

William Stallings

Computer Organization

and Architecture

Chapter 5

External Memory

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Types of External Memory

⌘ Magnetic Disk

- ☑ RAID

- ☑ Removable

⌘ Optical

- ☑ CD-ROM

- ☑ CD-Writable (WORM)

- ☑ CD-R/W

- ☑ DVD

⌘ Magnetic Tape

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Magnetic Disk

- ⌘ Metal or plastic disk coated with magnetizable material (iron oxide...rust)
- ⌘ Range of packaging
 - ☑ Floppy
 - ☑ Winchester hard disk
 - ☑ Removable hard disk

Data Organization and Formatting

⌘ Concentric rings or tracks

- ☑ Gaps between tracks
- ☑ Reduce gap to increase capacity
- ☑ Same number of bits per track (variable packing density)
- ☑ Constant angular velocity

⌘ Tracks divided into sectors

⌘ Minimum block size is one sector

⌘ May have more than one sector per block

Disk Data Layout

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Fixed/Movable Head Disk

⌘ Fixed head

- ☑ One read write head per track
- ☑ Heads mounted on fixed ridged arm

⌘ Movable head

- ☑ One read write head per side
- ☑ Mounted on a movable arm

Fixed and Movable Heads

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Removable or Not

⌘ Removable disk

- ☑ Can be removed from drive and replaced with another disk
- ☑ Provides unlimited storage capacity
- ☑ Easy data transfer between systems

⌘ Nonremovable disk

- ☑ Permanently mounted in the drive

Floppy Disk

⌘ 8", 5.25", 3.5"

⌘ Small capacity

☑ Up to 1.44Mbyte (2.88M never popular)

⌘ Slow

⌘ Universal

⌘ Cheap

Winchester Hard Disk (1)

- ⌘ Developed by IBM in Winchester (USA)
- ⌘ Sealed unit
- ⌘ One or more platters (disks)
- ⌘ Heads fly on boundary layer of air as disk spins
- ⌘ Very small head to disk gap
- ⌘ Getting more robust

Winchester Hard Disk (2)

- ⌘ Universal
- ⌘ Cheap
- ⌘ Fastest external storage
- ⌘ Getting larger all the time
 - ☑ Multiple Gigabyte now usual

Removable Hard Disk

⌘ ZIP

- ☑ Cheap
- ☑ Very common
- ☑ Only 100M

⌘ JAZ

- ☑ Not cheap
- ☑ 1G

⌘ L-120 (a: drive)

- ☑ Also reads 3.5" floppy
- ☑ Becoming more popular?

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Finding Sectors

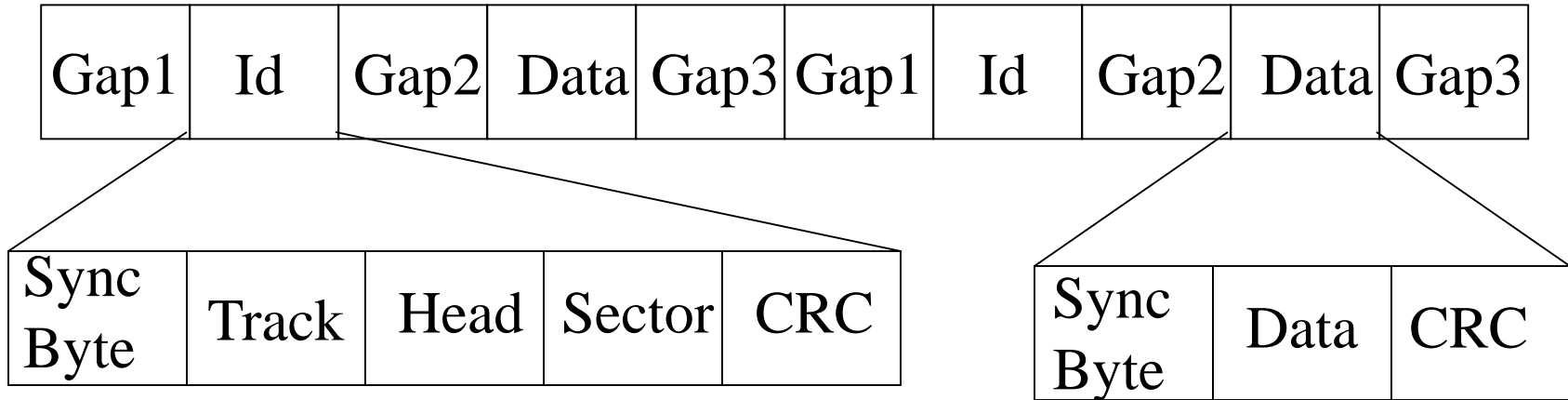
⌘ Must be able to identify start of track and sector

⌘ Format disk

Additional information not available to user

Marks tracks and sectors

ST506 format (old!)



⌘ Foreground reading

☑ Find others

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Characteristics

- ⌘ Fixed (rare) or movable head
- ⌘ Removable or fixed
- ⌘ Single or double (usually) sided
- ⌘ Single or multiple platter
- ⌘ Head mechanism
 - ☑ Contact (Floppy)
 - ☑ Fixed gap
 - ☑ Flying (Winchester)

Multiple Platter

- ⌘ One head per side
- ⌘ Heads are joined and aligned
- ⌘ Aligned tracks on each platter form cylinders
- ⌘ Data is striped by cylinder
 - ☑ reduces head movement
 - ☑ Increases speed (transfer rate)

Speed

⌘ Seek time

☑ Moving head to correct track

⌘ (Rotational) latency

☑ Waiting for data to rotate under head

⌘ Access time = Seek + Latency

⌘ Transfer rate

RAID

- ⌘ Redundant Array of Independent Disks
- ⌘ Redundant Array of Inexpensive Disks
- ⌘ 6 levels in common use
- ⌘ Not a hierarchy
- ⌘ Set of physical disks viewed as single logical drive by O/S
- ⌘ Data distributed across physical drives
- ⌘ Can use redundant capacity to store parity information

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RAID 0

- ⌘ No redundancy
- ⌘ Data striped across all disks
- ⌘ Round Robin striping
- ⌘ Increase speed
 - ☑ Multiple data requests probably not on same disk
 - ☑ Disks seek in parallel
 - ☑ A set of data is likely to be striped across multiple disks

RAID 1

- ⌘ Mirrored Disks
- ⌘ Data is striped across disks
- ⌘ 2 copies of each stripe on separate disks
- ⌘ Read from either
- ⌘ Write to both
- ⌘ Recovery is simple
 - ☑ Swap faulty disk & re-mirror
 - ☑ No down time
- ⌘ Expensive

RAID 2

- ⌘ Disks are synchronized
- ⌘ Very small stripes
 - ☑ Often single byte/word
- ⌘ Error correction calculated across corresponding bits on disks
- ⌘ Multiple parity disks store Hamming code error correction in corresponding positions
- ⌘ Lots of redundancy
 - ☑ Expensive
 - ☑ Not used

RAID 3

- ⌘ Similar to RAID 2
- ⌘ Only one redundant disk, no matter how large the array
- ⌘ Simple parity bit for each set of corresponding bits
- ⌘ Data on failed drive can be reconstructed from surviving data and parity info
- ⌘ Very high transfer rates

RAID 4

- ⌘ Each disk operates independently
- ⌘ Good for high I/O request rate
- ⌘ Large stripes
- ⌘ Bit by bit parity calculated across stripes on each disk
- ⌘ Parity stored on parity disk

RAID 5

- ⌘ Like RAID 4
- ⌘ Parity striped across all disks
- ⌘ Round robin allocation for parity stripe
- ⌘ Avoids RAID 4 bottleneck at parity disk
- ⌘ Commonly used in network servers

- ⌘ N.B. DOES NOT MEAN 5 DISKS!!!!

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Optical Storage CD-ROM

- ⌘ Originally for audio
- ⌘ 650Mbytes giving over 70 minutes audio
- ⌘ Polycarbonate coated with highly reflective coat, usually aluminum
- ⌘ Data stored as pits
- ⌘ Read by reflecting laser
- ⌘ Constant packing density
- ⌘ Constant linear velocity

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CD-ROM Drive Speeds

⌘ Audio is single speed

☑ Constant linear velocity

☑ 1.2 ms^{-1}

☑ Track (spiral) is 5.27km long

☑ Gives 4391 seconds = 73.2 minutes

⌘ Other speeds are quoted as multiples

⌘ e.g. 24x

⌘ The quoted figure is the maximum the drive can achieve

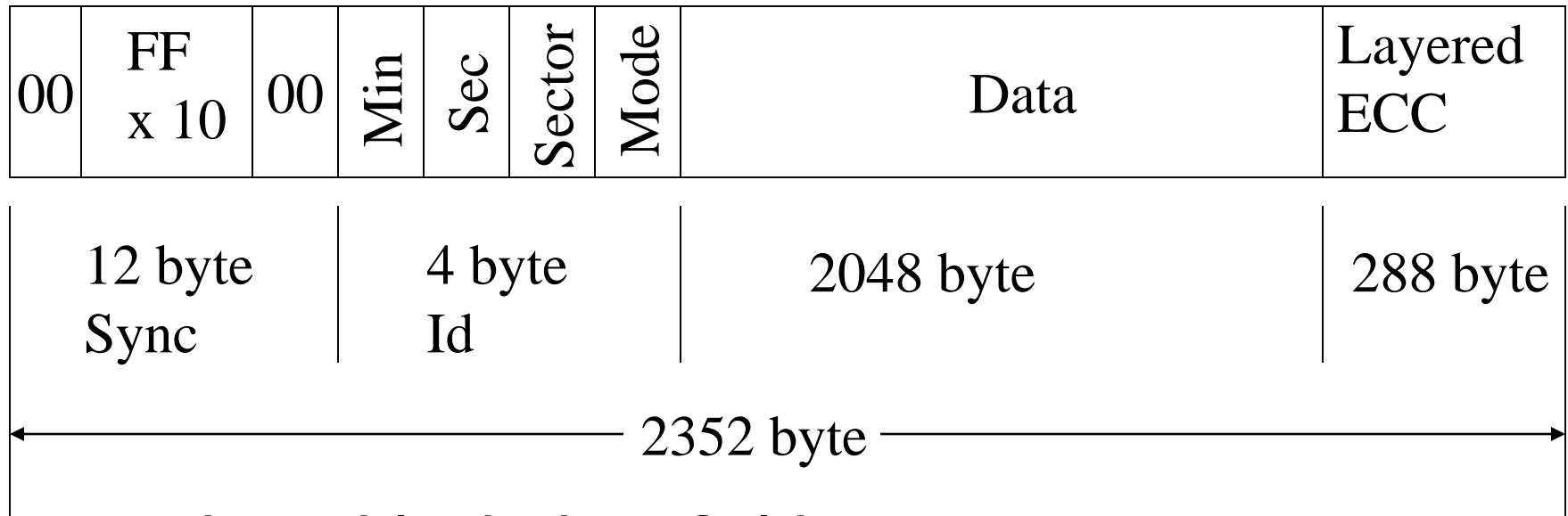
Comparison of Disk Layouts

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CD-ROM Format



- ⌘ Mode 0=blank data field
- ⌘ Mode 1=2048 byte data+error correction
- ⌘ Mode 2=2336 byte data

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Random Access on CD-ROM

- ⌘ Difficult
- ⌘ Move head to rough position
- ⌘ Set correct speed
- ⌘ Read address
- ⌘ Adjust to required location
- ⌘ (Yawn!)

CD-ROM for & against

- ⌘ Large capacity (?)
- ⌘ Easy to mass produce
- ⌘ Removable
- ⌘ Robust

- ⌘ Expensive for small runs
- ⌘ Slow
- ⌘ Read only

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Other Optical Storage

⌘ CD-Writable

- ☑ WORM

- ☑ Now affordable

- ☑ Compatible with CD-ROM drives

⌘ CD-RW

- ☑ Erasable

- ☑ Getting cheaper

- ☑ Mostly CD-ROM drive compatible

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DVD - what's in a name?

⌘ Digital Video Disk

☑ Used to indicate a player for movies

☒ Only plays video disks

⌘ Digital Versatile Disk

☑ Used to indicate a computer drive

☒ Will read computer disks and play video disks

⌘ Dogs Veritable Dinner

⌘ Officially - nothing!!!

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DVD - technology

- ⌘ Multi-layer
- ⌘ Very high capacity (4.7G per layer)
- ⌘ Full length movie on single disk
 - ☑ Using MPEG compression
- ⌘ Finally standardized (honest!)
- ⌘ Movies carry regional coding
- ⌘ Players only play correct region films
- ⌘ Can be “fixed”

DVD - Writable

- ⌘ Loads of trouble with standards
- ⌘ First generation DVD drives may not read first generation DVD-W disks
- ⌘ First generation DVD drives may not read CD-RW disks
- ⌘ Wait for it to settle down before buying!

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Foreground Reading

- ⌘ Check out optical disk storage options
- ⌘ Check out Mini Disk

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Magnetic Tape

- ⌘ Serial access
- ⌘ Slow
- ⌘ Very cheap
- ⌘ Backup and archive

Digital Audio Tape (DAT)

- ⌘ Uses rotating head (like video)
- ⌘ High capacity on small tape
 - ☑ 4Gbyte uncompressed
 - ☑ 8Gbyte compressed
- ⌘ Backup of PC/network servers