~~VIRTUALIZATION~~ and STORAGE

Permanent Storage:

Three categories:

1) Write Once, Read Many (WORM):
- once you've written, you can't write over it e.g. CD-ROM, DVD-ROM

2) Write Many, Read Many:
- the writes are fully reversible for the purposes of the computer e.g. HDD

3) Write (not too) Many, Read Many:
- devices will slightly wear on each write making them less effective
e.g. Rewritable CD (hundreds to thousands write cycles), flash (thousands to low millions)

Hard drives

- consist of multiple magnetic disks (around 4) laid on top of each other that spin around and can be written/read by a 'head'
- each disk can store around 2TB and rotate at four speeds: 5400RPM, 7200RPM, 10000RPM or 13000RPM

Seek Time = time it takes for the **head** to reach the target **track** on the platter

Search Time = time for the target sector to arrive under the head

Transfer Rate = amount of data that can be read per unit time

Disk Access Time = Seek Time + Search Time + Transfer Time

Example: compute access time of a disk: sector size is 512 B, seek time 8.5 ms, the disk rotates at 7200 RPM and the transfer speed is 177 MB/s

$$\text{Search time} = \frac{0.5 \text{ rotations} \cdot 60}{7200} = 4{,}16 \text{ ms}$$

$$\text{Transfer time} = \frac{512 \text{ B}}{177 \cdot 10^6 \text{ B/s}} = 2{,}89 \mu\text{s}$$

Disk access time = seek time + search time + transfer time

$$= 8{,}5 \text{ ms} + 4{,}16 \text{ ms} + 2{,}89 \cdot 10^{-3} \text{ ms}$$

An internal processor in the hard drive will re-order the operating system's sector requests so that they are in the most efficient order for retrieval

Why are disks slow?

1) High seek time
- multiple platters (=> more tracks / sectors per cylinder) ⟹ the head moves less

2) High search time (rotation speed)
- increase the rotation speed (server disks up to 15000 RPM)

3) Low sustained transfer rate
- "stripe" file system across multiple disks
- apply cache

RAID (Redundant Array of Independent Disks) → a type of storage virtualization

What happens when a disk fails?

RAID 0 Lose all data (hope there's more than one RAID layer)

RAID 1 Business as usual, hot-swap the failed disk

RAID 2-6 Operate in degraded mode

- If a data drive failed, then every read must be reconstructed
- If a parity drive failed, then there is a low performance impact (while the system recomputes the parity bits with a new drive)

SSD vs. HDD

- SSD's are much faster than hard drives since they don't have moving parts, so the data access is much faster
- SSD are made of flash memory. They have a Floating Gate Field Effect Transistor that can store 0's and 1's
- SSD have wear levelling is when logical block addresses are mapped to physical addresses differently over time so that specific blocks aren't worn out

age Virtualization

- RAID allows us to span file systems onto multiple drives by striping and mirroring.

A volume group is a set of drives in a pool and storage space in such a group is divided into physical extents.

A logical volume is made of physical extents.

These abstractions allow us to add more drives, extend partitions, take snapshots of a file system

Storage Area Networks

- implement Logical Volume Management features across multiple servers

ZFS

- combines file system and Logical Volume management