Tapes

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- ▶ Tapes
  - – are relatively inexpensive
  - – can store very large amounts of data
  - – good choice for ***archival*** storage
    - • we need to maintain data for a long period
    - • we do not expect to access it very often
- ▶ The main drawback of tapes
  - – they are sequential access devices
  - – we must essentially step through all the data in order
  - – cannot directly access a given location on tape
  - – Mostly used to back up operational data periodically

Magnetic Tape

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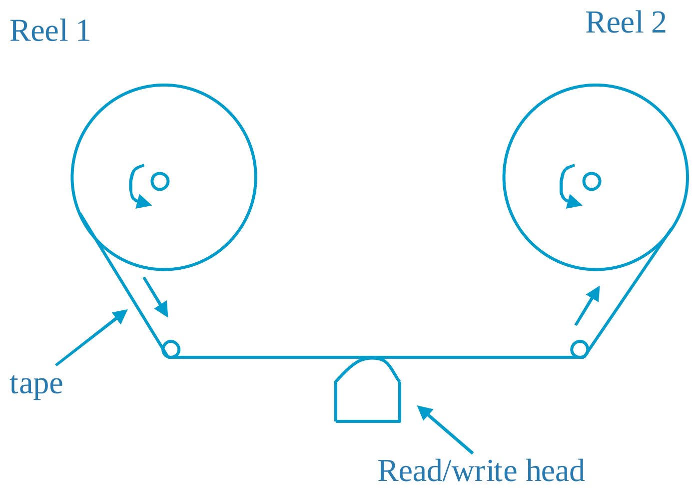
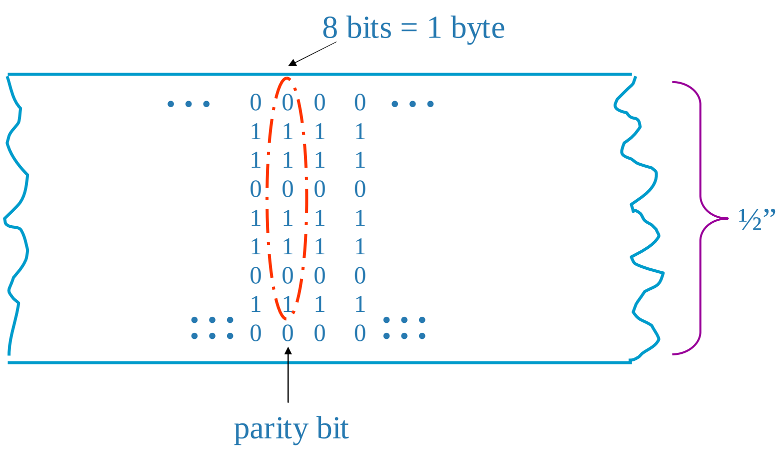
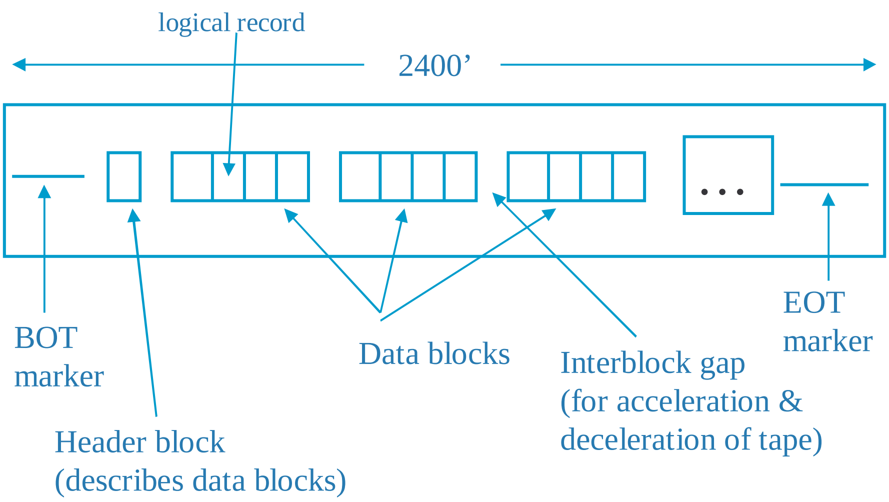
- ▶ A set of parallel tracks
- ▶ 9 tracks - parity bit
- ▶ Frame
  - – one-bit-wide slice of tape
- ▶ Interblock gaps
  - – permit stopping and starting



In detail



Tape Organization



Estimating Tape Length

- There is an interblock gap for each data block
- Space requirement **s**

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

  – **b** is the physical length of a data block
  – **g** is the length of an interblock gap
  – **n** is the number of data blocks
- Tape density
- Tape speed
- Size of interblock gap

Estimating Tape Length (Con't)

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- Example:
  - one million 100-byte records
  - 6,250 BPI tape
  - 0.3 inches of interblock gap
- How much tape is needed?
  - when blocking factor is between 1 and 50
- Nominal recording density
- Effective recording density:
  - number of byte per block / number of inches for block

Estimating Data Transmission Times

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- Factors of data transmission rate
  - interblock gaps
  - effective recording density
  - nominal recording density
  - speed of r/w head
  - time to start/stop the tape

Disks *vs.* Tapes

- **Disk**
  - Random access
  - Immediate access
  - Expensive seek in sequential processing
- **Tape**
  - Sequential access
  - Long-term storage
  - No seek in sequential processing

- Decrease in cost of disk and RAM
- More RAM space is available in I/O buffers,
- so disk I/O decreases
- Tertiary storage for backup: CD-ROM, tape ...

Example: Quantum DLT 8000

- **Sustained Transfer Rate (MB/sec)**
  - **Native** 6
  - **Compressed** (up to) 121
- **Burst Transfer Rate (MB/sec)**
  - **Synchronous** 20
  - **Asynchronous** 12
- **Formatted Capacity (GB)**
  - **Native** 40
  - **Compressed** 80
- **Average File Access Time (sec)** 60
- **Interface** SCSI–2 Fast/Wide

Introduction to CD-ROM

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- CD-ROM: Compact Disc Read-Only Memory
  - Can hold over 600MB (200,000 pages)
  - Easy to replicate
  - Useful for publishing or distributing medium
  - But, not storing and retrieving data
- CD-ROM is a child of CD audio
- CD audio provides
  - High storage capacity
  - Moderate data transfer rate
  - But, against high seek performance
    - →Poor seek performance

History of CD-ROM

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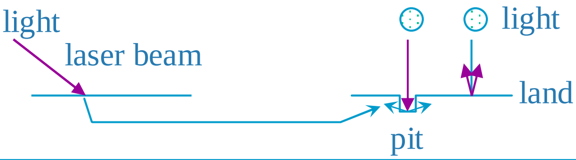
- CD-ROM
  - Philips and Sony developed CD-ROM in 1984 in order to store music on a disc
  - Use a digital data format
  - The development of CD-ROM as a licensing system results in widely acceptance in the industry
  - Promised to provide a standard physical format
  - Any CD-ROM drive can read any sector which they want
  - Computer applications store data in a file not in terms of sector, thus, file system standard should be needed
  - In early summer of 1986, an official standard for organizing files was worked out

Physical Organization of Master Disk

- **Master Disc**
  - Formed by using the digital data, 0 or 1
  - Made of glass and coated that is changed by the laser beam
- **Two part of CD-ROM**
  - **Pit**
    - The areas that is hit by the laser beam
    - Scatter the light
  - **Land**
    - Smooth, unchanged areas between pits
    - Reflect the light



Encoding Scheme of CD-ROM

- **Encoding scheme**
  - The alternating pattern of high- and low-density reflected light is the signal
  - 1 : transition from <u>pit</u> to <u>land</u> and back again
  - 0s : the amount of time between transitions
- **Constraint**

1_{10}	00000001_2	10000100000000_{EFM}

  - The limits of resolution of the optical pickup, there must be at least two 0's between any pair of 1's (<u>no two adjacent 1s</u>)
  - We cannot represent all bit patterns, thus, we need translation scheme
  - We need at least 14 bits to represent 8 bits under this constraint

Format of CD-ROM

- ▶ CD audio chose CLV format instead of CAV format
  - CD audio requires large storage space
  - CD audio is played from the beginning to the end sequentially

Format of CD-ROM

- ▶ Format of CD-ROM
  - CLV(Constant Linear Velocity)
  - A single spiral pattern
  - Same amount of space for each sector
  - Capability for writing all of sectors at the maximum density
  - Rotational speed is slower in reading outer edge than in inner edge
  - Finding the correct speed though trial and error
  - Characteristics
    - Poor seek performance
    - No straightforward way to jump to a specified location

Constant Angular Velocity Disk

- Magnetic disk usually uses CAV(Constant Angular Velocity)
  - Concentric tracks and pie-shaped sectors
  - Data density is higher in inner edge than in outer edge
  - Storage waste: total storage is less than a half of CLV
  - Spin the disc at the same speed for all positions
  - Easy to find a specific location on a disk → good seek performance

Addressing of CD-ROM

- Addressing
  - Magnetic disk: cylinder/track/sector approach
  - CD-ROM: a sector-addressing scheme
- Track density varies thus, each second of playing time on a CD is divided into 75 sectors
  - 75 sectors/sec, 2 Kbytes/sector
  - At least one-hour of playing time
  - Maximum capacity can be calculated: 600 Mbytes

    60 min * 60 sec/min * 75 sectors/sec = 270,000 sectors
- We address a given sector by referring minutes, second, and sector of play
  - 16:22:34 means 34th sector in the 22nd second in the 16th minutes of play

Fundamental Design of CD Disc

- Initially designed for delivering digital audio information
- Store audio data in digital form
- Wave patterns should be converted into digital form
- Measure of the height of the sound: 65,536 different gradation(16 bits)
- Sampling rate: 44.1 kHz, because of 2 times of 20,000 Hz upto which people can listen
- 16 bits sample, 44,100 times per second, and two channel for stereo sound, we should store 176,400 bytes per seconds
- Storage capacity of CD is 75 sectors per seconds, we have 2,352 bytes per sector
- CD-ROM divides this raw sector as shown in the following figure

Raw Sector

12 bytes synch	4 bytes sector ID	2,048 bytes user data	4 bytes error detection	8 bytes null	276 bytes error correction

File Structure Problem of CD-ROM

- Strong and weak sides of CD-ROM
  - Strong aspects of CD-ROM
    - Data transfer rate: 75 sectors/sec
    - Storage capacity : over 600 Mbytes
    - Inexpensive to duplicate and durable
  - Weak aspects of CD-ROM
    - Poor seek performance (weak random access)
      - » Magnetic disk: 30 msec, CD-ROM : 500 msec
  - Comparison of access time of a large file from several media
    - RAM: 20 sec, Disk: 58 days, CD-ROM: 2.5 years
- We should have a good file structure avoiding seeks to an even greater extent that on magnetic disk

What is DVD?

- DVD
  - Digital Video disk (DVD-Video)
  - Digital Versatile disk (DVD-ROM)
- In September 1995
  - As a movie-playback format
  - As a computer-ROM format
- Next-Generation optical disc storage technology will replace audio-CD, videotape, laserdisk, CD-ROM, etc.

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The History from CD to DVD

- ▶ 1980, Sony & Philips → CD-Audio
- ▶ 1985, Sony & Philips → CD-ROM
- ▶ 1989, Sony & Philips → CD-I
- ▶ 1990, Sony & Philips → CD-R
- ▶ 1995, → CD-E
- ▶ 1995, September → DVD

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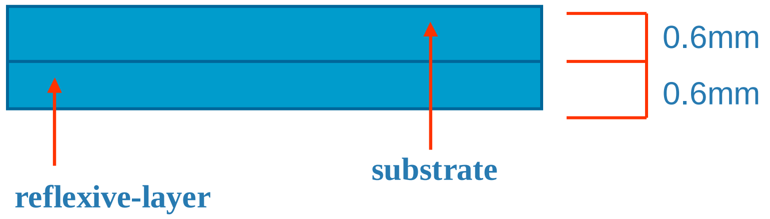
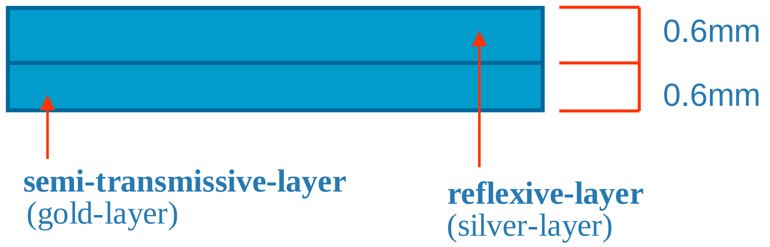
DVD Capacity

- ▶ Single-sided
  - DVD5 (4.7 GB/single-layer)
  - DVD9 (8.5 GB/dual-layer)
- ▶ Double-sided
  - DVD10 (9.4 = 4.7x2 GB/dual-layer)
  - DVD18 (17 = 8.5x2 GB/dual-layer)
- ▶ Write-Once
  - DVD-R (3.8 GB/side)
- ▶ Overwrite
  - DVD-RAM (more than 2.6 GB/side)

Single sided, single layer



Single sided, dual layer



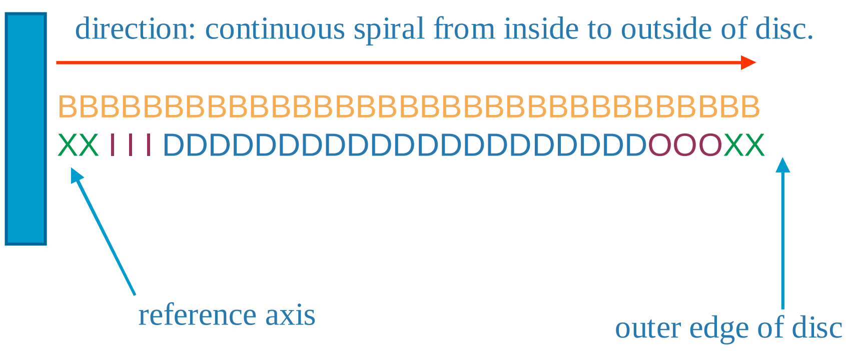
CD vs. DVD

- **Laser-Beam**
  - CD → infrared light (780nm)
  - DVD → red light (635-650nm)
- **Capacity**
  - CD → maximum 680MB
  - DVD → maximum 17GB (25 times of CD)
- **Reference Speed**
  - CD → 1.2m/sec. CLV
  - DVD → 4.0m/sec. CLV

Track Structure

- **Legend**
  - **I** Lead-in area (leader space near edge of disc)
  - **D** Data area (contains actual data)
  - **O** Lead-out area(leader space near edge of disc)
  - **X** Unusable area (edge or donut hole)
  - **M** Middle area (interlayer lead-in/out)
  - **B** Dummy-bonded layer
    (to make disc 1.2mm thick instead of 0.6mm)

Single Layer Disc



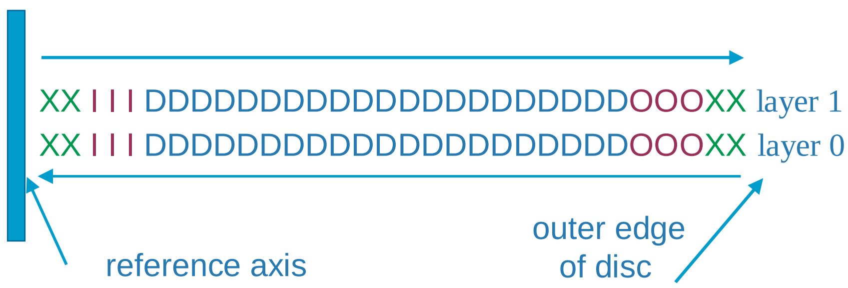
Dual Layer Disc

(A) Parallel track path (for computer CD-ROM use)
    Direction : same for both layers.

(B) Opposite track path (for movies)
    Direction : opposite directions
    (Since the reference beam and angular velocities are the same at the layer transition point, the delay comes from refocusing. This permits seamless transition for movie playback.)

Parallel track-path

Opposite track-path



Sector Structure

- **2064 bytes/sector**
  - organized into 12 rows, each with 172B
  - first row starts with 12B sector header (ID,IEC,Reserved bytes)
  - final row is punctuated with 4B (EDC bytes)

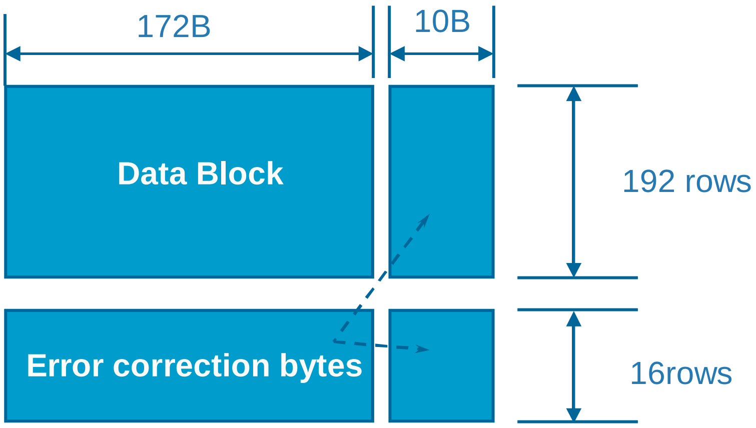
Row	Fields within row
0	ID(4B) IEC(2B) RESERVED(6B) Main data(160B : D[0]-D[159])
1	Main data(172B : D[160]-D[331])
2	Main data(172B : D[332]-D[503])
3	Main data(172B : D[504]-D[675])
4	Main data(172B : D[676]-D[847])
5	Main data(172B : D[848]-D[1019])
6	Main data(172B : D[1020]-D[1191])
7	Main data(172B : D[1192]-D[1363])
8	Main data(172B : D[1364]-D[1535])
9	Main data(172B : D[1536]-D[1707])
10	Main data(172B : D[1708]-D[1879])
11	Main data(168B : D[1880]-D[2047]) EDC(4B)

ID : Identification Data (32bit sector number)
IEC : ID Error Correction
EDC : Error Detection Code

Block Structure

- ▶ To combat burst error, 16 sectors are interleaved together

  (16 sectors * 12 rows/sector = 192 rows)
- ▶ Error correction byes are concatenated
  - 10bytes at the end of each row
  - 16 rows at the end of the block



$$\text{payload/block} = \frac{172 \times 192}{182 \times 208} \times 100 = 87\ \%$$

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DVD Video Features

- Over 2 hours of high-quality digital video
- Support wide screen movies & standard or widescreen TVs (4:3 & 16:9 aspect ratios)
- Up to 8 tracks of digital audio
- Up to 32 subtitle/karaoke tracks
- Up to 9 camera angles
- Multilingual identifying text for title name, album name, song name, actors, etc.

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DVD Video Encoding Data

- Encoding Video
  - MPEG-2 compression
    (developed by the Motion Pictures Experts Group)
  - High-Resolution (better than CD,LD
    3-times better than Video tape)
- Encoding Sound
  - Dolby Digital surround AC-3 sound compression
    (support five sound channel plus subwoofer channel
    => left, center, right, rear-left, rear-right channel)