Digital Storage for Professional Media and Entertainment

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Outline

- Drivers of digital storage in the media and entertainment industry
- Storage in:
  - Content capture
  - Editing and post production
  - Content distribution
  - Archiving and digital preservation
- Storage trends in media and entertainment
- Conclusions
- Sources
Digital Entertainment Content Value Chain (An Accelerating Positive Feedback Loop)

- PVR/DVR/set-tops
  - Game Machines
  - Mobile Devices

- Content Reception

- Content Creation

- Content Editing

- Content Distribution

- Content Archiving

- Tape
  - ATA Disk Arrays
  - Optical Jukeboxes

- Streaming Media
  - VOD
  - PPV

- Cameras
  - Animation

- Field Editing
  - Studio Editing
  - Special Effects
Why People Need More Storage

- Memories and information are our greatest resource, long term memory is a key part of being a human being
- Digital technologies allow new ways to create, capture, share and use content—these are the basis of the next economy
- There is more storage on more devices that we use everyday and even more in the future!
- Storage systems will be needed that make all of the different sources of content available to consumers
Assume 100 M American Households, each with an average of 11.8 TB of storage
This is 1.8 B TB of storage or 1,800 Exabytes of storage in US households by 2014
CE Devices are Content Devices

USB Storage in all Shapes and Colors

HP Media Server

Blu-ray Player

DVRs and Expanders

Media Server Products
Media Content Size Trends

Multimedia Object Size

Data Rate (Mbps)

1000

100

10

1

0.1

0.01

1KB 10KB 100KB 1MB 10MB 100MB 1GB 10GB 100GB 1TB

Virtual Reality, 3D Movie

Ultra HD Movie

HD Movie

DVD Movie (MPEG-2)

CD Quality Stereo Audio

One page ASCII text

Storage Developer Conference 2009
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Acquisition, Post-Production, and Distribution Workflow.
Example: Omnibus iTX System Architecture
Unique Features of Professional Media and Entertainment Work Flow

- There can be no pauses in real-time streaming and no dropped frames
- Increasing resolution demands, particularly for the original content, drive very high data rates
- Latency requirements for data access varies in workflow and is lowest (lowest latency) where the creative process takes place
  - Capture
  - Editing
  - Other post production work
## Example Resolution, Data Rates and Storage Capacity Requirements for Professional Media Standards

<table>
<thead>
<tr>
<th>Format</th>
<th>Resolution (width x height)</th>
<th>Frame Rate (fps)</th>
<th>Data Rates (MBps)</th>
<th>Storage Capacity/Hour (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPEG-4 (Compressed)</td>
<td>Varies</td>
<td>Varies</td>
<td>~0.750</td>
<td>~0.337</td>
</tr>
<tr>
<td>DVD MPEG 2 (NTSC, Compressed)</td>
<td>720 X 480</td>
<td>29.97</td>
<td>1.22</td>
<td>4.39</td>
</tr>
<tr>
<td>SDTV (NTSC, 4:2:2, 8-bit)</td>
<td>720 X 480</td>
<td>29.97</td>
<td>21</td>
<td>75.6</td>
</tr>
<tr>
<td>Blu-Ray Disc (Compressed)</td>
<td>1920 X 1080</td>
<td>24</td>
<td>4.56</td>
<td>16.4</td>
</tr>
<tr>
<td>HDTV (1080p, 4:2:2, 8-bit)</td>
<td>1920 X 1080</td>
<td>24</td>
<td>149</td>
<td>536</td>
</tr>
<tr>
<td>Digital Cinema 2k (4:2:2, 10-bit) RGB</td>
<td>2048 X 1080</td>
<td>24</td>
<td>199</td>
<td>716</td>
</tr>
<tr>
<td>Digital Cinema 4K (4:4:4, 16-bit) RGB</td>
<td>4096 X 2160</td>
<td>24</td>
<td>1,274</td>
<td>4,586</td>
</tr>
<tr>
<td>Ultra-HDTV</td>
<td>7680 X 4320</td>
<td>60</td>
<td>3,233</td>
<td>11,640</td>
</tr>
</tbody>
</table>
Feature Film Metrics (24 fps, 10-bit deep, 3-color file assumed)

<table>
<thead>
<tr>
<th></th>
<th>2K Resolution</th>
<th>4K Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of Single Frame</td>
<td>8.3 MB</td>
<td>53 MB</td>
</tr>
<tr>
<td>Avg. Storage Size of Finished Film</td>
<td>2 TB</td>
<td>8 TB</td>
</tr>
<tr>
<td>Data Generated During Production</td>
<td>100-400 TB</td>
<td>400-1,600 TB</td>
</tr>
<tr>
<td>Typical Data Rate for Real-Time Film Playback</td>
<td>200 MB/s</td>
<td>1,274 MB/s</td>
</tr>
</tbody>
</table>

- Note that 3D content can multiple the storage requirements by 1.5 X
- Ultra-HD content (8K) could increase demand by ~16 X
Content Capture, Editing and Post-Production
Panasonic, Sony and other high end video camera manufacturers are making flash memory-based mobile video cameras.

Most of these use proprietary flash card formats.
91% had DAS
  - Over 52% of these had over 1 TB of DAS
81% had NAS or SAN
  - Over 44% had over 16 TB of NAS or SAN

Coughlin Associates Professional M&E Survey, 2009
Professional NLE Bandwidth Requirements

<table>
<thead>
<tr>
<th>Uncompressed Format</th>
<th>Real Time Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2K NLE Bandwidth</td>
<td>300 MBps</td>
</tr>
<tr>
<td>4K NLE Bandwidth</td>
<td>1,200 MBps</td>
</tr>
</tbody>
</table>

Bandwidth Requirements for an Example High End Editing Facility.

<table>
<thead>
<tr>
<th>Definition/bandwidth requirements</th>
<th>Bandwidth per node</th>
<th>Number of workstations</th>
<th>Total bandwidth needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Definition (SD) at 30 Fps in RGB @40 bits def</td>
<td>42 MB/s</td>
<td>10</td>
<td>420 MB/s</td>
</tr>
<tr>
<td>High Definition (HD) 24P RGB @ 10 bits def</td>
<td>199 MB/s</td>
<td>4</td>
<td>796 MB/s</td>
</tr>
<tr>
<td>2K film resolution</td>
<td>306 MB/s</td>
<td>2</td>
<td>612 MB/s</td>
</tr>
<tr>
<td>4K film resolution</td>
<td>1223 MB/s</td>
<td>1 scanner and 1 station running on local storage</td>
<td>1223 MB/s</td>
</tr>
<tr>
<td>Unqualified applications doing I/O</td>
<td>Less than 10 MB/s Average 5MB/s</td>
<td>30</td>
<td>~150 MB/s total</td>
</tr>
<tr>
<td>Bandwidth Grand Total</td>
<td>3201 MB/s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Uses and Flow of metadata in the entertainment content process

- Most metadata is manually generated
- Some automated sensor input can provide metadata (e.g. GPS in some high end cameras)
Professional Broadcast Metadata
Generation Time

- ITN employ six shotlisters to process their 800,000 hours of footage and take, on average 5 hours to catalog 1 hour of footage
- BskyB (Sky News) employ 6 shot listers to process their 80,000 hours of footage and take, on average, 3 hours to catalog 1 hour of footage
- BBC employ 20 shotlisters to process their 2,000,000 hours of archive material and take anywhere between 2 hours and 8 hours to catalog 1 hour of footage
- The British Library has over 500,000 user created items and employs 6 shotlisters
- YouTube has over 65,000 videos uploaded EVERY DAY that have rudimentary user created metadata attached—this could increase 10X in the next few years
Automated Metadata Generation

- Sensor based such as GPS on devices
- Still and moving image recognition
- Voice to text conversion
- Indexing and generation of searchable information
- Metadata could become very large if it makes the original data easier to use

- SAml Automated Metadata Generation
- MeGA (Automatic Metadata Generation Applications) Project (Report from 2005)
Content Delivery
Content Delivery Survey Results

- Average hours on central content delivery system was about 200 hours (varied widely) with about 150 hours ingested monthly
- Majority had less than 5% of content on edge servers
- About 20% used flash memory on their edge servers

Percentage Content on Physical Media for Digital Content Distribution

- DVD discs: 26%
- Blu-ray discs: 7%
- Hard disk drives: 20%
- Flash memory or SSDs: 6%
- CD or VCD discs: 9%
- Digital tape: 32%

Coughlin Associates Professional M&E Survey, 2009
## VOD Capacity and Bandwidth Requirements

<table>
<thead>
<tr>
<th></th>
<th>Monthly Ingested Capacity (GB)</th>
<th>Streaming Bandwidth (Mbps)</th>
<th>Streaming Output Capacity (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Definition (SD)</td>
<td>~100</td>
<td>10,125-16,875</td>
<td>~720</td>
</tr>
<tr>
<td>High Definition (HD)</td>
<td>~900</td>
<td>91,125-151,875</td>
<td>~6,480</td>
</tr>
<tr>
<td>Y (Future Formats)</td>
<td>~10,800</td>
<td>1,081,500-1,822,500</td>
<td>~77,760</td>
</tr>
</tbody>
</table>

2009 Digital Storage for Media and Entertainment Report, Coughlin Associates
• Power use in data center is a major expense and storage plays a significant role (direct power use as well as HVAC power)

• SSDs are being promoted for Tier 0 (very high performance) applications as well as part of a power control solution in data-centers

High Performance Uses for Flash Storage in M&E Content Delivery

- Storage for metadata index to enable rapid search and access of content on HDD or tape
- Fast playout for delivery applications
- Caching of frequently accessed content for speedy delivery
- Can be used in central facility or for edge delivery
In 2008 we saw edge and central delivery products from several companies using flash memory including

- SeaChange
- Sun

SeaChange MFL-200

Sun Storage 7110
SSS Play Back Demonstration (SV09)
SSD Developments for Enterprise Applications

- STEC, Smart Modular, Fusion-io and many other current vendors
- HGST 4 yr. agreement with Intel—qualification products by end of year
- SUN flash DIMM modules announced (working with Samsung)
- Spansion Quad-NOR products for content delivery
Growth of Fast Interfaces
(Graph from Silicon Image, SV09)

http://www.storagesearch.com/ssd-law-1.html
HDTune and PCMark

- **HDTune Data Transfer Rate** – System Level MB/S DTR, no file size

- **PCMark05 – System Score** – System Level PCMark05 Generated Score

Solid State Storage Initiative
Archiving and Preservation
1 PB of storage using 1 TB HDDs with proper environment, racks, HVAC, etc. cost about $166,000 up front and $16,000 per year to maintain.

This cost is expected to decline significantly with 5 year refreshes in hardware.

Over 50% of the total cost of preserving the 1 PB of content is in the first year.
Survey Results (of those involved in digital archiving and preservation)

- 44% had >2,000 hours of content in a long term archive (many had well over 100,000 hours)
- 40% archived all the content captured from their cameras
- 55% archived copies of content in all of their distribution formats
- Average growth rate of digital archives (storage capacity) was between 6 and 10% annually
- 39% added 1,000 hours or greater to their archive annually
- About 48% had >2,000 hours of unconverted analog content
- The average annual conversion rate of analog content was about 5%

Coughlin Associates Professional M&E Survey, 2009
Long Term Archive Survey Results

Percentage of Digital Long Term Archives

- Digital tape: 33%
- Hard disk drives: 25%
- DVD discs: 11%
- Blu-ray discs: 7%
- CD discs: 6%
- Other: 18%

Growth Rate of Archival Media

- Digital tape: 29%
- Hard disk drives: 26%
- DVD discs: 13%
- Blu-ray discs: 10%
- CD discs: 11%
- Other: 11%

• Tape and HDDs predominate in long term archival media and are projected to show greatest growth in the future.

• About 41% never update their digital archives.

• 75% used different storage for archiving and working storage.
Media and Entertainment Storage Trends
In 2008

Archiving and Preservation 85%

Content Distribution 5%

Content Acquisition 4%

Post Production 6%

2009 Digital Storage for Media and Entertainment Report, Coughlin Associates
Media and Entertainment Market Storage Revenue Share by Segment (2008)

- Archiving and Preservation: 15%
- Content Acquisition: 20%
- Post Production: 15%
- Content Distribution: 50%

2009 Digital Storage for Media and Entertainment Report, Coughlin Associates
Market Share of Storage Media by Storage Capacity Shipped (2014)

- HDD: 26.6%
- Optical: 1.0%
- Flash: 1.2%
- Tape: 71.3%

2009 Digital Storage for Media and Entertainment Report, Coughlin Associates
Total New Storage Capacity for Media and Entertainment (over 39 Exabytes of New Storage by 2014)

Total revenue for media and entertainment storage will increase about 2.8X from 2008 through 2014 ($3.5 B to $9.9 B)
Conclusions

• Consumer demand for greater resolution and more involvement drives storage and bandwidth demand for media and entertainment

• Solid state storage devices allow faster performance, (esp. for playout) although current generation devices vary widely in their performance

• Concerns with power consumption, performance and cost expand the entertainment and media storage hierarchy

• Automated metadata generation will increase, making indexing and using content easier
Thanks!
Sources

- 2008 and 2009 CES and Storage Visions Conferences (www.storagevisions.com)
- 2008 and 2009 Creative Storage Conference (www.creativestorage.org)
- 2009 Digital Storage for Media and Entertainment Report, Coughlin Associates
- 2009 Survey on Storage for Media and Entertainment, Coughlin Associates
- Go to www.tomcoughlin.com (tech papers page)
- SNIA SSSI: http://www.snia.org/forums/sssi/