CS 3305A

Data Storage Systems

Lecture 19 & 20

Agenda

- Data Storage Intro
- Disk Mechanism and Access Time
- I/O Buses and I/O Controllers
- NAS and SAN
- Disk Scheduling
- RAID Structure

Long-term Information Storage

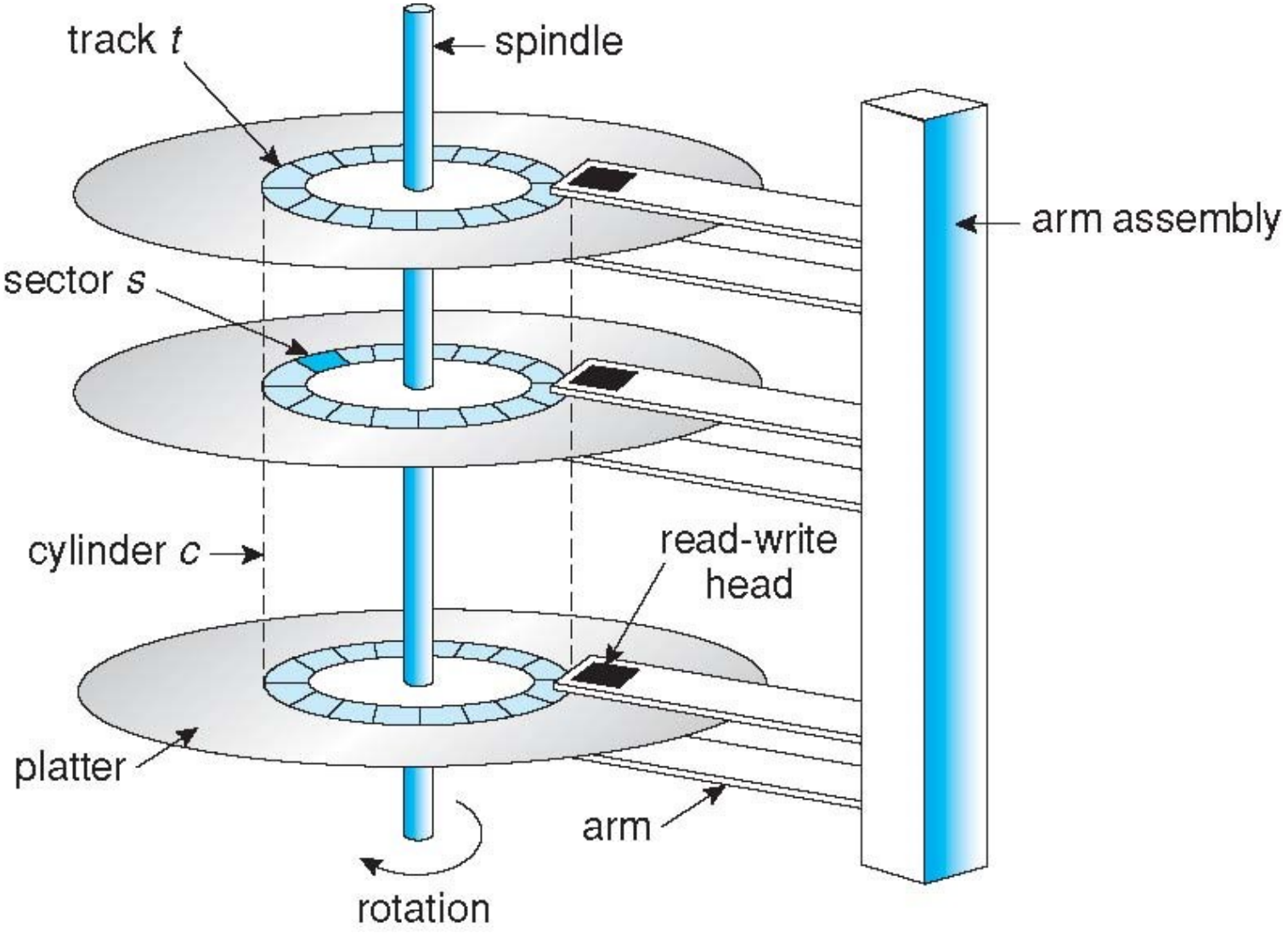
Three essential requirements:

- Must store large amounts of data
- Information stored must survive the termination of the process using it
- Multiple processes must be able to access the information concurrently

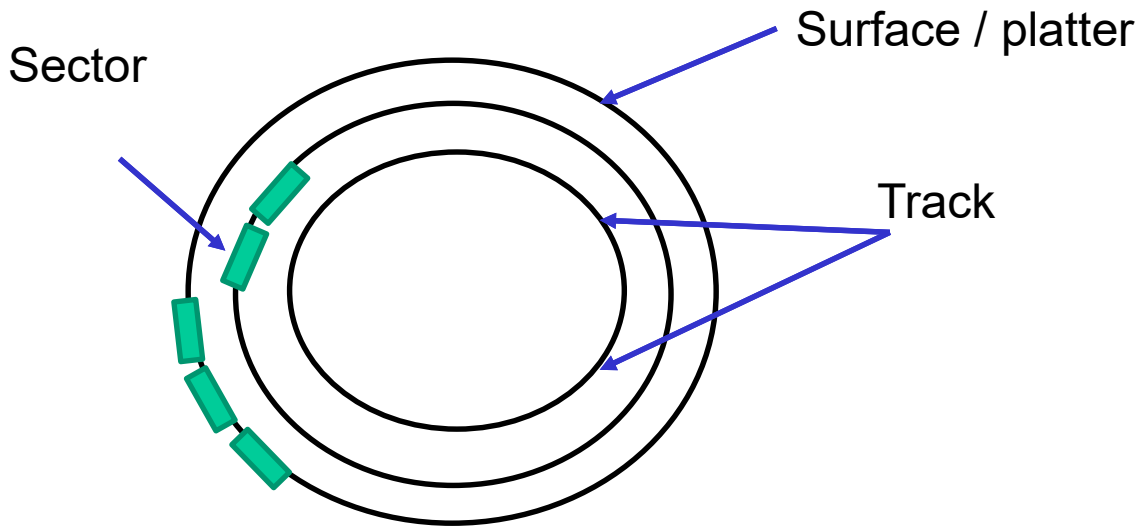
Examples of Mass Storage Strucutures

- Magnetic disks HDD and flash-memory based SSD secondary storage for modern computer systems (structure on next page)
- Magnetic tape was used as an early secondary-storage medium
  - Slow compared to magnetic disks and memory
  - Can hold large amounts of data
  - Read data sequentially
  - Mainly used for backup

Moving-head Disk Mechanism



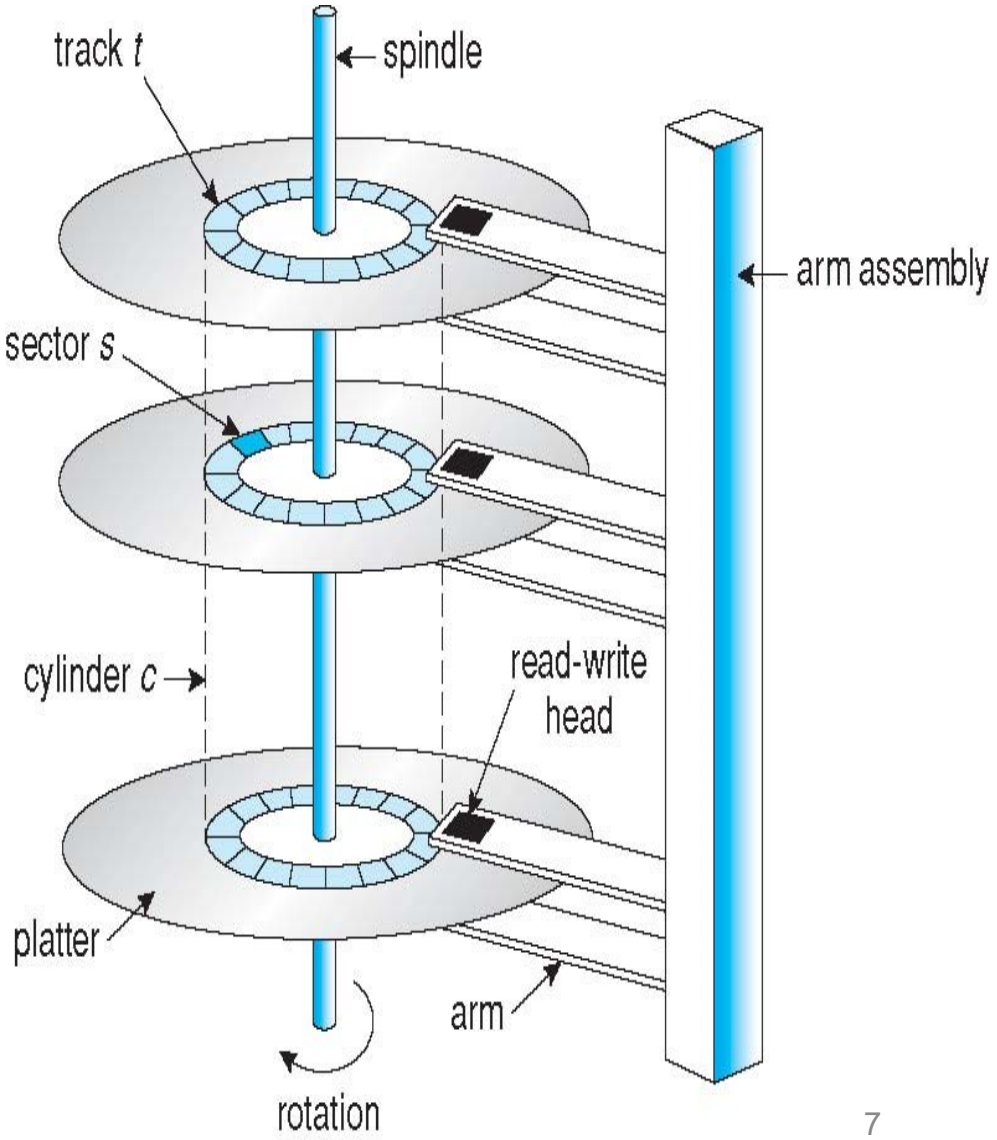
Disk Surface Layout



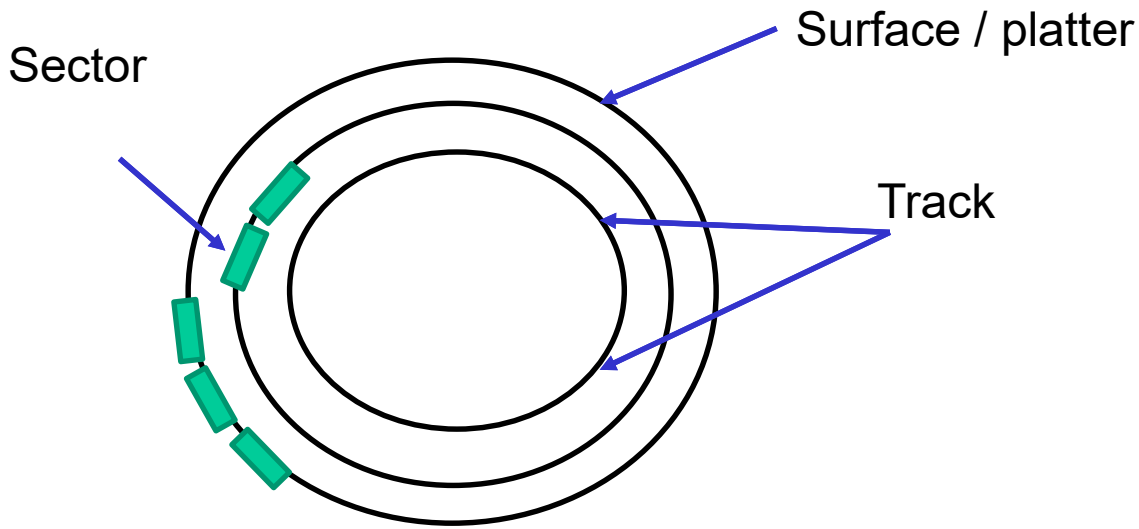
- Tracks: concentric rings on platter / surface
  - bits laid out serially on tracks
  - Track 0, 1, 2… etc
- Sectors: Each track is divided into a number of data blocks and each of these blocks are called sector
  - Usually each sector is 512 Bytes

Disk Pack: Multiple Disks

- Think of disks as a stack of platters
- On each side of a platter there is one arm with read-write head
- Cylinder = same track on each surface forms a Cylinder.
- # cylinders = # tracks



Disk Capacity



- Disk Size =

  (Number of surfaces * Number of tracks (or cylinders) per surface * Number of sectors per track) * size of each sector (in Bytes)

Solid-state Drive (SSD)

- A solid-state drive (SSD) is a solid-state storage device that uses integrated circuit assemblies to store data persistently, typically using flash memory, and functioning as secondary storage in the hierarchy of computer storage.

Item	HDD	SSD
Price	2-3 cents a GB based on 1 TB model	30 cents per GB based on 4TB model
Storage capacity	In 2018, 100TB	In 2018, 16TB
Reliability	Moving parts – potential failure/malfunction	No moving parts –high reliability
Random access	Much higher 2.9 – 12ms	Under 0.1
Power consumption	Half to a third of SSD	Much lower than HDD

Slide info source: https://en.wikipedia.org/wiki/Solid-state_drive

Reading/Writing

- Position the read/write heads over the correct track
- Rotate the disk platter until the desired sector is underneath the read/write head

Cost of Disk Operations

- Access Time: Composed of the following:
  - Seek time: The time to position head over correct track
  - Rotational time: The time for correct sector to rotate under disk head (disk rotates, not the RW head)
  - Transfer time: The time to transfer data
- Usually the seek time dominates
- Reducing seek time can improve system performance substantially

I/O Buses

- A disk drive is attached to a computer by a set of wires called an I/O bus.
- Types of I/O bus available:
  - Small computer-systems interface (SCSI): Mid 1980s
  - Parallel Advanced Technology Attachment P(ATA): Late 1980s
  - Serial ATA (SATA): 2003

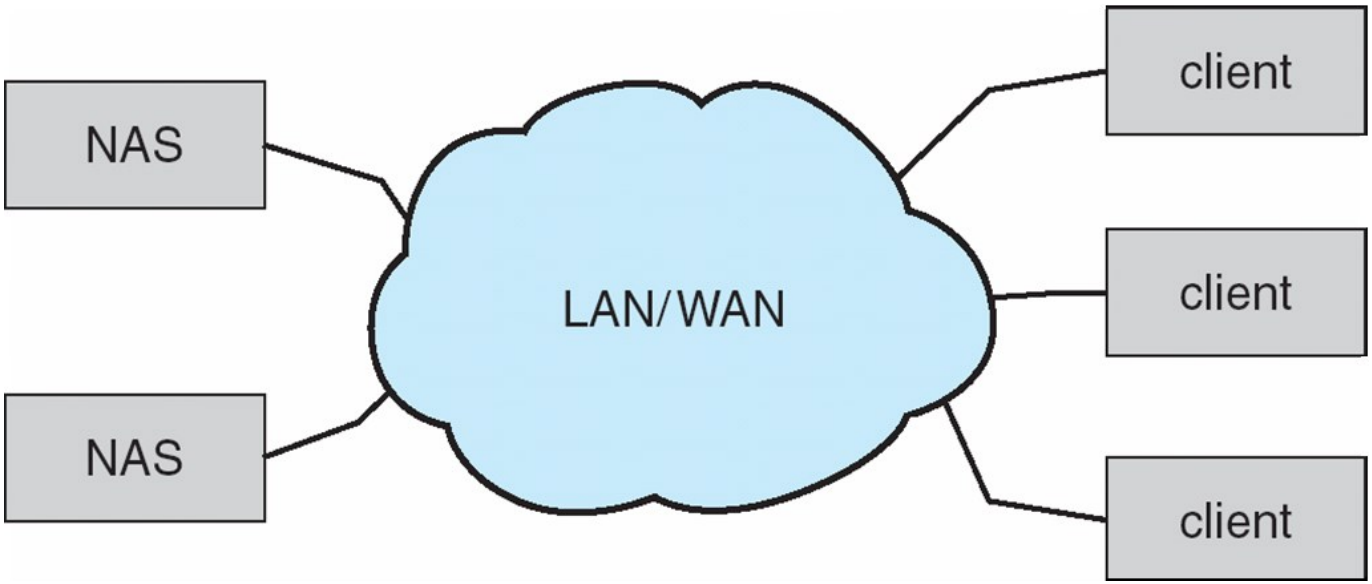
I/O Controllers

- The data transfers on a bus are carried out by special electronic processors called controllers
- The host controller is the controller at the computer end of the bus
- A disk controller is built into each disk drive

Networked Attached Storage

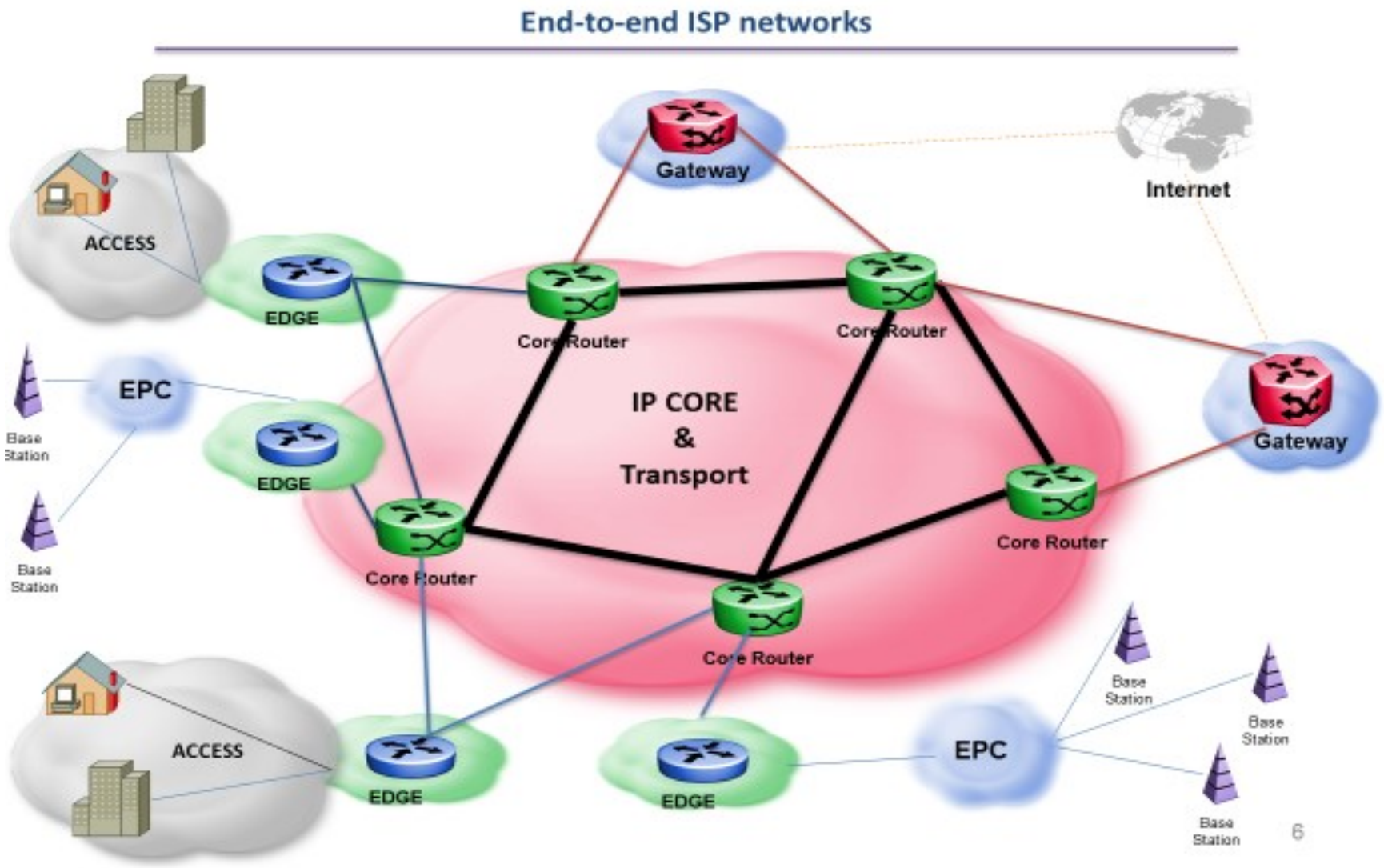
- Network-attached storage (NAS) is storage made available over a network rather than over a local connection
- Often a set of disks (storage array) are placed together
  - NFS (Network File Systems): Unix based network file systems introduced by Sun in 1984
  - CIFS (Common Internet File Systems) : Windows OS by Microsoft

Network-Attached Storage (NAS)



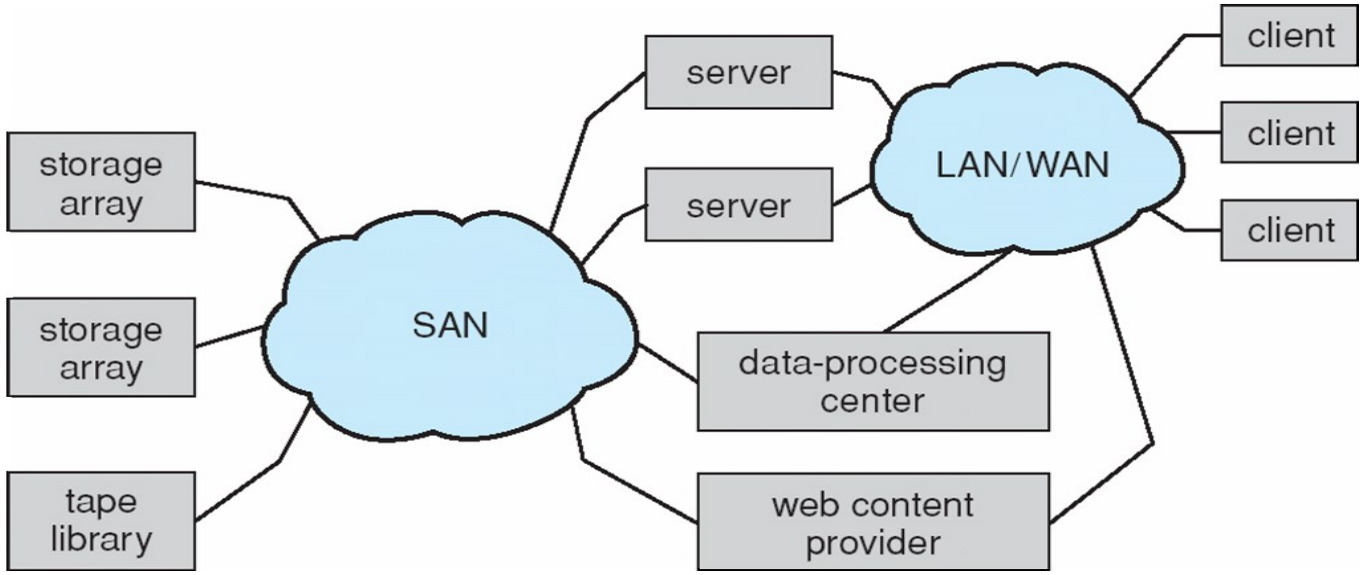
via NFS or CIFS

Today's ISP Network: An Example



Storage Area Network (SAN)

- Common in large storage environments (and becoming more common)



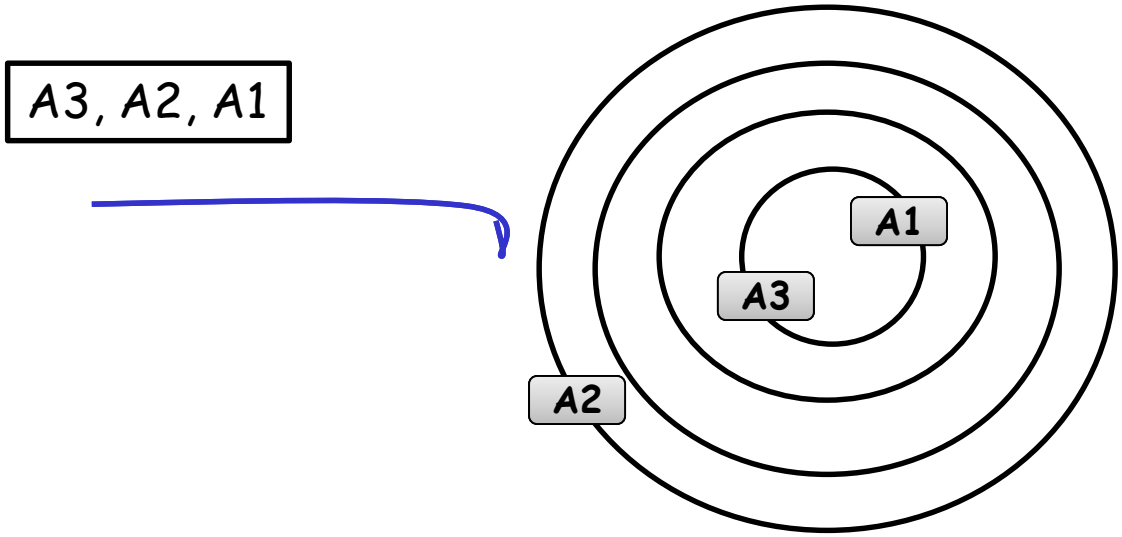
Disk Scheduling

- The disk accepts requests
  - What sort of disk arm scheduling algorithm is needed?
- The access time depends on the order in which disk I/O requests are serviced
- I/O requests include information such as:
  - Is the operation read/write
  - Disk address

First-Come, First-Served (FCFS)

- Method
  - First come first serve
- Pros
  - Fairness among requests
- Cons
  - Arrival may be on random spots on the disk (long seek time)

First-Come, First-Served (FCFS)



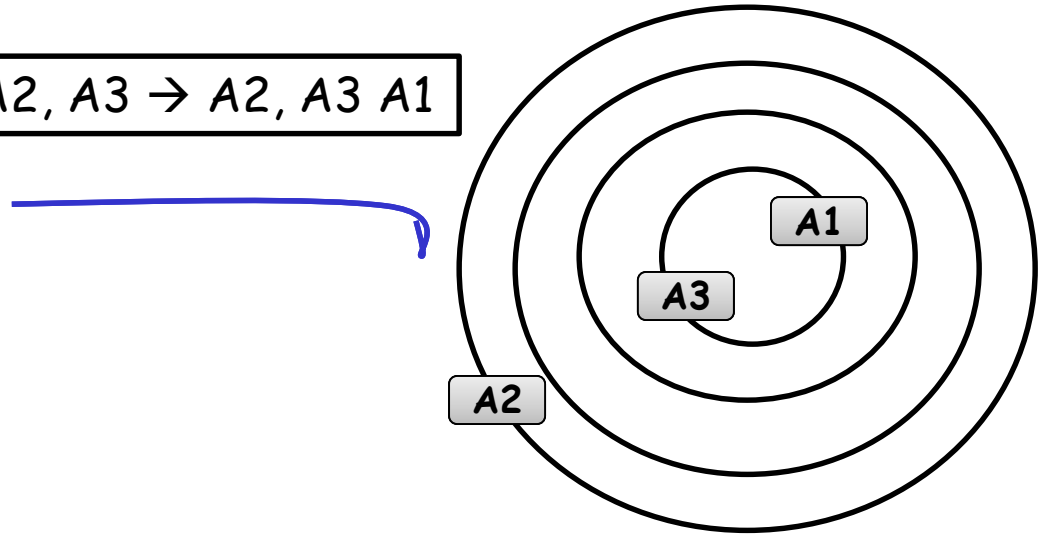
A1, A2, A3: 4 + 3 + 3 = 10 track distance

SSTF (Shortest Seek Time First)

- Method
  - Pick the one closest on disk
- Pros
  - Try to minimize seek time
- Cons
  - Starvation
- Often used

SSTF (Shortest Seek Time First)

A1, A2, A3 → A2, A3 A1



A2, A3, A1 = 1 + 3 + 0 = 4 track distance

Mass Storage

- Many systems today need to store large amounts of data
- Don't want to use single, large disk
  - too expensive
  - failures could be catastrophic
- Would prefer to use many smaller disks

Redundant Array of Independent Disks (RAID) Structure

- Using multiple disks attached to a computer system has these benefits:
  - Improve the rate at which data can be read or written
  - Improve reliability of data storage
    - Redundant information can be stored on multiple disks
- RAID – multiple disk drives provides reliability via redundancy.

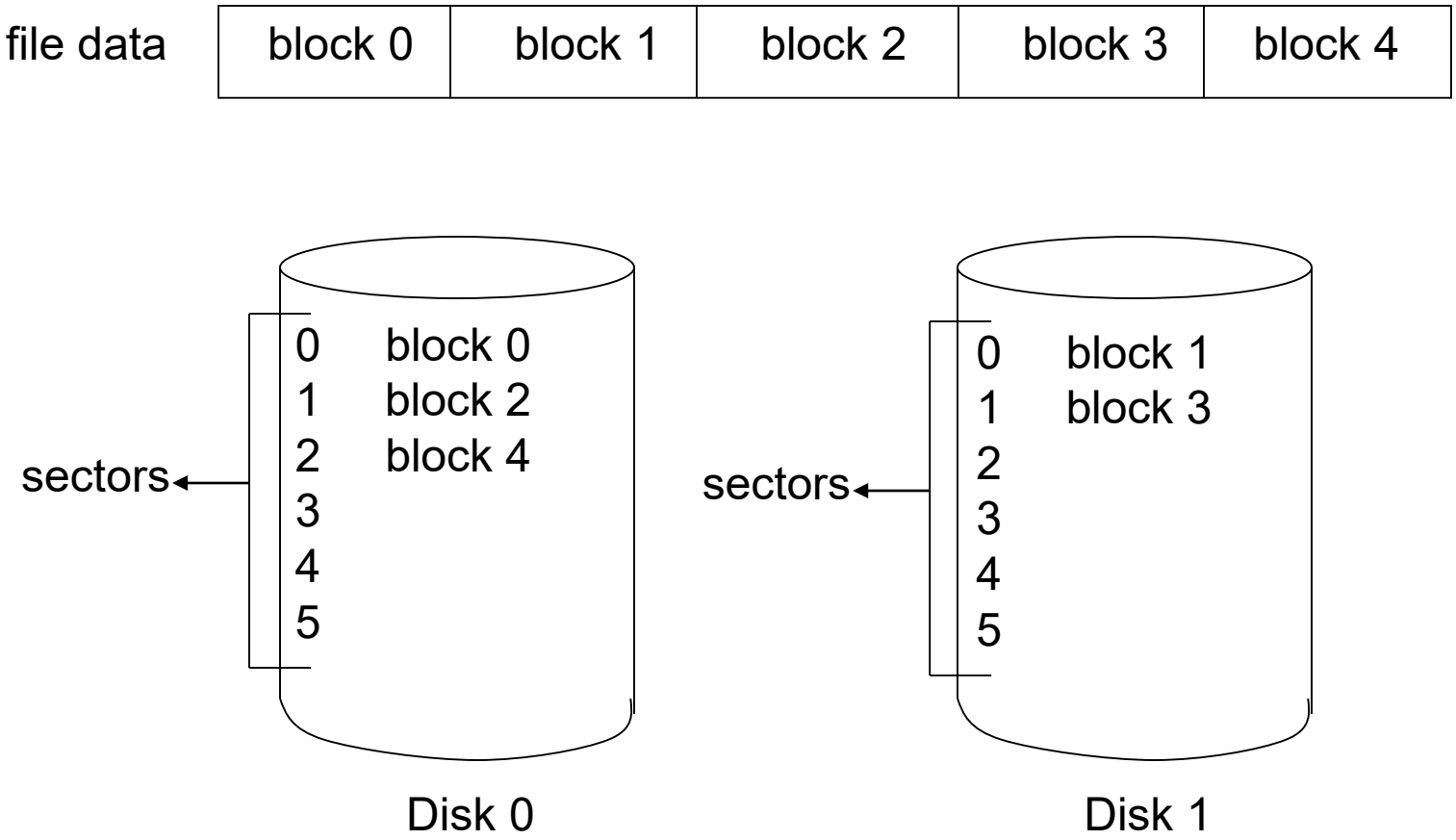
RAID Structure

- Improve performance via parallelism
- Improve reliability via information redundancy

RAID Structure

- Different schemes to provide redundancy at low cost and high performance have been proposed
- These schemes are classified into RAID levels

RAID Level-0


file data
block 0
block 1
block 2
block 3
block 4
sectors
0
1
2
3
4
5
block 0
block 2
block 4
Disk 0
sectors
0
1
2
3
4
5
block 1
block 3
Disk 1

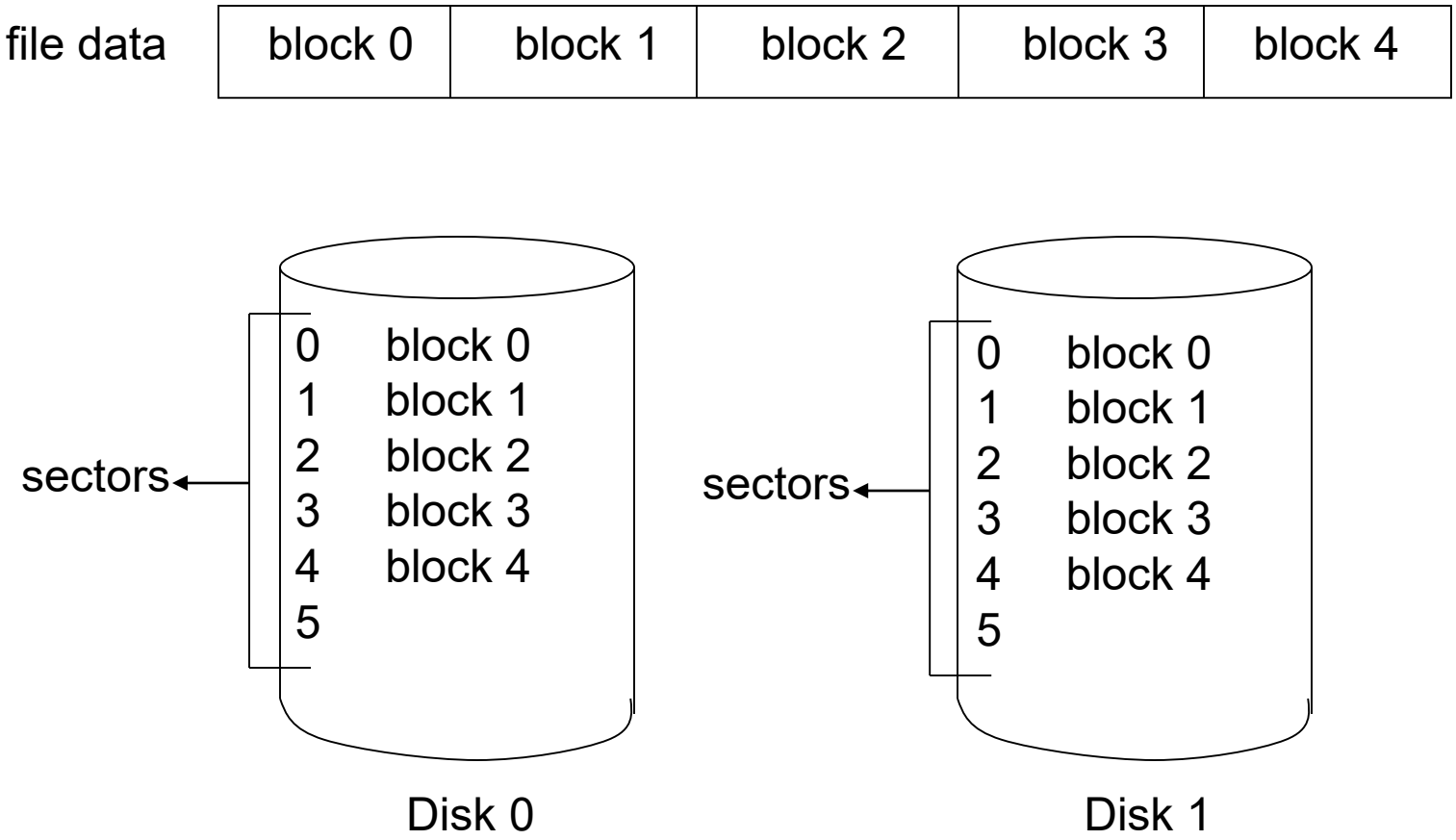
RAID Level-0

- Break a file into blocks of data
- Allocate the blocks across disks in the system
- Provides no redundancy and error corrections
- Uses
  - Some gaming systems where fast reads are required but minimal data integrity is needed

RAID Level 0

- No redundancy
  - No reliability
  - Loss of one disk means all is lost
- Can be very fast since data is being accessed in parallel
- Suitable for cases where speed is important but redundancy is not necessary

RAID Level-1


file data
block 0
block 1
block 2
block 3
block 4
sectors
0
1
2
3
4
5
block 0
block 1
block 2
block 3
block 4
Disk 0
sectors
0
1
2
3
4
5
block 0
block 1
block 2
block 3
block 4
Disk 1

RAID Level-1

- A complete file is stored on a single disk
- A second disk contains an exact copy of the file
- Provides complete redundancy of data
- Lose one disk you are ok
- Write performance suffers
  - Must write the data out twice
- Most expensive RAID implementation
  - requires twice as much storage space

RAID Level-1

- Read performance as good as RAID-0
- The redundancy is good but it does come up at a high cost
- Mission-critical missions use this level