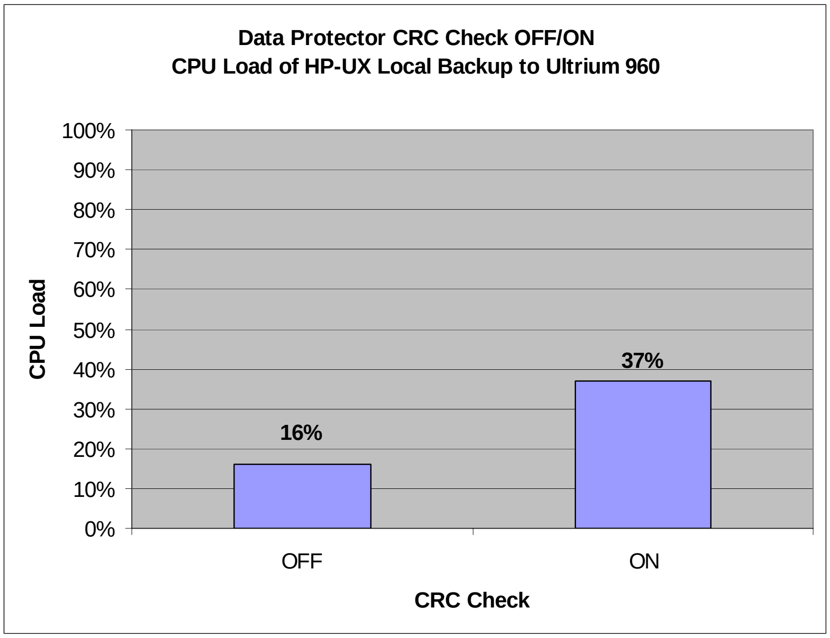


Figure 45 shows that enabling the CRC check required additional CPU resources. The CRC ON test resulted in more than twice the CPU load.

Figure 45. CPU load of HP-UX local backup to Ultrium 960 with CRC check OFF/ON



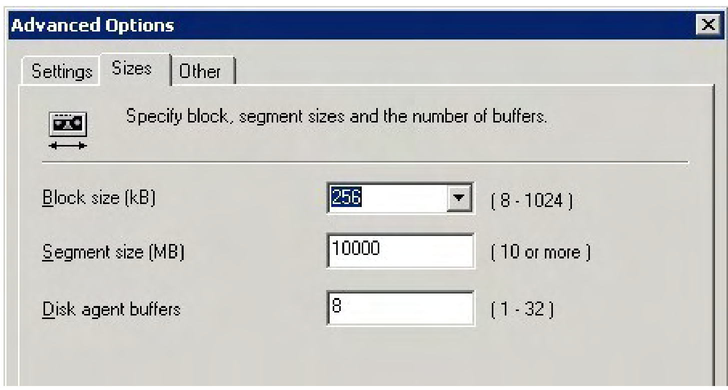
Block size

Segments are not written as a whole unit, but rather in smaller subunits called blocks. Data Protector uses a default device block size regarding different device types. The block size applies to all devices created by Data Protector and to Media Agents running on the different platforms.

Increasing the block size can improve performance. You can adjust the blocks sent to the device while configuring a new device or when changing the device properties using the advanced options for the device. A restore automatically adjusts the block size.

For the HP StorageWorks Ultrium 960, the block size was configured with a fixed value of 256 KB as shown in Figure 46 and as described in the Data Protector configuration section.

Figure 46. HP StorageWorks Ultrium 960 configuration—block size, segment size, and Disk Agent buffers

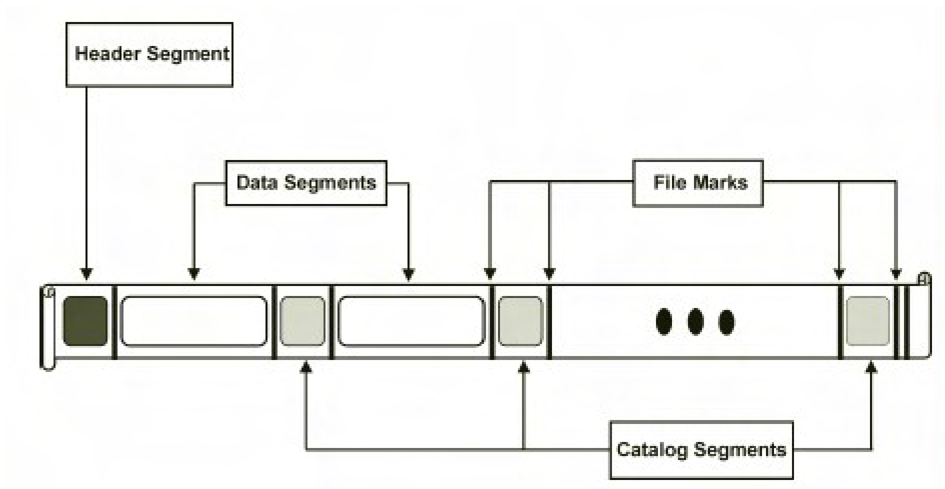


Segment size

A medium is divided into data segments, catalog segments, and a header segment. Header information is stored in the header segment, which is the same size as the block size. Data is stored in data blocks of data segments. Information about each data segment is stored in the corresponding catalog segment. This information is first stored in the Media Agent memory and then written to a catalog segment on the medium as well as to the IDB.

All segments are divided by file marks as shown in Figure 47.

Figure 47. Data Protector medium—data segments, catalog segment, header segment, and file marks



Segment size, measured in megabytes, is the maximum size of data segments. If you back up a large number of small files, the actual segment size can be limited by the maximum size of catalog segments. Segment size is user configurable for each device and influences the restore performance. You can adjust the segment size while configuring a new device or when changing the device properties using the Advanced options for the device.

Optimal segment size depends on the media type used in the device and the kind of data to be backed up. The average number of segments per tape is 50. The default segment size can be calculated by dividing the native capacity of a tape by 50. The maximum catalog size is limited to a fixed number (12 MB) for all media types.

Data Protector finishes a segment when the first limit is reached. When backing up a large number of small files, the media catalog limit could be reached faster, which could result in smaller segment sizes.

Figures 48 and 49 illustrate the results of backups with different segment sizes. Larger segment sizes, which improved the backup performance, resulted also in some additional CPU load.

Figure 48. Performance of HP-UX local backup to Ultrium 960 with segment sizes 10–10,000 MB

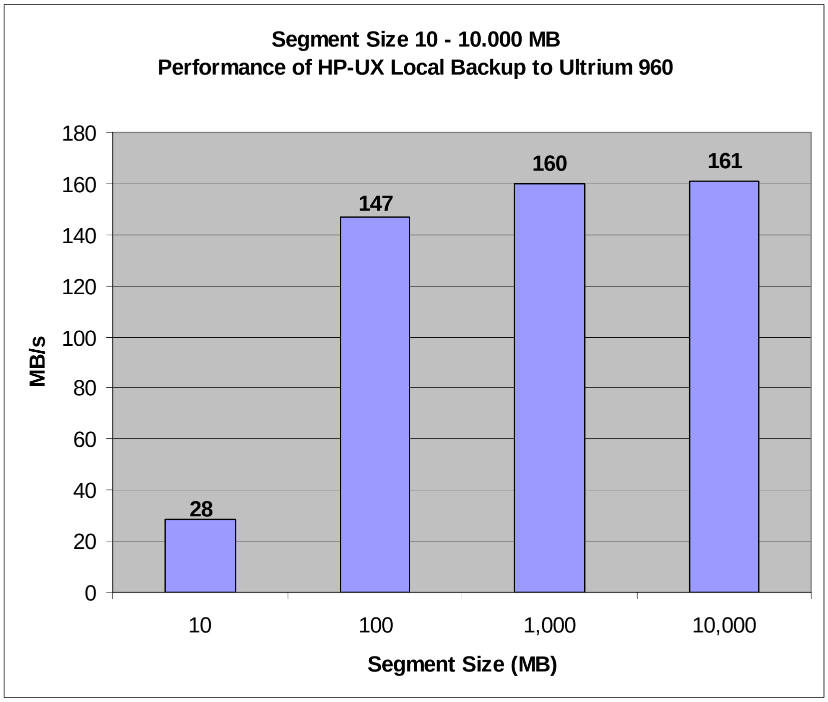
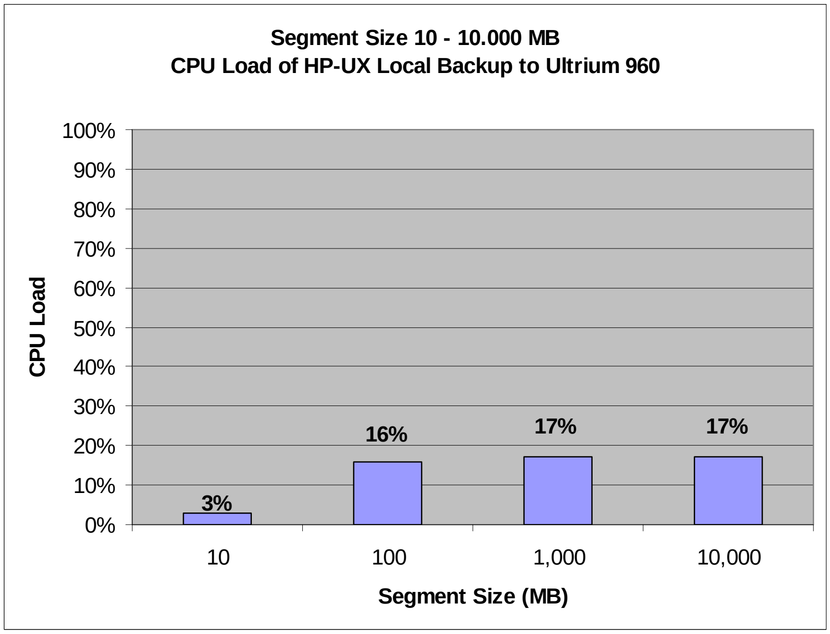


Figure 49. CPU load of HP-UX local backup to Ultrium 960 with segment sizes 10–10,000 MB



Note
Larger segments sizes improve the backup performance but could have negative impact on the restore performance. Data blocks are found faster if restored from a backup with smaller segment sizes.

Disk Agent buffers

Data Protector Media Agents and Disk Agents use memory buffers to hold data waiting to be transferred. This memory is divided into a number of buffer areas (one for each Disk Agent and depending on device concurrency). Each buffer area consists of eight Disk Agent buffers (of the same size as the block size configured for the device).

This value can be changed while configuring a new device or when changing the device properties using the advanced options for the device, although this is rarely necessary. There are two basic reasons to change this setting:

- Shortage of memory

  If there is a shortage of memory, the shared memory required for a Media Agent can be calculated as follows:

  Media Agent Shared Memory = Disk Agent Concurrency x Number of Buffers x Block Size

- Streaming

  If the available network bandwidth varies significantly during backup, it is important that a Media Agent has enough data ready for writing to keep the device in the streaming mode. In this case, increasing the number of buffers could help.

Figures 50 and 51 demonstrate that different numbers of Disk Agent buffers did not have a real performance impact in this local backup scenario. The Media Agent always had enough data ready for writing.

Figure 50. Performance of HP-UX local backup to Ultrium 960 with 1–32 Disk Agent buffers

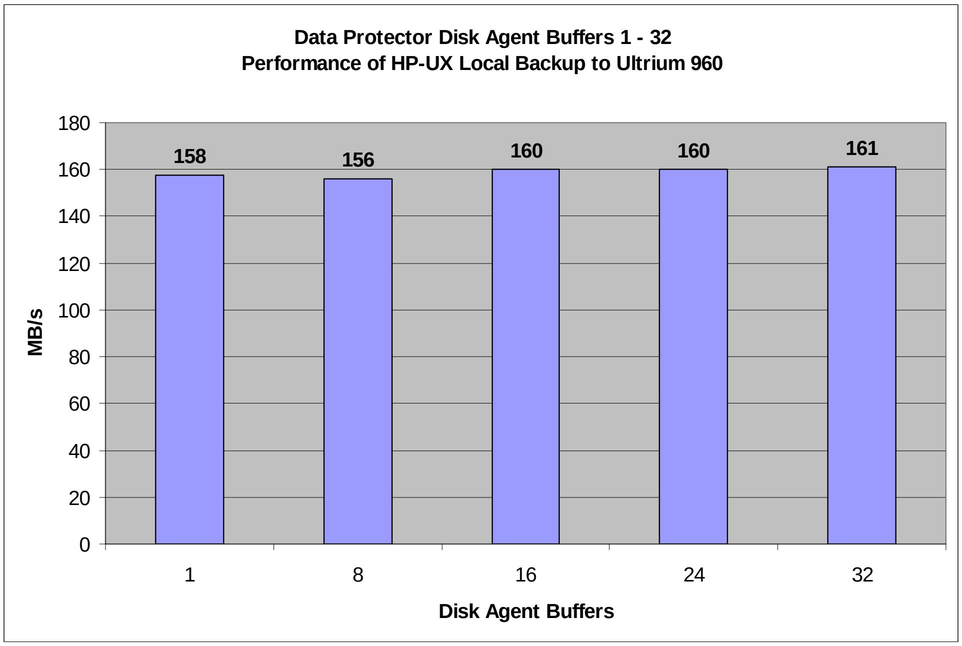
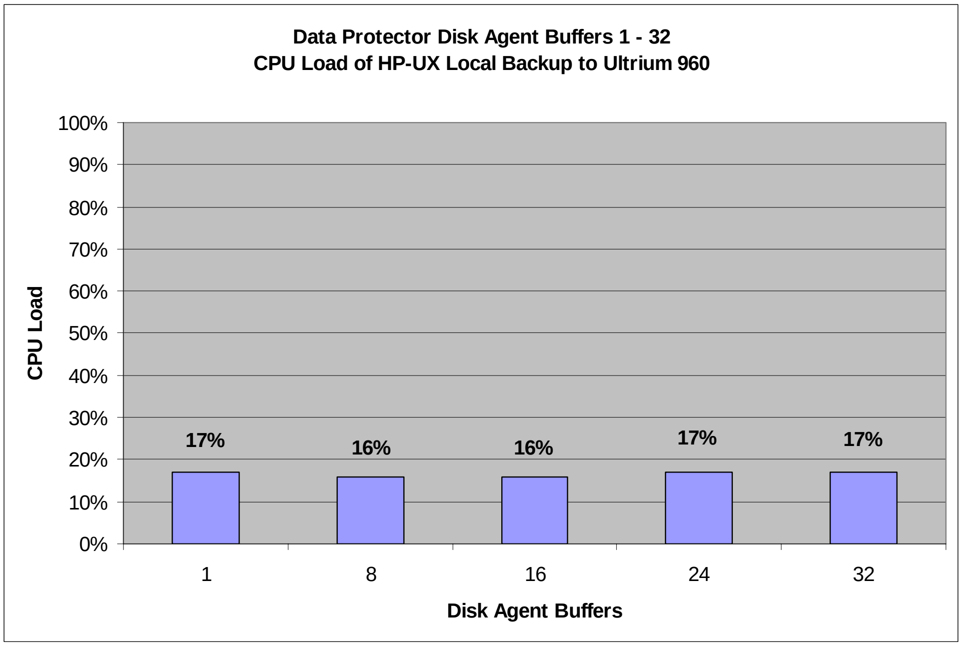


Figure 51. CPU load of HP-UX local backup to Ultrium 960 with 1–32 Disk Agent buffers



Hardware compression

Most modern backup devices provide built-in hardware compression that can be enabled by selecting the belonging device file or SCSI address in the device configuration procedure. Hardware compression increases the speed at which a tape drive can receive data, because less data is written to the tape.

Consider the following regarding hardware compression:

- Do not use software and hardware compression simultaneously because double compression decreases performance without giving better compression results.
- Keep the software compression option disabled when an Ultrium drive is configured with Data Protector.

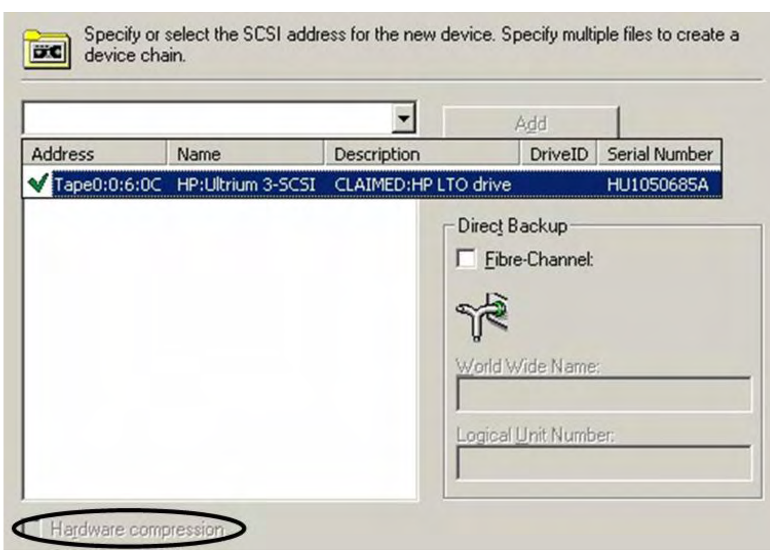
When configuring a device, the SCSI address can be selected from the dropdown list. Data Protector automatically determines whether the device can use hardware compression.

Figure 52 illustrates which devices are detected during the automatic configuration process for an Ultrium 960 drive. In this example, the hardware compression is selected. The end of the device/drive SCSI address is extended with the "C" option: Tape0:0:6:0C.

Figure 52. HP StorageWorks Ultrium 960 automatic configuration—SCSI address for hardware compression

Figure 53 shows down left that with the correct SCSI address selection, the Hardware compression option is grayed out.

Figure 53. HP StorageWorks Ultrium 960 configuration—Hardware compression enabled

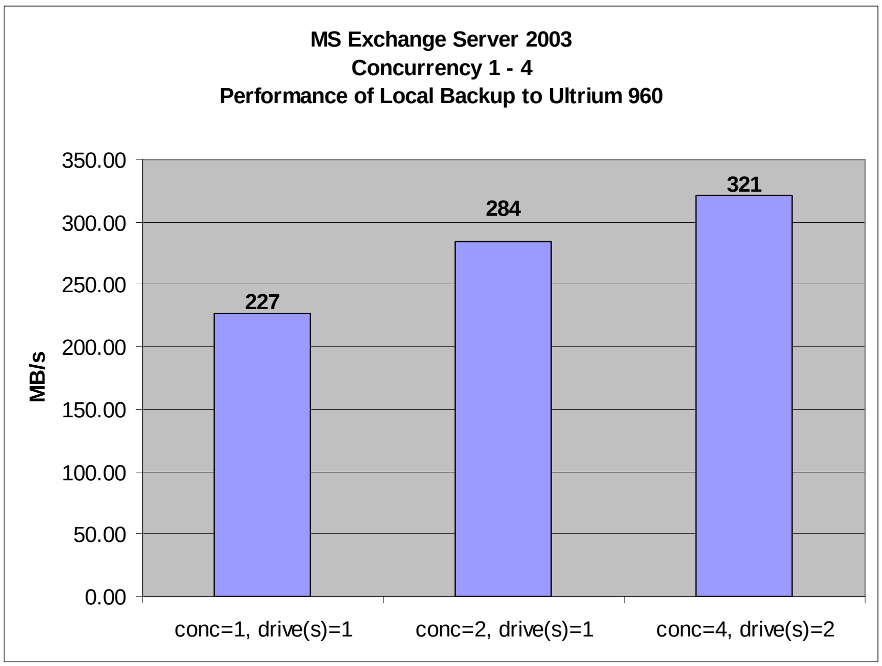


Tuning Data Protector performance for Microsoft Exchange Server 2003

Data Protector's backup and restore performance for Microsoft Exchange Server 2003 can be improved by modifying its configuration parameters for backups. All tests were executed with the NULL device to remove the tape drive as a bottleneck.

Figure 54 demonstrates how efficient a higher concurrency value could be. All tests were executed with the same buffer size of 64 KB because this is the minimum value for a concurrency of four (4 x 16 KB). The minimum buffer for each stream (concurrency = 1) is 16 KB.

Figure 54. Performance of MS Exchange Server 2003 local backup to Ultrium 960 with concurrency 1–4



Note
For the test with the concurrency of four, an additional NULL device had to be configured. Note for the Exchange Server integration that the maximum concurrency of one device is two.

Figure 55 shows that a higher concurrency caused a higher CPU load. But this slight increase can be disregarded if compared with the remarkable increase of the performance as shown in Figure 54.

Figure 55. CPU load of MS Exchange Server 2003 local backup to Ultrium 960 with concurrency 1–4

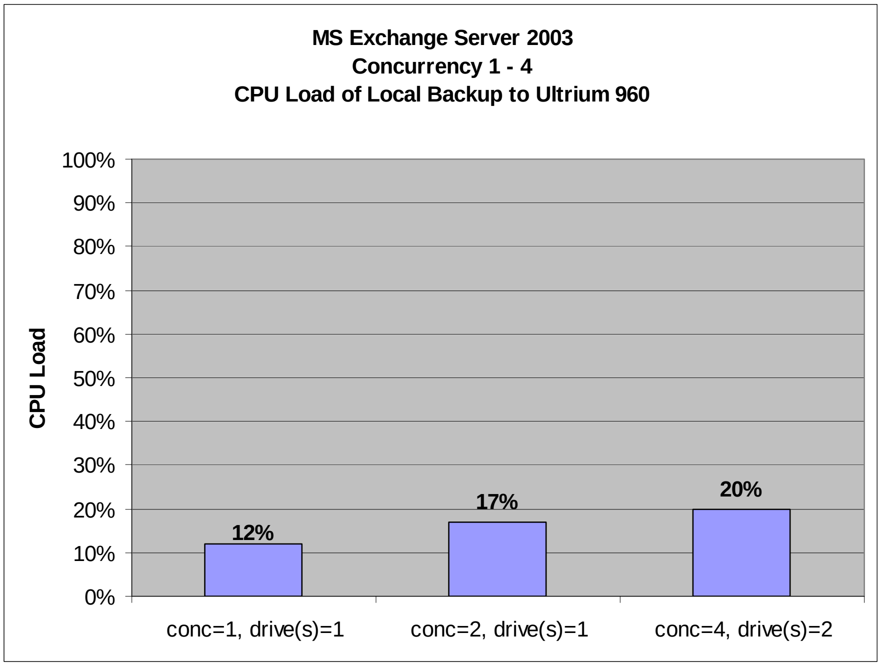


Figure 56 demonstrates that different buffer sizes resulted in similar backup performance. The default buffer size of 32 KB (per backup device) was already a good choice.

Figure 56. Performance of MS Exchange Server 2003 local backup to Ultrium 960 with buffer size 32–1,024 KB

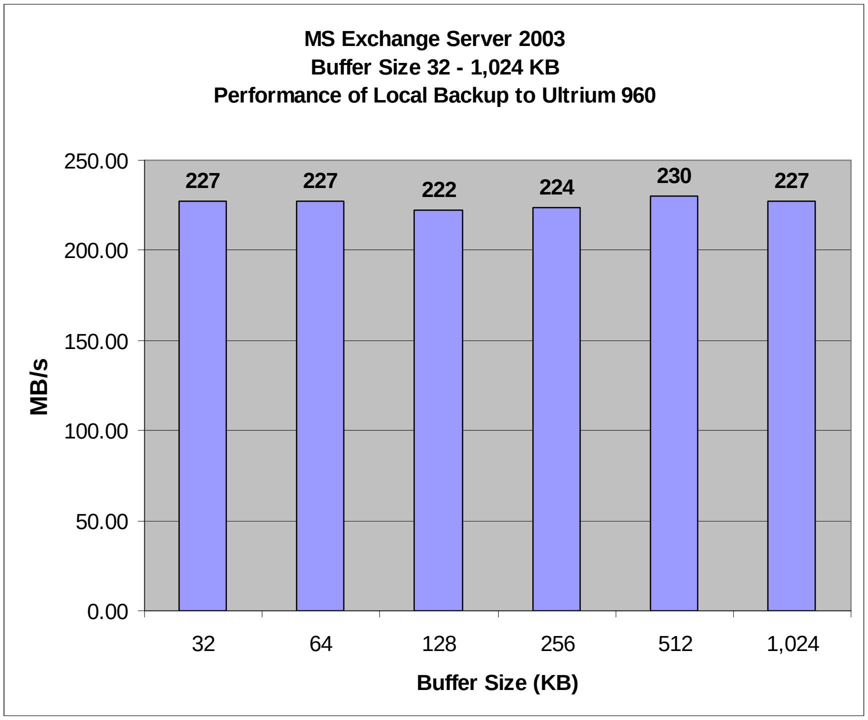
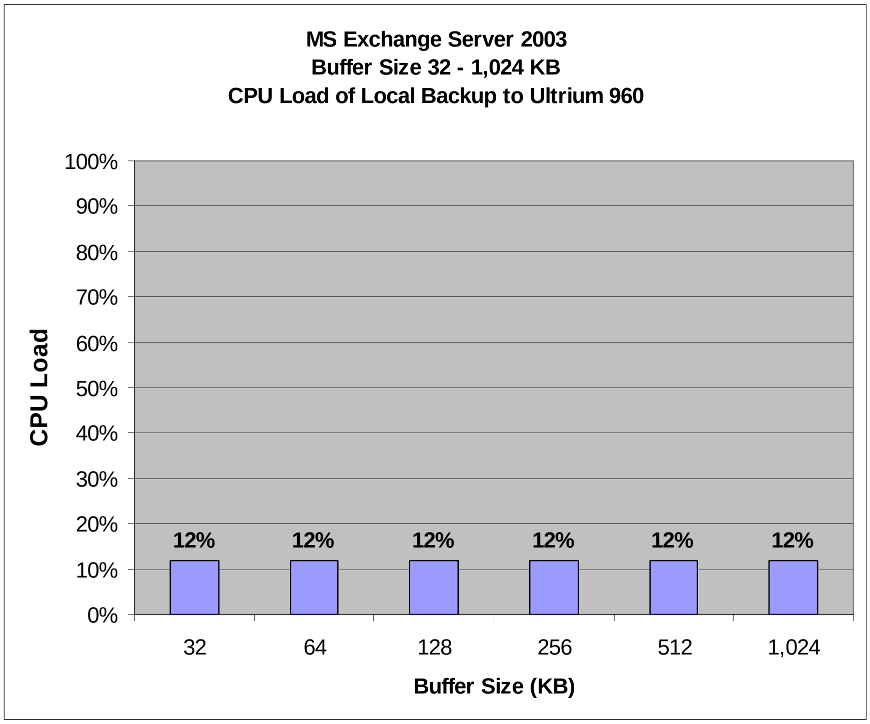


Figure 57 shows that different buffer sizes resulted in the same CPU load (12%). This was expected because there was only a small performance difference as demonstrated in Figure 56.

Figure 57. CPU load of Exchange Server 2003 local backup to Ultrium 960 with buffer size 32–1,024 KB



Tuning recommendations

Due to the high number of variables and permutations, it is not possible to give distinct recommendations that fit all user requirements and affordable investment levels. However, the following should be considered when trying to improve a backup or restore performance:

- Ensure that the server is sized for the backup requirements. For example, fast tape devices like the HP StorageWorks Ultrium 960 tape drive should be placed on a dedicated 133-MHz PCI-X bus and not share the bus with other HBAs like a Gigabit network adapter.
- During high-performance backups, Windows memory problems could occur. This is a general Windows kernel problem and applies to almost all backup applications—including NTBACKUP.

  The Data Protector error message looks like:

  [Major] From: VBDA@tpc131.bbn.hp.com "G:" Time: 29.03.2005 19:08:57

  [81:78] G:\1\file67108864_000003

  Cannot read 57256 bytes at offset 0(:1): ([1450] Insufficient system resources exist to complete the requested service.).

A Microsoft article (Q304101) has been found that explains the circumstances that can lead to this error and how to fix it.

Note
It is suggested to follow the instructions in Microsoft article Q304101, where causes and settings for avoiding memory problems are described. The link to this article:
http://support.microsoft.com/default.aspx?scid=kb;en-us;Q304101

- HP StorageWorks Ultrium 960 tape drives are best utilized with a block size of 256 KB as described in "Getting the most performance from your HP StorageWorks Ultrium 960 tape drive white paper" (http://h18006.www1.hp.com/storage/tapewhitepapers.html).
- For all HP StorageWorks Ultrium backups, it is recommended to keep the software compression option disabled when configured with Data Protector.
- If backup devices are SCSI- or SAN-attached, software compression should be disabled. On the other hand, software compression could make sense if executing network backups across slow LAN (100 Mb/s) environments. This could provide a better backup performance but it will also cause high CPU loads on the client server.
- If backing up typical files directly to the SCSI-attached Ultrium 960 tape drive, parallel backups (multiplexing/concurrency) are recommended because one single stream cannot fully utilize the tape drive. Data Protector's default concurrency is four.
- If backing up typical files by way of Gigabit Ethernet HBAs to a remote Ultrium 960 tape drive, backups without multiplexing/concurrency should be considered. The network is often the bottleneck and enabling multiplexing/concurrency does not really improve the performance.
- For Windows NTFS file systems with millions of small files, parallel backups with a high concurrency are recommended. These kinds of file systems are very slow and should be multiplexed. In case of the fast Ultrium 960 tape drive, a slower Ultrium tape drive or backup-to-disk technology should be considered.
- For Windows NTFS file systems with millions of small files, double tree walks should be disabled. The first tree walk briefly scans the files selected for the backup and calculates its size, so that the percentage done can be calculated during the backup. The second tree walk is executed during the actual file backup. On these particular systems, it is recommended to set the option "NoTreeWalk=1" in the Data Protector template "<Data_Protector_home>\omnirc."
- For Windows, it is recommended that file systems with millions of small files are only restored single due to problems with an overflow of the Windows system paged pool during parallel restores. This cannot be solved without Windows kernel tuning, which is not a focus of this white paper.
- For Exchange Servers, the recommended device concurrency is two for devices connected directly and one for devices connected remotely (backup server).

Appendix A. Reference documentation

HP documents and links

Storage

- HP StorageWorks Enterprise Virtual Array configuration best practices
  ftp://ftp.compaq.com/pub/products/storageworks/whitepapers/5982-9140EN.pdf

- Getting the most performance from your HP StorageWorks Ultrium 960 tape drive
  http://h18006.www1.hp.com/storage/tapewhitepapers.html

- HP StorageWorks SAN design reference guide
  http://h18000.www1.hp.com/products/storageworks/san/documentation.html

Backup

- Enterprise Backup Solution (EBS) design guide and compatibility matrix
  http://www.hp.com/go/ebs

Tools

- Performance troubleshooting and using performance assessment tools
  http://www.hp.com/support/pat

- Library and tape tools
  http://www.hp.com/support/tapetools

Microsoft documents and links

- Microsoft support and knowledge base
  http://support.microsoft.com

Glossary

- **ALDC** (Advanced Lossless Data Compression)—ALDC is a technique for data compression.
- **Cell Manager**—The main system in the cell where the essential software of Data Protector is installed and from which all backup and restore activities are managed.
- **CSI** (Command Screen Interface)—CSI is a non-graphical user interface, which is based on a menu structure.
- **DAS** (direct attached storage)—DAS is a digital storage system directly attached to a server or workstation, without a storage network in between.
- **Disk Agent**—Disk Agent is a Data Protector component needed on a client to back it up and restore it. The Disk Agent controls reading from and writing to a disk. During a backup session, the Disk Agent reads data from a disk and sends it to the Media Agent, which then moves it to the device. During a restore session, the Disk Agent receives data from the Media Agent and writes it to the disk.
- **GUI** (graphical user interface)—A Data Protector–provided GUI is a cross-platform (HP-UX, Solaris, Windows) graphical user interface, for easy access to all configuration, administration, and operation tasks.
- **HBA** (host bus adapter)—An HBA connects a host system (the computer) to other network and storage devices.
- **IDB**—The Data Protector IDB is an internal database, located on the Cell Manager, that keeps information regarding what data is backed up, on which media it resides, the result of backup, restore, copy, object consolidation, and media management sessions, and which devices and libraries are configured.
- **LAN** (local area network)—A computer network covering a small geographic area, like a home, office, or group of buildings.
- **MB** (Megabyte)—1 megabyte = 1,048,576 bytes (2^{20})
- **Mb** (Megabit)—1 megabit = 1,000,000 bits (10^6)
- **Media Agent**—A Data Protector process that controls reading from and writing to a device, which reads from or writes to a medium (typically a tape). During a backup session, a Media Agent receives data from the Disk Agent and sends it to the device for writing it to the medium. During a restore session, a Media Agent locates data on the backup medium and sends it to the Disk Agent. The Disk Agent then writes the data to the disk. A Media Agent also manages the robotics control of a library.
- **PCIe** (PCI Express)—PCI Express, officially abbreviated as PCIe (and sometimes confused with PCI Extended, which is officially abbreviated as PCI-X), is a computer system bus/expansion card interface format.
- **SAN** (storage area network)—A SAN is an architecture to attach remote computer storage devices such as disk array controllers and tape libraries to servers in such a way that to the operating system the devices appear as locally attached devices.
- **SPOF** (single point of failure)—SPOF describes any part of the system that can, if it fails, cause an interruption of required service. This can be as simple as a process failure or as catastrophic as a computer system crash.

For more information

- HP Data Protector software
  http://www.hp.com/go/dataprotector
- HP HP9000 and ProLiant servers
  http://h18000.www1.hp.com/products/servers
- HP StorageWorks Ultrium tape drives
  http://h18006.www1.hp.com/storage/tapestorage/ultriumdrives.html
- HP StorageWorks Enterprise Virtual Arrays (EVA)
  http://h18006.www1.hp.com/products/storageworks/eva
- HP Storage Solutions for Microsoft Exchange Server 2003
  http://www.hp.com/solutions/microsoft/exchange/storage
- Enterprise Backup Solution (EBS)
  http://www.hp.com/go/ebs
- Microsoft Exchange Server
  http://www.microsoft.com/exchange

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