Secondary Storage : Outline
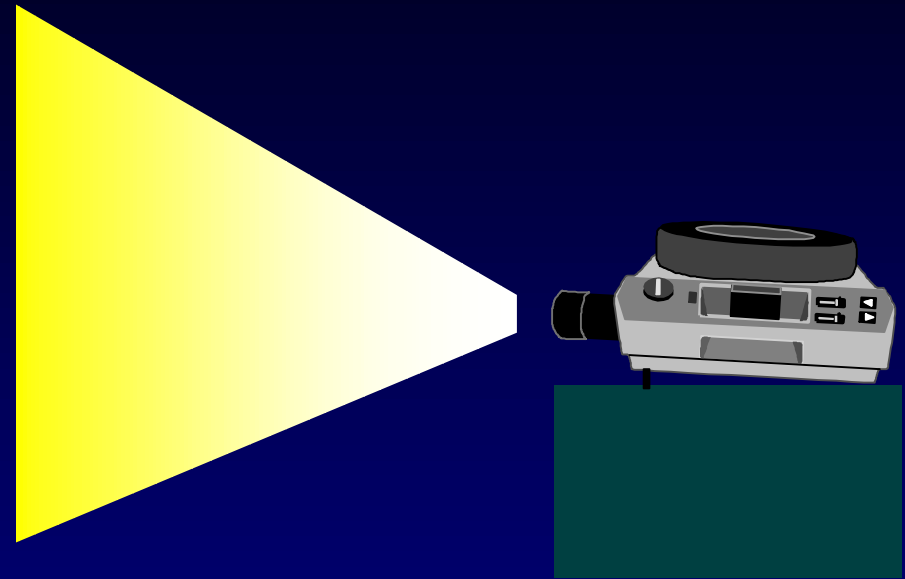
- Magnetic Tapes
- Disks
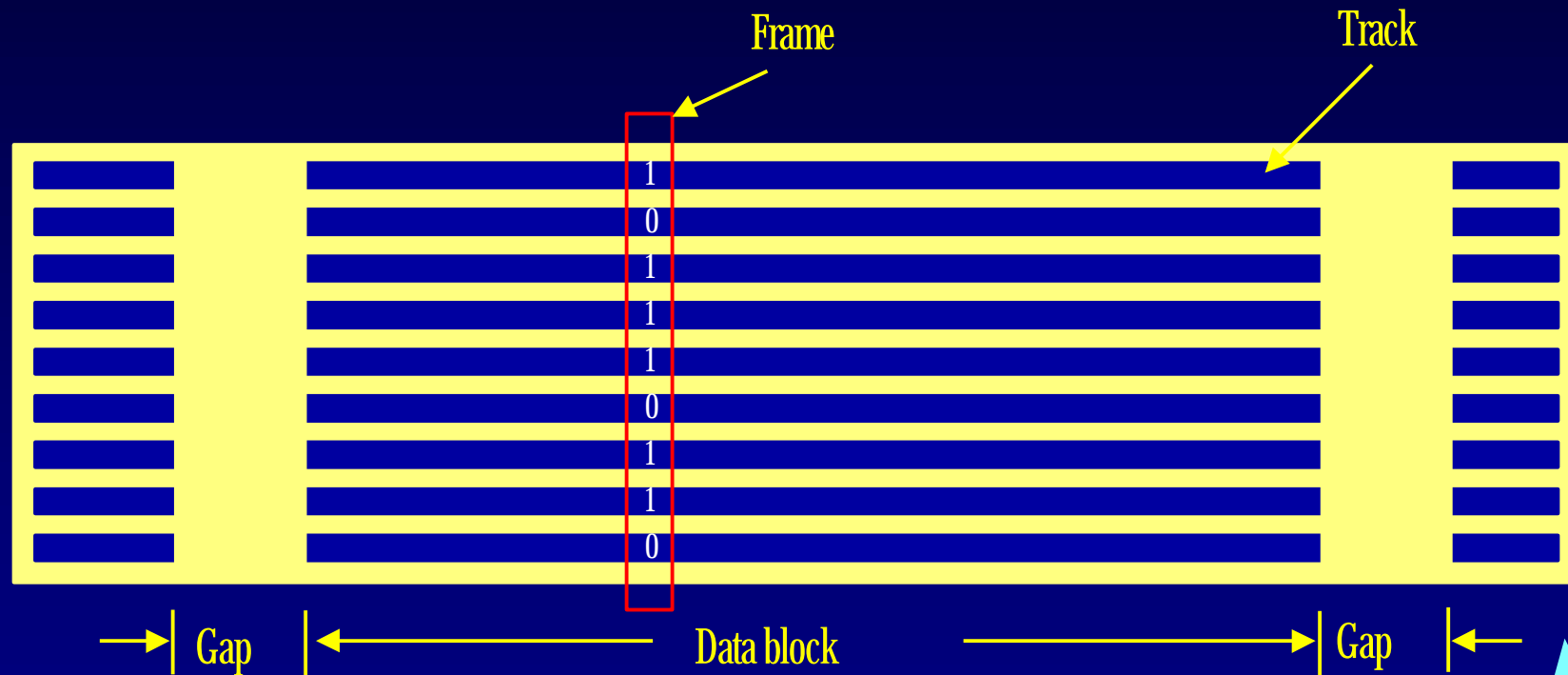
Magnetic Tape

▼Sequential access

▼Compact

▼Easy to store and transport

▼Less expensive

▼Storing data off-line

▼Archival storage

Organization of Data on Tapes

▼Data are stored sequentially on a set of parallel tracks.

Frame

Track

1
0
1
1
1
0
1
1
0

→| Gap |← ←————————— Data block —————————→ | Gap |←

Density and Capacity

▼*Density* (bytes per inch, bpi)

– the number of characters that can be recorded in an inch of tape.
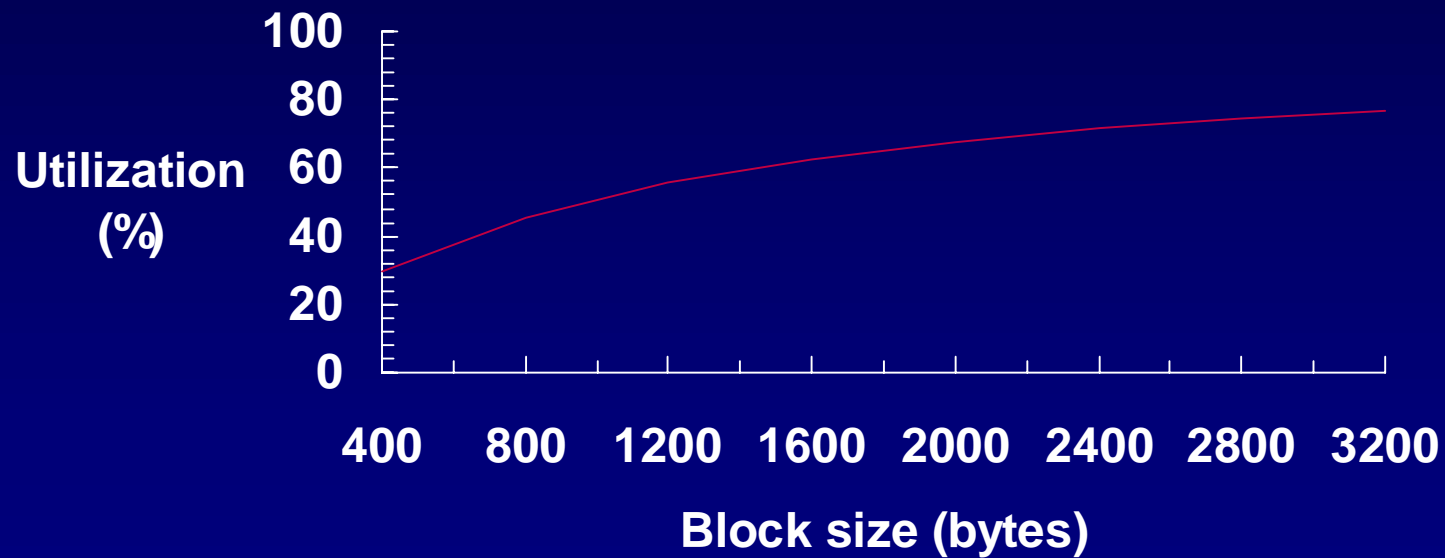(e.g. 800, 1600, 6250, 30000 bpi)

▼*Capacity*

– the number of bytes that can be stored in the entire tape.

▼Capacity = Length x Density

– (2400 x 12) x (1600 bpi) = 44 Mbytes

Utilization

$$Utilization = \frac{BlockSize}{BlockSize + GapSize}$$

Utilization (%) vs Block size (bytes)

Data Transfer Rate

▼Typical transfer rate : 10 ft / sec

▼However, the maximal data transfer rate (MDTR) is never attained.

▼Effective data transfer rate (EDTR)

- r : time to read user's data
- ss: time to start and stop the tape
- gt: time spent in the interblock gap
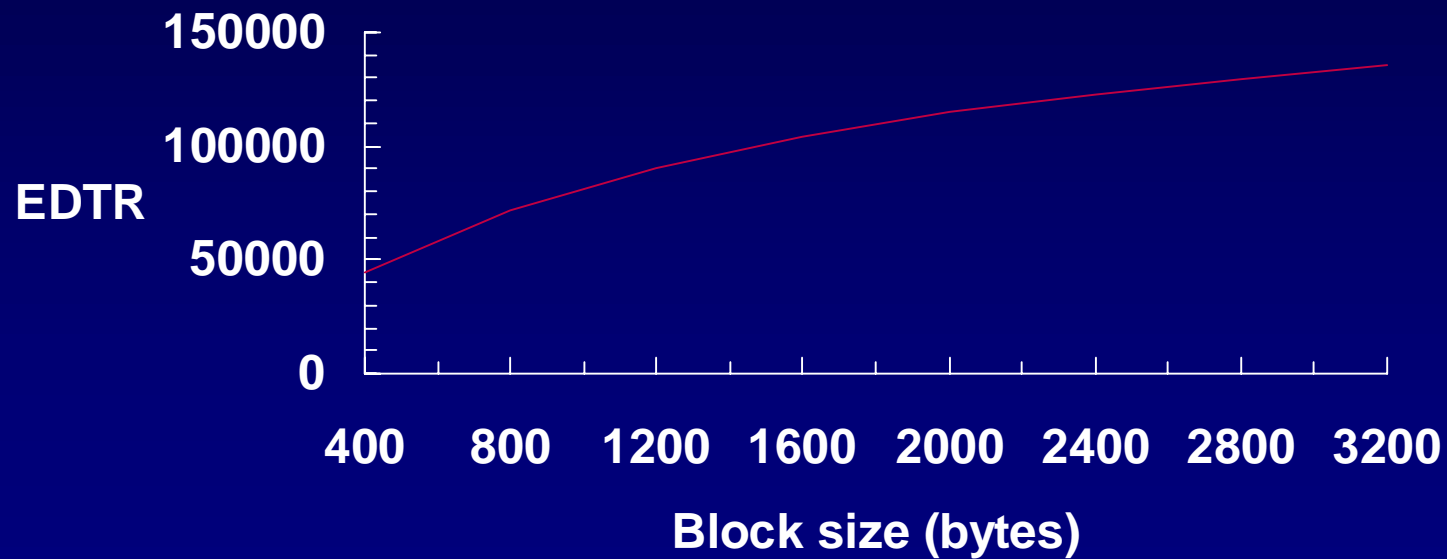
$$EDTR = \frac{r}{r + ss + gt} \cdot MDTR$$

Effective Data Transfer Rate

▼ *BlockSize = r · MDTR,   GapSize = gt · MDTR*

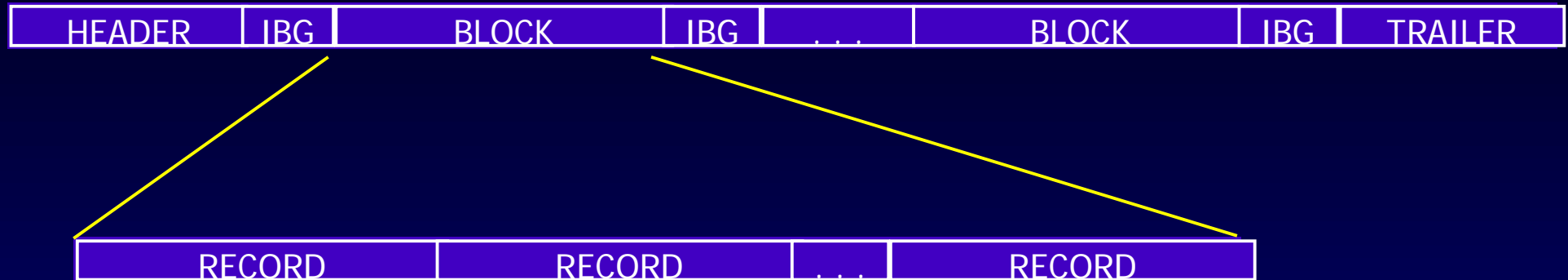$$EDTR = \frac{r}{r+s+gt} \cdot MDTR$$

Effective Data Transfer Rate

$$EDTR = \frac{r}{r + ss + gt} \cdot MDTR$$

150000
100000
EDTR
50000
0

400   800   1200   1600   2000   2400   2800   3200

Block size (bytes)

Fixed-Length Records

HEADER	IBG	BLOCK	IBG	. . .	BLOCK	IBG	TRAILER

RECORD	RECORD	. . .	RECORD

$$EDTR = \frac{r}{r + ss + gt} \cdot MDT$$

Variable-Length Records

HEADER	IBG	BLOCK	IBG	BLOCK	IBG	IBG	TRAILER

BDW	RDW	REC. 1

BDW	RDW	REC. 1	RDW	REC. 2	

BDW	SDW1	REC. 1	SDW2	REC. 2	IBG	BDW	SDW2	REC. 2	. . .
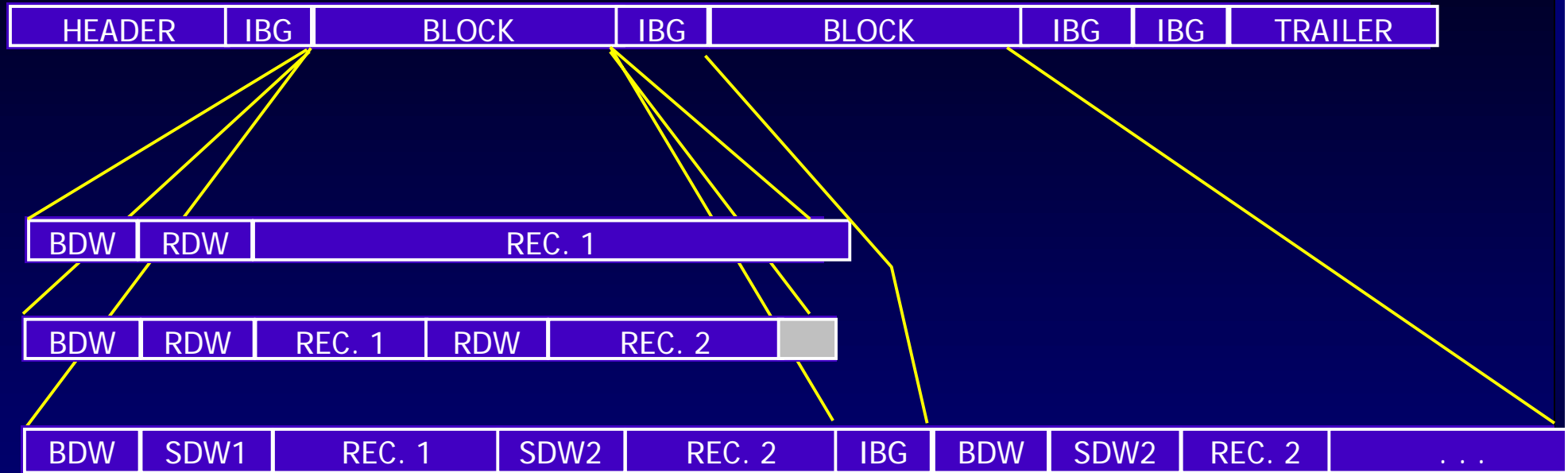
Variable-length unspanned unblocked record format
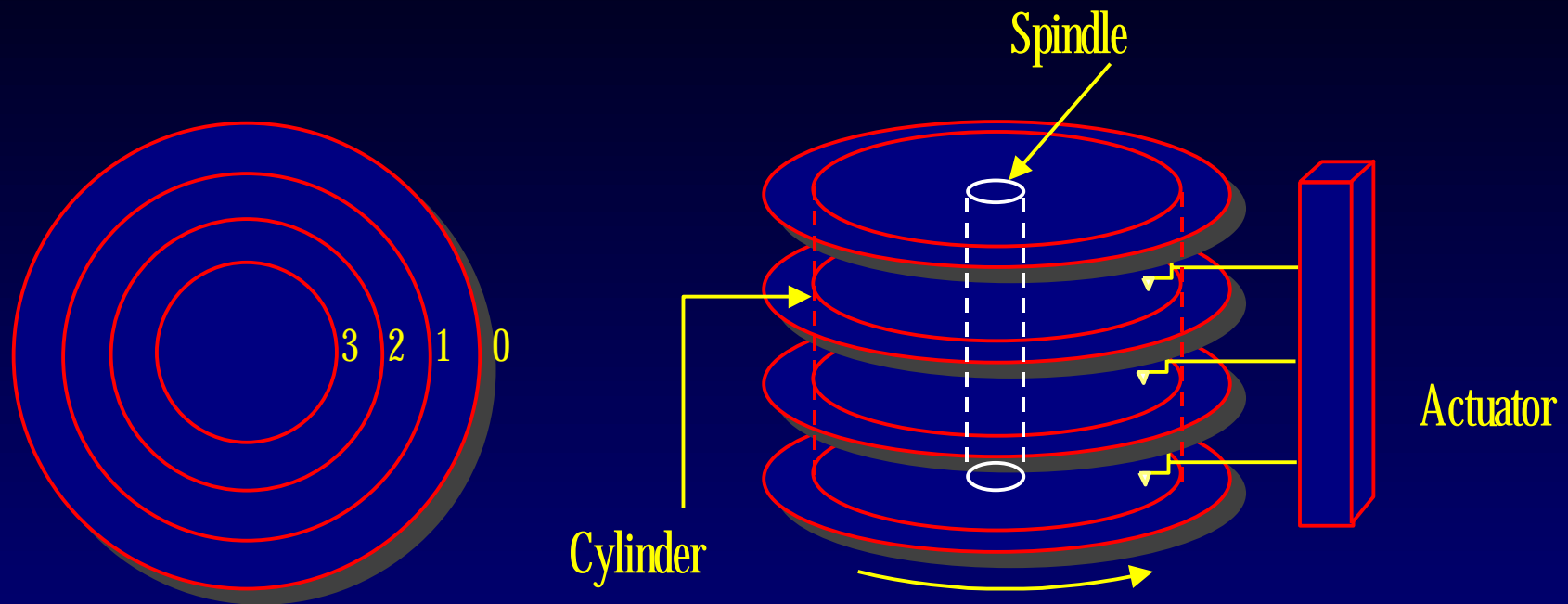
Variable-length unspanned blocked record format

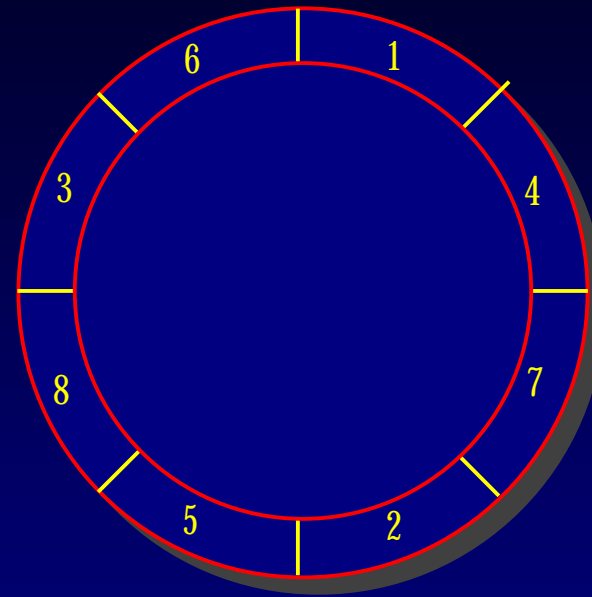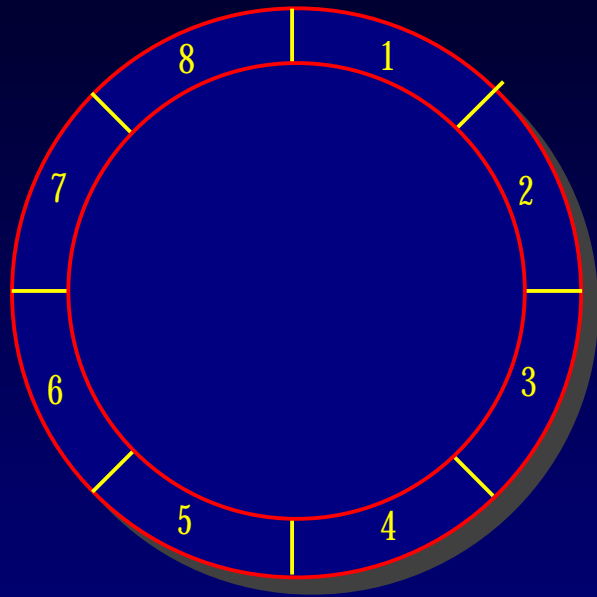Variable-length spanned blocked record format

Magnetic Disks

Spindle

3 2 1 0

Cylinder

Actuator

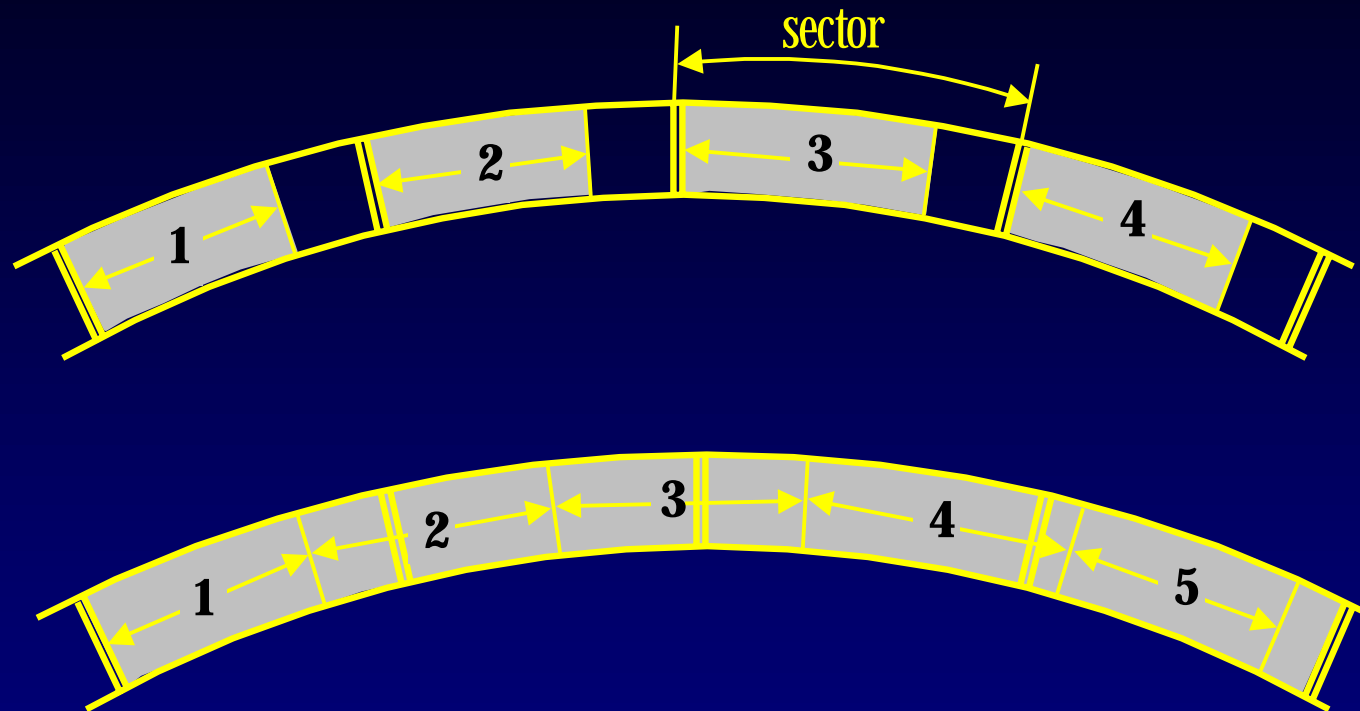**Direct Access Storage Device (DASD)**

Organizing Tracks

▼Sector-addressing

▼Block-addressing

Organizing Tracks by Sector

Interleaving factor
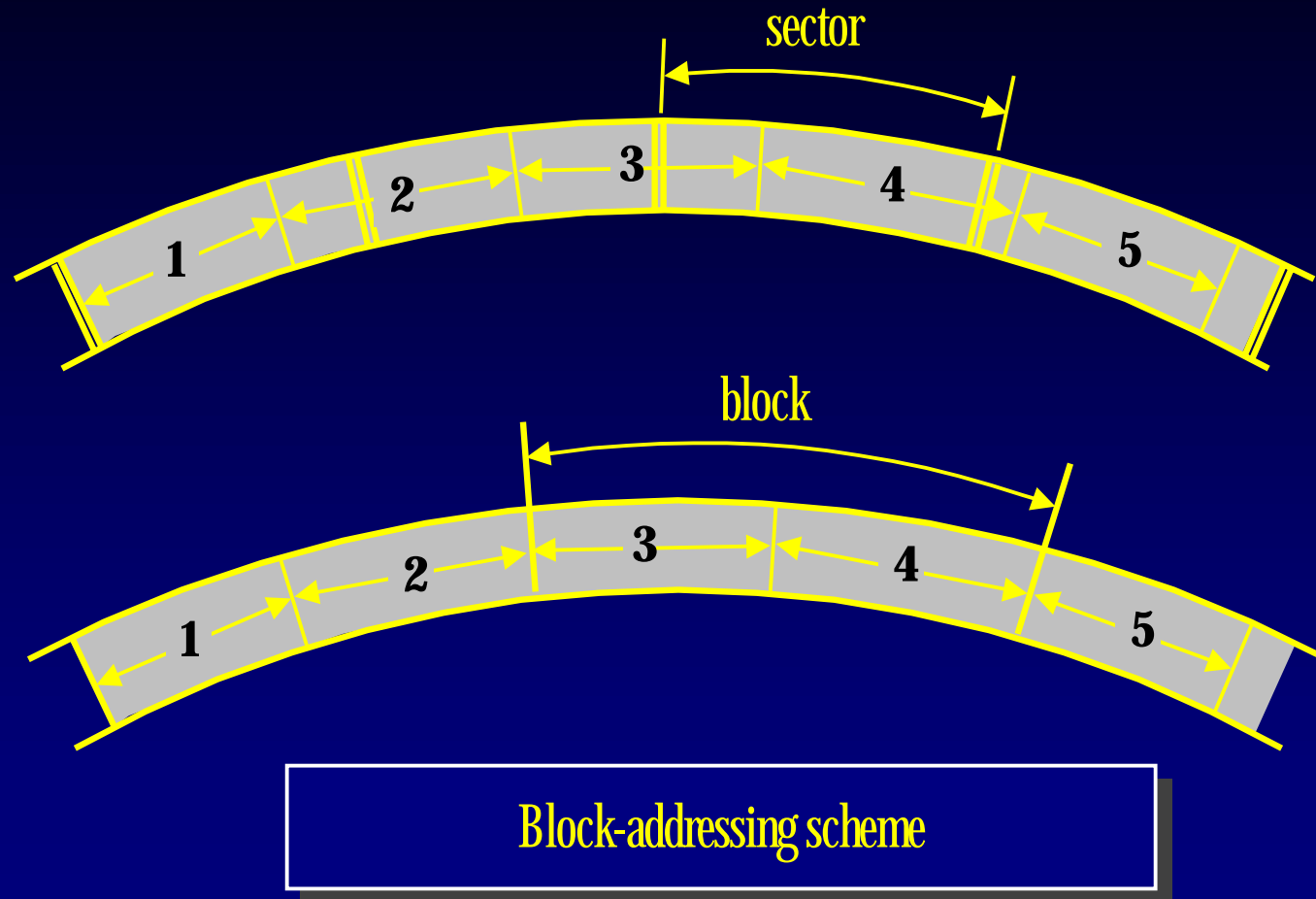
Organizing Tracks by Sector

sector

2

3

1

4

3

2

4

1

5

Sector-addressing scheme

Organizing Tracks by Block

sector

1 2 3 4 5

block

1 2 3 4 5

Block-addressing scheme

Organizing Tracks by Block

Count subblock	Data subblock		Count subblock	Data subblock

Count subblock	Key subblock	Data subblock	Count subblock	Key subblock	Data subblock

←———————— block ————————→ IBG ←———————— block ————————→
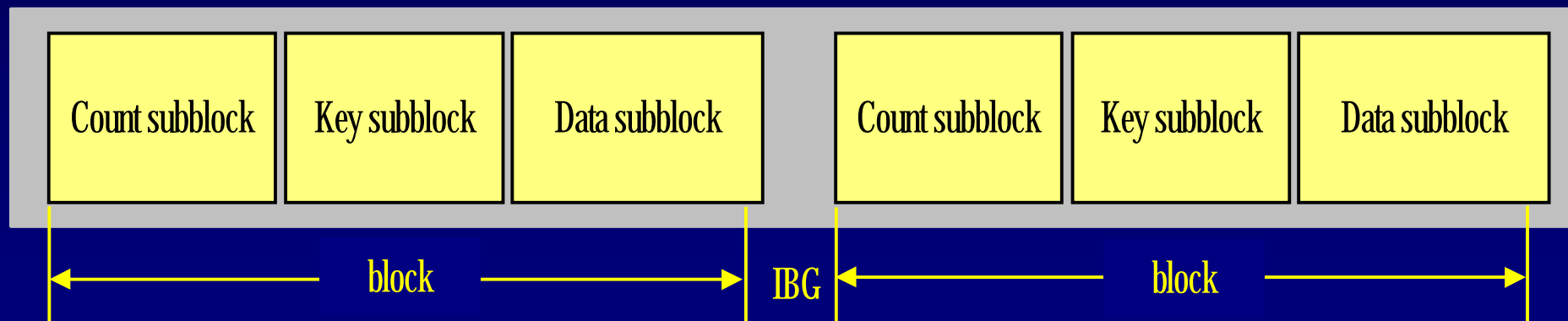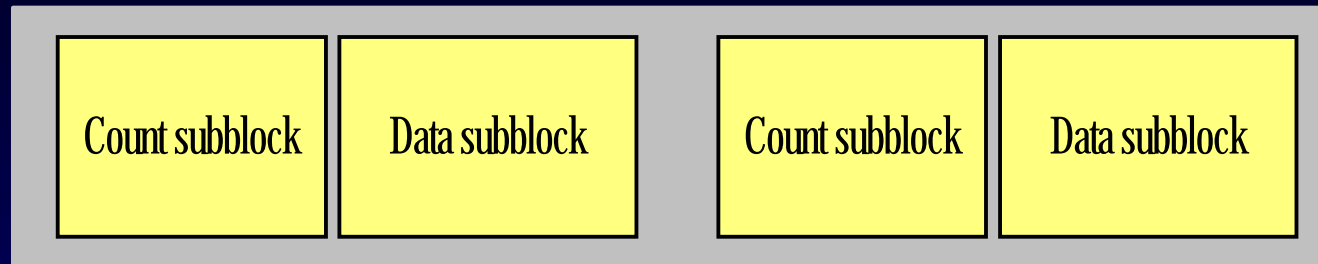
Organizing Tracks by Block

▼Plus :

– Physical space allocation of records corresponds to logical organization.

– No internal fragmentation.

– No need to load two blocks to access one record.

▼Minus :

– More nondata overhead.

– Extra work for programmer and file system.

– Large block may cause track fragmentation.

Clusters & Extents

▼Cluster :

– a collection of contiguous blocks (or sectors)

▼Extent :

– a collection of contiguous clusters.

▼A file : a series of

– blocks

– clusters

– extents

Minimize seek time

Disk Capacity

▼*NC* : Number of cylinders per disk pack

▼*TPC* : Number of tracks per cylinder

▼*TC* : Capacity of each track

▼*DC* : Disk capacity

$$DC = NC \cdot TPC \cdot TC \quad bytes$$

IBM3350 : 555 cylinders, 39 tracks/cyl, 19254 bytes/track

disk capacity = 397 MBytes (* including system data)

Disk Access

▼Seek time
  – average seek time $\approx 1/3$ of the max. seek time

▼Head-switching time
  – negligible ≈ 0

▼Rotational delay
  – half a revolution $(3600 \text{ rpm} \approx 8.3 \text{ msec})$

▼Data transfer time
  – # data transferred, rotation time

Comparisons of Disk Drives

Speed/Capacty	3.5-inch floppy	IBM 3380
Avg seek time (ms)	70	17
Rotational delay (ms)	50	8.3
Transfer rate (MB/s)	0.2	3.0
bytes/track	9,200	47,476
track/cylinder	2	15
cylinder/drive	80	1,770
MB/drive	1.4	2,520

Disk as Bottleneck

▼Disk performance is increasing.

▼But disk speeds still lag far behind CPU and local network speeds.

▼Techniques :

  – Disk striping - splitting a file on several drives

  – Disk cache

  – RAM disk

Device Storage Allocation

▼Keep track of what blocks are in use and what blocks are free.

– Bit map

used

free

– Free chain