Section 10. Data Storages

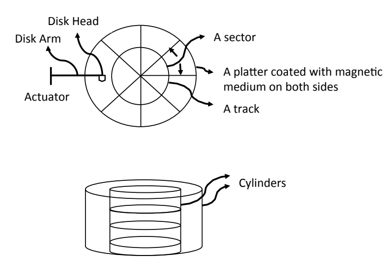
- Three Basic Functions of Any Digital System:
  - ➢ Data Processing
    - ❖ CPU/Memory/IO process data
    - ❖ Basic computations, searching, sorting, etc
  - ➢ Data Transmission
    - ❖ Buses, parallel/serial interfaces
    - ❖ Wired/wireless networking
  - ➢ Data Storage
    - ❖ Keeping persistent data
    - ❖ Disks, Flash memory, Tapes etc.

Data Explosion!

Important Issues in Data Storage

- Performance
  - ➢ Improve I/O performance not to drag down CPU and memory
    - ✓ Hard disk drive technology
    - ✓ Disk arrays: RAID architecture
- Reliability
  - ➢ Data are important assets of businesses and organizations
  - ➢ Keeping data reliable is important
- Recoverability
  - Be able to recover data in case of failure
  - Existing data recovery technology and a new one

Terminologies in a Hard Disk Drive



Necessary Steps of a Disk Access

1. **Controller command interpretation**
   - Take and interpret commands, LBA, Sizes from host
2. **Seek**
   - Move disk head to the track where data is stored
3. **Rotation**
   - Wait for the accessed sector to rotate right under the disk head
4. **Data Transfer**
   - Transfer data from disk to controller buffer then to host

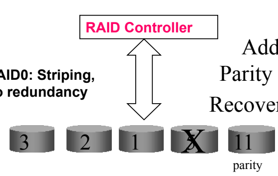
RAID Architectures

1. **Motivations:**
   - Cost of disks is low, is getting less expensive
   - Improve performance, throughput, by parallelism
     - ✓ Multiple I/O requests are done in parallel
     - ✓ Striping single request into chunks
   - Improve reliability using redundancy
2. **Different RAID Architectures**
   - RAID0: striping, no redundancy
   - RAID1: Mirroring, or shadowing, no striping, 2xN redundancy
   - RAID2: Memory like ECC, Hamming code
   - RAID3: Knowing which disk failed, erasure code, Bit-interleaved,
   - RAID4: Block-interleaved, one dedicated parity disk, striping unit varies
   - RAID5: Block-interleaved, distributed parity, load balancing.

RAID Architectures

RAID, redundant array of inexpensive disks

For high speed and high reliability



RAID0: Striping, no redundancy

Add a parity disk:

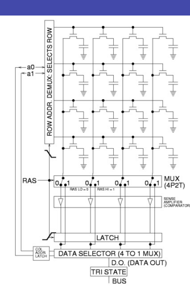
Parity = 3+2+1+5 =11

Recover data: 5=11-3-2-1

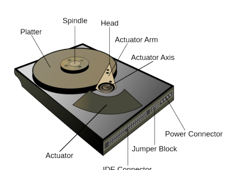
RAID-4: striping & parity disk

If parity blocks for different stripes are distributed evenly across disks, we got RAID-5

Traditional Storage Technologies



DRAM: Volatile



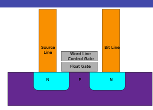
Controller command interpretation: Take and interpret commands, LBA, Sizes from host

Seek: Move disk head to the track where data is stored

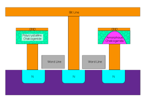
Rotation: Wait for the accessed sector to rotate right under the disk head

Data Transfer: Transfer data from disk to controller buffer then to host

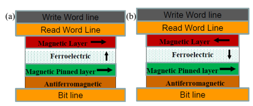
Emerging Storage Technologies



Flash Memory: Store a bit by trapping charges
Read is fast, write is slow and wearing

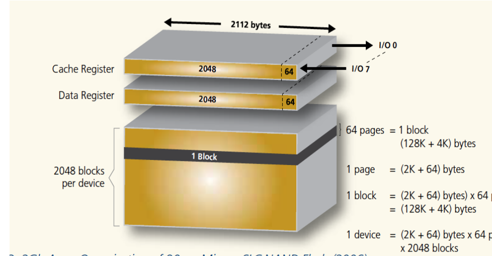


Phase Change Memory:
crystalline and amorphous states of chalcogenide glass have dramatically different resistivity
Much faster switching
Fast read, slow write, wearing, too, but less than flash



Magnetoresistance RAM: fast switching, symmetric, no durability issue
Promising technology once cost comes down

A typical NAND Flash



3: 2Gb Array Organization of 90nm Micron SLC NAND Flash (2006)

Newer SLC NAND Flash

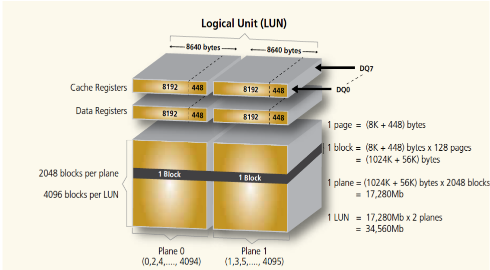


Figure 4: 32Gb Array Organization of 25nm Micron SLC NAND Flash (2010)