Computer Organization

Part 28 : Secondary Storage

UNIT – IV

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Secondary Storage

- Magnetic Disks
  - Hard Disks
  - Floppy Disks
- Magnetic Tape
- Optical Storage
  - CD-ROM
  - DVD-ROM
Hard Disk
Magnetic Disk

Fig. 6.59 Bit representation of magnetic disk
Rotating Shaft
Mechanical Structure
Read/Write Head
Data Organization
Disk Track Format

Seagate ST-506
Material Causing Crash
Organization of Disks

- Disk contains concentric **tracks**.
- Tracks are divided into **sectors**
- A **sector** is the smallest addressable unit in a disk.
Disk Operations

- Seek
- Read
- Write
- Error Checking
Accessing Data

• When a program reads a byte from the disk, the operating system locates the surface, track and sector containing that byte, and reads the entire sector into a special area in main memory called buffer.

• The bottleneck of a disk access is moving the read/write arm. So it makes sense to store a file in tracks that are below/above each other in different surfaces, rather than in several tracks in the same surface.
Cylinders

• A **cylinder** is the set of tracks at a given radius of a disk pack.
  – i.e. a cylinder is the set of tracks that can be accessed without moving the disk arm.

• All the information on a cylinder can be accessed without moving the read/write arm.
Cylinders
Estimating Capacities

- Track capacity = \# of sectors/track * bytes/sector
- Cylinder capacity = \# of tracks/cylinder * track capacity
- Drive capacity = \# of cylinders * cylinder capacity
- Number of cylinders = \# of tracks in a surface
Exercise

• Store a file of 20000 records on a disk with the following characteristics:
  
  # of bytes per sector = 512
  
  # of sectors per track = 40
  
  # of tracks per cylinder = 12
  
  # of cylinders = 1331

Q1. How many cylinders does the file require if each data record requires 256 bytes?

Q2. What is the total capacity of the disk?
The Cost of a Disk Access

- The time to access a sector in a track on a surface is divided into 3 components:

<table>
<thead>
<tr>
<th>Time Component</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seek Time</td>
<td>Time to move the read/write arm to the correct cylinder</td>
</tr>
<tr>
<td>Rotational delay (or latency)</td>
<td>Time it takes for the disk to rotate so that the desired sector is under the read/write head</td>
</tr>
<tr>
<td>Transfer time</td>
<td>Once the read/write head is positioned over the data, this is the time it takes for transferring data</td>
</tr>
</tbody>
</table>
Seek time

- Seek time is the time required to move the arm to the correct cylinder.
- Largest in cost.

Typically:
- 5 ms (milliseconds) to move from one track to the next (track-to-track)
- 50 ms maximum (from inside track to outside track)
- 30 ms average (from one random track to another random track)
Average Seek Time ($s$)

- Since it is usually impossible to know exactly how many tracks will be traversed in every seek, we usually try to determine the average seek time ($s$) required for a particular file operation.
- If the starting and ending positions for each access are random, it turns out that the average seek traverses one third of the total number of cylinders.
- Manufacturer’s specifications for disk drives often list this figure as the average seek time for the drives.
- Most hard disks today have $s$ of less than 10 ms, and high-performance disks have $s$ as low as 7.5 ms.
Latency (rotational delay)

- **Latency** is the time needed for the disk to rotate so the sector we want is under the read/write head.
- Hard disks usually rotate at about 5000rpm, which is one revolution per 12 msec.
- **Note:**
  - Min latency = 0
  - Max latency = Time for one disk revolution
  - **Average latency** \( (r) = \frac{\text{min} + \text{max}}{2} \)
    \[= \frac{\text{max}}{2} \]
    \[= \text{time for } \frac{1}{2} \text{ disk revolution} \]
- Typically 6 – 8 ms average
Transfer Time

• Transfer time is the time for the read/write head to pass over a block.

• The transfer time is given by the formula:

\[
\text{Transfer time} = \frac{\text{number of bytes transferred}}{\text{number of bytes on a track}} \times \text{rotation time}
\]

• e.g. if there are 63 sectors per track, the time to transfer one sector would be \(1/63\) of a revolution.
Exercise

• Specifications of a 300MB disk drive:
  – Min seek time = 6ms.
  – Average seek time = 18ms
  – Rotational delay = 8.3ms
  – Transfer rate = 16.7 ms/track or 1229 bytes/ms
  – Bytes per sector = 512
  – Sectors per track = 40
  – Tracks per cylinder = 12
  – Tracks per surface = 1331
  – Interleave factor = 1
  – Cluster size = 8 sectors
  – Smallest extent size = 5 clusters

Q) How long will it take to read a 2048Kb file that is divided into 8000 256 byte records?

i) Access the file sequentially

ii) Access the file randomly
Characteristics

• Head Motion
  – Fixed, Movable
• Disk Portability
  – Non-removable, Removable
• Sides
  – Single-sided, Double-sided
• Disk/Surface
  – Single Surface, Multiple Surface
• Head Mechanism
  – Contact, Fixed gap, Aerodynamic Gap
## Typical Disks

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Cylinders</th>
<th>Heads</th>
<th>Sectors</th>
<th>Bytes/sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.302 GB</td>
<td>523</td>
<td>255</td>
<td>63</td>
<td>512</td>
</tr>
<tr>
<td>2.159 GB</td>
<td>523</td>
<td>128</td>
<td>63</td>
<td>512</td>
</tr>
<tr>
<td>1.08 GB</td>
<td>523</td>
<td>64</td>
<td>63</td>
<td>512</td>
</tr>
</tbody>
</table>
Disk Controller
Floppy Disk

- Metal shutter
- Hard plastic jacket
- Label
- Write-protection notch in the open position
- Data access area
- Front of disk
- Inside of disk
- Track
- Sector
Floppy Internals
5.25” Floppy
FDD Cable

Standard Five-Connector Floppy Interface Cable

- Pin 1 (Red Wire)
- Pin 34
- "Twist"
- 3.5" Drive "A" Connector
- 5.25" Drive "A" Connector
- Motherboard Connector
- 5.25" Drive "B" Connector
- 3.5" Drive "B" Connector
## Specifications

<table>
<thead>
<tr>
<th>Physical Specifications</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.25” One sided</td>
<td>180 KB</td>
</tr>
<tr>
<td>5.25” Two sided</td>
<td>360 KB</td>
</tr>
<tr>
<td>5.25” Two sided</td>
<td>1.2 MB</td>
</tr>
<tr>
<td>3.5” Two sided</td>
<td>1.44 MB</td>
</tr>
</tbody>
</table>
Disk Format

IBM 3740
High Capacity Floppy Disks

Known as a *floppy-disk cartridge*

- Require special disk drives
- Three well known types
  - Zip disks
  - HiFD disks
  - SuperDisks
Magnetic Tape

Quarter inch cartridges (QIC) are widely used for desktop backup. QIC uses .25" tape, and both QIC-Wide and Travan use .315" (8mm) tape.

QIC-Wide drives accept QIC cartridges, and Travan drives accept QIC and QIC-Wide tapes.

Verbatim's QIC-EX cartridges hold more tape for both QIC and Travan drives.
Magnetic Tape
Magnetic Recorded Tape
Organization of Data
Magnetic Tape

• Advantages
  – Unlimited Storage
  – High Data Density
  – Low Cost
  – Rapid Transfer Rate
  – Ease of handling
  – Portability

• Disadvantages
  – Sequential Access
  – Environmental Restrictions
Digital Audio Tape
RAID

- Redundant Array of Inexpensive Disks
- Data Stripping
RAID Levels

Fig. 6.71 RAID level 0 (Non-Redundant)

Fig. 6.72 RAID level 1 (Mirrored)
Fig. 6.73 RAID level 2 (Redundancy through hamming code)

Fig. 6.74 RAID level 3 (Bit-interleaved parity)
Fig. 6.75 RAID level 4 (Block level parity)

Fig. 6.76 RAID level 5 (Block-level distributed parity)
Reference

• Computer Architecture and Organization
  – *By A. P. Godse*

• Computer Organization
  – *By Hamacher and Zaky*