Re-evaluating HDD Error Correction
Bit Error Rates, UER and Cloud Hard Drives

David Burks
Seagate Technology
CAUTION!

Geek
Detail Oriented
Socially Inept
Emotionally Unstable
Dweeb
Dorks
Spaz
Detail Oriented

Diagram showing overlapping circles labeled 'Socially Inept', 'Dweeb', 'Geek', 'Dorks', 'Spaz', and 'Emotionally Unstable', with a caution sign in the background.
A Short History of HDDs & Error Correction
The 50’s

IBM RMAC 305

Error Correction Capabilities

What’s Error Correction?

Our reliability spec insures that 70% of our drives power up straight out of the box!
The 60’s

IBM 1311

Error Correction Capabilities

Be really careful with it!

- “Precaution should be exercised to prevent foreign particles from entering the 1311 disk pack...”
- “Use of cleaning implements that raise dust such as brooms and feather dusters should be avoided.”
IBM 3340

Error Correction Capabilities

We'll tell what might work...

3340/3344 Recovery Action Table (continued)

<table>
<thead>
<tr>
<th>Action</th>
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<td>b. Examine bit 7 of the file mask. If this bit is off, go to step c. If this bit is on, return to user with indication that data has been corrected. (User is operating in PCI fetch mode and must supply restart recovery action.) Note: Only applies with OS/360.</td>
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<tr>
<td>c. Increment the seek argument by one. Cylinder bytes and the high-order head byte are obtained from the user. The low-order head byte is obtained from bits 3 through 7 of sense byte 6.</td>
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<td>d. Construct Restart CCW 2.</td>
<td></td>
</tr>
<tr>
<td>e. Complete the interrupted operation and continue the user's chain (if appropriate) by executing the following command chain.</td>
<td></td>
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</table>

Seek
Set File Mask (same as original)
Set Sector (argument 0)
Search ID Equal (record 1)
TIC = 8
Restart CCW 2

Note: If the modified seek argument is not within the user's extent, then IOS must supply the correct seek argument before issuing the seek. If that is impossible, then IOS must perform Action 2.
The 70’s

IBM 3340

Error Correction Capabilities

We’ll tell what might work...

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</tr>
<tr>
<td>-------------</td>
<td>-------------------------</td>
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<td>Seek</td>
<td>(argument from step c)</td>
</tr>
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<td>Set File Mask</td>
<td>(same as original)</td>
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<td>Set Sector</td>
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<td>(record 1)</td>
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<tr>
<td>TIC* – 8</td>
<td></td>
</tr>
<tr>
<td>Restart CCW 2</td>
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<tr>
<td>TIC</td>
<td>(channel status word)</td>
</tr>
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Note: If the modified seek argument is not within the user’s extent, then I/O must supply the correct seek argument before issuing the seek. If that is impossible, then I/O must perform Action 2.
The 80’s

Seagate ST 506

Error Correction Capabilities

Published UER!

1 bit $100,000,000,000$ will be uncorrectable

($10 \times 10^{12}$)
The 90’s

Seagate ST 4051

Error Correction Capabilities

UER Improvements...

1 bit $10,000,000,000,000$ will be uncorrectable ($10 \times 10^{14}$)
The 21 Century

Seagate 15K Enterprise

Error Correction Capabilities

The era of modern ECC!

1 bit $1,000,000,000,000,000,000$ will be uncorrectable
($10 \text{ e16}$)

And the Era of Cloud Computing....
What is a Cloud HDD?

They don’t yet exist!

But if they did, would they need the awesome error correction features of modern HDDS?
Error Correction and Tail Latency

The Cloud Drive

Worst UER

10 e10

Best UER

10 e16
Back to Future

• What if we took UER back to 1980?
• What might that achieve for a Cloud HDD?

**Near Term**

- Better command completion times (CCT)
- Lower tail latency & improved SLA (better performance)

**Long Term**

- Improved HDD yields
- Better TTM for new capacities
- Reduced costs for the HDD ecosystem driving lower $/TB
A Classic “Chicken & Egg” Challenge

• Error rate assumptions are “baked” into many, many aspects of HDD design & manufacturing.
  ✓ Head & media engineering & manufacturing criteria
  ✓ ASIC design
  ✓ Servo-mechanical capabilities
  ✓ Firmware
  ✓ Test processes

This opportunity demands industry collaboration!
Key Questions to Pursue

• Is there a “sweet spot” of reduced UER common the the CSP community?
• How would this best be determined?
• Can OCP be leveraged to organize, standardize and operationalize opportunities like these for the benefit of the booming Cloud market place?
Visit our Booth B7

Learn about the industry’s broadest catalog of storage devices

<table>
<thead>
<tr>
<th>ENTERPRISE &amp; CLOUD</th>
<th>CLIENT (DESKTOP &amp; MOBILE)</th>
<th>NAS</th>
<th>SURVEILLANCE</th>
<th>VIDEO &amp; MEDIA</th>
</tr>
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