Storage System

Physical Storage Media

Persistent of Storage Media

- Volatile : Data is lost when power is off
- Non-Volatile : Data is retained when power is off
    - Note that is **not safe** on system crash
- Stable Storage : Data is **never** lost
    - Just theoretical concept
    - Implement with multiple copies of data

Hierarchical Storage

- Primary Storage : volatile storage
    - CPU Registers
    - Cache
    - Main Memory
- Secondary Storage : on-line storage, non-volatile storage
    - Magnetic Disks(HDD)
    - Flash Memory
    - Solid State Drives(SSD)
- Tertiary Storage : off-line storage, non-volatile storage
    - Optical Disks(CD, DVD, Blu-ray)
    - Magnetic Tapes

Magnetic Disks

Components

- Platters
    - Divided into tracks : concentric circles
    - Each track is divided into sectors : pie-shaped wedges
- Arms
    - Each arm has a head
    - Each head can read/write one track at a time
        - Head read/write data using magnet
- Hard Disck Assembly
    - Normally, multiple platters are stacked on a disk
    - All heads are attached to a single arm and each head used to read/write one platter

Performance

- Access Time
    - Seek Time : time delay for move arm vertically

        - Average seek time is half of the maximum seek time
        - Maximum seek time is the time to move the arm from the outermost track to the innermost track
    - Rotational Latency : time delay for rotate disk
        - Average rotational latency is half of the maximum rotational latency
        - Maximum rotational latency is the time to wait for a full rotation of the disk
- Data Transfer Rate
    - Rate at which data can be read from or written to the disk
    - Depends on the rotational speed of the disk and the data density
- Mean Time to Failure(MTTF)
    - Average time between disk failures
    - Usually 1 million hours

Optimizing Disk Performance

RAID(Redundant Array of Independent Disks)

Overview

- Reliability via redundancy
    - Mirroring
        - Write to multiple disks
        - Read from any disk
    - Parity : information about the data for recover corrupted data
        - store parity information on a separate disk
- Performance via parallelism
    - Block-level striping : divide data into blocks and store each block on a different disk
        - Read/Write data in parallel

RAID 0

- Block-level striping
- Danger in system crash
    - If one disk fails, all data is lost

RAID 1

- RAID 0 + Mirroring
    - Best write performance

RAID 5

- Block-level striping + Parity
    - Parity information is distributed across all disks
- Via RAID1
    - lower storage overhead

- lower write performance
- good for frequent read, rare write