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Contents

Sizing the Compaq StorageWorks Enterprise Backup Solution

Abstract: Nothing is more critical to the success of a business than the data it runs on—data that is often business-specific and irreplaceable.

The increased use of multi-user and multi-server systems is swelling the amount of this data exponentially, and on-line data storage has exploded into the range of hundreds of gigabytes (GBs) and terabytes (TBs).

This increase in data, coupled with the need for 7x24 data access, distributed data, shrinking backup windows, and downsized staffing has substantially complicated the process of protecting corporate data against inadvertent or catastrophic loss.

The Compaq StorageWorks Enterprise Backup Solution (EBS) is the Compaq answer to this complex backup environment. To help you size an EBS solution, Compaq has developed the Compaq StorageWorks Backup Sizing Tool. This tool is available via the Internet at http:\\www.Compaq.com\products\StorageWorks\ebs\, and contains all the product information and algorithms necessary to size an EBS solution—saving you hours of manual calculations.

Should you not have access to the Compaq StorageWorks Backup Sizing Tool, this white paper will help you understand the EBS components, define the information that must be gathered, and assist you in manually sizing an Enterprise Backup Solution.

For additional information, see the *Compaq StorageWorks Enterprise Backup Solution Tech Note* available on the Internet at http:\\www.Compaq.com\products\storageworks\ebs\EBSwhitepapers.

Notice

Sizing the Compaq StorageWorks Enterprise Backup Solution
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The Compaq StorageWorks Enterprise Backup Solution (EBS)

The Compaq StorageWorks Enterprise Backup Solution (EBS) utilizes Compaq servers, tape libraries, high-performance software, and Fibre Channel interconnect technology to provide consolidated backup of Microsoft Windows NT and Novell NetWare servers.

The Compaq EBS provides all of the operational advantages of a centralized network backup, with the performance advantages of a dedicated tape backup Storage Area Network (SAN). By utilizing a dedicated Fibre Channel network, backups and restores can run throughout the day without consuming corporate network bandwidth. This allows users continuous access to data at normal performance levels, thereby effectively expanding the available backup window to 24 hours per day.

EBS Architecture

By examining a broad range of technologies and working closely with industry-leading Independent Software Vendors (ISVs), Compaq developed an integrated Enterprise Network Storage Architecture (ENSA) that will propel customers well into the twenty-first century.

Figure 1 illustrates the EBS network architecture. Fully integrated into existing networks, the EBS provides advanced hardware to meet the performance requirements demanded by today's business environment. Through Compaq's partnerships with Seagate Software Inc. and Computer Associates Inc., Compaq delivers the first end-to-end solution to insure software and hardware systems perform as a team in today's and in tomorrow's enterprise environments.

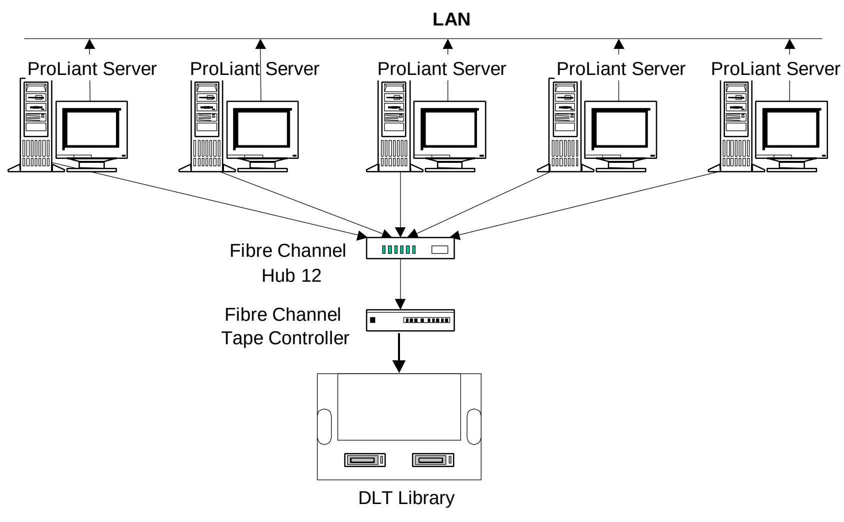

Figure 1. Compaq StorageWorks Enterprise Backup Solution Architecture

The EBS network architecture virtually eliminates bandwidth constraints and contention with user access on the corporate LAN. Since user access takes place over the LAN, and storage access takes place over the separate Fibre Channel network, there is no resource contention.

EBS Components and Technology

As shown in Figure 1, the Compaq StorageWorks Enterprise Backup Solution consists of a series of specialized and optimized components, each of which is described in the following sections.

Fibre Channel Technology

Fibre Channel is the next generation in storage technology, combining the reliability and low latency of a serial channel with the flexibility and connectivity of a network. The result is a 100 megabytes/second storage network that supports simultaneous transfer of multiple data protocols, including SCSI, IPI, ATM, and IP. The current EBS supports 50-micron, multi-mode fiber-optic cables in lengths up to 500 meters.

Fibre Channel Host Controller

A Fibre Channel Host Controller resides in each server and provides the PCI to Fibre Channel interface. This interface allows the servers to log on to the Fibre Channel loop and share tape libraries on the SAN.

The Compaq Fibre Channel Host Controller uses optical/electrical technology and encapsulates traditional SCSI data exchanges within the Fibre Channel protocol.

Fibre Channel Storage Hub 12

A single Fibre Channel Storage Hub 12 enables multiple servers and tape devices to be connected to a Fibre Channel loop (up to 12 direct Fibre Channel connections), for a centralized backup solution. For example, nine servers can be connected to the storage hub, leaving three available ports for connection to Fibre Channel Tape Controllers.

The storage hub is a rack-mountable unit and is a 1U form factor.

Fibre Channel Tape Controller

A Fibre Channel Tape Controller (FCTC) translates Fibre Channel protocol to SCSI protocol between the Fibre Channel Network and the SCSI devices, and allows sharing of these SCSI devices. The controller handles single-channel-in/single-channel-out SCSI. Each controller can support two drives. For example, a Model 3570-1 DLT Tape Library configured with a single DLT drive can be upgraded with a second DLT 35/70 drive without the addition of a second Fibre Channel Tape Controller.

Tape Library/Tapes

Tape library automation is an important element of the Compaq StorageWorks Enterprise Backup Solution. Compaq identified the reliable Model 3570 DLT Tape Library as the first step in the tape storage solution. The DLT Library can contain two DLT 35/70 tape drives capable of storing up to 1 TB of data on 15 tapes (at 2:1 compression).

EBS Fundamentals

Determining the speed of backup and restore processes in a real world environment is the most important factor in designing and implementing the Compaq StorageWorks EBS. Compaq tested both Seagate Software's Backup Exec and Computer Associates' (CA's) ARCserveIT in an EBS environment to benchmark the DLT drive performance.

Because the amount of compression has a direct impact on the rate that a DLT 7000 drive can write to a tape, tests were varied with compression ratios ranging from 1:1 to 3.3:1. Tests were also scaled up to the six DLT drives supported by the EBS. The results showed that:

- Both Seagate Software Backup Exec and CA ARCserveIT generated consistent base-rate throughput of 15 GB per hour (GPH).
- The number of DLT drives and compression scaled near 1:1 but the total rate of combined throughput declined as compression increased.
- The maximum throughput on a single DLT drive is 43 GPH.

Using this information, Compaq generated the fundamental EBS backup formula:

If ((Base Rate ∗ Compression) – (Compression^2)) < 43

Then ((Base Rate ∗ Compression) – (Compression^2))∗ Drives = Backup Rate

Else (43 ∗ Drives) = Backup Rate

Where*:*

- The **Base Rate** for 1:1 backups is 15 GBH.
- **Drives** equals the number of DLT drives backing up data.
- The compression loss is equal to **Compression^2**.

Sizing the Compaq StorageWorks Enterprise Backup Solution

Before you can begin the sizing process, you must have a thorough understanding of the network, the type of data to be backed up, and the back-up window parameters. The easiest and most precise way to size an Enterprise Backup System is to use the Compaq StorageWorks Enterprise Backup Solution sizer software, which may be obtained from the Internet at http:\\www.Compaq.com\products\StorageWorks\ebs\. If you do not have access to the software, the following sections will walk you through the manual sizing process. A calculation worksheet is provided at the end of this document to help you organize and use your specific information.

Note: You must size your servers individually, then combine them for a total enterprise solution.

Data Compression Ratio

The type of data contained on the server greatly impacts compressibility, which in turn affects backup speed and the number of tapes required to hold the data. Each tape holds up to 35 GB of data. As the data compression ratio increases, tape storage capacity increases. For example: At 1:1 compression, a tape can store 35 GB of data; at 2:1 compression, it can store 70 GB of data. Typical compression ratios are shown in Table 1.

Table 1. Typical Compression Ratios

Data Type	Typical Compressibility
CAD	3.8 : 1
Spreadsheet/Word Processing	2.5 : 1
Oracle/SAP Databases	1.2 : 1
Microsoft Exchange/SQL Server Databases	1.4 : 1
Lotus Notes Databases	1.6 : 1
Typical File/Print Server	2 : 1
MPEG or JPEG image/video data	1 : 1

As an example, we will be sizing servers that contain SAP databases. Since SAP databases typically compress at a 1.2:1 ratio, the compression equals 1.2.

Step 1: Calculate the Base Rate

1.1 Determine Compression

1.2 Calculate the Base Rate. Begin with a 1:1 rate of 15 GPH per DLT drive, then apply the following compression formula:
$(15 * \text{Compression}) - (\text{Compression}^2) = \text{Base Rate}$

Example A

Compression = 1.2

Base Rate = $(15\text{ GPH} * 1.2) - (1.2^2) = 16.56\text{ GPH}$

Controller Type

The type of controller you are using has a direct effect on the speed at which the server can send data to the tape device. Ideal primary storage feed speed would be greater than three times the backup rate (3:1) of each DLT drive. This would allow the data to stream to the DLT drive and achieve nearly 100 percent performance.

Keep in mind that:

- An internal SCSI controller can feed approximately 30 GPH (gigabytes per hour).
- SMART-2 controllers can feed approximately 100 GPH.
- Fibre Channel controllers can feed approximately 280 GPH.

When determining (or selecting) the controller to be used in the tape backup system, plan for future needs. For example, a SMART-2 Array Controller can support a maximum of 14 drives; a Fibre Channel Host Controller can connect vast Disk Arrays scaling through the Fibre Channel Storage Systems to the RA8000 and ESA12000 High Availability Disk Systems.

For our example, we will be using SCSI controllers.

Step 2: Adjust the Base Rate

2.1 Determine Feed Speed based on controller type.

2.2 The Base Rate must be adjusted as follows:

- If Feed Speed (ratio of controller speed to Base Rate) is 3:1, leave Base Rate as is.
- If Feed Speed is < 3:1, but > 2:1, reduce Base Rate by 20 percent.
- If Feed Speed is < 2:1, reduce Base Rate by 50 percent.

Example B

Our Base Rate is 16.56 GPH, and the speed of SCSI controllers is 30 GPH. This makes the Feed Speed equal to 16.56:30, or 1.81:1. According to the adjustment rules above, we must reduce our Base Rate by 50 percent.

Adjusted Base Rate = (16.56 GPH ∗ .50) = 8.28 GPH

Amount of Data

You will need to have a good estimation of the total gigabytes of data to be backed up on your servers.

For our example, we will be backing up 90 GB of data.

Size of the Backup Window

Assuming that all data is stored on the servers, a Fibre Channel backup system permits users to access the information they require, even during backups. Network bandwidth is not reduced during backups because there is a direct path between the server and the tape backup solution.

Keep in mind, however, that the backup window will be affected if the servers on the Fibre Channel loop must first pull data from the PCs attached to the network.

Depending on the backup software being utilized, users may not be able to access "locked" files that are currently being backed up. If immediate and constant access to files is critical, you may need to plan for a dedicated backup window.

For our example, we assume a 4-hour backup window.

Step 3: Calculate Number of DLT Drives Needed

3.1 Determine Total Data to be backed up

3.2 Determine number of Hours in Backup Window

3.3 Divide the Total Data by the Adjusted Base Rate = Total Hours for 1 Drive

3.4 Divide the Total Hours for 1 drive by Hours in Backup Window = Number of Drives Needed

Example C

Total Data = 90 GB

Hours in Backup Window = 4 Hours

Total Hours for 1 Drive = (90 GB ÷ 8.28 GPH) = 10.87 hours

Number of Drives Needed = (10.87 Hours ÷ 4 Hours) = 2.72, or 3 drives

Backup Type

The type of backup being utilized affects not only the speed of the backup and/or restore process, but also the amount of data being retained on tape. There are three types of backup:

- **Full Backups Only** (F) – All data is backed up every time a backup is conducted (regardless of the frequency of the backups). This method uses the highest amount of tape cartridges and tape bandwidth, but offers the highest level of disaster recovery and restore speed. When performing full backups that exceed the capacity of a single tape, the mechanical process of changing tapes may reduce the base backup rate, 15 GB, by up to 7 percent (13.8 GB).
- **Full and Incremental Backups** (F/I) – Each backup cycle will include one full backup and multiple incremental backups. Incremental backups store all data that has changed since the last backup of any type. Incremental backups are slower than full backups because all the data on the system must be read to determine which files are "new" or have been modified since the last backup cycle. This method minimizes the number of cartridges used over the other two methods, but also offers the slowest restore time. Incremental backups with approximately 20 percent of the data changed may reduce the base backup rate, 15 GB, by up to 14 percent (12.9 GB).
- **Full and Differential Backups** (F/D) – Each backup cycle will include one full backup and multiple differential backups. Differential backups store all the data that has changed since the last full backup. Differential backups take longer than incremental backups, but recoveries are faster (and safer) since all data is restored from the last full backup and only the most recent differential backup. This method uses fewer cartridges than the full-only method, but normally increases the restore time for large restores. Single file restore performance should not be affected. Differential backups are subject to the same 14 percent performance decrease while determining which files are new. The Compaq StorageWorks EBS sizer software reduces all incremental and differential backups to produce a conservative estimate.

Tape Retention Schedule

How you are storing the backup data on the tapes, and how long you keep them before they are erased, greatly impacts the total number of tapes needed to maintain the desired backup schedule. Keep in mind the following when determining how many tape sets are required:

- Each tape can hold up to 35 GB of data at 1:1 compression.
- Each library can hold up to 15 tapes.
- A fully-configured library stores up to 1 TB of data at 2:1 compression. Total storage capacity is affected by factors such as the data compression ratio and type of backups.
- Increasing the number of libraries allows you to store more data; it will not increase the speed of the backup beyond the maximum of 43 GPH per DLT drive.
- If your retention parameters demand more storage than the tape capacity of the libraries sized to fit your backup window, you may need to increase the number of libraries to maintain a lights-out operation schedule.

Consider the following when determining your retention parameters:

- How many partial backups will be kept (if any)?
  - ➢ Will partial backups be kept on the same tape set as the corresponding full backup?

    Keeping partial and full backups on the same tape set may alter the total number of tapes needed. Partial backups must remain on the tape set as long as the corresponding full backups are retained.
  - ➢ Will partial backups be kept together on a tape set separate from the full backup?

    Keeping partial backups together, on a separate tape set from the full backup, may alter the total number of tapes needed. Partial backups only remain on the tape set until new partial backups are recorded after a full backup. Subsequent partial backups after a full backup will overwrite existing partial backups to the same tape set.
  - ➢ Will each partial backup be kept on its own tape set?

    Keeping each partial backup on its own tape set may alter the total number of tapes needed.
- How long will the partial backups be kept (if applicable)?
  - ➢ Will they be kept as long as the full backup (required if partial backups are kept on the same tape set as full backups)?
  - ➢ Will they be kept until χ subsequent full backups are taken (where χ can range from 1 to the number of full backups to be kept)?
- Since differential backups record all the changes since the last full backup, how many differential backups should be kept between full backups (if applicable)?
  - ➢ Will you keep all differential backups?
  - ➢ Will the number of differential backups be limited to no more than χ (where χ can range from 2 to the maximum number of differential backups between full backups)?

Step 4: Determine the Retention Parameters

4.1 Determine the kinds of backups to be performed (F, F/I, or F/D)

4.2 Write in the calendar "F: Server # - χ GB" where # is the label for the server and χ is the amount of data to be backed up for all full backups.

4.3 If partial backups are being created, enter "P: Server # - χ GB" where # is the label for the server and χ is the amount of data to be backed up for each partial backup that uses a unique tape set. If a partial backup is overwriting a previous tape set, leave the entry blank.

Example D

Consider this case: Three servers each require a full backup once a week on Saturday, backing up 90 GB of information. Incremental backups are performed on Tuesday and Thursday. Partial backups are retained on the same tape set, separate from the full backup. Three full backups are retained. Partial backups are retained until the next full backup is recorded.

Note: To retain χ number of full tape sets, a total of χ + 1 tapes is required so none of the retained tape sets are overwritten until the last backup is completed.

Table 2. Case Servers

Server	Amount of Data to be Backed Up	Estimated Data Change Since Last Backup (Not Required for Full Backups Only)
1	20 GB	15% (or 3 GB)
2	30 GB	20% (or 6 GB)
3	40 GB	25% (or 10 GB)
	(90 GB Total)	(19 GB Total)

Consider the backup schedule shown in Table 3:

Note: The arrows indicate at which point a tape set is overwritten and reused for a subsequent backup.

Table 3. Sample Retention Schedule (Full and Incremental)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		P: Server 1 - 3 GB P: Server 2 - 6 GB P: Server 3 - 10 GB		P: Server 1 - 3 GB P: Server 2 - 6 GB P: Server 3 - 10 GB		F: Server 1 - 20 GB F: Server 2 - 30 GB F: Server 3 - 40 GB
						F: Server 1 - 20 GB F: Server 2 - 30 GB F: Server 3 - 40 GB
						F: Server 1 - 20 GB F: Server 2 - 30 GB F: Server 3 - 40 GB
						F: Server 1 - 20 GB F: Server 2 - 30 GB F: Server 3 - 40 GB

Example D2

Consider this case: Three servers each require a full backup once a week on Saturday, backing up 90 GB of information. Differential backups are performed on Monday, Wednesday, and Friday. Partial backups are retained on individual tape sets, separate from the full backup, and are erased with the full backups. Three full backups are retained.

Note: To retain χ number of full tape sets, a total of $\chi + 1$ tapes is required so none of the retained tape sets are overwritten until the last backup is completed.

Table 4. Sample Retention Schedule (Full and Differential)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	P: Server 1 - 3 GB P: Server 2 - 6 GB P: Server 3 - 10 GB		P: Server 1 - 6 GB P: Server 2 - 12 GB P: Server 3 - 20 GB			F: Server 1 - 20 GB F: Server 2 - 30 GB F: Server 3 - 40 GB
	P: Server 1 - 3 GB P: Server 2 - 6 GB P: Server 3 - 10 GB		P: Server 1 - 6 GB P: Server 2 - 12 GB P: Server 3 - 20 GB			F: Server 1 - 20 GB F: Server 2 - 30 GB F: Server 3 - 40 GB
	P: Server 1 - 3 GB P: Server 2 - 6 GB P: Server 3 - 10 GB		P: Server 1 - 6 GB P: Server 2 - 12 GB P: Server 3 - 20 GB			F: Server 1 - 20 GB F: Server 2 - 30 GB F: Server 3 - 40 GB
	P: Server 1 - 3 GB P: Server 2 - 6 GB P: Server 3 - 10 GB		P: Server 1 - 6 GB P: Server 2 - 12 GB P: Server 3 - 20 GB			F: Server 1 - 20 GB F: Server 2 - 30 GB F: Server 3 - 40 GB

Note: Since differential backups always store data changed since the last full backup, the percent (and amount of) data changed since the last backup increases with each differential backup before the next full backup. In this example, for server 1, we assume 15 percent of the data changes since the last backup, so at the time of the second differential backup for server 1, $(2 * 15\%) = 30\%$ of the data has changed since the last full backup ($.30 * 20$ GB = 6 GB).

Step 5: Determine Number of Tapes Required

Number of tapes required for full backups:

5.1. Calculate the storage capacity of each tape (35 GB ∗ Compression = Tape Capacity).

5.2. For full backups only, by server, divide the amount of data to be backed up for each full backup by the tape capacity, then total the number of tapes needed for that server. Repeat this step for each server.

Note: This can vary based on customer preferences. If you append full backups to the preceding full backup, then you would total the amount of data for all full backups, by server, and divide the total by the tape capacity. For example, (4 ∗ 20 GB) = 80 GB; (80 GB ÷ 42 GB) ~ 2 tapes total for server 1. For this procedure, we assume a unique tape set for each full backup.

Another assumption made here that can influence this calculation is that each server backs up to a unique tape set. If you write data from different servers to the same tape set, then you would total the data from all servers for each full backup and divide that by the tape capacity. For example, (20 GB + 30 GB + 40 GB) ÷ 42 GB ~ 3 tapes for first full backup.

5.3. Add up results for each server to determine the total number of tapes required for full backups.

Number of tapes required for partial backups:

5.4. For partial backups only, by server, add up the amount of data to be backed up = Retained Media Quantity.

This quantity varies depending on whether you are keeping the partial backups together or on individual tape sets. If the partial backups are being kept together (as in the first example), then total the data, per server, for all of the partial backups before dividing by the tape capacity. If the partial backups are being kept on unique tape sets (the second example), then divide the backup data quantity for each partial backup by the tape capacity.

For this calculation, like the full backup calculation, it is assumed that partial backups are stored on unique tape sets for each server.

5.5 Calculate the number of tapes needed (Retained Media Quantity ÷ Tape Capacity = Number of Tapes Required for partial backup for one server). Repeat this step for each server.

5.6 Add up the results for each server to determine the total number of tapes required for partial backups.

5.7 Add the number of tapes required for full and partial backups to determine the total number of tapes required.

Example E

1. Tape Capacity = (35 GB ∗ 1.2) = 42 GB
2. Server 1: (20 GB ÷ 42 GB) ~ 1 tape for first full backup. Similarly for weeks 2-4. Total tapes for server 1 full backup = 4.
   Server 2: (30 GB ÷ 42 GB) ~ 1 tape for first full backup. Similarly for weeks 2-4. Total tapes for server 2 full backup = 4.
   Server 3: (40 GB ÷ 42 GB) ~ 1 tape for first full backup. Similarly for weeks 2-4. Total tapes for server 3 full backup = 4.
3. Total tapes required for full backups = 4 + 4 + 4 = 12 tapes.
4. Server 1 Retained Media Quantity: (3 GB + 3 GB) = 6 GB
   Server 2 Retained Media Quantity: (6 GB + 6 GB) = 12 GB
   Server 3 Retained Media Quantity: (10 GB + 10 GB) = 20 GB
5. Server 1: 6 GB ÷ 42 GB ~ 1 tape
   Server 2: 12 GB ÷ 42 GB ~ 1 tape
   Server 3: 20 GB ÷ 42 GB ~ 1 tape
6. Total tapes required for partial backups = 1 + 1 + 1 = 3 tapes
7. Total tapes required = 12 full backup tapes + 3 partial backup tapes = 15 tapes

Example E2

1. Tape Capacity = 35 GB ∗ 1.2 = 42 GB
2. Same calculation as last example.
3. Same calculation as last example

   Total tapes required for full backups = 12 tapes.
4. Server 1 partial backup tapes: (3 GB ÷ 42 GB) + (3 GB ÷ 42 GB) ~ 2 tapes for week 1.

   Since the differential backups are not being erased until the corresponding full backups are erased, they must be retained for the same period. In a similar manner, calculate the number of tapes for weeks 2-4.

   Total number of tapes for server 1 partial backups = 2 + 2 + 2 + 2 = 8 tapes
5. Server 2 partial backup tapes: (6 GB ÷ 42 GB) + (6 GB ÷ 42 GB) ~ 2 tapes

   Total number of tapes for server 2 partial backups = 2 + 2 + 2 + 2 = 8 tapes
6. Server 3 partial backup tapes: (10 GB ÷ 42 GB) + (10 GB ÷ 42 GB) ~ 2 tapes

   Total number of tapes for server 3 partial backups = 2 + 2 + 2 + 2 = 8 tapes

   Total tapes required for partial backups = 8 + 8 + 8 = 24 tapes.
7. Total tapes required = 12 full backup tapes + 24 partial backup tapes = 36 tapes

Data Growth Rate

The storage architect must analyze the data volume today, then anticipate the growth rate to arrive at the best storage solution. If the backup solution for today requires one fully configured tape library, but you anticipate rapid growth, the best solution may be to purchase multiple libraries today.

Step 6: Determine Number of Libraries Needed

6.1 Increase the results from Step 5.7 by the percent of growth per year and the number of years of growth specified.

6.2 Test the number of drives from Step 3.4 versus the number of tapes from Step 6.1 = 15 tapes per library versus 1 or 2 drives per library.

Example F

We expect to grow by 50 percent over the next year: 15 tapes ∗ 150 percent ~ 23 tapes.

23 tapes (2 libraries) are required for capacity, and 3 drives (2 libraries) are required for performance. Thus, this solution needs 2 libraries to meet both requirements.

Calculation Worksheet

Table 5. Sample Calculations

Step	Calculations:	Results
1.1	**Determine the Compression:** • Data Type — Typical Compressibility CAD — 3.8:1 Spreadsheet/Word Processing — 2.5:1 Oracle/SAP Databases — 1.2:1 Microsoft Exchange/SQL Server Databases — 1.4:1 Lotus Notes Databases — 1.6:1 Typical File/Print Server — 2:1 MPEG or JPEG image/video data — 1:1	Using SAP database, so Compression = 1.2
1.2	**Calculate Base Rate:** • (15 ∗ Compression) – ($Compression^2$) = Base Rate	Base Rate = (15 ∗ 1.2) - $(1.2)^2$ = 16.56 GPH
2.1	**Determine Feed Speed based on controller type:** • Internal SCSI controller ~ 30 GPH • SMART-2 controller ~ 100 GPH • Fibre Channel controller ~ 280 GPH	Using SCSI controller, so Feed Speed = 30 GPH
2.2	**Adjust the Base Rate:** • If Feed Speed (ratio of controller speed to Base Rate) is 3:1, leave Base Rate as is • If Feed Speed is < 3:1, but > 2:1, reduce Base Rate by 20% • If Feed Speed is < 2:1, reduce Base Rate by 50%	(30 ÷ 16.56) ~ 1.8, which is < 2:1, so reduce by 50% Adjusted Base Rate = (16.56 ∗ .5) = 8.28 GPH
3.1	**What is the Total Data to be backed up?**	Total Data = 90 GB
3.2	**What is the number of Hours in Backup Window?**	Hours in Backup Window = 4
3.3	**Calculate Total Hours for 1 Drive:** • Total Hours for 1 Drive = Total Data ÷ Adjusted Base Rate	Total Hours for 1 Drive = (90 ÷ 8.28) = 10.87 hours
3.4	**Calculate Number of Drives Needed:** • Number of Drives Needed = Total Hours for 1 Drive ÷ Hours in Backup Window	Number of Drives Needed = (10.87 ÷ 4) = 2.72, or 3 drives
4.1	**What kinds of backups are being performed (F, F/I, or F/D)?**	F/I
4.2	**Enter full backups in calendar:** • Write in calendar "F: S# - χ GB" where # is label for server and χ is amount of data to be backed up for all full backups.	See calendar on next page
4.3	**Enter partial backups in calendar (if needed):** • If partial backups are being created, enter "P: S# - χ GB" where # is label for server and χ is amount of data to be backed up for each partial backup that uses a unique tape set. If a partial backup is overwriting a previous tape set, leave the entry blank.	See calendar on next page

continued

Table 5. Sample Calculations *(continued)*

Sun	Mon	Tues	Wed	Thurs	Fri	Sat
		P: S1 - 3 GB P: S2 - 6 GB P: S3 - 10 GB		P: S1 - 3 GB P: S2 - 6 GB P: S3 - 10 GB		F: S1 - 20 GB F: S2 - 30 GB F: S3 - 40 GB
						F: S1 - 20 GB F: S2 - 30 GB F: S3 - 40 GB
						F: S1 - 20 GB F: S2 - 30 GB F: S3 - 40 GB
						F: S1 - 20 GB F: S2 - 30 GB F: S3 - 40 GB

Step	Calculations:	Results
5.1	**Calculate the Tape Capacity (storage capacity of each tape):** • Tape Capacity = 35 GB ∗ Compression	Tape Capacity = (35 ∗ 1.2) = 42 GB
5.2	**Calculate tapes needed for full backups on each server:** • For full backups only, by server, divide the amount of data to be backed up for each full backup by the tape capacity, then total the number of tapes needed for that server. Repeat for each server.	S1: 20 GB ÷ 42 GB ~ 1 tape for each full backup (4 tapes total) S2: 30 GB ÷ 42 GB ~ 1 tape for each full backup (4 tapes total) S3: 40 GB ÷ 42 GB ~ 1 tape for each full backup (4 tapes total)
5.3	**Calculate total number of tapes needed for all full backups:** • Add up results from 5.2	Tapes needed for full backups = S1 + S2 + S3 = 4 + 4 + 4 = 12 tapes
5.4	**Calculate Retained Media Quantity for partial backups only:** • RMQ = By server, add up the amount of data to be backed up	RMQ S1 = 3 GB + 3 GB = 6 RMQ S2 = 6 GB + 6 GB = 12 RMQ S3 = 10 GB + 10 GB = 20
5.5	**Calculate number of tapes needed for partial backups on each server:** • Tapes needed = Retained Media Quantity ÷ Tape Capacity	S1 = 6 ÷ 42 ~ 1 tape S2 = 12 ÷ 42 ~ 1 tape S3 = 20 ÷ 42 ~ 1 tape
5.6	**Calculate total number of tapes needed for partial backups:** • Add up results from 5.5	Tapes need for partial backups = S1 + S2 + S3 = 1 + 1 + 1 = 3 tapes
5.7	**Calculate total number of tapes required for all backups:** • Results from 5.3 + Results from 5.6	Total tapes needed = (12 + 3) = 15 tapes
6.1	**Increase tapes needed by number of years and % of growth per year:** • Results from 5.7 ∗ (100% + % growth)	Tapes needed = (15 ∗ 150%) ~ 23 tapes
6.2	**Compare tapes required for capacity and performance needs:** • Test the number of drives from Step 6.1 versus the number of tapes from Step 3.4	23 tapes (2 libraries) required for capacity; 3 drives (2 libraries) needed for performance -> 2 libraries required to meet both requirements

Table 6. Your Calculation Worksheet

Step	Calculations:	Results
1.1	**Determine the Compression:** • Data Type — Typical Compressibility CAD — 3.8:1 Spreadsheet/Word Processing — 2.5:1 Oracle/SAP Databases — 1.2:1 Microsoft Exchange/SQL Server Databases — 1.4:1 Lotus Notes Databases — 1.6:1 Typical File/Print Server — 2:1 MPEG or JPEG image/video data — 1:1	
1.2	**Calculate Base Rate:** • (15 ∗ Compression) – (Compression^2) = Base Rate	
2.1	**Determine Feed Speed based on controller type:** • Internal SCSI controller ~ 30 GPH • SMART-2 controller ~ 100 GPH • Fibre Channel controller ~ 280 GPH	
2.2	**Adjust the Base Rate:** • If Feed Speed (ratio of controller speed to Base Rate) is 3:1, leave Base Rate as is • If Feed Speed is < 3:1, but > 2:1, reduce Base Rate by 20% • If Feed Speed is < 2:1, reduce Base Rate by 50%	
3.1	**What is the Total Data to be backed up?**	
3.2	**What is the number of Hours in Backup Window?**	
3.3	**Calculate Total Hours for 1 Drive:** • Total Hours for 1 Drive = Total Data ÷ Adjusted Base Rate	
3.4	**Calculate Number of Drives Needed:** • Number of Drives Needed = Total Hours for 1 Drive ÷ Hours in Backup Window	
4.1	**What kinds of backups are being performed (F, F/I, or F/D)?**	
4.2	**Enter full backups in calendar:** • Write in calendar “F: S# - χ GB” where # is label for server and χ is amount of data to be backed up for all full backups.	See calendar on next page
4.3	**Enter partial backups in calendar (if needed):** • If partial backups are being created, enter “P: S# - χ GB” where # is label for server and χ is amount of data to be backed up for each partial backup that uses a unique tape set. If a partial backup is overwriting a previous tape set, leave the entry blank.	See calendar on next page

continued

Table 6. Your Calculation Worksheet *(continued)*

Sun	Mon	Tues	Wed	Thurs	Fri	Sat

Step	Calculations:	Results
5.1	**Calculate the Tape Capacity (storage capacity of each tape):** • Tape Capacity = 35 GB ∗ Compression	
5.2	**Calculate tapes needed for full backups on each server:** • For full backups only, by server, divide the amount of data to be backed up for each full backup by the tape capacity, then total the number of tapes needed for that server. Repeat for each server.	
5.3	**Calculate total number of tapes needed for all full backups:** • Add up results from 5.2	
5.4	**Calculate Retained Media Quantity for partial backups only:** • RMQ = By server, add up the amount of data to be backed up	
5.5	**Calculate number of tapes needed for partial backups on each server:** • Tapes needed = Retained Media Quantity ÷ Tape Capacity	
5.6	**Calculate total number of tapes needed for partial backups:** • Add up results from 5.5	
5.7	**Calculate total number of tapes required for all backups:** • Results from 5.3 + Results from 5.6	
6.1	**Increase tapes needed by number of years and % of growth per year:** • Results from 5.7 ∗ (100% + % growth)	
6.2	**Compare tapes required for capacity and performance needs:** • Test the number of drives from Step 6.1 versus the number of tapes from Step 3.4	