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)
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

• Storage systems will be needed that make this content available to consumers
Accumulated Digital Content Per Average US Household

- Consumer Survey on Digital Storage in Consumer Electronics (Coughlin Associates, 2008)
  - 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

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CE Devices are Content Devices

USB Storage in all Shapes and Colors

HP Media Server

Blu-ray Player

DVRs and Expanders

Media Server Products

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Acquisition, Post-Production, and Distribution Workflow.
Example: Omnibus iTX System Architecture
Unique Features of Profession 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</td>
<td>2 TB</td>
<td>8 TB</td>
</tr>
<tr>
<td>Finished Film</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Generated During</td>
<td>100-400 TB</td>
<td>400-1,600 TB</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Data Rate for</td>
<td>200 MB/s</td>
<td>1,274 MB/s</td>
</tr>
<tr>
<td>Real-Time Film Playback</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Note that 3D content can add about 1.5 X to the storage requirement
- Ultra-HD content (8K) could increase demand by ~16 X
Content Capture, Editing and Post-Production
Flash Based High End Digital Cameras

Percentage of Recording Media in Cameras

- Flash memory: 19%
- Optical discs: 9%
- Hard disk drives: 23%
- Magnetic tape: 34%
- Film: 15%

Coughlin Associates Professional M&E Survey, 2009

- 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
Coughlin Associates Professional M&E Survey, 2009

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
**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 @ 10 bits def</td>
<td>42 MB/s</td>
<td>10</td>
<td>420 MB/s</td>
</tr>
<tr>
<td>High Definition (HD) 24P</td>
<td>199 MB/s</td>
<td>4</td>
<td>796 MB/s</td>
</tr>
<tr>
<td>2K film resolution</td>
<td>305 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></td>
<td></td>
<td>3201 MB/s</td>
</tr>
</tbody>
</table>

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Uses and Flow of metadata in the entertainment content process

- Most metadata is manually generated
- Some automated sensor input from provide metadata (e.g. GPS in some high end cameras)
- MXF is most common metadata wrapper for profession M&E workflow
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
## 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>SD</td>
<td>~100</td>
<td>10,125-16,875</td>
<td>~720</td>
</tr>
<tr>
<td>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>
Speed and Power Driving New Storage Hierarchy

- 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


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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
Flash Based Content Delivery

• In 2008 we saw edge and central delivery products from several companies using flash memory including
  – SeaChange
  – Sun
SSS 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
- Announcements by Seagate and others expected this year
Growth of Fast Interfaces
(Graph from Silicon Image, SV09)

- **USB1**
- **USB2**
- **1394b**
- **GbE**
- **SATA1.5G**
- **SATA3.0G**
- **SATA6.0G**
- **SSD**
- **HDD**

Mbits/s

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

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

- **PCMark05 – System Score**
  System Level PCMark05 Generated Score
Archiving and Preservation
Cost for Storing 1 PB for 20 Years

- 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
• 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
Distribution of Storage Capacity for Entertainment Creation, Archiving, and Distribution (2008)

- Archiving and Preservation: 85%
- Content Acquisition: 4%
- Content Distribution: 5%
- Post Production: 6%

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

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

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

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

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 products will allow faster performance, particularly for read although current generation devices vary widely in their performance

• Concerns with power consumption, performance and cost will expand the storage hierarchy—particularly for enterprise applications

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

• Storage security will improve with standards introduced for PC and enterprise storage applications

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Thanks!
Sources

- 2008 and 2009 CES and Storage Visions Conferences (www.storagevisions.com)
- 2008 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)