Trends in Worldwide Media and Entertainment Storage

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Our Agenda Today

- M&E Storage Drivers
- Content Capture
- Post-production
- Content Delivery
- Why IP Based Video
- Content Preservation and Archiving
- Breakdown of Storage Capacity and Revenue for Media and Entertainment Applications
- Media and Entertainment Storage Trends
## Examples of Professional Media

<table>
<thead>
<tr>
<th>Format</th>
<th>Resolution (width X height)</th>
<th>Frame Rate (fps)</th>
<th>Data Rates (MB/s)</th>
<th>Storage Capacity GB/Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDTV (NTSC, 8-bit)</td>
<td>720 X 480</td>
<td>~30</td>
<td>31</td>
<td>112</td>
</tr>
<tr>
<td>HDTV (1080p, 8-bit) RGB</td>
<td>1920 X 1080</td>
<td>24</td>
<td>149</td>
<td>537</td>
</tr>
<tr>
<td>UHD-1 4K (10-bit) RGB</td>
<td>3840 X 2160</td>
<td>60</td>
<td>1,866</td>
<td>6,718</td>
</tr>
<tr>
<td>UHD-2 8K (12-bit) RGB</td>
<td>7680 X 4320</td>
<td>120</td>
<td>17,916</td>
<td>64,497</td>
</tr>
<tr>
<td>Digital Cinema 2K (10-bit) YUV</td>
<td>2048 X 1080</td>
<td>24</td>
<td>199</td>
<td>717</td>
</tr>
<tr>
<td>Digital Cinema 4K (12-bit) YUV</td>
<td>4096 X 2160</td>
<td>48</td>
<td>1,910</td>
<td>6,880</td>
</tr>
<tr>
<td>Digital Cinema 8K (16-bit) YUV</td>
<td>8192 X 4320</td>
<td>120</td>
<td>25,480</td>
<td>91,729</td>
</tr>
</tbody>
</table>

8K Ultra-HD may use more than 170X capacity of HD!
Exabyte Video Projects Coming?

Video at 16,000 X 8,000 pixel resolution, 24 bits/pixel, 300 fps raw content could require 115 GB/s data rates and 414 TB/hour. If 4 cameras were used to create data for a 360 degree presentation, the raw data would be 1.66 PB for an hour of content.

Within 10 years we could have pro-video projects with close to an exabyte of data.
Digital Entertainment Content Workflow
Content Acquisition

2018 Results

<table>
<thead>
<tr>
<th>Year</th>
<th>Magnetic Tape</th>
<th>HDD</th>
<th>Optical</th>
<th>Flash Memory</th>
<th>Film</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>34%</td>
<td>23%</td>
<td>9%</td>
<td>19%</td>
<td>15%</td>
</tr>
<tr>
<td>2010</td>
<td>25%</td>
<td>22%</td>
<td>17%</td>
<td>28%</td>
<td>8%</td>
</tr>
<tr>
<td>2012</td>
<td>20%</td>
<td>22%</td>
<td>12%</td>
<td>44%</td>
<td>2%</td>
</tr>
<tr>
<td>2013</td>
<td>15%</td>
<td>18%</td>
<td>7%</td>
<td>59%</td>
<td>1%</td>
</tr>
<tr>
<td>2014</td>
<td>7%</td>
<td>24%</td>
<td>10%</td>
<td>57%</td>
<td>2%</td>
</tr>
<tr>
<td>2015</td>
<td>4%</td>
<td>21%</td>
<td>8%</td>
<td>66%</td>
<td>1%</td>
</tr>
<tr>
<td>2016</td>
<td>2%</td>
<td>34%</td>
<td>8%</td>
<td>54%</td>
<td>2%</td>
</tr>
<tr>
<td>2017</td>
<td>5%</td>
<td>33%</td>
<td>3%</td>
<td>59%</td>
<td>0.16%</td>
</tr>
<tr>
<td>2018</td>
<td>2%</td>
<td>35%</td>
<td>2%</td>
<td>56%</td>
<td>5%</td>
</tr>
</tbody>
</table>
In 2018, 51% of Respondents said they capture 6 or more hours of content for 1 hour of finished work and 77% said more 90% of their content was born digital.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>&lt;10%</td>
<td>3.9%</td>
<td>0.9%</td>
<td>1.1%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>1.2%</td>
<td>2.1%</td>
</tr>
<tr>
<td>11% to 20%</td>
<td>1.3%</td>
<td>0.4%</td>
<td>0.0%</td>
<td>1.1%</td>
<td>1.6%</td>
<td>3.4%</td>
<td>0.0%</td>
<td>2.1%</td>
</tr>
<tr>
<td>21% to 30%</td>
<td>3.2%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>1.1%</td>
<td>1.6%</td>
<td>3.4%</td>
<td>1.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>31% to 40%</td>
<td>3.2%</td>
<td>2.6%</td>
<td>1.1%</td>
<td>2.1%</td>
<td>1.6%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>2.1%</td>
</tr>
<tr>
<td>41% to 50%</td>
<td>5.2%</td>
<td>2.2%</td>
<td>3.3%</td>
<td>2.1%</td>
<td>0.8%</td>
<td>1.1%</td>
<td>3.6%</td>
<td>2.1%</td>
</tr>
<tr>
<td>51% to 60%</td>
<td>5.2%</td>
<td>1.7%</td>
<td>2.2%</td>
<td>1.1%</td>
<td>1.6%</td>
<td>3.4%</td>
<td>1.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>61% to 70%</td>
<td>5.8%</td>
<td>3.1%</td>
<td>6.5%</td>
<td>4.2%</td>
<td>1.6%</td>
<td>1.1%</td>
<td>0.0%</td>
<td>6.3%</td>
</tr>
<tr>
<td>71% to 80%</td>
<td>8.4%</td>
<td>8.3%</td>
<td>10.9%</td>
<td>7.4%</td>
<td>5.7%</td>
<td>4.5%</td>
<td>7.1%</td>
<td>2.1%</td>
</tr>
<tr>
<td>81% to 90%</td>
<td>16.1%</td>
<td>10.9%</td>
<td>15.2%</td>
<td>15.8%</td>
<td>7.3%</td>
<td>14.8%</td>
<td>13.1%</td>
<td>6.3%</td>
</tr>
<tr>
<td>91% to 100%</td>
<td>47.7%</td>
<td>69.9%</td>
<td>59.8%</td>
<td>65.3%</td>
<td>78.0%</td>
<td>68.2%</td>
<td>72.6%</td>
<td>77.1%</td>
</tr>
</tbody>
</table>

Hours of Content Shot for 1 Hour of Completed Video (2018)
Digital Content Acquisition
Capacity Growth

- Projecting approaching 70 Exabytes of storage capacity used for content acquisition and creation by 2023.
- About 4.5X growth from 2017 to 2023.
Professional Non-linear Editing Model System

- Besides direct attached storage and traditional NAS and SAN, there is an increasing use of cloud storage to facilitate collaborative workflows.
- Flash memory, using NVMe interfaces is becoming more popular in editing as resolution, frame rate, number of concurrent streams and bits per frame increase.
In 2018 48% of said they used cloud-based storage for editing and post production.

In 2018 56% said that they had 1 TB or more storage capacity in the cloud.
Conventional Internet Content Distribution System (CDN)
Content Distribution

- Note that in 2018 39% of survey respondents said that they used flash memory in their central delivery servers.

- High-speed enterprise solid-state drives (SSDs) and other solid-state storage technology for edge content delivery was 48% in 2018.

- In 2018 internet distribution was the most popular way to view proxies.

2018 Proxy Distribution Survey Results
Why IP-based Video?
Raw Video Quality Increase

Need for Higher Performance Networking and Storage Solutions
Ethernet Enables Higher Efficiency

Why have 2 or even 3 networks?
When you can deploy a single network for video storage

- Ethernet is significantly lower cost than both FC and Serial Digital Interface (SDI)
- Mellanox can deliver an E2E solution - Single support point
- Can be less than $260/port @ 25Gb/s for the NIC, switch and the cabling

- Use an Ethernet storage platform - it'll grow with you (100GbE is 3x FC)
- Reduce your failures with reduced adapters
- Ethernet is much easier to manage and our tools are FREE!
- Put all your workloads on the same wire and segregate them
Why IP-based Video
Delivering Converged Fabrics for Video Studio

❖ Current Generation Connectivity
  ♦ Serial Digital Interface (SDI)
    › Expensive and proprietary
    › Coax cables with BNC connectors
  ♦ Installation
    › Multiple cables to support multiple streams
    › Inflexible, heavy and easy to break

❖ Next-Gen Video Processing Connectivity: SMPTE ST2110*
  ♦ Ethernet Cables
    › Cheaper – multiple vendors, open standard
    › Leveraging IP technology from data centers
  ♦ Installation
    › Single optical cable supporting multiple HD streams
    › Light, flexible and resilient
  ♦ Upgrades
    › Upgrade transceivers - re-use existing cables!

*The Society of Motion Picture and Television Engineers (SMPTE®) Professional Media Over Managed IP Networks standards suite
Exponential Bandwidth & Storage Growth

Bandwidth Impact (Uncompressed)

- **4K(2160p) vs 1080i HD=400%**
- **HFR(50-60fps->100-120fps)=200%**
- **“HDR+” (HDR+WCG+10-bit)=25%**

<table>
<thead>
<tr>
<th>Format</th>
<th>Resolution</th>
<th>Color Depth</th>
<th>FPS</th>
<th>Bandwidth per Stream</th>
<th>10GbE #Streams</th>
<th>25GbE #Streams</th>
<th>40GbE #Streams</th>
<th>50GbE #Streams</th>
<th>100GbE #Streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>4K DPX</td>
<td>4096 x 2160</td>
<td>10-bit</td>
<td>24</td>
<td>6.4 Gb/s</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>4K-Full DPX</td>
<td>4096 x 3112</td>
<td>10-bit</td>
<td>24</td>
<td>9.2 Gb/s</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>4K-Full EXR</td>
<td>4096 x 3112</td>
<td>16-bit</td>
<td>24</td>
<td>14.7 Gb/s</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>8K DPX</td>
<td>7680 x 4320</td>
<td>10-bit</td>
<td>24</td>
<td>23.4 Gb/s</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>8K EXR</td>
<td>7680 x 4320</td>
<td>16-bit</td>
<td>24</td>
<td>28.2 Gb/s</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4K-Full EXR</td>
<td>4096 x 3112</td>
<td>16-bit</td>
<td>60</td>
<td>36.7 Gb/s</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

SD
HD 1920x1080
4K UHD 3480x2160
8K UHD 7680x4320

Visible Banding

Wide Color Gamut (WCG)

TV Color Gamut

Image Resolution

High Dynamic Range (HDR)

8-bit
10-bit

Higher Visual Depth

Higher Frames Rate (HFR)
Flash Storage Requires Lower Latency

Ethernet

Network hops multiply latency
Remote Direct Memory Access RDMA

- Transport offload
- Kernel bypass

Remote Data Transfer

- Application
- Buffer
- Kernel Bypass
- Protocol Offload
Networking Offloads Boosts Video over IP Efficiency

Throughput vs CPU Usage - Single Video Stream via 1 CPU Core

- Rivermax Transmitting 4K UHD
- Packet Pacing 2110-21
- 10.5 Gb/s with 5% CPU Single Core Util.
- Kernel fails to deliver throughput Running @ 100% CPU Utilization 12.2 Gb/s out of 20.5 Gb/s
Deploy Video over IP with **Ethernet Video Fabric** NOW

**Ultra HD video resolution** drives high-bandwidth requirements

8K Ultra HD

<table>
<thead>
<tr>
<th>Resolution</th>
<th>RAW (Uncompressed) Video Bandwidth [Gb/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full HD 1920 x 1080</td>
<td>2.5</td>
</tr>
<tr>
<td>4K UHD 3840 x 2160</td>
<td>23.8</td>
</tr>
<tr>
<td>8K UHD 7680 x 4320</td>
<td>143.3</td>
</tr>
</tbody>
</table>

**Move from old SDI format to All-IP based streams**

Old-Gen SDI-Studio

- Expensive & Proprietary
- Serial Digital Interface (SDI)
- Inefficient
- 35% Bandwidth overhead

Ethernet Video Fabric

**Powers the Next-Gen IP-Studio**

- Off-the-shelf commodity hardware
- Flexibility!
- Single multi-purposed network

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Content Archiving Storage Media

Magnetic Tape

Optical Disc

HDD
For the last two years the survey has shown HDDs percentage higher than magnetic tape.

LTO is the biggest percentage of tape storage, at 74%.

Growth in archiving content in the cloud among survey participants.

In 2018 32% had more than 2,000 hours in a long term archive.
Digital Storage Projections for Archiving and Digital Content Conversion & Preservation

- Average annual analog conversion rate was 4% (Survey)
- Over the next few years content that will be digitized will start to diminish
- Increasing size of new content will drive archive growth

2018 Digital Storage in Media and Entertainment Report, Coughlin Associates
77% said that they did proxy distribution through the Internet
6% said that they archived on a private or public cloud in 2018
66% said they would use a private or public cloud for archiving in 2018
2018 Media and Entertainment Storage

Distribution of Storage Capacity

Storage Revenue Share by Segment

2018 Digital Storage in Media and Entertainment Report, Coughlin Associates
2018 Market Share of Storage Media by Storage Capacity Shipped

- HDD: 71.0%
- Tape: 22.7%
- Flash: 2.0%
- Optical: 4.3%

2018 Digital Storage in Media and Entertainment Report, Coughlin Associates
Flash Revenue Share in Media & Entertainment

**2017**
- Tape: 4%
- Flash: 14%
- HDD: 81%

**2023**
- Tape: 2%
- Flash: 27%
- HDD: 71%

2018 Digital Storage in Media and Entertainment Report, Coughlin Associates
Where Will This Flash Be Used?

2023 Projections

- Flash memory used in professional video camera media by 56% of survey participants in 2018
- Use of flash in post production is expected to grow
- For CDN content delivery about 39% used flash memory on their edge servers in 2018

2018 Digital Storage in Media and Entertainment Report, Coughlin Associates
Media and Entertainment Storage Trends

- Increasing resolution, higher dynamic range, higher frame rate and multiple camera projects will drive M&E storage demand.
- Flash memory use will grow as price declines and bandwidth demands increase.
- Cloud storage (public and private) will play an increasingly important role in all aspects of professional media and entertainment.
- HDDs, optical discs and tape will serve a bulk storage role.
References

- 2018 Survey of Storage in Professional Media and Entertainment, Coughlin Associates
- 2018 Digital Storage in Media and Entertainment Report, Coughlin Associates
- NAB 2019 Conference
  - https://www.nabshow.com/
Thanks for Attending

Q&A at http://sniassssiblog.org

Visit www.snia.org/sssi for information on Solid State Storage