Instrumental
HIGH PERFORMANCE INNOVATION

Global IT Executive Summit Tape vs. Optical a fair comparison
September 12, 2013

Henry Newman

Instrumental Inc.

CTO/CEO

hsn@instrumental.com

- Optical overview
- Optical drives and media
- Optical robots
- Tape comparison

Optical overview

What is out there

Overview of the technologies

- Blu-ray Disc Recordable (BD-R) media provides 25 GB to 50 GB of capacity depending on if the disc is single sided or double sided
  - Write-Once, Read-Many (WORM) format that is more reliable than rewriteable options.
- BD-XL discs are multi-layered (usually 3 to 4 layers) discs that can provide between 100 GB and 128 GB of capacity per disk in a WORM format
- MDisc BD-R is a specialized product from Millenniata that provides the same capacity as BD-R, but increased reliability by etching actual pits into a solid surface rather than changing a chemical dye or crystalline metal as normal BD-R and BD-XL media

Optical drives and media

A bit about optical drives and media vendors

- While both Sony and Panasonic manufacture their own Blu-ray disc and drive products, they have begun to work together as a joint vendor in developing archival Blu-ray and optical storage products
  - Increasing capacity – Current BD products from Sony and Panasonic offer 25 Gigabytes (GB) to 100 GB of data capacity per disc, however this new product will initially have 300 GB capacity with a goal of achieving 1 TB capacity in the future
    - But where is the roadmap on when

- Pioneer is also acting as a vendor in the optical media archival market as it but drives BD-R drives that come with products from software companies like CyberLink and Digistor that develop and sell software for data storage or archive appliances
- Largest archive project currently available uses Mitsubishi 100 GB discs designed for archiving in its newer drives for reliable data storage
  - In the future, Pioneer is working with Memory-Tech, as well as technical cooperation from Mitsubishi, to develop an extremely high capacity multi-layer disc for archive storage
- In addition, there is no information on how Pioneer plans to maintain or improve data integrity despite increasing the number of layers or decreasing sizes of data written on the disc
  - No media robotics and software to manage the system

- Joint venture between Hitachi and LG Electronics
- Hitachi is also looking to develop new advanced optical storage media for use in archive storage environments
  - AT the 2013 IEEE Conference on Massive Data Storage, pointed toward development of a new optical holographic storage media where data is stored in three-dimensional images on the media and capacities up to 1 TB by 2015
  - However it has been very quite since then

Millenniata

- Although not as large as other vendors, it is worth mentioning Millenniata as an optical archive vendor for their M-Disc product

- This is either a DVD or Blu-ray disc that is designed to endure exposure to extreme environments with minimal data loss.

- This endurance is a result of a high powered laser etching actual pits into the storage media
  - Instead of changing the crystalline structure of a metal or color of a dye), resulting in permanent pits in the media so that data does not dissipate or wear out over time like it can with crystalline metals This option is viable and available now with both Hitachi and LG offering drives compatible with Millenniata's M-Disc
  - But significantly lower performance for writes

Optical robots

Not much out there

Robots

- Most archive appliances tend to only have 2 to 6 drives and one robot per drive
  - As a result, read and write speeds are partially dictated by the rate at which the robots can load and unload discs
- Most appliances from vendors such as DISC, HIT, or Open Source Storage have relatively quick exchange times of 3 to 8 seconds depending on the size of the appliance and number of discs.
- However, this does not account for the amount of time it takes to get a disc, read all the data, and then get another disc
  - While it is difficult to estimate those times because the capacity of discs may vary from 25 GB to 100 GB, it is safe to estimate that it will take between 23 and 45 minutes
- This means that optical storage libraries are best suited for use by a very limited number of users at a time
- The one exception is Hitachi's HL100 library, which offers 12 BD drives for every 500 discs and redundant robotics to perform multiple exchanges at a time
- Hitachi claims that its library system can provide access times of 24 maximum of seconds, and can offer read rate of 216 MB/s and write rate (with verify) or 108 MB/s when all 12 drives are working
  - This is considerably faster than the 9 MB/s and 18 MB/s claims of vendors such as DISC and Open Source Storage

- Developed the HL100, an entire archive appliance and system including discs, drives, robotics, and cartridges in a 4U server library
  - This technology is far different than optical jukeboxes of the past given the software interfaces and hardware design
  - The library is scalable up to 450 TB and can provide 108 drives (12 drives per library, 9 libraries per 42U Rack)
- In addition, Hitachi-LG has also developed specialized processes and device driver to offer a high level of reliability for Blu-ray discs, claiming to provide a hard error rate of 1E21

Optical Challenges

If it was easy

Performance Challenges

- First, Blu-ray has very limited read and write speeds for archiving. The maximum read and write speeds for Blu-ray discs and drives is 16x base Constant Angular Velocity (CAV)
  - With a base "1x" CAV that results in about 4.5 MB/s, this translates into approximately 72 MB/s maximum for outer cylinders, but the disc must spin slower on parts of the data groove closer to the center
  - In addition, read and write rates for actual archive appliances are much slower at between 2x and 6x, or 9 MB/s to18 MB/s

- Second, even the most advanced Blu-ray discs continue to lack the raw storage capacity of other media options
  - Sony's Archival Disc, which is being developed with Panasonic, is projected to have a capacity of about 300 GB while Pioneer's next generation high-capacity disc is projected to have 512 GB per disc

- Third, reliability tends to present a problem when considering Blu-ray as an archiving solution
  - Since the last standard for optical storage only requires reliability comparable to computer connections, most current estimates place Blu-ray hard error rates at around 1E12
    - In addition, the USB or SATA connections used also do not provide good error correction in the channel
  - The only exception here is Hitachi-LG's optical archive library, which incorporates added measures, error correction and error detection to achieve a hard error rate of 1E21

Tape comparison

What does it all mean
Warning Geekout time

Background information

Storage Media	TS1140	T10000D	LTO-6	Current Blu-ray (HLDS HL100)	Current Blu-ray (DISC ArXtor 7000)	Current Blu-ray (Open Source Storage Blu-ray Archive)
Introduction	June 2011	September 2013	February 2013	April 2014	November 2012	?
Capacity in 1000s	4TB	8.5TB	2.5TB	100GB	50GB	50GB
Interface	FC-8	FC-16/FCoE 40 Gb	6 Gb/s SAS / FC-8	SATA	SATA	SATA
Hard Error Rate	1.00E+20	1.00E+19	1.00E+17	1.00E+21	~1.00E12?	~1.00E12?

Storage Media	TS1140	T10000D	LTO-6	Current Blu-ray (HLDS HL100)	Current Blu-ray (DISC ArXtor 7000)	Current Blu-ray (Open Source Storage Blu-ray Archive)
Read Data Rate (MiB/s)	238	246	153	17.16	8.58	8.58
Write Data Rate (MiB/s)	238	246	153	8.58	8.58	8.58
Pick Time (s) in Automation (Robot/Library)	5	11	5	8[2]	6	8
Load Time (s) for Media in Device	16	13	16	6[2]	6	6
Average File Access (s)	47	50	50	66[4]	0.17[3]	66[5]
Time (hr) to Read 1GiB	0.020	0.022	0.022	0.039	0.055	0.055
Time (hr) to Read 1TiB	1.24	1.20	1.92	17.00	33.97	33.97
Time (hr) to Read 1PiB	1253.2	1212.5	1949.4	17381.2	34762.4	34762.4
Time (hr) to Write 1GiB	0.020	0.022	0.022	0.055	0.055	0.055
Time (hr) to Write 1TiB	1.24	1.20	1.92	33.97	33.97	33.97
Time (hr) to Write 1PiB	1253.2	1212.5	1949.4	34762.4	34762.4	34762.4

2. Pick and load time are unavailable but assumed to be similar to other Blu-ray models.
3. While this number is what the vendor publishes, it assumes access from a hard disk cache. The average file access time (66 s) for similar models is used.
4. This average file access time is calculated from Hitachi's published time for access to first byte (see http://hlds.co.jp/v2/HLDS_BD_140212_V1.pdf) it seems excessive in Instrumental's opinion.
5. Average file access time is unavailable but assumed to be similar to other Blu-ray models.

Environvmentals and stuff

Storage Media	TS1140	T10000D	LTO-6	Current Blu-ray (HLDS HL100)	Current Blu-ray (DISC ArXtor 7000)	Current Blu-ray (Open Source Storage Blu-ray Archive)
Storage	34°F to 140°F (+1°C to +60°C)	50°F to 104°F (+10°C to +40°C)	61°F to 95°F (+16°C to +35°C)	50°F to 95°F (+10°C to +35°C)[1]	50°F to 104°F (+10°C to +40°C)	50°F to 95°F (+10°C to +35°C)[1]
	Humidity 10% to 90% non-condensing	Humidity 10% to 95% non-condensing	Humidity 20% to 80% non-condensing	Humidity 10% to 80% non-condensing	Humidity 10% to 75% non-condensing	Humidity 5% to 95% non-condensing

- ## Tape has advantages in:
  - Performance large files

  - Automation

  - Scalability of infrastructure

  - End to end reliability and for most part media

- ## Optical has advantage in:
  - Small file access of less than 1 GB