# Filesystem Maintenance

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# Lectures

1. System administration introduction
2. Operating System installation
3. User management
4. Application management
5. System monitoring
6. **Filesystem Maintenance**
7. Network services
8. Security and Protection
9. Introduction to Public Cloud

# Outline

# Goals

## Knowledge

- Filesystems
- Backup tools
- Backup media

## Abilities

- Filesystem resizing
- Filesystem verification
- Perform and restore backups

# Outline

# Filesystems (I)

- FAT (FAT16) –> DOS
  - Small disks (< 4GB)
  - File names 8+3
- FAT32 (VFAT) –> Win95
  - Larger disks
  - Long filenames
  - Partial definition of soft-links
  - No owner or file access privileges
- exFAT
  - FAT32 Extension
  - Theoretical maximum capacity of 64ZiB (512TiB real)
- NTFS –> WinNT, XP, Vista, Windows 7
  - Integrates ownership and privileges (create, modify, access...)
  - Maps to Windows NT security model

# Filesystems (II)

- ext2
  - UNIX Filesystem
  - Soft/hard links
  - Access privileges
  - Long filenames
- ext3
  - Adds journaling (eases error recovery)
- reiserfs
  - Files and directories organized similarly to a database
  - Features journaling
  - Very efficient in small files
  - No internal block fragmentation

# Filesystems (III)

- xfs
  - journaling
  - Dynamic i-node management
  - ACLs
  - Very large disk sizes
  - Filesystem activity log
- jfs
  - journaling
  - Dynamic i-node management
  - ACLs and MAC (Mandatory Acess Control)
  - Very large disk sizes

# Filesystems (and IV)

- ext4
  - 64 bits addressing, improvements in journaling
  - Delayed allocation
  - Extents
  - 1 exbibyte (EiB) maximum size
- btrfs
  - Extents
  - Online resizing
  - Online balancing
  - Online filesystem check

# *Journal* filesystems

- Journal: disk operation registry
  - Eases the recovery of the FS in case of crash or error
  - Slightly decrease in disk operations performance
- Journal outside the buffer cache
  - Journal can be stored in another disk or partition
- Ext3/4, reiserfs, JFS, XFS, NTFS, BTRFS have journal

# Outline

# Disk verification

- Process to check a drive for errors
- Detecting errors early may avoid data loss

## Reasons

- Hardware errors
- Power shortage
- Operating system bugs
- Administration errors
  - Incorrect machine shutdown

## Never verify a mounted filesystem

- High probability of disk corruption
- Verification access skips the buffer cache and acts directly on the device

# Types of Disk verification

## Logical verification

- Filesystem metadata
- Directory structure
- Lost data recovery
  - Directory `lost+found`

## Physical recovery

- Disk blocks with Input/output errors
- Command: `badblocks`

# What to do when a partition gets full

- We can buy another disk and integrate it into the system
- We could try to increase the partition size
  - Danger of data loss

## Install and configure the new disk

- Create filesystem and decide the mount points
- Transfer the required data to the new partition (onto a temporary mount point)
- Re-Mount the partition to the final destination
  - Update `/etc/fstab`
- Maybe you have to reorganize existing directories
  - `/home` → `/homeA + /homeB`
  - `/home` → `/home/students + /home/professors`

# Exercise

## Plan and issue a filesystem resizing for the parititons

- `/home`
- `/var`

# Disk quota (I)

## Quota

Ability to limit the amount of data a user (or user group) is able to use in a filesystem (partition)

## Requires

- Support from the filesystem
- Support from the kernel

# Quota management (II)

## Partition preparation

- Mounted using options `'usrquota'` and/or `'grpquota'`
- It can be done from `/etc/fstab`

```
/dev/sda3   /home   ext4     defaults,usrquota,grpquota    1   1
```

- `quotacheck` command to create the quota files

```
quotacheck -v    -a  -g    -u   -m
verbose all group user no-remount
```

- Creates
  - `/aquota.user`
  - `/aquota.group`

# Quota management (III)

- Quota enabling

```
quotaon -v      -a  -g    -u
        verbose all group user
```

  - Activates quota mechanisms, usually from `/etc/init.d/`
- Quota disabling
  - `/sbin/quotaoff`
- Quota editing (`edquota`)

```
Disk quotas for user rserral (uid 1000):
  Filesystem    blocks     soft     hard    inodes    soft    hard
  /dev/sda3      10246  1024716  2024716         0       0       0
```

  - Data blocs and i-nodes quota
  - It is not possible to edit the used blocks/inodes, but the limits of the quota can be changed

# Quota management (and IV)

- Visualize quotas: `quota -v`

```
Disk quotas for user rserral (uid 1000):
  Filesystem   blocks   quota   limit   grace  files  quota  limit   grace
  /dev/sda3  1324716* 1024716 2024716   6days    145      0      0       -
```

  - We are above the quotas, within the "`hard`" limit!!
- "Grace period"
  - Grace time where the user can reach the hard limit, it only raises warnings
  - If the grace period expires, then the system does not allow to go above the soft limit

# Other maintenance tasks

## Monitoring

- Free space (`df`)
  - Most systems reserve a (5%) of the space to be exclusively used by root
- Occupied space (`du`)

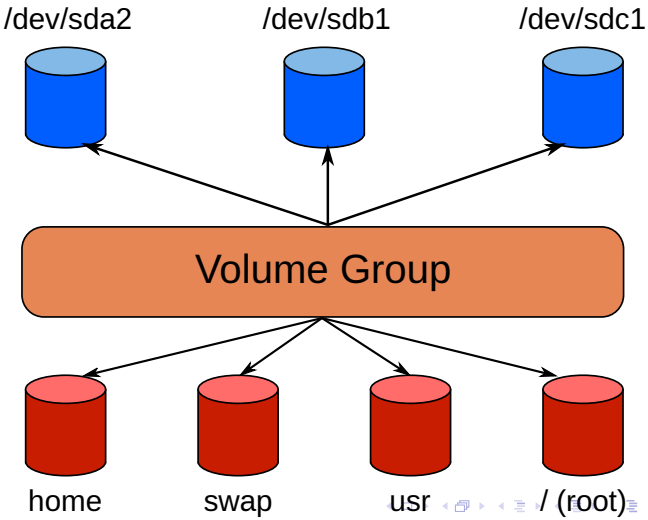
## Synchronization

- Write to disk the modified buffers
  - `sync`
  - Update daemon

# Outline

# Logical Volume Manager (LVM) (I)

Physical Volumes (PV)




Logical Volumes (LV)

# Logical Volume Manager (and II)

- High level abstraction of the disk space
- Aggregates multiple physical partitions/disks
  - Allows to add more partitions to the volume
- It allows logical partitions within the volume
  - They can be assigned logical names
  - Customized distribution among the physical volumes
    - Resizing
    - Move
- Example: `/etc/fstab`

```
/boot     /dev/sda1       ...
swap      /dev/vg00/swap  ...
/         /dev/vg00/root  ...
/home     /dev/vg00/home  ...
/usr      /dev/vg00/usr   ...
```

# Outline

# Backups

## Preliminary considerations

- Data to copy
  - User data (home, mail)
  - Program data (DBs, GIT, web, . . . )
  - System configuration
  - Binary?
- Backup types
  - Full Backup (all)
  - Incremental Backup (only changes)
  - Reverse Incremental Backup (only changes)
  - Differential Backup
- Backup frequency
  - Data confidence
  - Data importance

# Backups

## Physical support

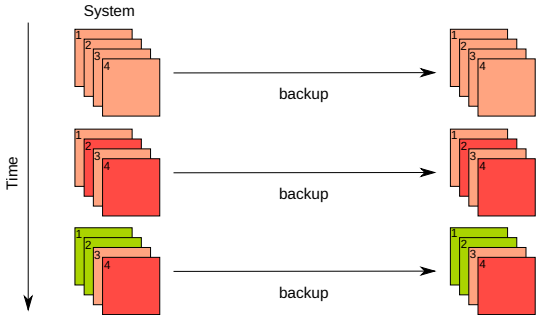
- Floppy, disc, CD, tape, network...
- To consider:
  - Cost size ratio
  - Reliability
  - Availability
  - Usability
  - Speed

## Copy location

- Accident protection
- Fireproof boxes
- Keep some backups outside the company premises
- Stealing protection

# Full Backup

- Always copy all the data
  - Fast to restore
  - Large size
- It is the base for all backup types
- Can be compressed
- Can be used on any storage medium



# Incremental Backup

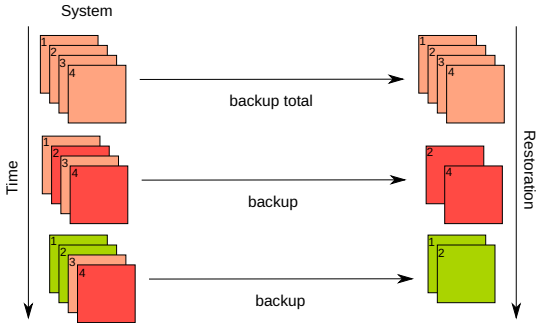
- It only backs up the changed files
- Can be compressed
- Can be used on any storage medium

## Advantages

- Smaller size

## Inconveniences

- It is slower to restore
- Tedious with long chains



# Reverse Incremental Backup

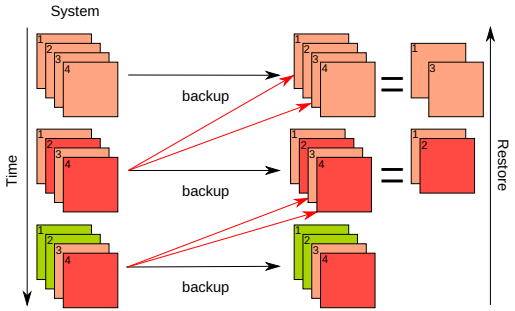
- Everything is copied (linked) from the previous backup
- Except for the modified files
  - Which are taken from the original data

## Advantages

- Fast to restore
- Little space

## Inconveniences

- Only random access storage



# Differential Backup

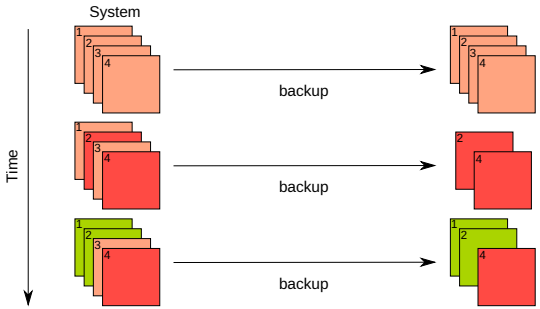
- All changes since the last full backup are copied

**Advantages**

- Allows to remove Incremental
- Allows a shorter backup chain

**Inconveniences**

- Large space needs
- Admin should erase incremental



# Backups – Tapes

| | LTO-1 | LTO-2 | LTO-3 | LTO-4 | LTO-5 | LTO-6 | LTO-7 | LTO-8 | LTO-9 | LTO-10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Release date | 2000 | 2003 | 2005 | 2007 | 2010 | 2012 | 2015 | 2017 | 2021 | TBA |
| Native/raw data capacity | 100 GB | 200 GB | 400 GB | 800 GB | 1.5 TB | 2.5 TB | 6.0 TB | 12 TB | 18 TB | 45 TB |
| Max uncompressed speed (MB/s) | 20 | 40 | 80 | 120 | 140 | 160 | 300 | 360 | 400 | 1100 |
| Time to write a full tape at max uncompressed speed(hh:mm) | 1:25 | 1:25 | 1:25 | 1:50 | 3:10 | 5:30 | 5:33 | 9:16 | 12:30 | 12:40 [1] |
| Compression capable? | Yes, "2:1" | | | | | Yes, "2.5:1" | | | | Planned, "2.5:1" |
| WORM capable? | No | | Yes | | | | | | | Planned |
| Encryption capable? | No | | | Yes | | | | | | |
| Max. number of partitions | 1 (no partitioning) | | | | 2 | 4 | | | | |

[1] Source: https://en.wikipedia.org/wiki/Linear_Tape-Open

# Exercise

**Define a backup policy:**

- Data to backup
- Backup type(s)
- Frequency
- Storage Media
- Compression
- Expiration policy

For a server with:

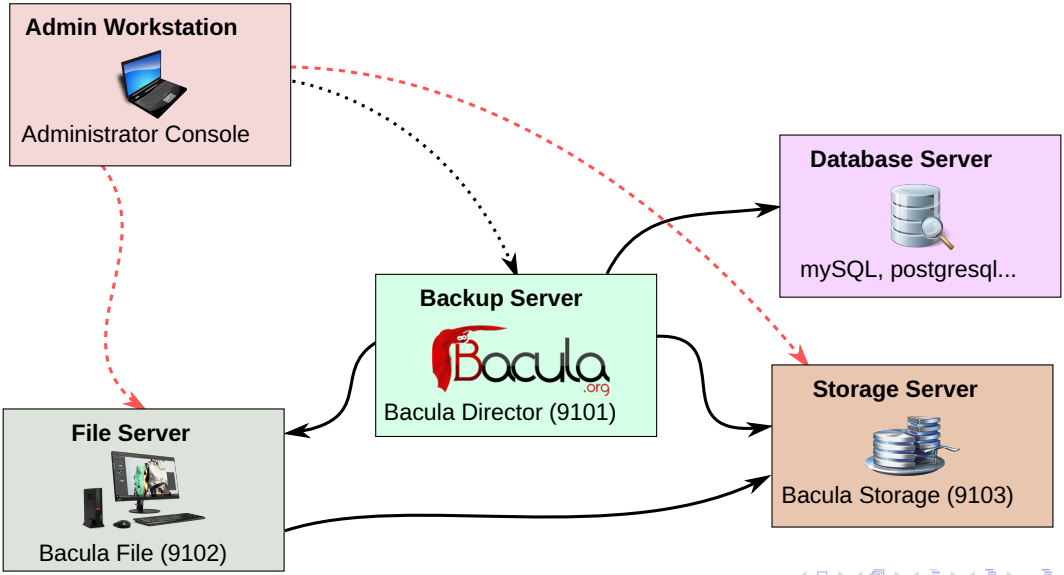
- **Users**: 50 Gb. disk per user (80 users)
- **Mail**: 1 Gb per user
- **Web pages**
  - 2 Gb Main site
  - 100Gb Database
- **Code repository**
  - 100 GB distributed among 10 projects
  - Only 5 active projects

# Other considerations

- Dedicate specific machines for backup
  - It takes many resources
  - easier to administer
- Consider how much data you want to potentially loss
- Consider how much storage you will need
- Be aware of legislation

**Tools:**

`bacula`, `Borg`


Admin Workstation
Administrator Console
Database Server
mySQL, postgresql...
Backup Server
Bacula .org
Bacula Director (9101)
Storage Server
Bacula Storage (9103)
File Server
Bacula File (9102)

# Personal Homework

- Task automation
  - Programming language: `bash`, `perl`
  - Information search: `find`, `grep`...