

# Backups

tsaimh (2022, CC BY)

lwhsu (2019-2020, CC BY)

? (?-2018)

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# Outline

- Backup devices and media
- Backup philosophy
- Unix backup and archiving commands

# Key Concepts

- The backup that has never been verified is the same as **no backup**
- Types
  - Scope
    - Full
    - Incremental
    - Differential
  - Storage
    - Hot/Cold
    - Online/Offline
    - Remote

# Backup Media – By Physical Characteristics

- Hard Disk
  - Pro: common
  - Con: fragile
- Optical Disk
  - Pro: durable
  - Con: size
- Magnetic Tape
  - Pro: cost-effective
  - Con: slow

# Backup Media – By Product

- RAID
  - Redundant Array of Independent Disks
- NAS
  - Network Attached Storage
- SAN
  - Storage Area Network

# Backup Media – By Availability

- Off-line Storage

- CD、DVD、MO

- Adv:

- Low cost, high reliability

- Disadv:

- Not-convenient, low speed

- Near-line Storage

- JukeBox、Tape Library

- Adv:

- High capacity, high reliability

- Disadv:

- High malfunction rate, Not-convenient

- On-line Storage

- Disk Array (RAID)

- Adv:

- Fast and high availability

- Disadv:

- High cost



Tape Library (3U/720TB)

Source: <https://www.backupworks.com/Qualstar-Q40-LTO-8-Tape-Library.aspx>



JukeBox

Source: <https://kintronics.com/products/archiving/hit-storage-optical-jukebox-library-system/>

# Backup Media – Cloud

- Azure Backup
- AWS S3 Glacier / Deep Archive
- GCP Archival Cloud Storage



<https://www.safer-computing.com/?p=5010>

# Backup Philosophy

- Perform all dumps from one machine
- Label your tapes
- Pick a reasonable backup interval
- Choose filesystems carefully
- Make daily dumps fit on one tape
- Make filesystems smaller than your dump device
- Keep Tapes off-site
- Protect your backups
- Limit activity during dumps
- Check your tapes
- Develop a tape life cycle
- Design your data for backups
- Prepare for the worst



# Dumping filesystems – dump command (1)

- Used to backup filesystem into a large file to archive to an external device
- Advantages:
  - Backups can span multiple output media
  - Files of any type can be backed up and restored
  - Permissions, ownerships, and modification times are preserved
  - Files with holes are handled correctly
  - Backups can be performed **incrementally**
- Limitations:
  - Each filesystems must be dumped **individually**
  - Only filesystems on the local machine can be dumped
    - NFS filesystem is not allowed

# Dumping filesystems – dump command (2)

- Backup level
  - 0 ~ 9
    - Level 0 -> full backup
    - Level N -> incremental backup of Level  $\leq$  N-1 for N = 1 ~ 9
- dump command format
  - % dump [arguments] file-system
- dump command arguments
  - **u**: update the **/etc/dumpdates** file after dump
  - **f**: the output backup file
    - Special device file, like /dev/nrsa0
    - Ordinary file
    - '-' to standard out
    - "user@host:file"
  - **d**: tape density in bytes per inch
  - **s**: tape length in feet
  - **a**: auto-size, bypass all tape length considerations (default d = 1600, s = 2300)

# Dumping filesystems – dump command (3)

- Example: Full backup

```
zfs[/mnt] ls -lh
drwxr-xr-x  3 root  wheel   512B   Nov 22 15:34 ./
drwxr-xr-x 20 root  wheel   25B    Nov 18 20:02 ../
-rw-r--r--  1 root  wheel  512M   Nov 21 22:20 haha
zfs[/mnt] cat /etc/dumpdates
zfs[/mnt] df -h
Filesystem      Size      Used      Avail    Capacity  Mounted on
zfs              15G       4.1G     11G      27%       /
devfs            1.0K      1.0K      0B       100%      /dev
/dev/da0s1a     8.7G      512M      7.G      6%        /mnt
zfs[/mnt] sudo dump 0uLf - /dev/da0s1a > ~/dump.0
DUMP: Date of this level 0 dump: Sun Nov 22 15:37:44 2009
DUMP: Date of last level 0 dump: the epoch
DUMP: Dumping snapshot of /dev/da0s1a to standard output
DUMP: mapping (Pass I) [regular files]
DUMP: mapping (Pass II) [directories]
DUMP: estimated 525772 tape blocks.
DUMP: dumping (Pass III) [directories]
DUMP: dumping (Pass IV) [regular files]
DUMP: DUMP: 525625 tape blocks
DUMP: finished in 36 seconds, throughput 14600 KBytes/sec
DUMP: level 0 dump on Sun Nov 22 15:37:44 2009
DUMP: DUMP IS DONE
zfs[/mnt] cat /etc/dumpdates
/dev/da0s1a          0 Sun Nov 22 15:37:44 2009
```

# Dumping filesystems – dump command (4)

- Example: Incremental backup

```
zfs[/mnt] sudo cp -Rp /etc /mnt/
zfs[/mnt] ls -lh
drwxr-xr-x  4 root  wheel   512B Nov 22 15:48 ./
drwxr-xr-x 20 root  wheel   25B Nov 18 20:02 ../
drwxr-xr-x 20 root  wheel  2.0K Nov 22 15:35 etc/
-rw-r--r--  1 root  wheel  512M Nov 21 22:20 haha
zfs[/mnt] sudo dump 2uLf - /dev/da0s1a > ~/dump.2
DUMP: Date of this level 2 dump: Sun Nov 22 15:49:04 2009
DUMP: Date of last level 0 dump: Sun Nov 22 15:37:44 2009
DUMP: Dumping snapshot of /dev/da0s1a to standard output
DUMP: mapping (Pass I) [regular files]
DUMP: mapping (Pass II) [directories]
DUMP: estimated 2267 tape blocks.
DUMP: dumping (Pass III) [directories]
DUMP: dumping (Pass IV) [regular files]
DUMP: DUMP: 2124 tape blocks
DUMP: finished in less than a second
DUMP: level 2 dump on Sun Nov 22 15:49:04 2009
DUMP: DUMP IS DONE
zfs[/mnt] cat /etc/dumpdates
/dev/da0s1a          0 Sun Nov 22 15:37:44 2009
/dev/da0s1a          2 Sun Nov 22 15:49:04 2009
zfs[/mnt] ls -lh ~/dump*
-rw-rw-r--  1 tsaimh  user  513M Nov 22 15:38 /home/tsaimh/dump.0
-rw-rw-r--  1 tsaimh  user  2.1M Nov 22 15:49 /home/tsaimh/dump.2
```

# Restoring from dumps – restore command (1)

- Restore can do
  - Restoring individual files
  - Restoring entire filesystem
- Options of restore command
  - i: interactive restore
  - r: restore an entire filesystem
  - f: the backup file that restore is going to use

# Restoring from dumps – restore command (2)

- Restore individual file interactively

```
zfs[/tmp] cat ~/dump.2 | restore if -  
restore > ?
```

Available commands are:

ls [arg] - list directory

cd arg - change directory

pwd - print current directory

add [arg] - add `arg' to list of files to be extracted

delete [arg] - delete `arg' from list of files to be extracted

extract - extract requested files

setmodes - set modes of requested directories

quit - immediately exit program

what - list dump header information

verbose - toggle verbose flag (useful with ``ls'')

help or `?' - print this list

If no `arg' is supplied, the current directory is used

# Restoring from dumps – restore command (3)

- Restore individual file interactively (cont.)

```
zfs[/tmp] cat ~/dump.2 | restore if -
restore > ls
.:
.snap/ etc/
restore > cd etc
restore > add make.conf
restore > extract
set owner/mode for '.'? [yn] n
restore > quit
zfs[/tmp] ls -ld etc
drwxr-xr-x  2 tsaimh  wheel   3 Nov 22 15:35 etc/
zfs[/tmp] ls -l etc
drwxr-xr-x   2 tsaimh  wheel    3 Nov 22 15:35 ./
drwxrwxrwt  10 root    wheel   42 Nov 22 15:58 ../
-rw-r--r--   1 tsaimh  wheel  590 Nov 19 23:04 make.conf
```

# Restoring from dumps – restore command (4)

- Restore entire filesystem

- The target filesystem should be newfs-ed and mounted first

```
$ newfs /dev/ada2
```

```
$ mount /dev/ada2 /mnt
```

```
$ cd /mnt
```

```
$ restore -rf /home/temp/root.0
```

- Restore will leave a file ‘restoresymtable’ for incremental backup. You can remove it after all incremental backups are restored.

- Steps

- Restore level 0 first
- Restore incremental dumps

```
● 0 0 0 0 0
● 0 5 5 5 5
● 0 3 2 5 4 5
● 0 9 9 5 9 9 3 9 9 5 9 9
● 0 3 5 9 3 5 9
```



# Other archiving programs

- tar command

- Read multiple files and packages them into one file

- Example

```
# tar czvf etc.tar.gz /etc/  
# tar xzvf etc.tar.gz  
# tar cf - fromdir | tar xfp - -C todir
```

- dd command

- Copy filesystems between partitions of exactly the same size

- Example

```
# dd if=/dev/rst0 of=/dev/rst1
```

```
# dd if=/tmp/kern.flp of=/dev/fd0
```

```
# dd if=/dev/da1 of=/dev/da2 bs=1048576
```

# CS home backup

- Using rsync
  - rsync -a --delete
    - -a: archive mode
      - Recursive and preserve everything
    - --delete:
      - Delete any file that are not in the sending sid

```
0 4 * * 1 (cd /raid && /usr/local/bin/rsync -aH --delete cs /backup/user/)
0 4 * * 2 (cd /raid && /usr/local/bin/rsync -aH --delete gcs /backup/user/)
0 4 * * 3 (cd /raid && /usr/local/bin/rsync -aH --delete dcs /backup/user/)
0 4 * * 4 (cd /raid && /usr/local/bin/rsync -aH --delete alumni /backup/user/)
```

# CS home backup

- Snapshot
  - CS home snapshot

```
tsaimh@csduty.cs.nctu.edu.tw[/u/gcs][20:14]$ ls -a
.          01          103         109         91          95          99
..         100         104         193         92          96
.snap     101         105         199         93          97
.snapshot 102         106         90          94          98
tsaimh@csduty.cs.nctu.edu.tw[/u/gcs/.snapshot][20:14]$ cd .snapshot/
tsaimh@csduty.cs.nctu.edu.tw[/u/gcs/.snapshot][20:14]$ ls
4hour.2018-01-02_0000  4hour.2018-01-02_2000  daily.2018-01-01_0010
4hour.2018-01-02_0400  daily.2017-12-28_0010  daily.2018-01-02_0010
4hour.2018-01-02_0800  daily.2017-12-29_0010  weekly.2017-12-17_0015
4hour.2018-01-02_1200  daily.2017-12-30_0010  weekly.2017-12-24_0015
4hour.2018-01-02_1600  daily.2017-12-31_0010  weekly.2017-12-31_0015
```

# UFS Snapshot

```
derek[/] df -h
Filesystem      Size      Used      Avail Capacity  Mounted on
/dev/ad4s1a     70G       16G       48G       25%          /
devfs           1.0K      1.0K       0B       100%         /dev
derek[/] sudo mount -u -o snapshot /.snap/snapshot /
derek[/] df -h
Filesystem      Size      Used      Avail Capacity  Mounted on
/dev/ad4s1a     70G       16G       48G       25%          /
devfs           1.0K      1.0K       0B       100%         /dev
derek[~] sudo mdconfig -a -t vnode -f /.snap/snapshot -u 1
WARNING: opening backing store: /.snap/snapshot readonly
derek[~] sudo mount -r /dev/md1 /mnt
derek[~] ls /mnt/
./          COPYRIGHT  compat@   ftp/      mnt/      sys@
../         bin/      dev/     home/    proc/     tmp/
.cshrc     boot/    dist/    lib/     rescue/   usr/
.profile   cdrom/   entropy  libexec/ root/     var/
.snap/     cdrom1/  etc/     media/   sbin/
derek[~] sudo umount /mnt
derek[~] sudo mdconfig -d -u 1
```

# Appendix

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# Backup Media – By Storage (1)

- By Storage category

- Hard disk

- **SATA / SAS / SSD**

- **120 ~ 450 MB /s**

- **1 TB SATA3: NT 1,500**

- **2 TB SATA3: NT 2,000**

- **4 TB SAS: NT 9,000**

- **256 G SSD: NT 2,500**

- **Different "types"**

- **RAID**

- **Cold Archive**

- CD/DVD R RW

- CD

- 6 ~ 8 MB/s

- DVD

- 8 ~ 15 MB/s

- CD-R 0.7G: NT 6

- DVD-R 4.7G: NT 9

- DVD DL 8.5GB: NT 35

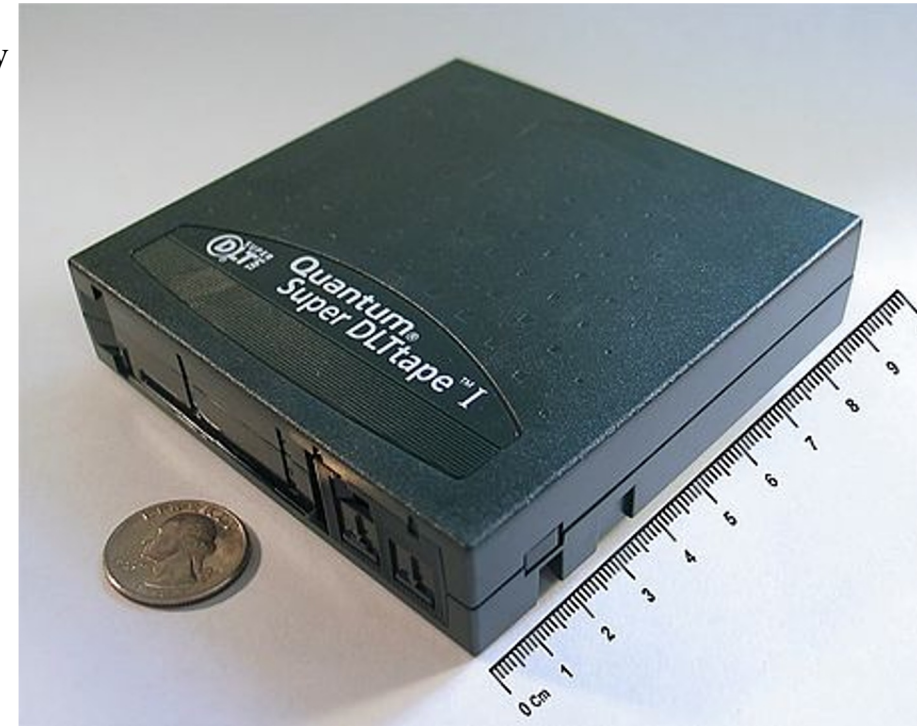
- BD

- 4x 18 MB/s, 12x 64 MB/x

- 6x double-layer BD-R 50GB : NT 60

# Backup Media – By Storage (2)

- Types
  - **DAT (Digital Audio Tape) 4mm tapes**
    - **DDS (Digital Data Storage), Minimal Error Rate, Higher Efficiency**
    - **DDS-4 (often used)**
      - 20/40GB(compressed), about NT 400.
      - 1.0~3.0MB/s
  - **Travan tapes**
    - **High Transfer Rate**
    - **Travan 40 (often used)**
      - 20/40GB(compressed), about NT 2000.
      - Up to 8.0MB/s
  - **DLT (Digital Linear Tape)**
    - **High Capacity, Solid Reliability**
    - **Media**
      - Max 800 GB, about NT 4000.
      - Speed: Up to 60 MB/s
  - **LTO Ultrium**
    - **Fast Transfer Rate, High Performance, and High Storage Capacity**
    - **LTO Ultrium 3 (often used)**
      - Max 1600 GB, about NT 5000.
      - Speed: up to 80 MB/s
      - Tape Drive is much more expensive.....



[https://en.wikipedia.org/wiki/Digital\\_Linear\\_Tape](https://en.wikipedia.org/wiki/Digital_Linear_Tape)

# Backup Media – By Storage (3.1)

- Backup media compare

Medium	Capacity	Speed	Drive	Media	Cost/GB	Reuse?	Random?
CD-R	700MB	7MB/s	\$15	15¢	21¢	No	Yes
CD-RW	700MB	4MB/s	\$20	30¢	42¢	Yes	Yes
DVD ± R	4.7GB	30MB/s	\$30	30¢	6¢	No	Yes
DVD + R DL	8.5GB	30MB/s	\$30	\$1	12¢	No	Yes
DVD ± RW	4.7GB	10MB/s	\$30	40¢	9¢	Yes	Yes
Blu-ray	25GB	30MB/s	\$100	\$3	12¢	No	Yes
DDS-4 (4mm)	20GB	30MB/s	\$100	\$5	25¢	Yes	No
DLT/S-DLT	160GB	16MB/s	\$500	\$10	6¢	Yes	No
DLT-S4	800GB	60MB/s	\$2,500	\$100	13¢	Yes	No
AIT-4 (8mm)	200GB	24MB/s	\$1,200	\$40	20¢	Yes	No
AIT-5	400GB	24MB/s	\$2,500	\$50	13¢	Yes	No
VXA-320	160GB	12MB/s	\$800	\$60	38¢	Yes	No
LTO-3	400GB	80MB/s	\$200	\$25	6¢	Yes	No
LTO-4	800GB	120MB/s	\$1,600	\$40	5¢	Yes	No



# Backup Media – By Storage (3.2)

- **MO (Magneto-Optical)**
  - **MO 540M, 640M, 1.3G, 2.3G**
- **Removable Media**
  - **Floppy, ZIP, LS-120**
- **Jukebox**
  - **Automatically change removable media**
    - **DAT, DLT, CD, ...**
- **Tape Library**
  - **Hardware backup solution for large data set**

# Backup Media – By Storage (4)

- Jukebox
  - Automatically change removable media
  - Available for several types of media
    - DAT, DLT, CD

Specifications	
Number of Magazines (50-disc Magazine)	Max. 6 units (front: max. 4, rear: max. 3)
Number of Magazines (20-disc)	1
Number of Drives	Max. 8 drives
Disc Change Time	Max. 8 seconds

# Backup Media – By Storage (5)

## ● Tape Library

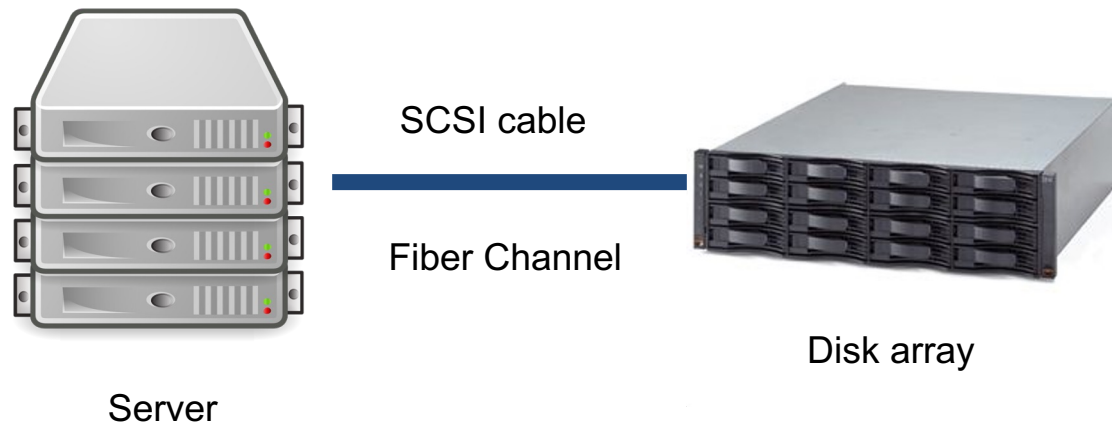
[IBM TS4500 Tape Library](#)

機櫃定義	<p>L25 - TS1155、TS1150 及 TS1140 (3592) 磁碟機及磁帶匣的基礎機櫃 - 包含 32 個輸入/輸出 (I/O) 插槽</p> <p>D25 - 適用於 TS1155、TS1150 及 TS1140 (3592) 磁碟機及磁帶匣的可使用磁碟機及儲存擴充機櫃</p> <p>S25 - 適用於 3592 的擴充機櫃 (僅限儲存設備)</p> <p>L55 - 適用於 LTO 磁碟機和磁帶匣的基礎機櫃 - 包含 36 個 I/O 插槽</p> <p>D55 - 適用於 LTO 磁碟機和磁帶匣的可使用磁碟機及儲存擴充機櫃</p> <p>S55 - 適用於 LTO 磁帶匣的擴充機櫃 (僅限儲存設備)</p>
磁帶機類型	TS1155、TS1150 及 TS1140 (3592)、LTO Ultrium 8、7、6 及 5 磁帶機
每個磁帶櫃的機櫃數量	一個基本機櫃，最多 17 個擴充機櫃，配備最多 7 個 Dx5 機櫃
磁碟機數目	<p>每個機櫃多達 16 個 (機櫃 1 中多達 12 個)</p> <p>每個磁帶櫃字串中多達 128 個</p>
磁帶匣數量	<p>L25 - 多達 660 個 (機櫃 1 中多達 550 個)</p> <p>D25 - 多達 740 個 (機櫃 1 中多達 590 個)</p> <p>S25 - 多達 1,000 個 (機櫃 1 中多達 798 個)</p> <p>每個磁帶櫃支援總數目：多達 17,550 個</p> <p>L55 - 多達 882 個 (機櫃 1 中多達 730 個)</p> <p>D55 - 多達 970 個 (機櫃 1 中多達 774 個)</p> <p>S55 - 多達 1,320 個 (機櫃 1 中多達 1,054 個)</p> <p>每個磁帶櫃支援總數目：最多 23,170 個</p>
容量*	<p>3592 進階磁帶匣：每個磁帶櫃高達 263.25 PB (採用 3:1 壓縮時為 789.75 PB)</p> <p>LTO Ultrium 8 磁帶匣：每個磁帶櫃高達 278 PB (採用 2.5:1 壓縮時，最高可達 695 PB)</p>



# Backup Media – By Enterprise Product (1)

- RAID architecture



IBM TotalStorage DS6000 的目標：

- 以合理價格的儲存系統解決方案，為大中型企業提供高可用性
- 具有企業級功能、模組化、可擴充特性，能支援開放性平台與大型主機
- 提供進階複製服務，與 IBM TotalStorage DS8000 系列及 IBM TotalStorage Enterprise Storage Server® (ESS) 800 和 750 系統互通
- 提供 GUI 介面與「快捷組態 (Express Configuration)」精靈，透過隨附的 IBM TotalStorage DS Storage Manager 來簡化系統配置與管理
- 採用模組化、3U、16 個磁碟機、機架式，隨儲存需求而增，最高可達 67.2 TB 的實體容量

# Backup Media – By Enterprise Product (2)

- NAS (Network Attached Storage)
  - Storage + Server + Cross-platform access OS + network access protocol



IBM NAS 300G  
Supported Protocol:  
NFS, HTTP, FTP, CIFS  
Netware

