

6. External Memory

punched card, paper tape, magnetic tape

Magnetic Disk

History

- o 1956 IBM RAMAC
 - 24 inch, 50 platters, 50,000 characters/surface
 - 1 second access time, 1 ton, \$millions for lease
- o 2000 IBM disk for palmtop computer/digital camera
 - 1 inch, 1 G byte
 - 15 ms access time, \$300

Types

- (1) Fixed (Rigid/Hard) Disks
 - maximum 15,000 rpm (5400rpm or 7200 rpm)
- (2) Flexible (Floppy)
 - head touches the surface
 - 300 rpm or 360 rpm
 - 3.5" 1.44 MB Dos/Windows diskette
 - 18 sectors/track, 80 tracks/surface, 512 data bytes
- (3) Winchester Disks (Seagate ST 506)
 - IBM 1974
 - 30 MB
 - access time: 30 ms

Head Motion	Platters
Fixed head (one per track)	Single platter
Movable head (one per surface)	Multiple platter
Disk Portability	Head Mechanism
Nonremovable disk	Contact (floppy)
Removable disk	Fixed gap
	Aerodynamic gap (Winchester)
Sides	
Single sided	
Double sided	

Table 6.1 Physical Characteristics of Disk Systems

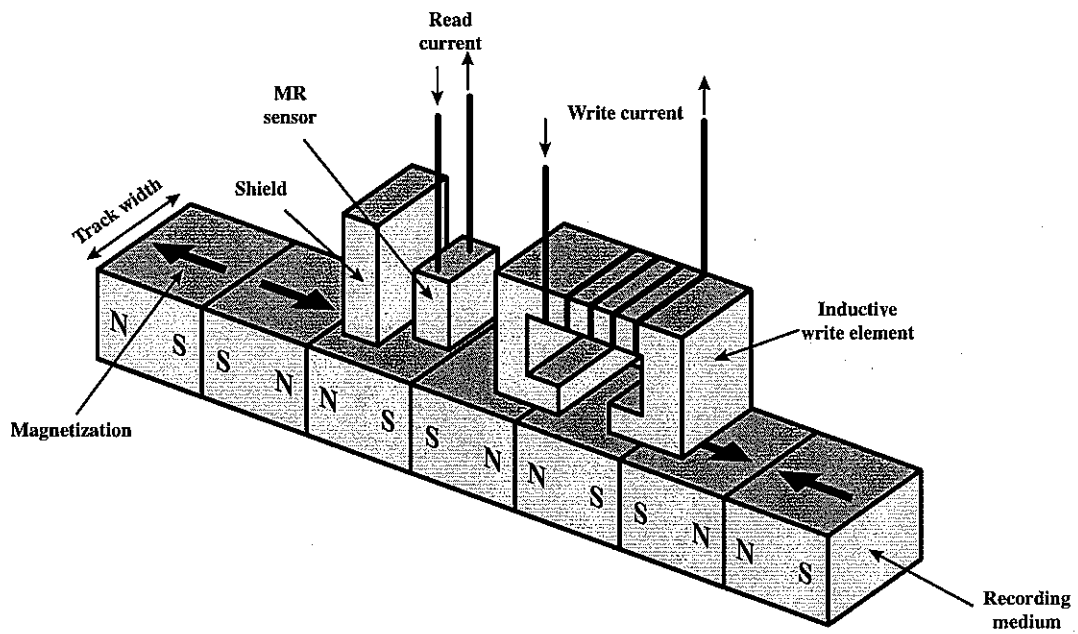


Figure 6.1 Inductive Write/Magnetostrictive Read Head

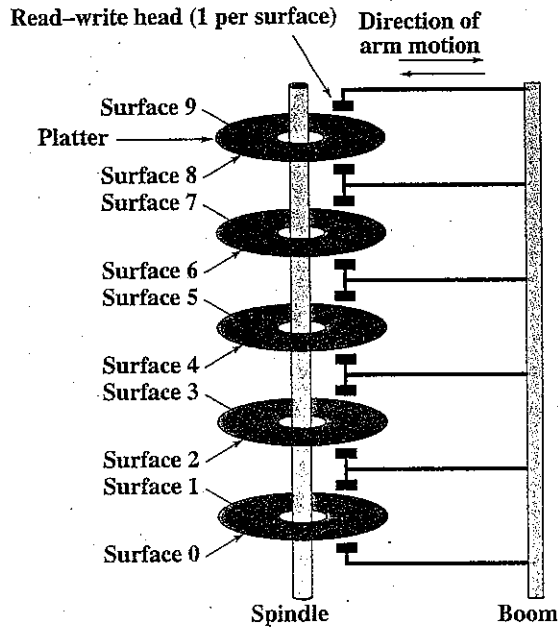


Figure 6.5 Components of a Disk Drive

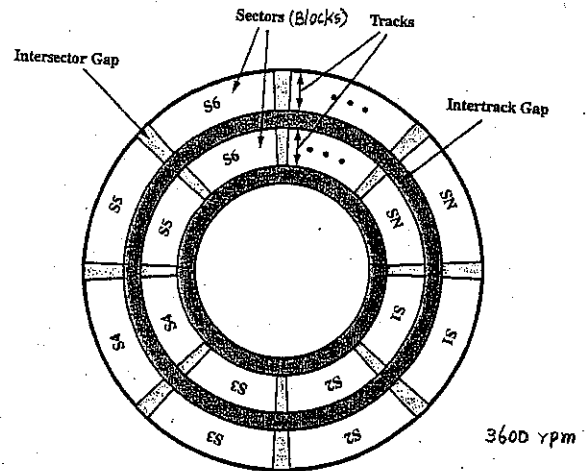


Figure 6.2 Disk Data Layout.

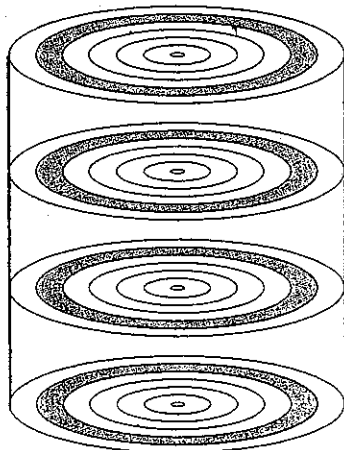
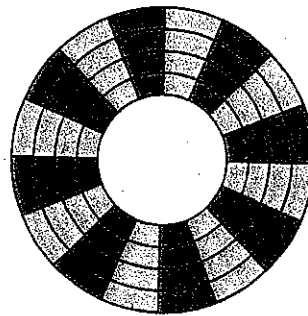
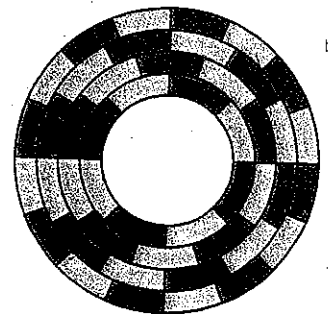


Figure 6.6 Tracks and Cylinders



(a) Constant angular velocity



(b) Multiple zoned recording

Figure 6.3 Comparison of Disk Layout Methods

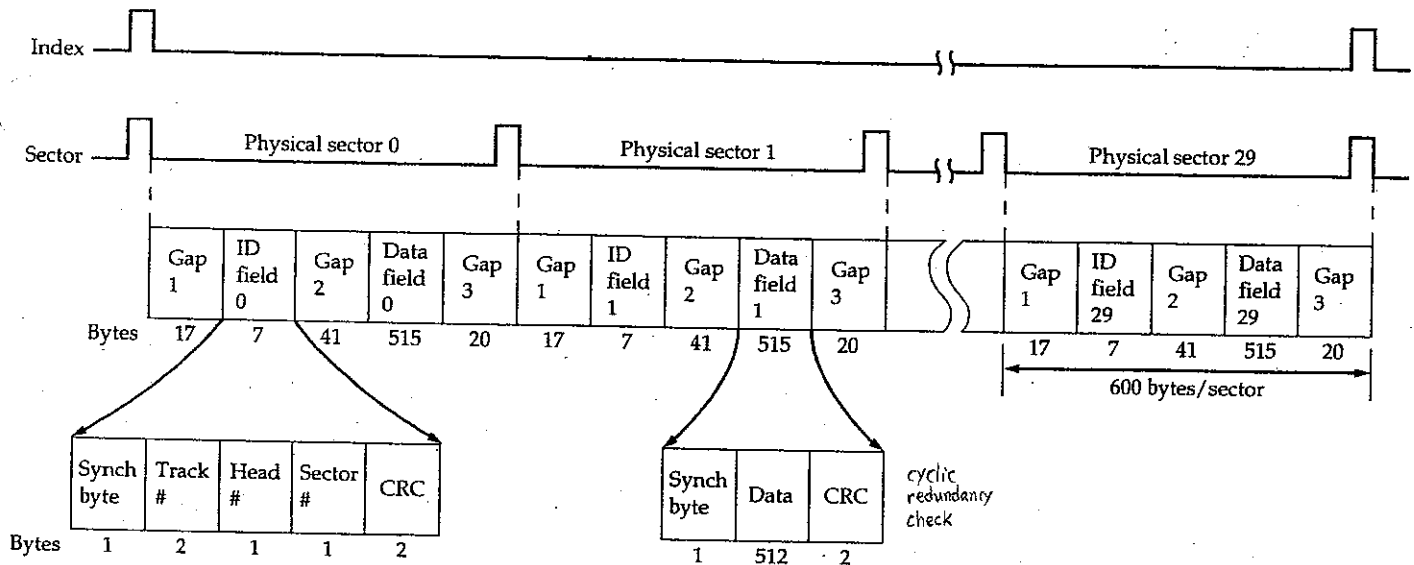


Figure 6.4 Winchester Disk Track Format (Seagate ST506)

Disk Access Time

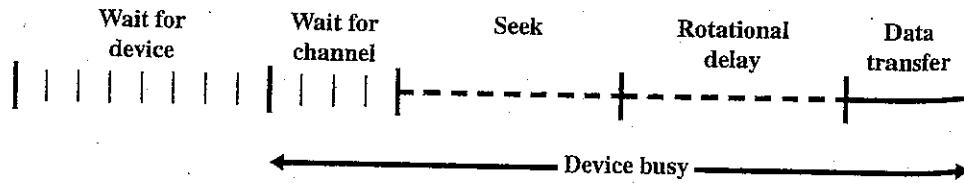


Figure 6.7 Timing of a Disk I/O Transfer

- { Seek time – head moves to the correct track position (mechanical)
- { Latency time – the sector rotates to line up with the head (1/2r)
- Transfer time – actual data transfer.

$$b / r \cdot N \quad (b: \# \text{bytes to transfer, } N: \# \text{bytes on a track})$$

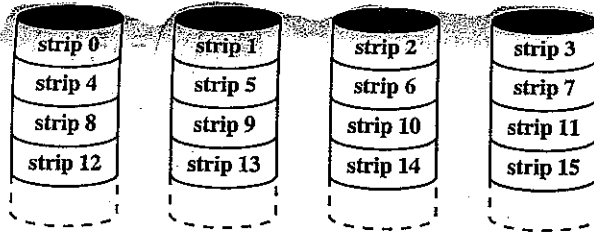
$$\text{Total average access time } T_a = T_s + \frac{1}{2r} + \frac{b}{r \cdot N}$$

For multiprogramming system, there may be many processes to request disk access → Disk scheduling

- FCFS
- SSTF
- SCAN (LOOK)
- C-SCAN

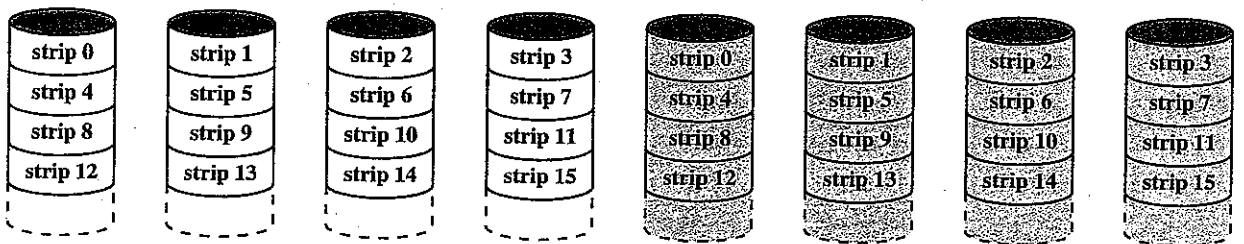
Table 6.3 RAID Levels

Category	Level	Description	I/O Request Rate (Read/Write)	Data Transfer Rate (Read/Write)	Typical Application
Striping	0	Nonredundant	Large strips: Excellent	Small strips: Excellent	Applications requiring high performance for noncritical data
Mirroring	1	Mirrored	Good/fair	Fair/fair	System drives; critical files
Parallel access	2	Redundant via Hamming code	Poor	Excellent	
	3	Bit-interleaved parity	Poor	Excellent	Large I/O request size applications, such as imaging, CAD
Independent access	4	Block-interleaved parity	Excellent/fair	Fair/poor	
	5	Block-interleaved distributed parity	Excellent/fair	Fair/poor	High request rate, read intensive, data lookup
	6	Block-interleaved dual distributed parity	Excellent/poor	Fair/poor	Applications requiring extremely high availability



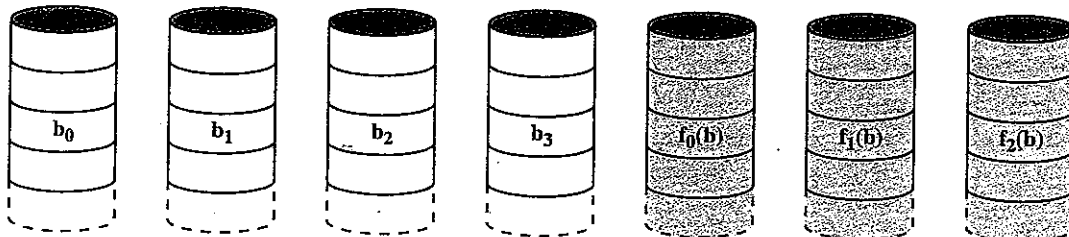
(a) RAID 0 (Nonredundant)

Parallel I/O



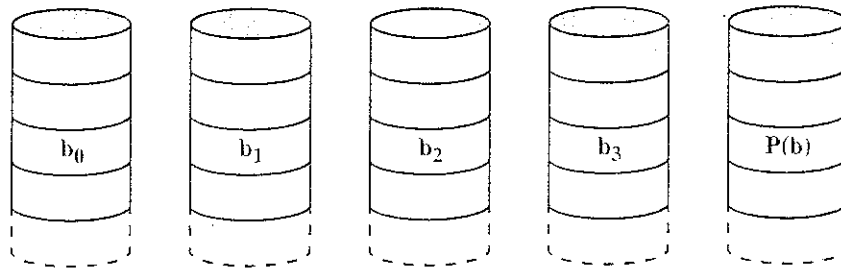
(b) RAID 1 (Mirrored)

Dual: minimum seek time (read), parallel write - real time back up

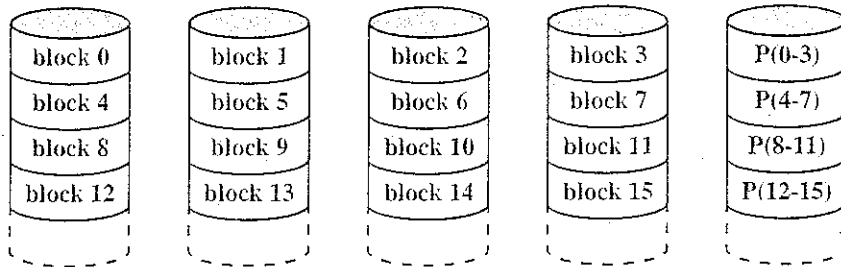


(c) RAID 2 (Redundancy through Hamming code)

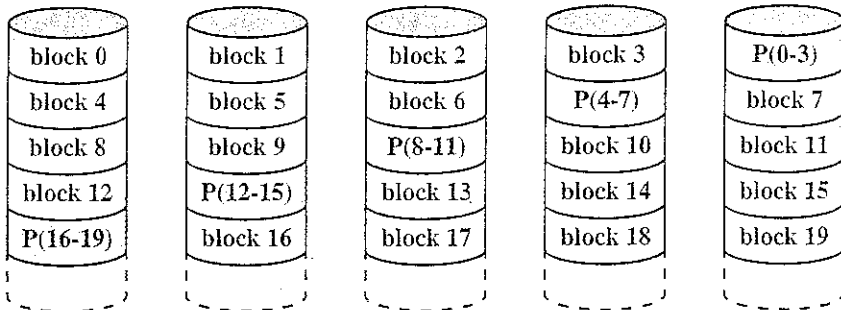
SEC-DED



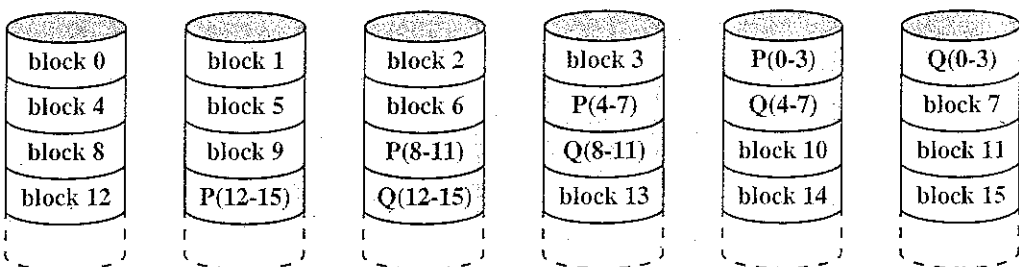
(d) RAID 3 (Bit-interleaved parity) \oplus



(e) RAID 4 (Block-level parity)



(f) RAID 5 (Block-level distributed parity)



(g) RAID 6 (Dual redundancy) *2 parities*

Redundant Array of Independent Disks

Parity = recoverability

Optical Memory

1. Compact Disk (CD)
 - 1983
 - 4.8", 680 MB, 60 min music

CD-ROM (read-only)

CD-R (recordable)

CD-RW (rewritable)

WORM (write once read many)

2. Digital Versatile Disk (DVD)
 - 4.7 GB
 - two sided

	CD	DVD
laser	780 nm	650 nm
pit lengthy	0.834 micron	0.4 micron
track pitch	1.6 micron	0.74 micron

Blue-Violet Laser Disk

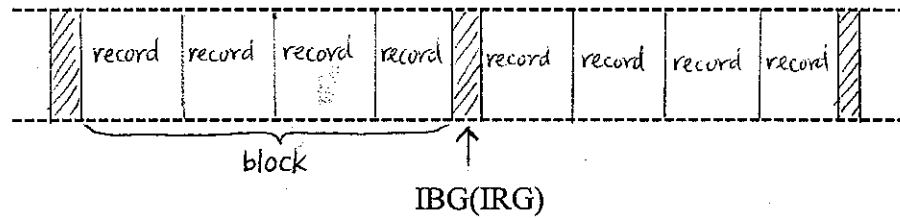
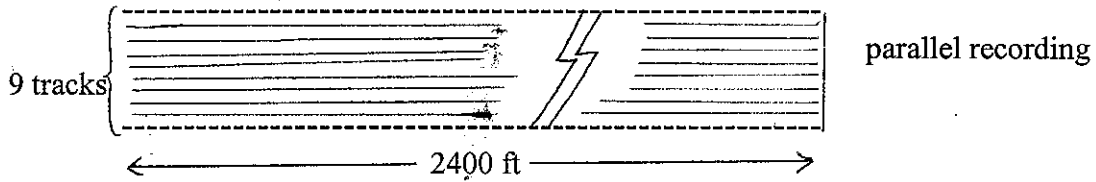
Blu-Ray Disk

- 25 GB
- consortium of 9 manufacturers (Sony, Samsung, ...)
- pit length: 0.13 nm
- track pitch: 0.32 nm

Magnetic Tape

- sequential access
- slow speed
- low cost
- backup

1970's - reel



Ex. block factor = 4

Note. Block: I/O unit - physical record

Modern - cartridge

Serpentine reading/writing

