

Secondary Storage Devices: Magnetic Tapes

Last Time : Secondary Storage Devices: Magnetic Disks. Up to non data overhead

Today

- Continuing on last week's notes on disks (nondata overhead, the cost of a disk access, disk as a bottleneck)
- Magnetic tapes
 - Characteristics of magnetic tapes
 - Data organization on 9-track tapes
 - Estimating tape length requirements
 - Estimating data transmission times
 - Disk versus tape

Reference: Folk, Zoellick and Riccardi. Sections 3.2.

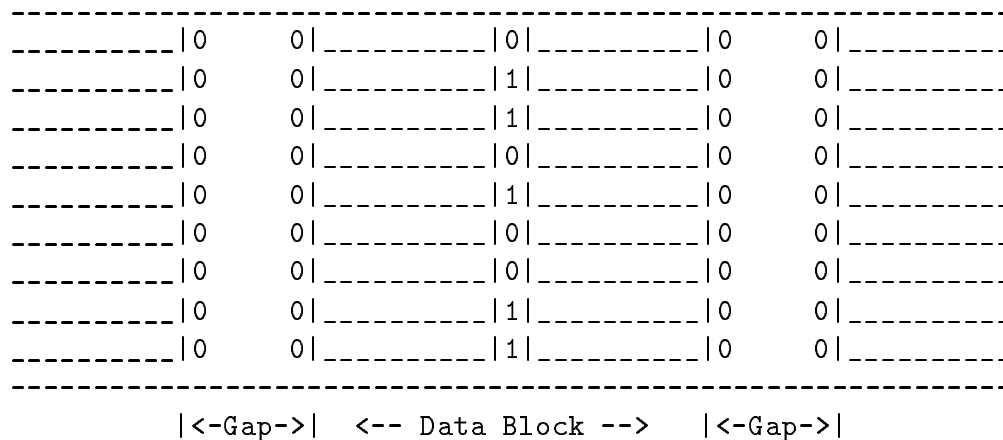
Characteristics of Magnetic Tapes

- No direct access, but very fast sequential access.
- Resistant to different environmental conditions.
- Easy to transport, store, cheaper than disk.
- Before it was widely used to store application data; nowadays, it's mostly used for backups or archives (terciary storage).

Data Organization on Nine-Track Tapes

In a tape, the **logical position** of a byte within a file is the same as its **physical position** in the file (sequential access).

Nine-track tape:



- **Data blocks** are separated by interblock GAPS.
- 9 parallel tracks (each is a sequence of bits)
- A **frame** is a 1-bit slice of the tape corresponding to 9 bits (one in each track) which correspond to 1 byte plus a **parity bit**.

In the example above, the byte stored in the frame that is shown is: 01101001
The parity bit is 1, since we are using **odd parity**, i.e., the total number of bits is odd.

Complete the parity bit in the examples below:

```
11111111  
00000000  
00100000
```

Since 00000000 cannot correspond to a valid byte, this is used to mark the **interblock gap**.

So, if we say that this tape has 6,250 **bits per inch** (bpi) per track, indeed it stores 6,250 **bytes per inch** when we take into account the 9 tracks.

Estimating Tape Length Requirements

Performance of tape drives can be measured in terms of 3 quantities:

- Tape density = 6250 bpi (bits per inch per track)
- Tape speed = 200 inches per second (ips)
- Size of interblock gap = 0.3 inch

File characteristics:

- Number of records = 1,000,000
- Size of record = 100 bytes

How much tape is needed?

It depends on the blocking factor (how many records per data block). Let us compute the space requirement in two cases:

- A) Blocking factor = 1
- B) Blocking factor = 50

Space requirement (s)

b = length of data block (in inches)

g = length of interblock gap (in inches)

n = number of data blocks

$$s = n \times (b + g)$$

- A) Blocking factor = 1

$$b = \text{block size} / \text{tape density} = 100 / 6250 = 0.016 \text{ inch}$$

$$n = 1,000,000$$

$$s = 1,000,000 \times (0.016 + 0.3) \text{ inch} = 316,000 \text{ inches} \sim 26,333 \text{ feet}$$

(Absurd to have the length of the data block smaller than the interblock gap!)

- B) Blocking factor = 50

$$b = 50 \times 100 / 6,250 = 0.8 \text{ inch}$$

$$n = 1,000,000 / 50 = 20,000$$

$$s = 20,000 \times (0.8 + 0.3) \text{ inch} = 22,000 \text{ inches} \approx 1,833 \text{ feet}$$

An enormous saving by just choosing a higher blocking factor.

Effective Recording Density (ERD)

ERD = number of bytes per block / number of inches to store a block

In previous example :

A) Blocking factor =1: E.R.D. = $100/0.316 \sim 316.4$ bpi

B) Blocking factor =50: E.R.D. = $5,000/1.1 \sim 4,545.4$ bpi

The **Nominal Density** was 6,250 bpi!

Estimating Data Transmission Times

Nominal Rate = tape density (bpi) x tape speed (ips)

In a 6,250 - bpi , 200 - ips tape :

Nominal Rate = $6,250 \times 200 = 1,250,000$ bytes/sec $\sim 1,250$ KB/sec

Effective Transmission Rate = E.R.D. x tape speed

In the previous example:

A) E.T.R. = $316.4 \times 200 = 63,280$ bytes/sec ~ 63.3 KB/sec

B) E.T.R. = $4,545.4 \times 200 = 909,080$ bytes/sec ~ 909 KB/sec

Note : There is a tradeoff between **increasing** blocking factor for increasing speed & space utilization and **decreasing** it for reducing the size of the I/O buffer.

Disk versus Tape

In the past : Disks and Tapes were used for secondary storage: disks preferred for random access and tapes for sequential access.

Now :

Disks have taken over most of secondary storage (lower cost of disk and lower cost of RAM which allows large I/O buffer). Tapes are mostly used for **tertiary storage**.