Disk Management

- Management and ordering of disk access requests is important:
  - Huge speed gap between memory and disk
  - Disk throughput is extremely sensitive to
  - Request order $\Rightarrow$ Disk Scheduling
  - Placement of data on the disk $\Rightarrow$ file system design
  - Disk scheduler must be aware of disk geometry

Disk Geometry

- Physical geometry of a disk with two zones
  - Outer tracks can store more sectors than inner without exceed max information density
  - A possible virtual geometry for this disk

Evolution of Disk Hardware

<table>
<thead>
<tr>
<th>Parameter</th>
<th>IBM 360-KB floppy disk</th>
<th>WD 18300 hard disk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cylinders</td>
<td>40</td>
<td>10601</td>
</tr>
<tr>
<td>Tracks per cylinder</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Sectors per track</td>
<td>9</td>
<td>281 (avg)</td>
</tr>
<tr>
<td>Sectors per disk</td>
<td>729</td>
<td>35742000</td>
</tr>
<tr>
<td>Bytes per sector</td>
<td>512</td>
<td>512</td>
</tr>
<tr>
<td>Disk capacity</td>
<td>360 KB</td>
<td>18.5 GB</td>
</tr>
<tr>
<td>Seek time (adjacent cylinders)</td>
<td>6 msec</td>
<td>0.6 msec</td>
</tr>
<tr>
<td>Seek time (average case)</td>
<td>77 msec</td>
<td>6.9 msec</td>
</tr>
<tr>
<td>Rotation time</td>
<td>200 msec</td>
<td>8.33 msec</td>
</tr>
<tr>
<td>Motor stop/start time</td>
<td>250 msec</td>
<td>20 sec</td>
</tr>
<tr>
<td>Time to transfer 1 sector</td>
<td>22 msec</td>
<td>17 msec</td>
</tr>
</tbody>
</table>

Disk parameters for the original IBM PC floppy disk and a Western Digital WD 18300 hard disk

Things to Note

- Average seek time is approx 12 times better
- Rotation time is 24 times faster
- Transfer time is 1300 times faster
  - Most of this gain is due to increase in density
  - Represents a gradual engineering improvement

Storage Capacity is 50000 times greater
Disk Performance is Entirely Dominated by Seek and Rotational Delays

- Will only get worse as capacity increases much faster than increase in seek time and rotation speed
- Note it has been easier to spin the disk faster than improve seek time
- Operating System should minimise mechanical delays as much as possible

Disk Arm Scheduling Algorithms

- Time required to read or write a disk block determined by 3 factors
  1. Seek time
  2. Rotational delay
  3. Actual transfer time
- Seek time dominates
- For a single disk, there will be a number of I/O requests
  → Processing them in random order leads to worst possible performance

First-in, First-out (FIFO)

- Process requests as they come
- Fair (no starvation)
- Good for a few processes with clustered requests
- Deteriorates to random if there are many processes

Request tracks: 55, 58, 39, 18, 90, 160, 150, 38, 184

Shortest Seek Time First

- Select request that minimises the seek time
- Generally performs much better than FIFO
- May lead to starvation

Request tracks: 55, 58, 39, 18, 90, 160, 150, 38, 184
Elevator Algorithm (SCAN)
- Move head in one direction
- Services requests in track order until it reaches the last track, then reverses direction
- Better than FIFO, usually worse than SSTF
- Avoids starvation
- Makes poor use of sequential reads (on down-scan)
- Inner tracks serviced more frequently than outer tracks

Request tracks: 55, 58, 39, 18, 90, 160, 150, 38, 184

Modified Elevator (Circular SCAN, C-SCAN)
- Like elevator, but reads sectors in only one direction
- When reaching last track, go back to first track non-stop
- Note: seeking across disk in one movement faster than stopping along the way.
- Better locality on sequential reads
- Better use of read ahead cache on controller
- Reduces max delay to read a particular sector

Request tracks: 55, 58, 39, 18, 90, 160, 150, 38, 184