Outline

Marketplace
• personal – desktop, low-end servers
• enterprise – servers, workstations, arrays
• consumer – appliances
• mobile – laptops

Mechanics & Electronics
• choices, comparison

Performance
• the direct impact

Reliability
• factors

Summary
Disc characteristics

User-visible characteristics

• Data rate $\sim (2\pi r) \times (density) \times (rpm)$
• Capacity $\sim (\pi r^2) \times (density)$
• Seek time $\sim r$

Internal characteristics

• Areal density – $density$
• Platter size – $r$
• Spindle speed – $rpm$
Areal density

Data rate ~ \((2\pi r) \times (\text{density}) \times (\text{rpm})\)

Capacity ~ \((\pi r^2) \times (\text{density})\)

Seek time ~ \(r\)

Areal density – density
- how many bits you can squeeze in

The bad news
- requires more signal processing
- tolerates less “noise”
- harder to do track-following (servo)

higher density, higher data rate
higher density, higher capacity
Platter size

Data rate \( \sim (2\pi r) \times (\text{density}) \times (\text{rpm}) \)
Capacity \( \sim (\pi r^2) \times (\text{density}) \)
Seek time \( \sim r \)

Platter size – \( r \)
• large, smaller, smallest

More bad news
• larger platter, more power

larger platter, higher data rate
larger platter, higher capacity
bad news – larger platter, higher seek time
Spindle speed

Data rate $\sim (2\pi r) \times (\text{density}) \times (\text{rpm})$

Capacity $\sim (\pi r^2) \times (\text{density})$

Seek time $\sim r$

Spindle speed – $rpm$
  - slow, fast, very fast

The bad news
  - creates more “noise”
  - more (bad) vibration
  - more speed, more power

faster platter, higher data rate
Comparing mechanics

Cheetah 10K.6 enterprise

- 84 mm
- More rigid structure
- Larger actuator assembly

Barracuda 7200.7 personal

- 95 mm
Comparing mechanics (2)

smaller platters – less mass, shorter seeks => less capacity
Mechanics summary

Basic design choices

• how high data rate
• how much capacity
• how small seek time

Each one affects which parts you pull off the shelf

• how you put them together depends on how they will be used
• some decisions driven by the marketplace
• some driven by cost
Outline

Marketplace
• personal
• enterprise

Mechanics
• choices – pick your parts
• the choices made to date – comparison

Electronics
• comparison

Performance
• the direct impact

Summary
Spindle speed

- highest spindle speed will be perfected in enterprise drives
- when it becomes cheap enough, it becomes the norm in personal drives as well

product information for Seagate and Control Data disc drives since 1988
Capacity

- wider spacing for enterprise drives
- wait until you get 2x
- this can confuse comparisons based on equivalent capacity
- highest capacity was always in enterprise drives, until 2003

product information for Seagate disc drives introduced since 1991
Seek time

- enterprise always more aggressive on seek performance
- trend is toward further separation
- sensitive to both the mechanics and the signal processing
  - moving the arm fast enough (starting)
  - staying on track (stopping)

product information for Seagate disc drives introduced since 1991
Rotational vibration

- rotation of one drive affects neighboring drives
- personal drives not designed to reject the external energy
- manifests itself as a performance problem

- state of the art cabinets have 15 adjacent drives
- measurement of cabinets shows vibration up to 45 rad/s² (best cabinets at 5 rad/s²)

comparison of Cheetah 18LP and Barracuda III
Outline

Marketplace
  • personal
  • enterprise

Mechanics
  • choices & comparison

Electronics
  • this is the *only* place where interface matters directly

Performance
  • the direct impact

Summary
Electronics comparison

Servo processor – track following
  • more tracks require more processing
  • enterprise drives will use two processors
Data mover ASIC – for all common-case data transfer
  • more complex interface requires more gates
Program & data memory – every KB counts here!
  • more complex interface requires more RAM & flash
  • command queuing, multi-host support, parallel tasks
    • requires more code, more data space
  • we only put in the functions users *need* and *use*
Command queuing

- enterprise has a much larger improvement due to more sophisticated queuing
  - requires more memory
  - and more code

- note – queuing benefit on writes would be even larger without (unsafe) caching

Comparison of Cheetah 73LP and Barracuda IV
Outline

Marketplace
  • personal
  • enterprise

Mechanics
  • choices & comparison

Electronics
  • this is the only place where interface matters directly

Performance
  • the direct impact

Summary
## Performance comparison

<table>
<thead>
<tr>
<th></th>
<th>cap</th>
<th>rpm</th>
<th>seek</th>
<th>density</th>
<th>dia</th>
<th>p</th>
<th>ext bw</th>
</tr>
</thead>
<tbody>
<tr>
<td>UltraStar 36 LZX</td>
<td>36 GB</td>
<td>10000</td>
<td>4.9 ms</td>
<td>7.0 Gb/in²</td>
<td>84 mm</td>
<td>6</td>
<td>36 MB/s</td>
</tr>
<tr>
<td>DeskStar 75</td>
<td>30 GB</td>
<td>7200</td>
<td>8.5 ms</td>
<td>11.0 Gb/in²</td>
<td>95 mm</td>
<td>2</td>
<td>37 MB/s</td>
</tr>
</tbody>
</table>

- **UltraStar 36 LZX** is SCSI with a slower spindle, higher areal density, and equivalent areal density compared to **DeskStar 75**. It has faster seek times and a larger platters count.
- **DeskStar 75** is ATA with a faster spindle, higher areal density, and larger platter size. It has a slower seek time and a smaller platters count.

---

<table>
<thead>
<tr>
<th></th>
<th>cap</th>
<th>rpm</th>
<th>seek</th>
<th>density</th>
<th>dia</th>
<th>p</th>
<th>ext bw</th>
</tr>
</thead>
<tbody>
<tr>
<td>UltraStar 36Z15</td>
<td>36 GB</td>
<td>15000</td>
<td>4.1 ms</td>
<td>10.7 Gb/in²</td>
<td>65 mm</td>
<td>6</td>
<td>53 MB/s</td>
</tr>
</tbody>
</table>

- **UltraStar 36Z15** is a faster spindle model of **UltraStar 36 LZX**, with much higher enterprise bandwidth. It has a faster seek time, smaller platters, and more platters compared to the **DeskStar 75** model.
Summary and conclusions

Drives are designed from the ground up to meet a specific set of usage characteristics
  • more sophisticated than just $ / GB

If you want to understand the state-of-the-art
  • make sure you look at enterprise drives
  • and make sure you are comparing apples to apples

There is room for a wider variety of models
  • tell us what points are worthwhile
More Details?

Just ask.

dave.b.anderson@seagate.com
james.e.dykes@seagate.com
erik.riedel@seagate.com
Detail Slides
Number of platters

- trend toward depopulated drives, as users trade capacity for performance and reliability
- even to odd-numbered head and single head drives, to save head costs

*product information for entire industry since 1998*
Areal density vs. linear density

- most of the recent improvement due to higher tracks per inch (tpi)
- linear density, bits per inch (bpi) is much higher, but growing more slowly

Product information from the Appendix of “SCSI vs. ATA – more than an interface” in 2nd FAST Conference, April 2003
Linear density

- enterprise lags personal by a little
- takes longer to get the signal processing into the right tolerances

- data rate and capacity are the drivers in personal

*product information for Seagate disc drives introduced since 1991*