Random Access

cylinder = set of similar tracks for all platters

platter

spindle

arm

(virtual) tracks

(disk) heads
Cost of a Random Access

1. seek-time $t_s$ (arm movement)

2. rotational delay $t_r$ (wait for the right angle)

\[
12000 \text{ RPM} \div 60 = 200 \text{ KPS}
\]

\[
\frac{\wedge}{200} \text{ sec}
\]

\[
t_r = \frac{\wedge}{400} = 2.5 \text{ ms}
\]
Sequential Access

cylinder = set of similar tracks for all platters

platter

(virtual) tracks

spindle

arm

(disk) heads
Cost of a Sequential Access

1. seek to cylinder $t_s$ (arm movement)

2. rotational delay $t_r$ (wait for the right angle)

3. transfer time $t_{tr}$ (transfer the actual data)
Cost of a Sequential Access

1. seek to cylinder $t_s$ (arm movement)
2. rotational delay $t_r$ (wait for the right angle)
3. transfer time $t_{tr}$ (transfer the actual data)
4. switch to different head on the same track
5. rotational delay $t_r$ (wait for the right angle)
6. transfer time $t_{tr}$ (transfer the actual data)
Track Skewing

rotation done while moving disk head

next block read

last block read
## Hard Disk Evolution

<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>2012</th>
<th>improvement factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM 3330</td>
<td>30ms</td>
<td>5ms</td>
<td>6</td>
</tr>
<tr>
<td>Seagate Savvio 15K.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average access time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sequential</td>
<td>0.8MB/sec</td>
<td>174MB/sec</td>
<td>218</td>
</tr>
</tbody>
</table>
Simulation: Read 1,000 blocks of size 8 KB

TR: transfer rate in MB/sec

Each block **randomly** read:

$t_{random} = 1,000 \times (\text{avg access time} + 8\text{KB/TR})$
Simulation: Read 1,000 blocks of size 8 KB

TR: transfer rate in MB/sec

each block **randomly** read:
\[ t_{\text{random}} = 1,000 \times (\text{avg access time} + 8\text{KB/TR}) \]

**sequential** read:
\[ t_{\text{seq}} = 1 \times \text{avg access time} + 1,000 \times 8\text{KB/TR} \]
<table>
<thead>
<tr>
<th></th>
<th>1970</th>
<th>2012</th>
<th>improvement factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>each block randomly read</td>
<td>IBM 3330</td>
<td>Seagate Savvio 15K.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40,410ms</td>
<td>5,046ms</td>
<td>8</td>
</tr>
<tr>
<td>sequential read</td>
<td>10,440ms</td>
<td>51ms</td>
<td>205</td>
</tr>
<tr>
<td>improvement factor</td>
<td>4</td>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>
Hard Disk Evolution for Enterprise Disks
