Optical Media Roadmap

“The Revival of Optical Storage”

Ken Wood
Director of Technology and Strategy
Hitachi Data Systems
Today’s Session Format

☐ Session Chair, Ken Wood - @KenWoodOnTech

☐ Presentations – Please hold all questions until the end of the session

  o **Optical Media Technical Roadmap** – ~30 minutes
    ▪ Ken Wood, HDS
  o **Long Term Data Preservation of an Optical Library** – ~30 minutes
    ▪ Akinobu Watanabe, Hitachi
  o **Achieving 1000-year Data Persistence: “Engraved in Stone”** – ~30 minutes
    ▪ Doug Hansen, Millenniata

☐ All 3 presenters will come back on stage for Q&A&Q
What’s Being Covered

- Session Format
- A Little Introductory History
- Intangibles & Tangibles
- 321 == 322
- Not all Media is Created Equally
- What’s Happening Inside?
  - Show ~3 minute video with me narrating
- More Compatibility
- Where are we Going?

NOTE & WARNING
Content presented here about future product, technology, concepts & directions is general in nature, for information only, and does not represent definite plans or commitments and should not be incorporated into any contract.
Optical recording since the dawn of man

Oldest form of human recording

An example of preserving the “bits” forever while not really understanding the application that created it

Full circle theme here
Optical Recording Throughout History – Digital Data

☐ The first commercially available audio CD is Billy Joel’s “52nd Street” released in Japan on October 1st, 1982
  ○ That’s almost 31 years ago

☐ 50 titles were also released on CD in those first early years including Pink Floyd’s “Dark Side of the Moon” in May of 1983

☐ Still plays today on the latest devices supporting the newest formats
Research Emphasis on Extremely Long-term Data Preservation

- All Optical-based Technologies
  - 50 - 100 Year BDXL Media
  - Holographic Storage
  - M-Disc – 1,000 year media
    - DOTS – Digital Optical Technology System
    - Sapphire Hard Disc – 1M yrs
  - Quartz glass plate storage technology – 100M yrs

Hitachi areas of R&D
Beyond Speeds & Feeds – the Intangibles

**Longevity**
“Optical” recording has been used for over 10,000 years in human data recording history.

**Compatibility**
Since BD can be read on general purpose PCs with consumer devices, there is less possibility that media and data will be inaccessible due to obsolete devices.

**Contactless**
Since there is no contact with the media surface, there is less possibility of abrasion, scratch or other media wear.

**Survivability**
Only data stored on optical disc survived hurricane Katrina.
Optical Data Storage Benefit

- **Non-Magnetic**
  2 recording technologies are needed for a sound data preservation strategy, with magnetic recording being considered as one.

- **Reliable**
  Since device and media are separated, reliability and replacement of devices doesn’t affect the reliability of media.

- **Ubiquitous**
  Several industries use optical devices which supports a mass volume industry and maintains compatibility. UHD?

- **Green**
  Almost no electricity nor special environmental condition is needed to store media for a long time.
Optical Media Value Proposition

Operating Cost
Real cost for Archiving is OPERATING COST, not just acquisition
“Best TCO”

<table>
<thead>
<tr>
<th>Data migration</th>
<th>Power Consumption</th>
<th>IT cost</th>
<th>S/W</th>
<th>H/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.9</td>
<td>0.8</td>
<td>0.7</td>
<td>2.4</td>
<td>0.9</td>
</tr>
</tbody>
</table>

*Case Study: 100TB, 20 Years
*Source: Buckley’s White Paper

CO² Emission
“Eco” is not only “Economy” but also Ecology
“Lowest CO² Emission”

<table>
<thead>
<tr>
<th>Disk Array</th>
<th>Tape Library</th>
<th>Optical Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>$7.7m</td>
<td>$1.6m</td>
<td>$2.9m</td>
</tr>
</tbody>
</table>

*Case Study: 1,000TB, 1Year
*Source: Japanese Gov. MIC report ’08

Longevity (Archival Life)
“LONGEST LIFE AND COMPATIBILITY”

<table>
<thead>
<tr>
<th>2000s</th>
<th>2010s</th>
<th>2020s</th>
<th>2030s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Mechanical or Magnetic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Accessibility
“FASTER THAN TAPE & Glacier” Retrieval

<table>
<thead>
<tr>
<th>HDD</th>
<th>ODD</th>
<th>Tape</th>
<th>Glacier</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3</td>
<td>100</td>
<td>30,000</td>
<td>3-5 Hours</td>
</tr>
</tbody>
</table>

[Source: Buckley’s White Paper]

ODD = Optical Disk Drive
Blu-ray and BDXL and Density

- BD is 25GB & 50GB per disc - 2006
- BDXL is 100GB & 128GB per disc - 2010

- A 128GB disc is 157GB/ci uncompressed (.8ci)
  - Dual sided is 314GB/ci
- A 1.5TB LTO5 tape is 114GB/ci (13ci)

- That’s 2.5TB in 13 ci, the same space that a LTO5 cartridge occupies
  - Double sided is 5TB

In the same physical volume $X \times 16 = \sim 1x$
Today, you can buy new standard drives that are compatible with media written over 30 years ago. This trend will continue due to markets for consumer and distribution driven volume.
Long-term Data Preservation Strategies

☐ 321 == 3 copies, 2 sites and 1 other technology, *or visa versa*
☐ 322 == 3 copies, 2 sites and 2 technologies

☐ Several long-term data preservation strategists are coming to consensus that the 2 recoding technologies used today, hard disks and tape, are considered the same technology – magnetic
  o Similar vulnerabilities

☐ Long-term TCO is still a key goal
  o Life of the company
  o Life of the republic
  o Life that spans republics
Not All Optical Media is Created Equally

- **Low-to-High –** LTH low cost, organic dye based
  - Dye Change Recording
    - **NOT FOR LONG TERM ARCHIVING!**
  - Gives Optical technology a bad name

- **High-to-Low –** Normal Blu-ray characteristic
  - Phase Change Recording using in-organometallic compound
  - Basis for long-term optical archiving

- **True WORM Media**
  - Hard concept to grasp
  - Other flaws

- **Zero-space race**

## Advancement In Laser and Lens Mechanism

<table>
<thead>
<tr>
<th>Disc Layout</th>
<th>CD</th>
<th>DVD</th>
<th>HD DVD (Obsolete)</th>
<th>BD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Layer</td>
<td><img src="image1" alt="CD Diagram" /></td>
<td><img src="image2" alt="DVD Diagram" /></td>
<td><img src="image3" alt="HD DVD Diagram" /></td>
<td><img src="image4" alt="BD Diagram" /></td>
</tr>
<tr>
<td><strong>Capacity (per Layer)</strong></td>
<td>640MB - 700MB, etc</td>
<td>4.7GB</td>
<td>15GB</td>
<td>25GB/33GB</td>
</tr>
<tr>
<td><strong>λ</strong></td>
<td>780nm (Near infrared)</td>
<td>650nm (Red)</td>
<td>405nm (Violet Blue)</td>
<td>405nm (Violet Blue)</td>
</tr>
<tr>
<td><strong>Numerical Aperture</strong></td>
<td>0.45</td>
<td>0.60</td>
<td>0.65</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>μ</strong></td>
<td>1.4um</td>
<td>0.89um</td>
<td>0.51um</td>
<td>0.39um</td>
</tr>
</tbody>
</table>
Movie Time

Quick Video on Blu-ray Operations

Narrated by yours Truly
Low Cost, Backwards Compatibility

- Very inexpensive to build and support
- Over 500 media types, write strategies and formats supported
- Already in the firmware
- Many devices can support new “types” with new firmware
Holographic Data Storage

- Holographic Storage store data elements as images at different angels.

Record by interference between signal and reference beam.

Readout by presenting reference beam to the media.

2 Dimension Data (Mega pixels)
# Holographic Data Storage – The Different Approaches

<table>
<thead>
<tr>
<th></th>
<th>Angular Multiplexing</th>
<th>Collinear</th>
<th>Micro-Hologram</th>
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</thead>
<tbody>
<tr>
<td><strong>Principle Concept</strong></td>
<td>Reference beam</td>
<td>SLM</td>
<td>SLM</td>
</tr>
<tr>
<td></td>
<td>SLM</td>
<td>Sig. beam</td>
<td>Sig. beam</td>
</tr>
<tr>
<td></td>
<td>Signal beam</td>
<td></td>
<td>Ref. beam</td>
</tr>
<tr>
<td><strong>Transfer Rate</strong></td>
<td>Page-based Read/Write</td>
<td>Page-based Read/Write</td>
<td>Bit by Bit Read/Write</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>3D Recording</td>
<td>3D Recording</td>
<td>Multi-layered bitwise Recording</td>
</tr>
<tr>
<td><strong>BD compatibility</strong></td>
<td>Not Compatible with BD</td>
<td>Some Compatibility</td>
<td>Compatible</td>
</tr>
</tbody>
</table>
Thank You