Big Data Processing Technologies

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Schedule

- lec1: Introduction on big data and cloud computing
- lec2: Introduction on data storage
- lec3: Data reliability (Replication/Archive/EC)
- lec4: Data consistency problem
- lec5: Block level storage and file storage
- lec6: Object-based storage
- lec7: Distributed file system
- lec8: Metadata management

Collaborators

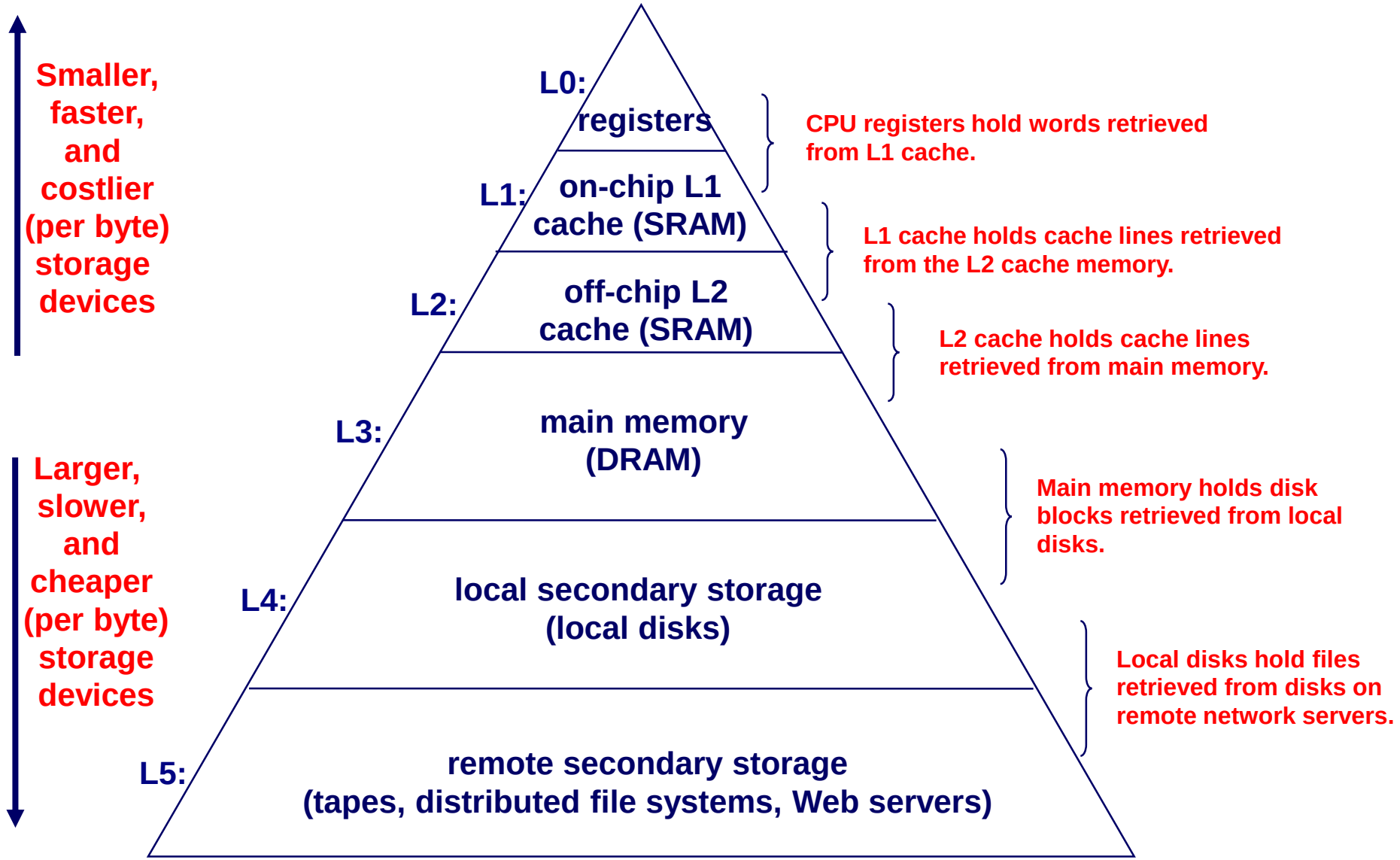
Google 谷歌

阿里云 aliyun.com

DELL EMC

1 Introduction on Storage Devices

An Example Memory Hierarchy



Read Only Memory (ROM)

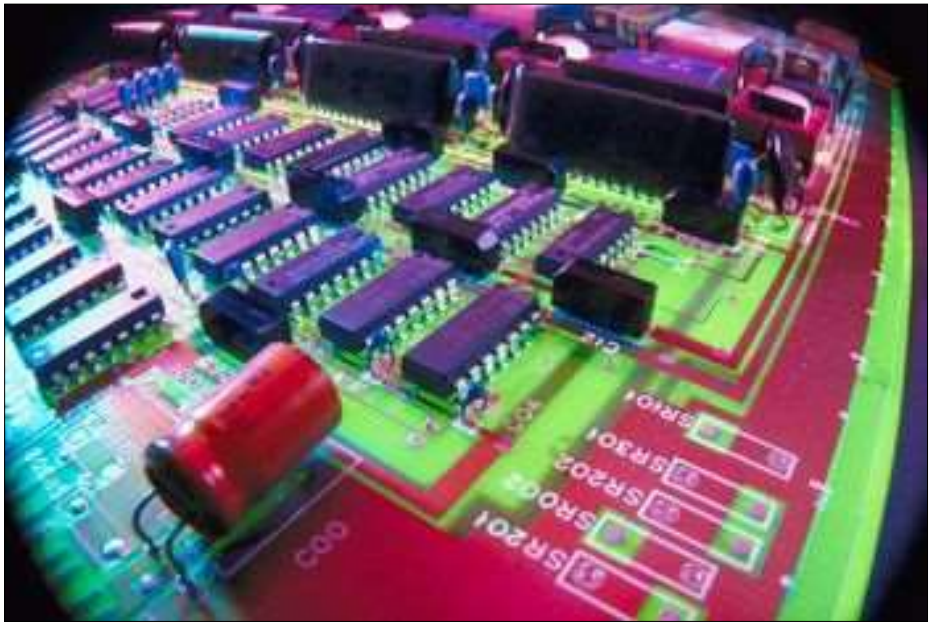
When a computer is first switched on, it needs to load up the BIOS (Basic Input/Output System) and basic instructions for the hardware.

These are stored in **ROM** (**R**ead **O**nly **M**emory).

This type of memory is called **non-volatile** because it **retains the data**.

Data stored in ROM remains there even when the computer is switched off.

ROM can be found on the **motherboard**.



Random Access Memory (RAM)

Computers store temporary data in the **RAM** (**R**andom **A**ccess **M**emory). These could be operating instructions, loose bits of data or content from programs that are running.

The contents of RAM are constantly rewritten as the data is processed.

When the computer is switched off, all the data is **cleared** from the RAM.

This type of memory is called **volatile** because it only **stores** the data whilst the computer is **switched on**.

RAM sticks are found on the motherboard.

Secondary Storage/Backup Storage

Computers need backing storage outside the CPU to store data and programs not currently in use.
There are three main types of **storage device**:

- Those that store data by **magnetizing** a special material that coats the surface of a disk.

- Those that store data using **optical technology** to etch the data onto a plastic-coated metal disk. Laser beams are then passed over the surface to read the data.

- **Flash drives** use **solid state technology** and store data in a similar way to the BIOS chip.

Hard Disk Drives (HDDs)

- The **hard disk** of the computer stores the system information, programs and data that the computer uses every day.

- Computer servers will use **RAID** systems with many hard drives to provide huge capacity and safer storage. The drives can be **mirrored** so that data written to one of them is also written to others, so if one drive fails, the others just take over.

- **Removable hard drives** plug into the **USB** port and can be used for backup or transfer of data to another computer.

What's Inside A Disk Drive?

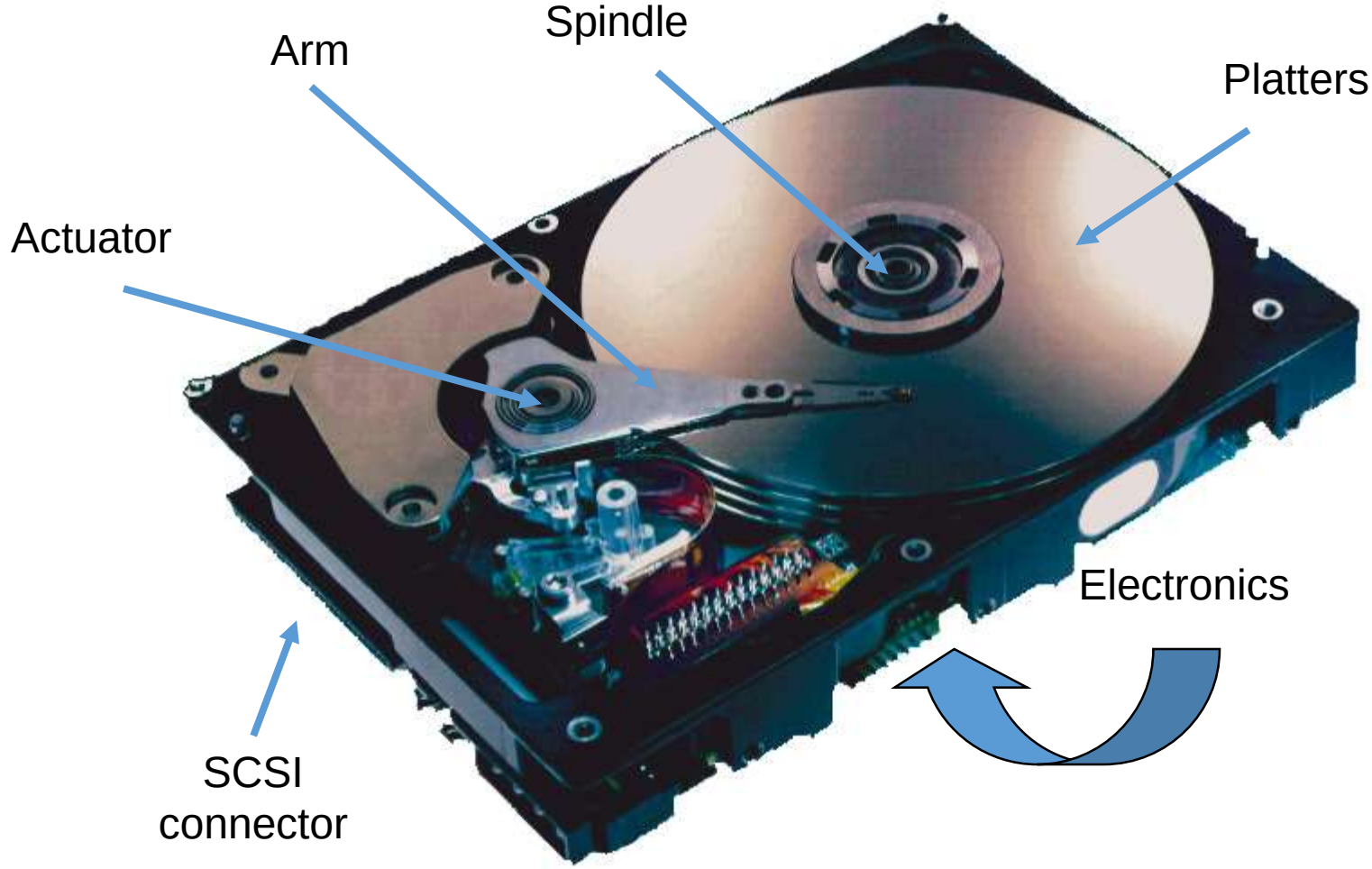


Image courtesy of Seagate Technology

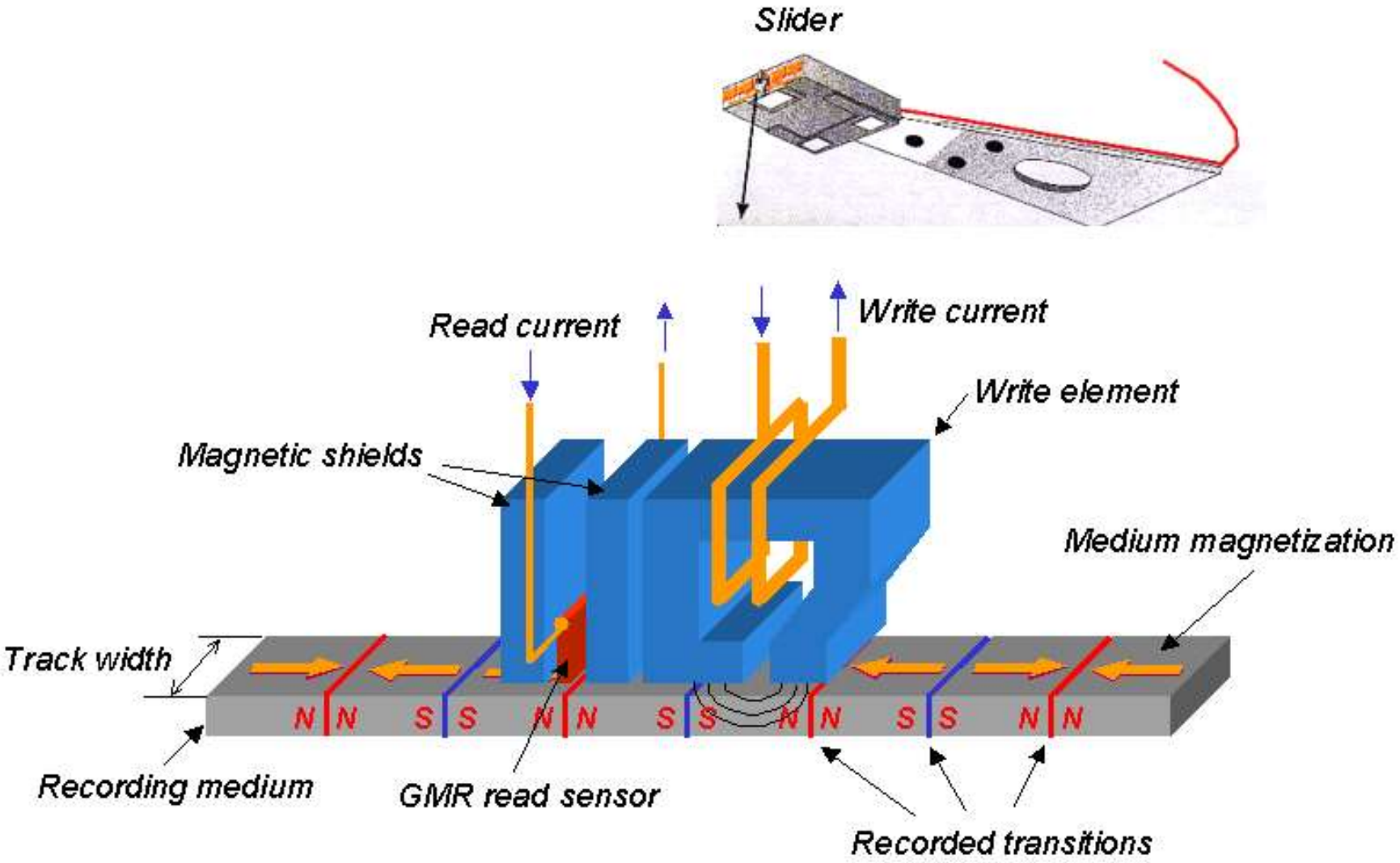
Disk Electronics

Quantum Viking (circa 1997)

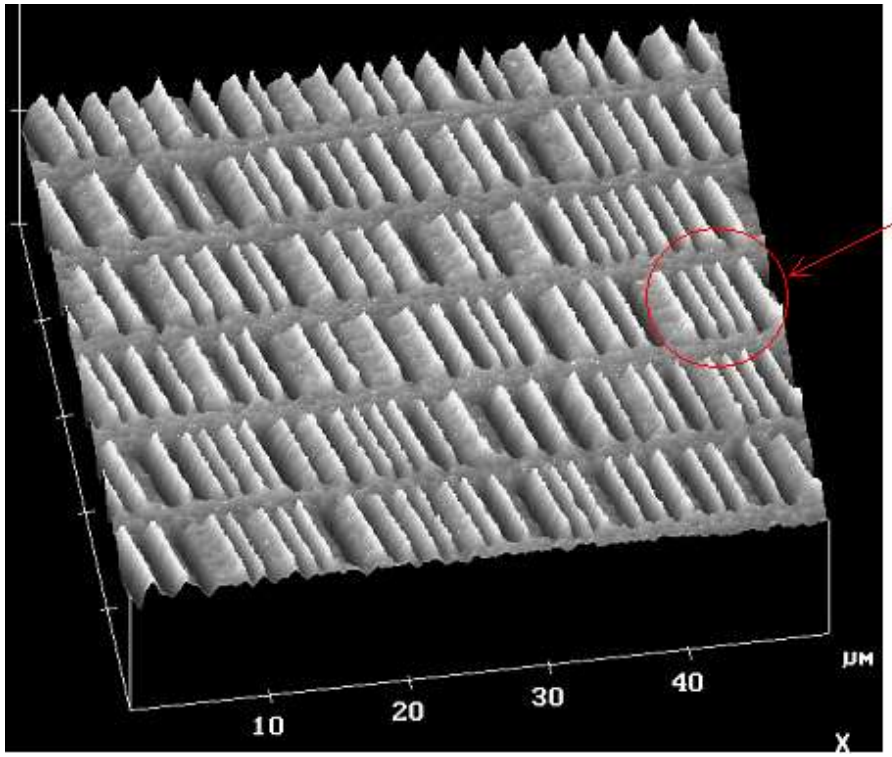
Just like a small computer – processor, memory, network interface

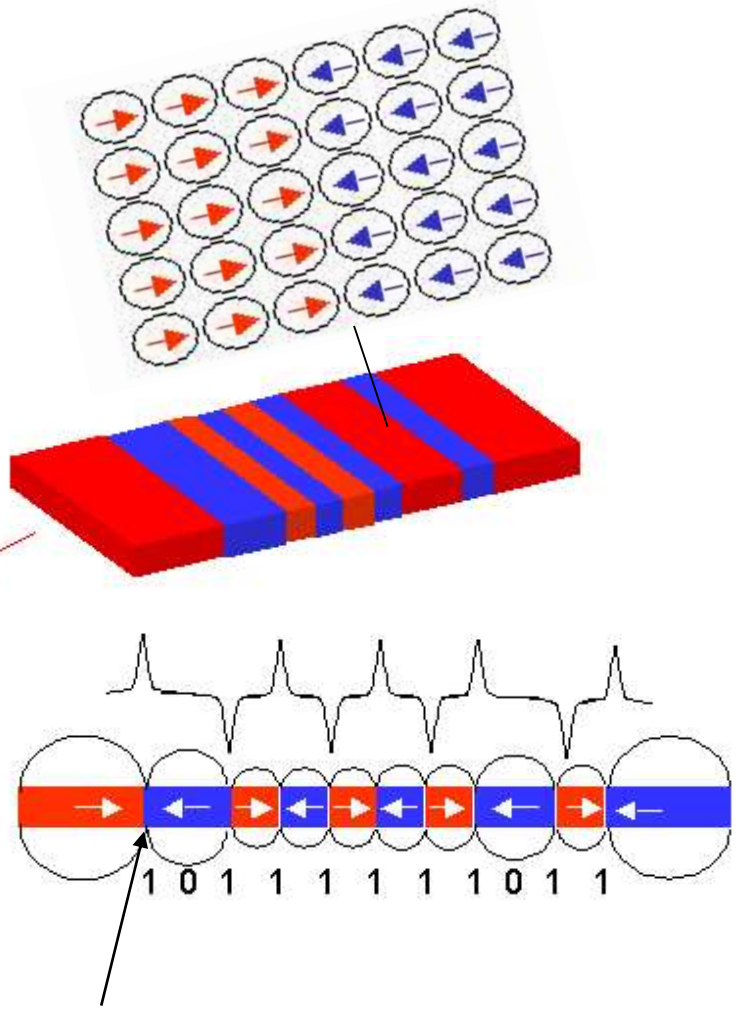
- Connect to disk
- Control processor
- Cache memory
- Control ASIC
- Connect to motor

Longitudinal Recording



How Bits Are Stored



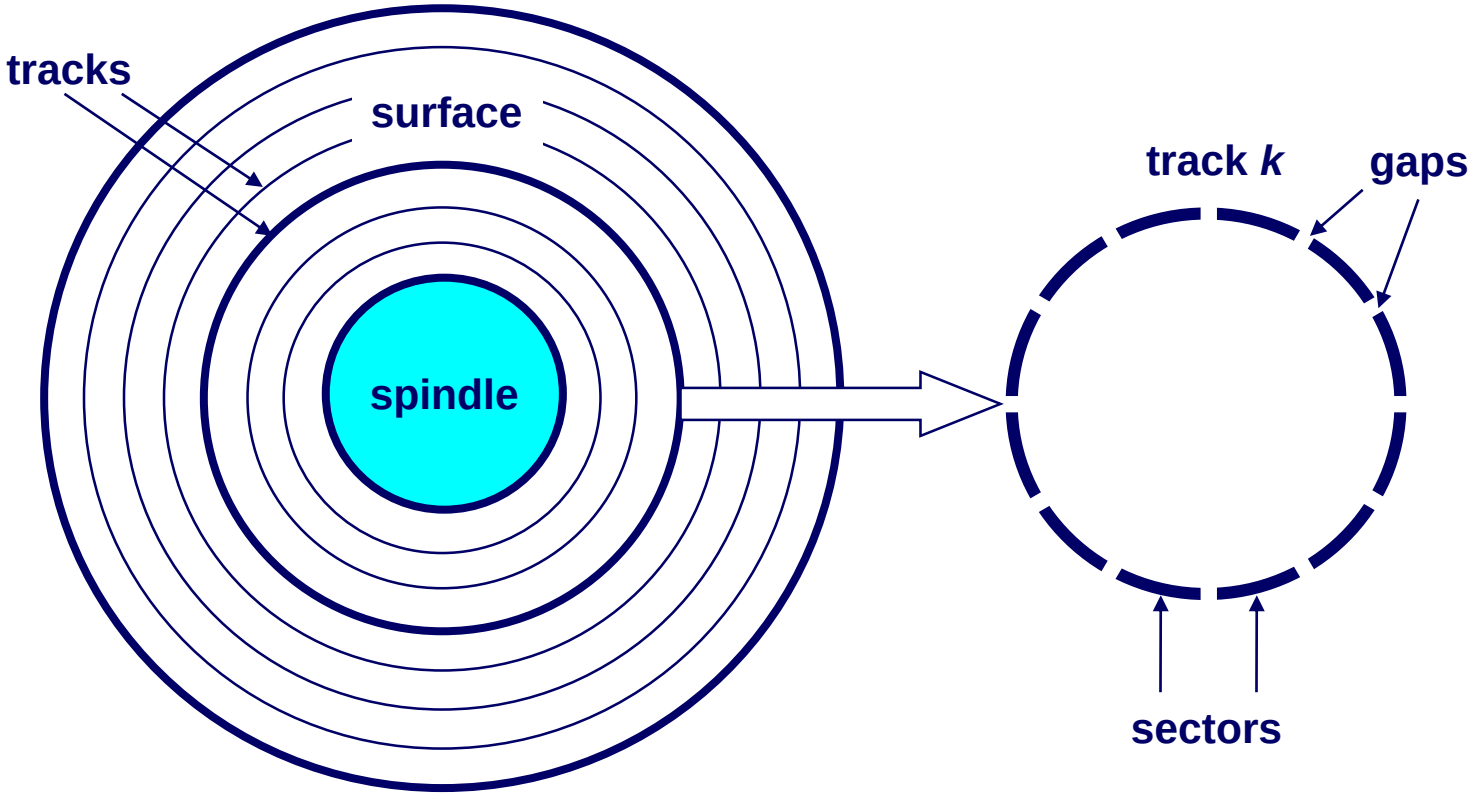


Disk "Geometry"

Disks contain platters, each with two surfaces

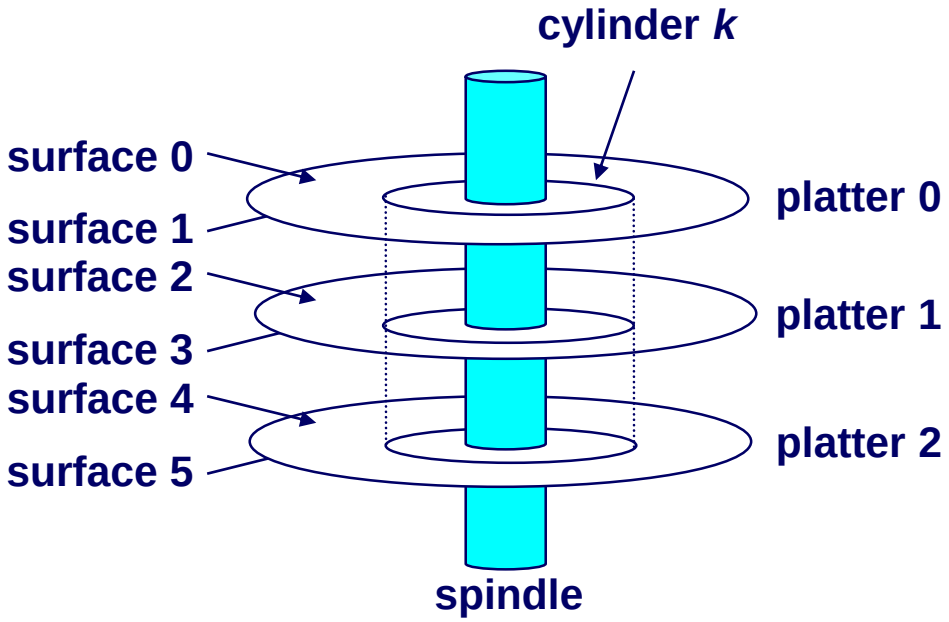
Each surface organized in concentric rings called tracks

Each track consists of sectors separated by gaps

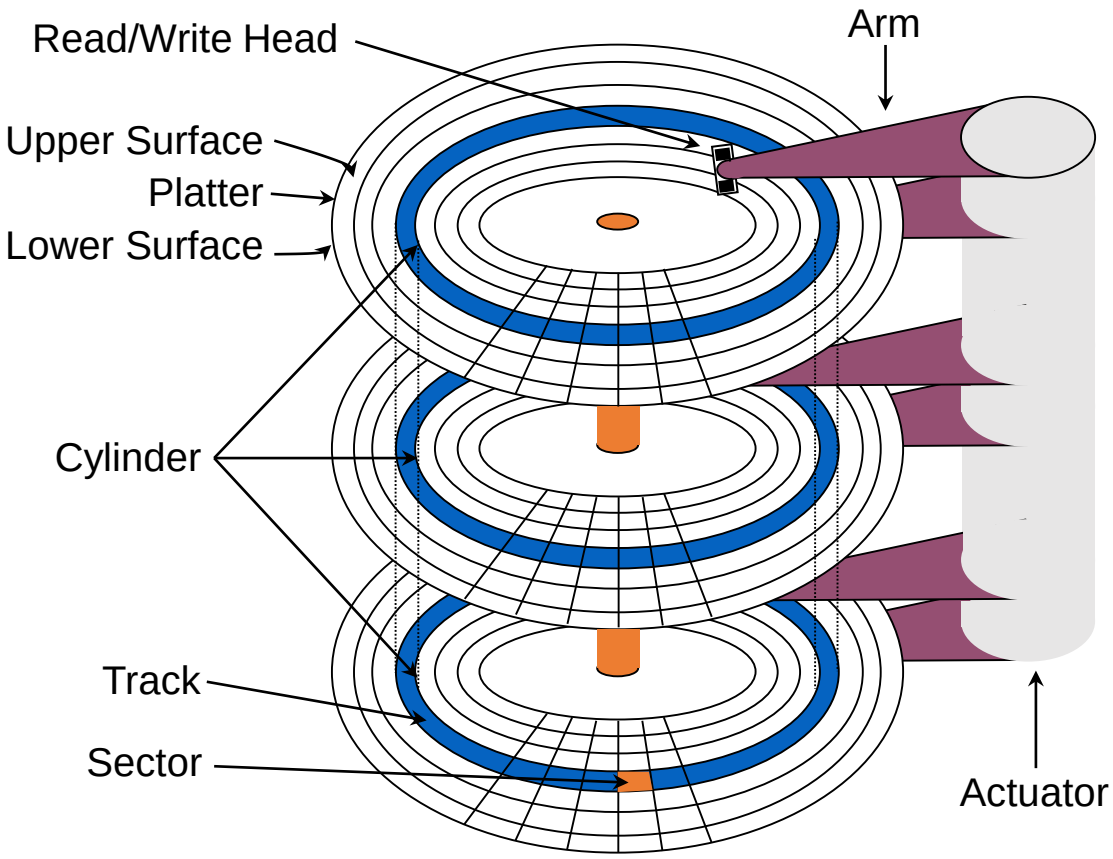


Disk Geometry (Muliple-Platter View)

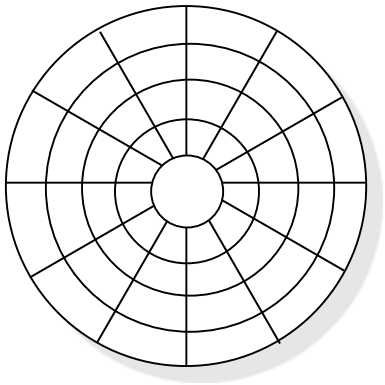
Aligned tracks form a cylinder



Disk Structure



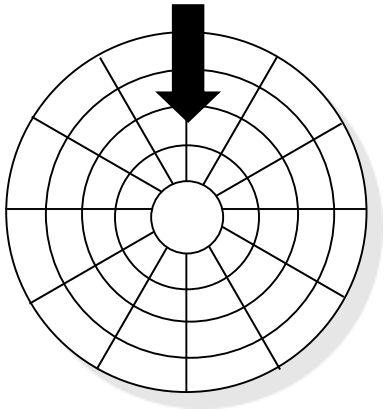
Disk Structure - top view of single platter



Surface organized into tracks

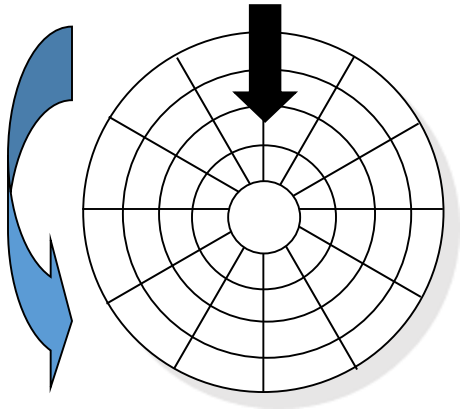
Tracks divided into sectors

Disk Access



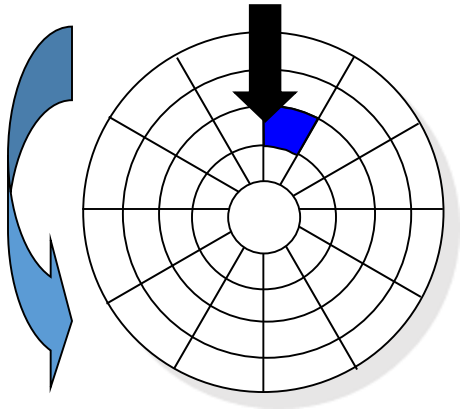
Head in position above a track

Disk Access



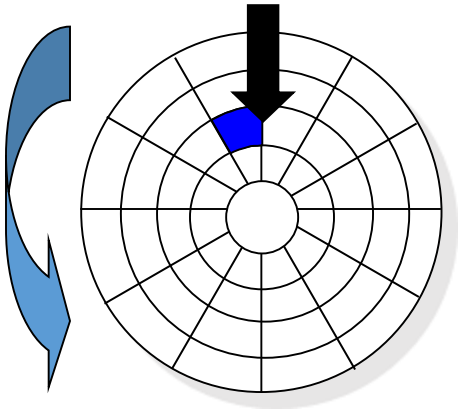
Rotation is counter-clockwise

Disk Access – Read



About to read blue sector

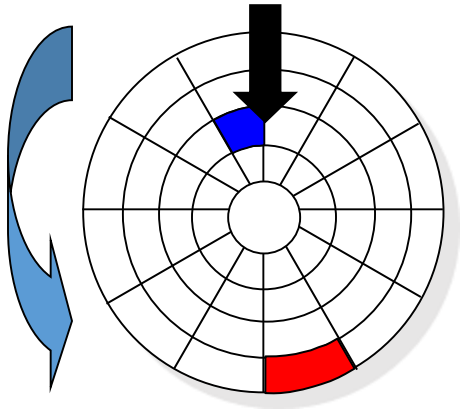
Disk Access – Read



After BLUE read

After reading blue sector

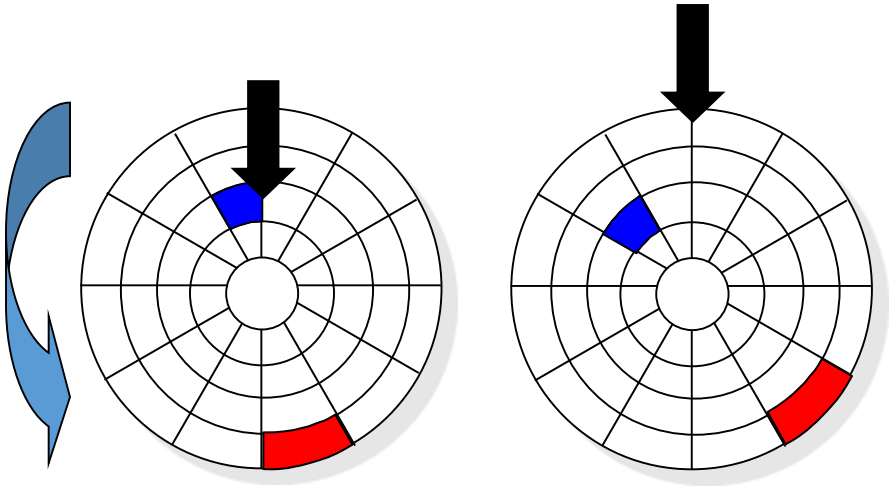
Disk Access – Read



After BLUE read

Red request scheduled next

Disk Access – Read

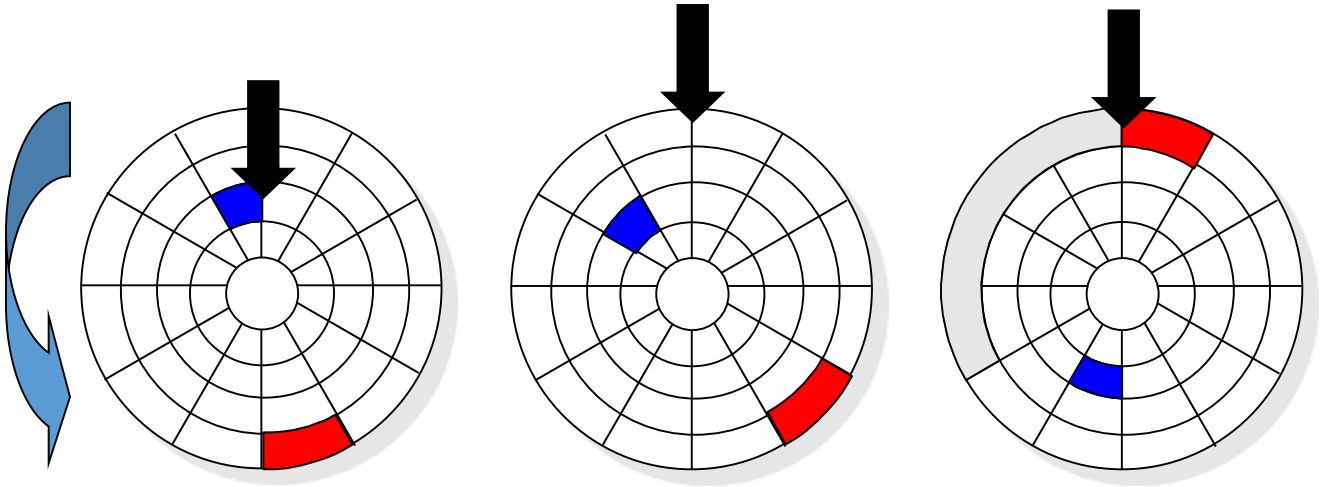


After BLUE read

Seek for RED

Seek to red's track

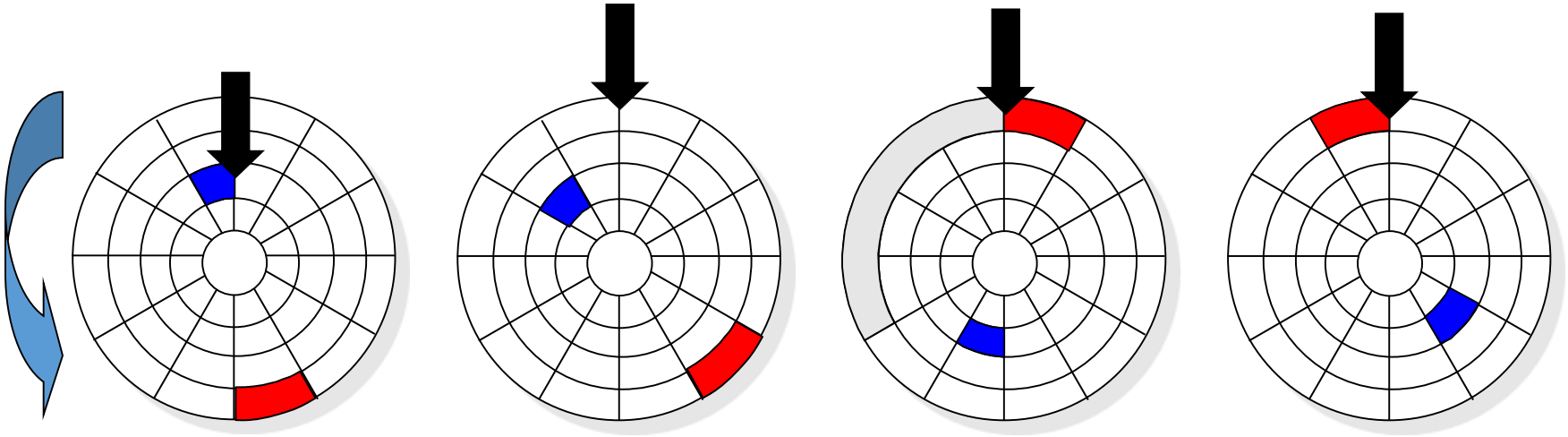
Disk Access – Read



After BLUE read Seek for RED Rotational latency

Wait for red sector to rotate around

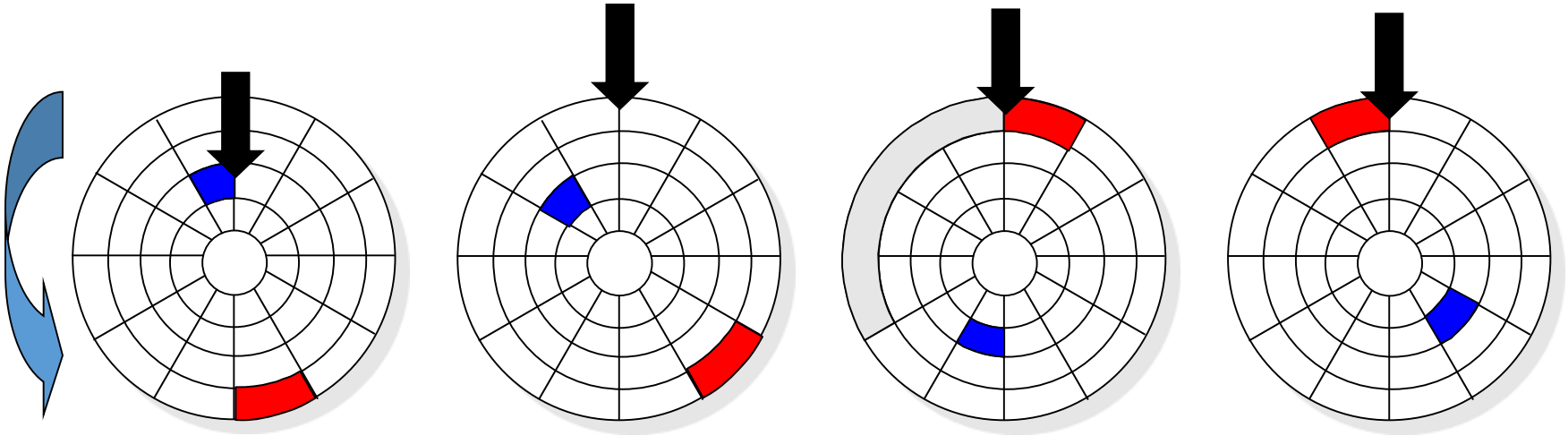
Disk Access – Read



After BLUE read | Seek for RED | Rotational latency | After RED read

Complete read of red

Disk Access – Read



Seek
Rotational Latency
Data Transfer

Disk Access Time

Average time to access a specific sector approximated by:

- Taccess = Tavg seek + Tavg rotation + Tavg transfer

Seek time (Tavg seek)

- Time to position heads over cylinder containing target sector
- Typical Tavg seek = 3-5 ms

Rotational latency (Tavg rotation)

- Time waiting for first bit of target sector to pass under r/w head
- Tavg rotation = 1/2 x 1/RPMs x 60 sec/1 min
  - e.g., 3ms for 10,000 RPM disk

Transfer time (Tavg transfer)

- Time to read the bits in the target sector
- Tavg transfer = 1/RPM x 1/(avg # sectors/track) x 60 secs/1 min
  - e.g., 0.006ms for 10,000 RPM disk with 1,000 sectors/track
  - given 512-byte sectors, ~85 MB/s data transfer rate

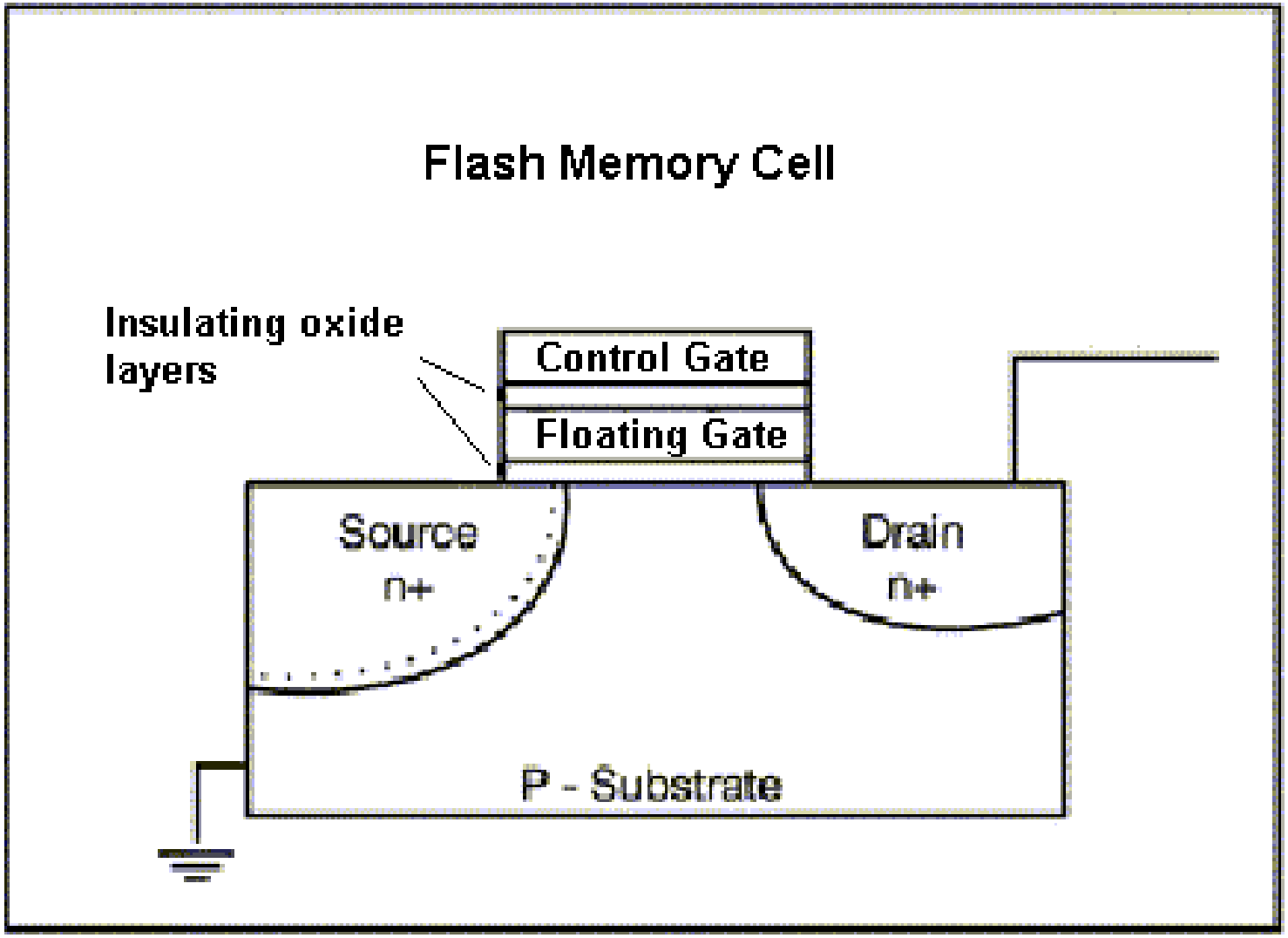
Solid State Drives

Samsung intros Spinpoint MP2, reiterates plans for 256GB SSD in 2009

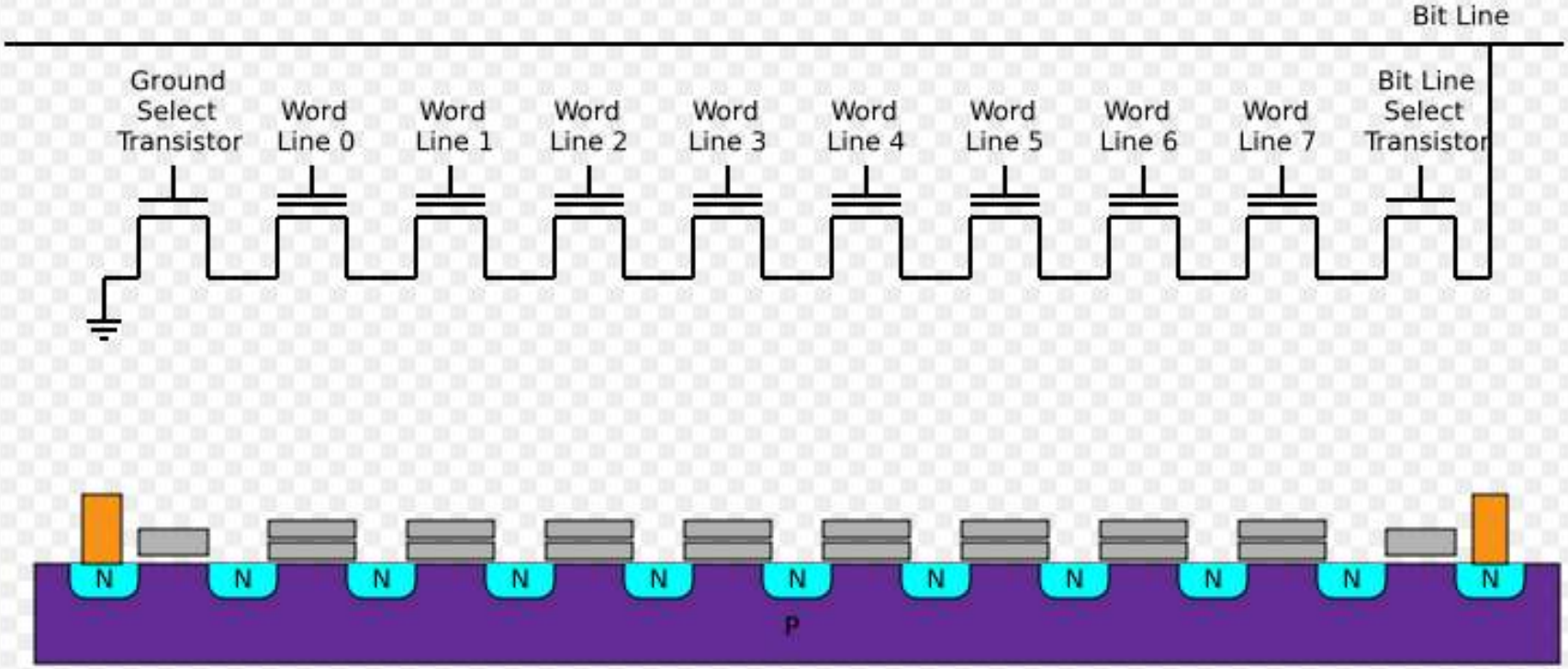
Posted Mar 4th 2008 11:55PM by Darren Murph

Filed under: Storage

Flash Memory Cell

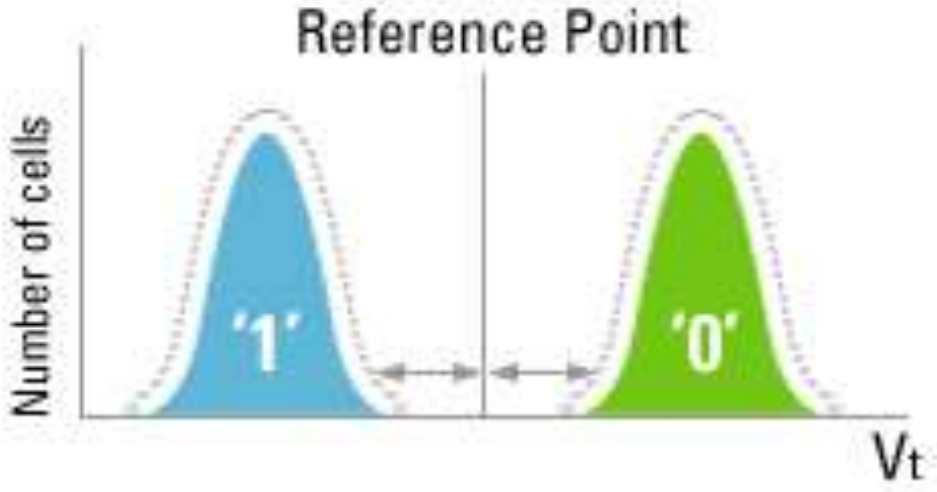


NAND-Flash

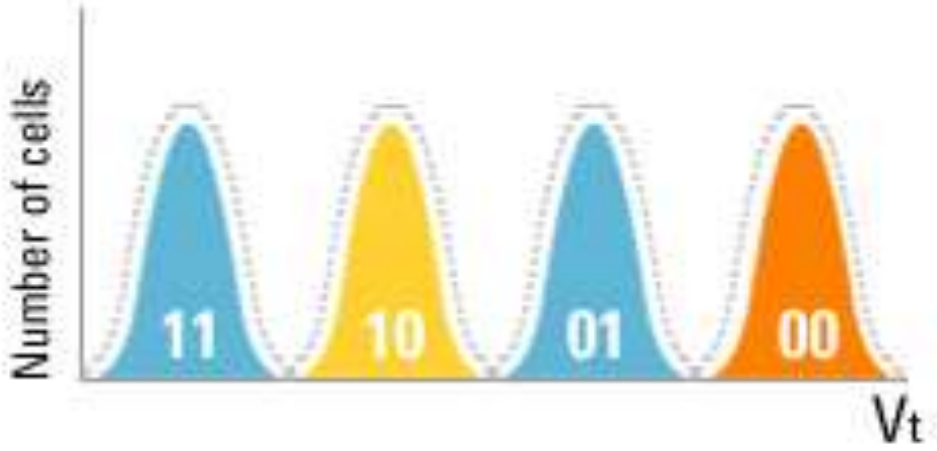

Bit Line
Ground Select Transistor
Word Line 0
Word Line 1
Word Line 2
Word Line 3
Word Line 4
Word Line 5
Word Line 6
Word Line 7
Bit Line Select Transistor
N
P

SLC and MLC

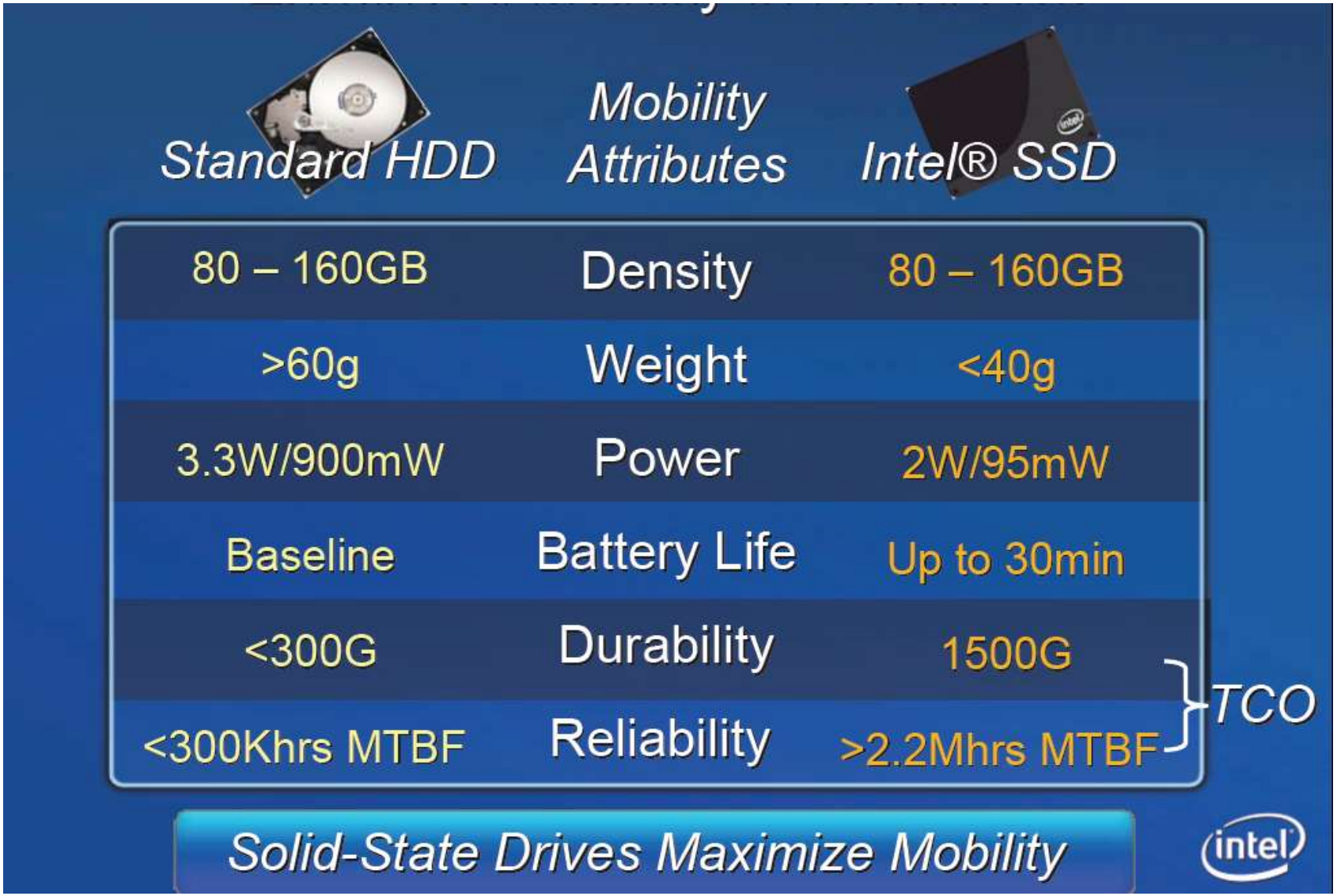
SLC
One bit per cell



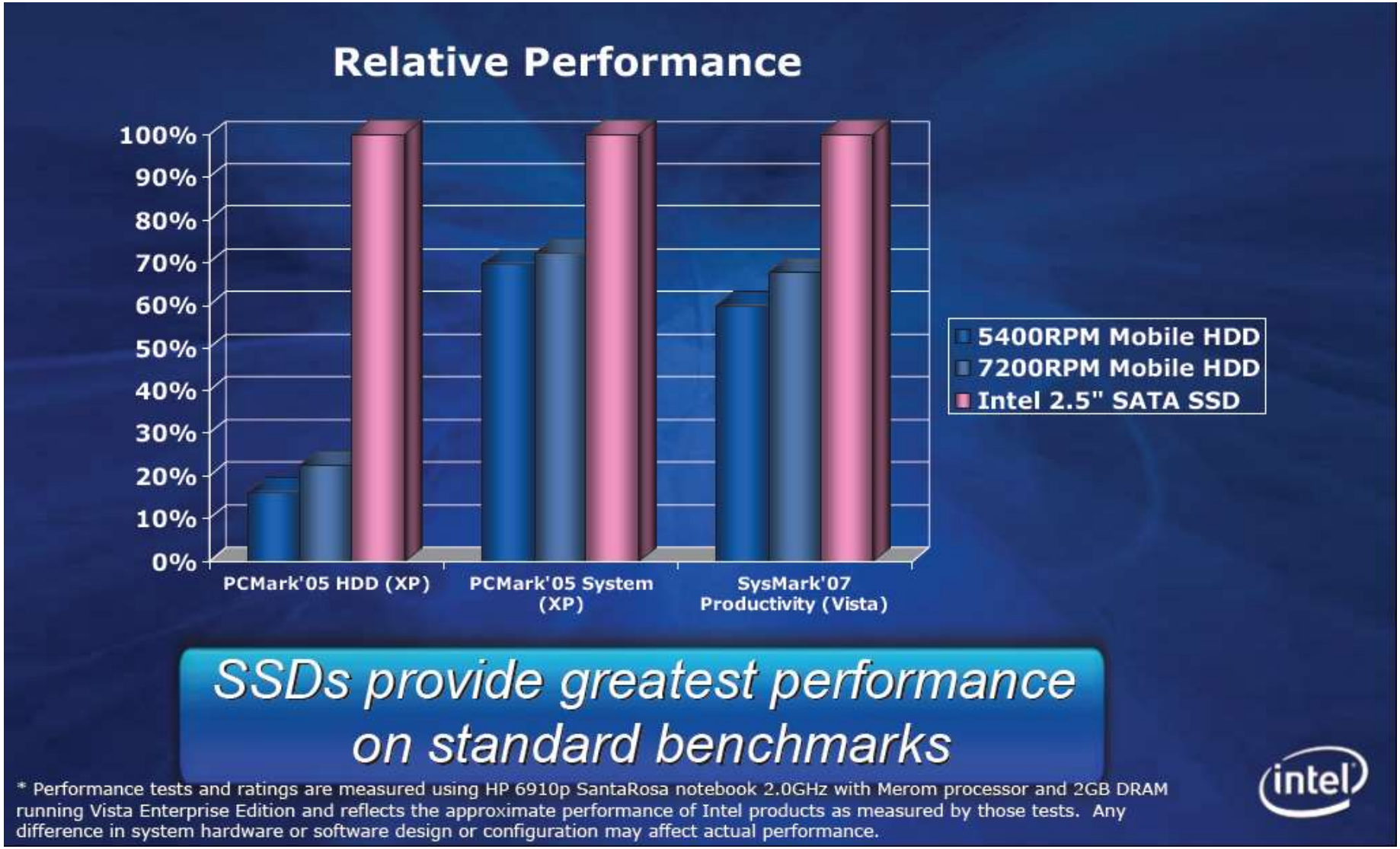
MLC
Two bits per cell



Performance Comparison HDD vs SSD



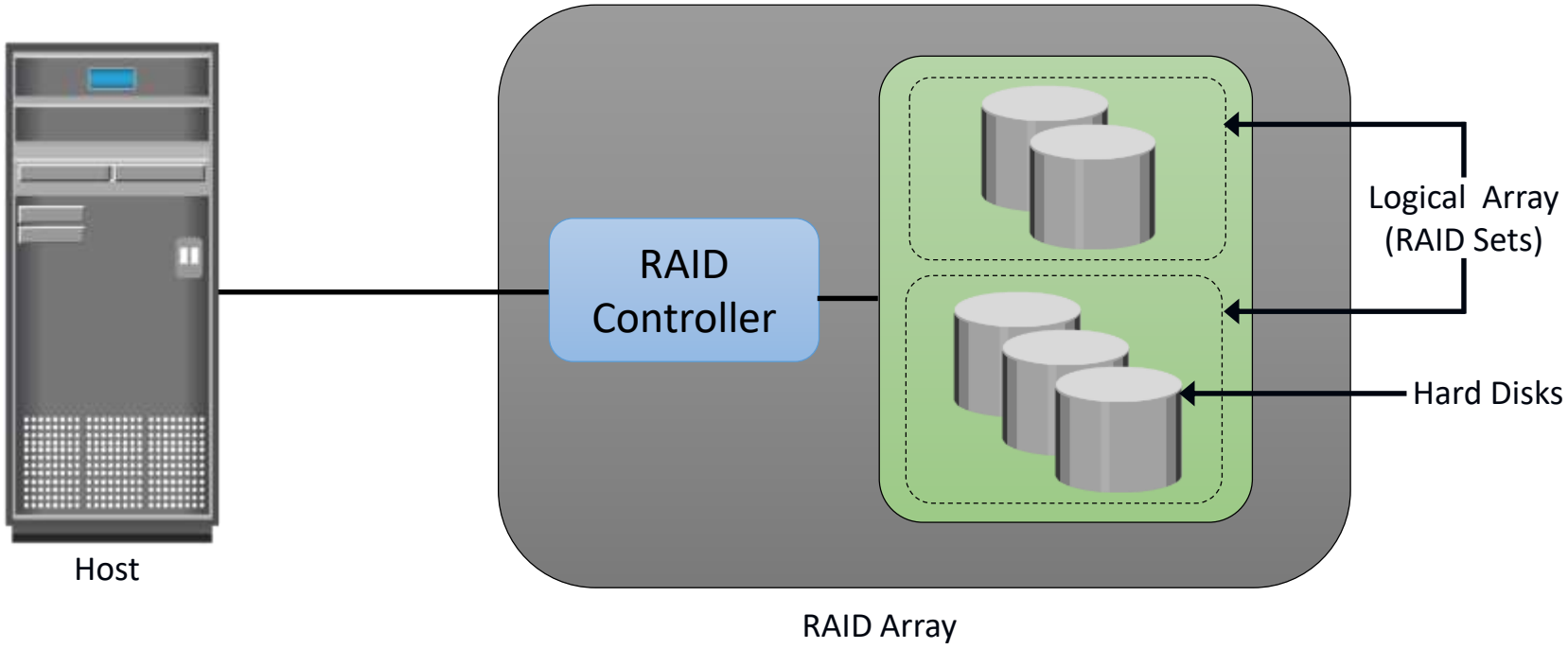
Performance Comparison HDD vs SSD



2

Introduction to RAID

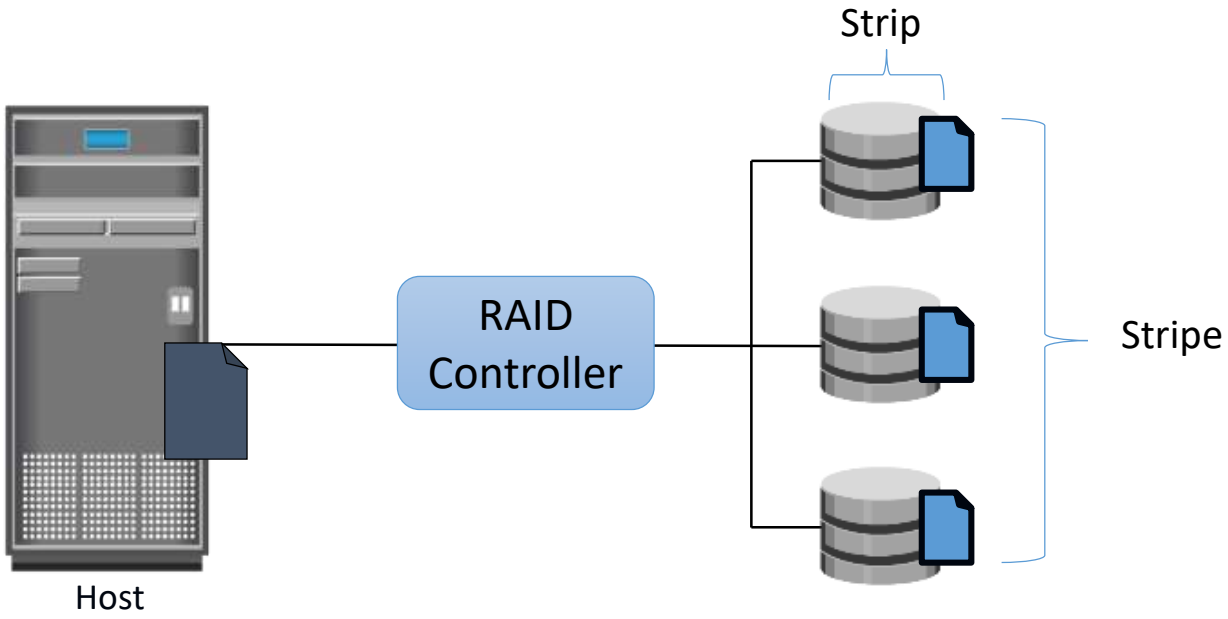
RAID Array Components



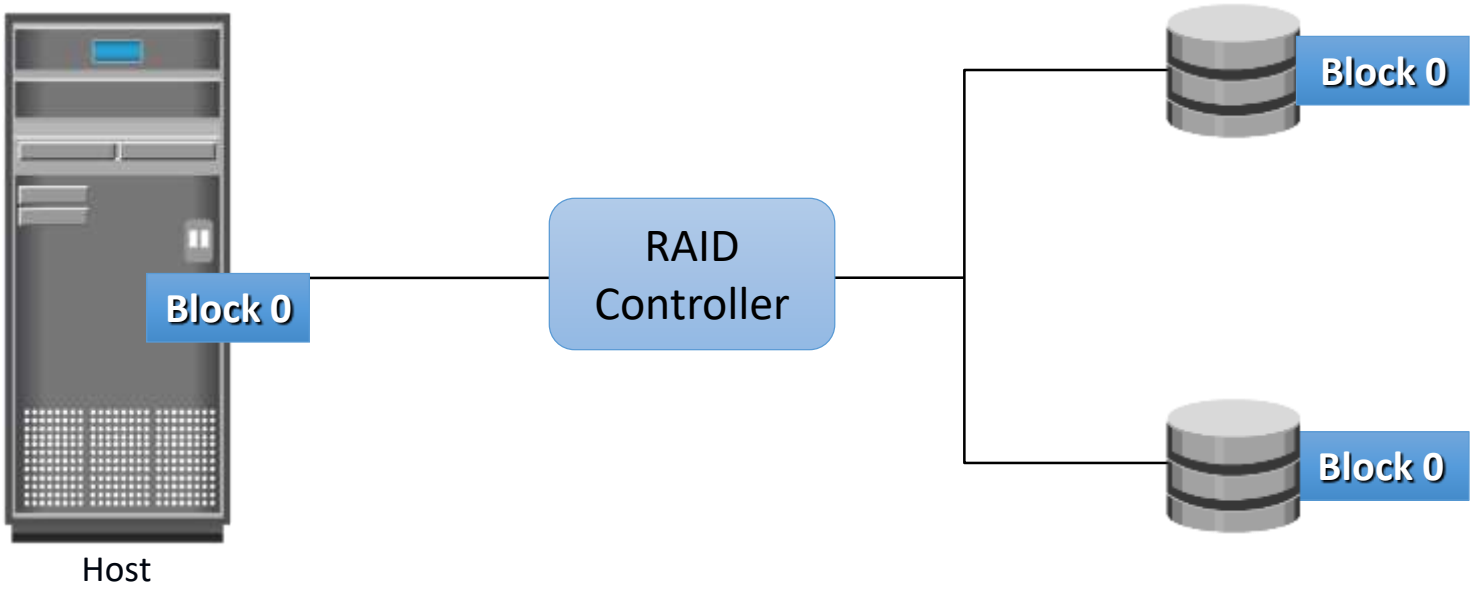
RAID Techniques

- Three key techniques used for RAID are:
  - Striping
  - Mirroring
  - Parity

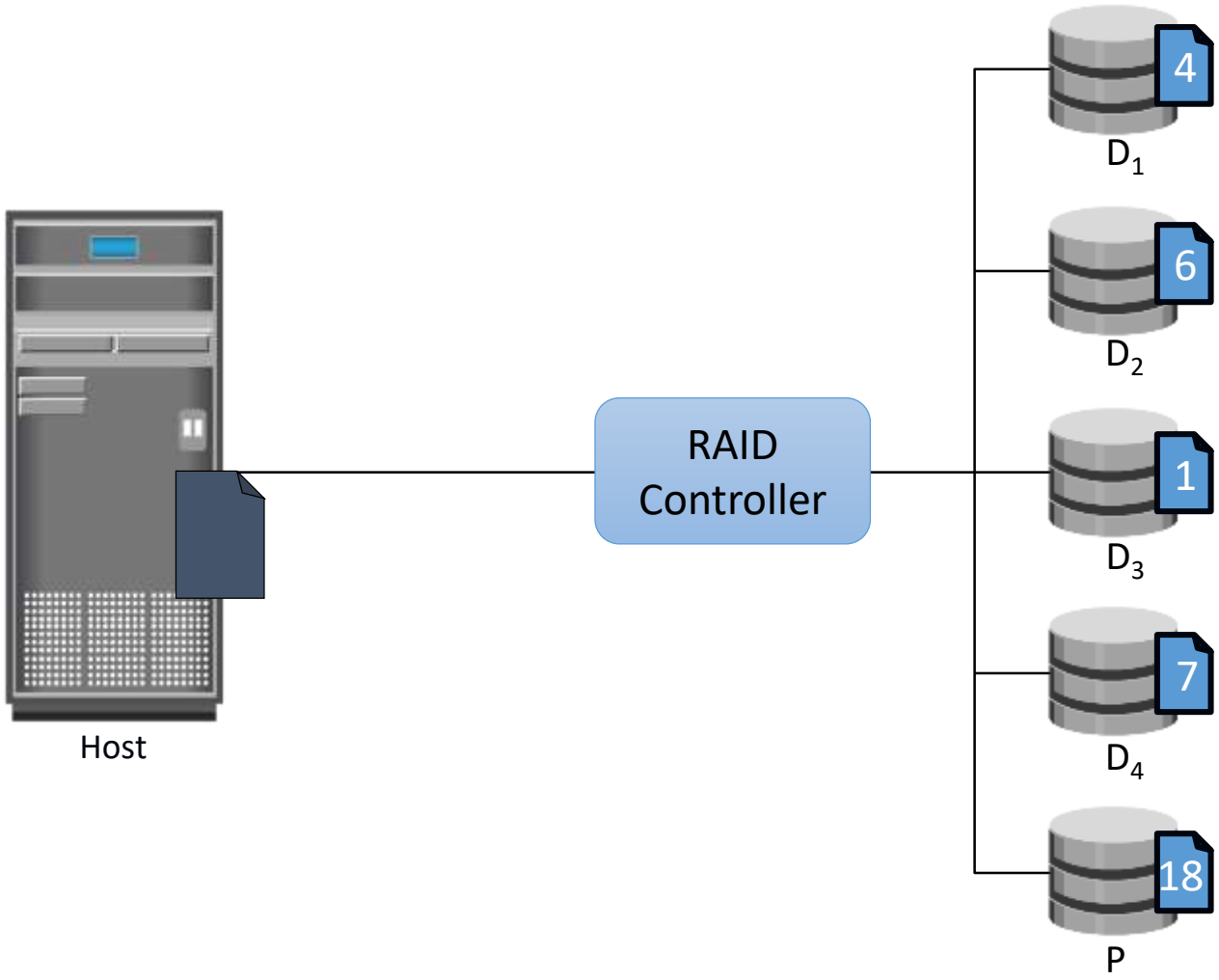
RAID Technique – Striping



RAID Technique – Mirroring

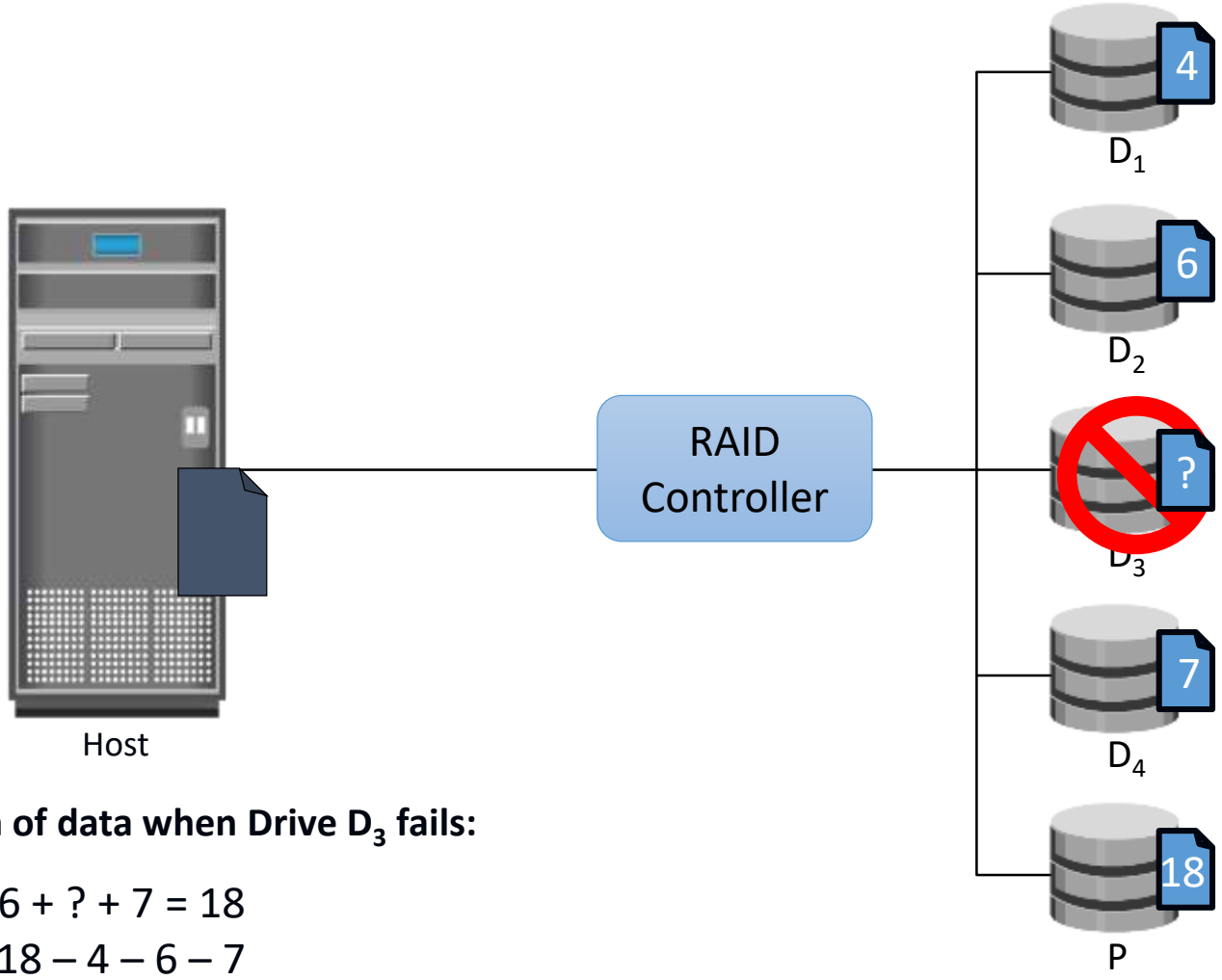


RAID Technique – Parity



Actual parity calculation is a bitwise XOR operation

Data Recovery in Parity Technique



Regeneration of data when Drive D_3 fails:

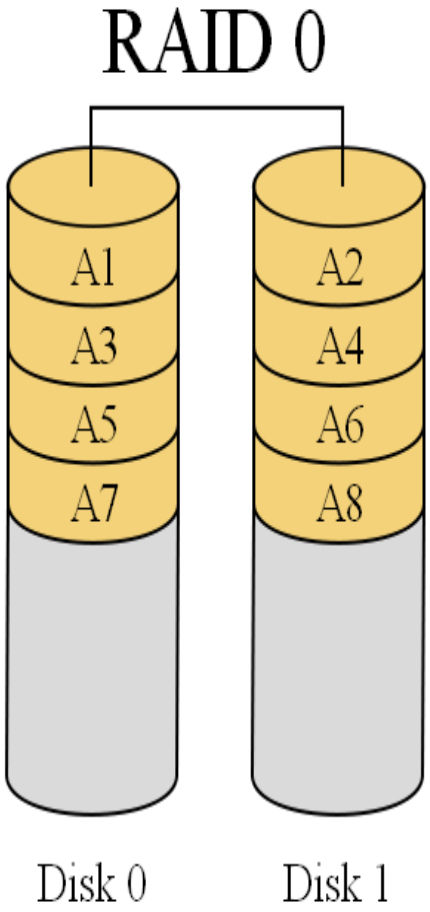
4 + 6 + ? + 7 = 18

? = 18 – 4 – 6 – 7

? = 1

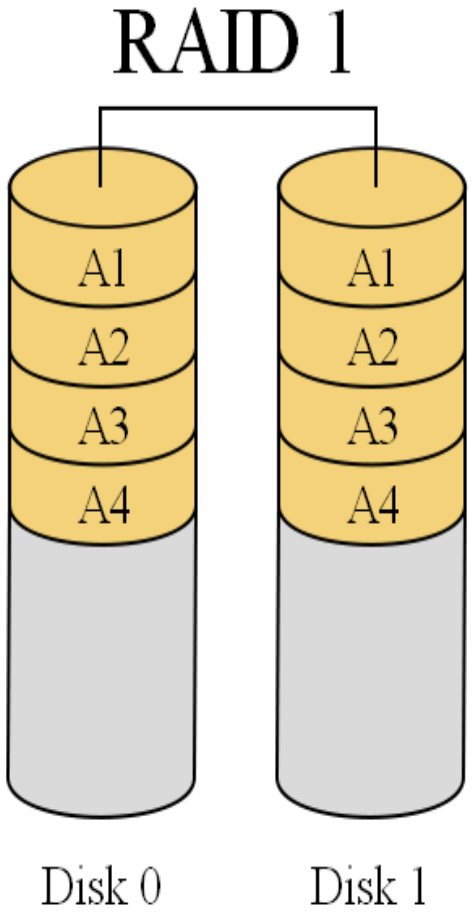
RAID-0

- It splits data among two or more disks.
- Provides good performance.
- Lack of data redundancy means there is no fail over support with this configuration.
- In the diagram to the right, the odd blocks are written to disk 0 and the even blocks to disk 1 such that A1, A2, A3, A4, … would be the order of blocks read if read sequentially from the beginning.
- Used in read only NFS systems and gaming systems.



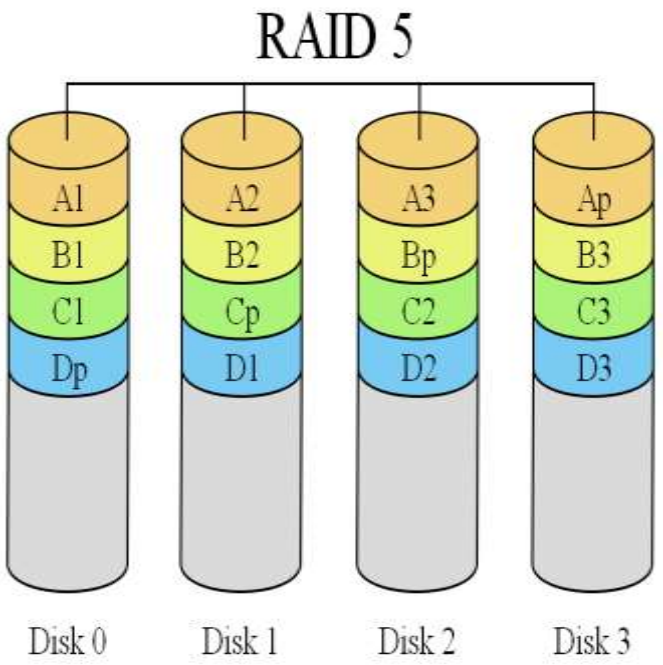
RAID-1

- RAID1 is ‘data mirroring’.
- Two copies of the data are held on two physical disks, and the data is always identical.
- Twice as many disks are required to store the same data when compared to RAID 0.
- Array continues to operate so long as at least one drive is functioning.



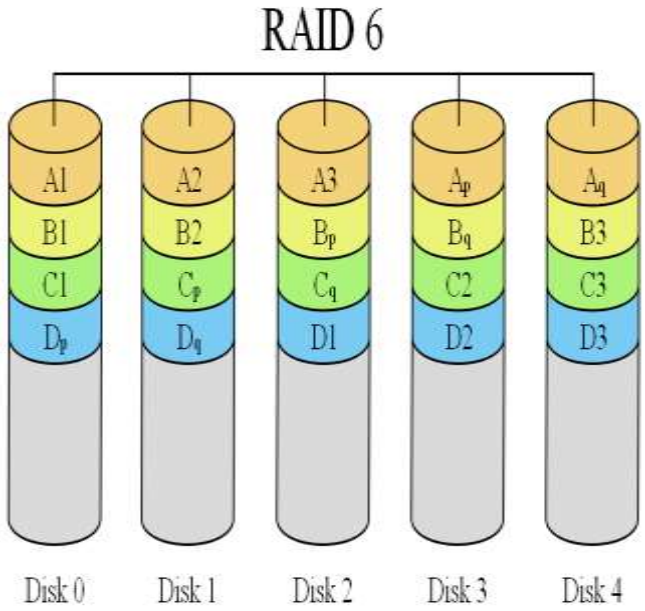
RAID-5

- RAID 5 is an ideal combination of good performance, good fault tolerance and high capacity and storage efficiency.
- An arrangement of parity and CRC to help rebuilding drive data in case of disk failures.
- “Distributed Parity” is the key word here.



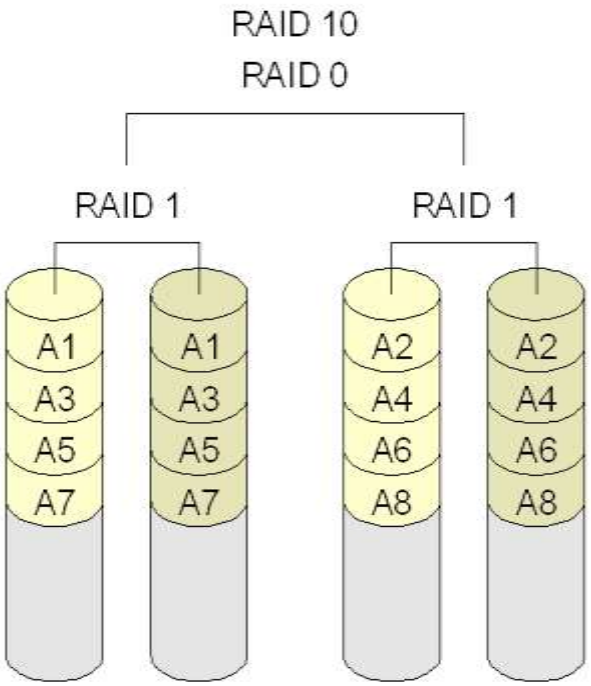
RAID-6

- It is seen as the best way to guarantee data integrity as it uses double parity.
- Lesser MTBF compared to RAID5.
- It has a drawback though of longer write time.



RAID-10

- Combines RAID 1 and RAID 0.
- Which means having the pleasure of both - good performance and good failover handling.
- Also called ‘Nested RAID’.



Implementations

Software based RAID:

- Software implementations are provided by many Operating Systems.
- A software layer sits above the disk device drivers and provides an abstraction layer between the logical drives(RAIDs) and physical drives.
- Server's processor is used to run the RAID software.
- Used for simpler configurations like RAID0 and RAID1.

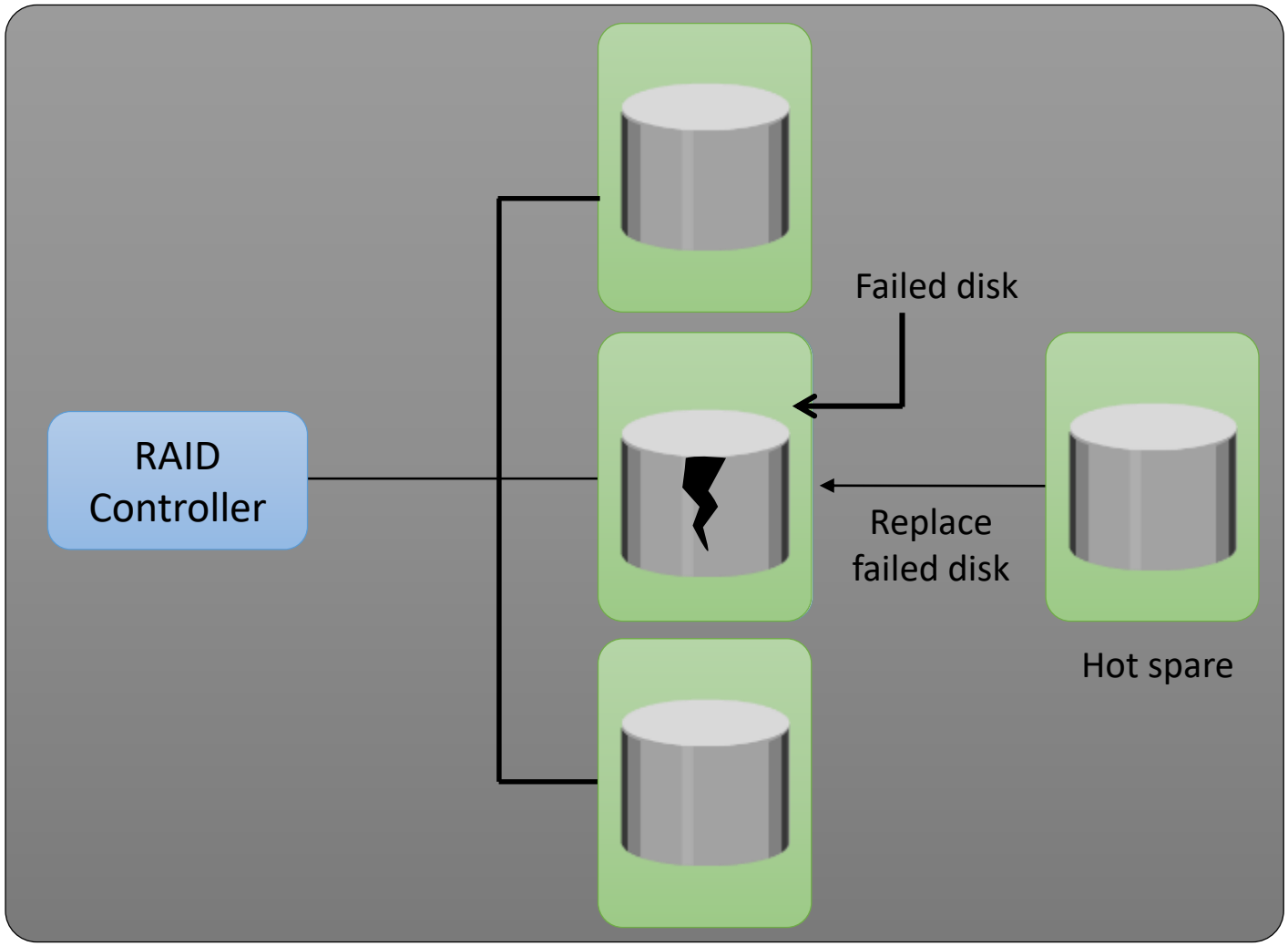
Implementations (Contd.)

A PCI-bus-based, IDE/ATA hard disk RAID controller, supporting levels 0, 1, and 01.

Hardware based RAID:

- A hardware implementation of RAID requires at least a special-purpose RAID controller.
- On a desktop system this may be built into the motherboard.
- Processor is not used for RAID calculations as a separate controller present.

Hot Spare



Thank you!