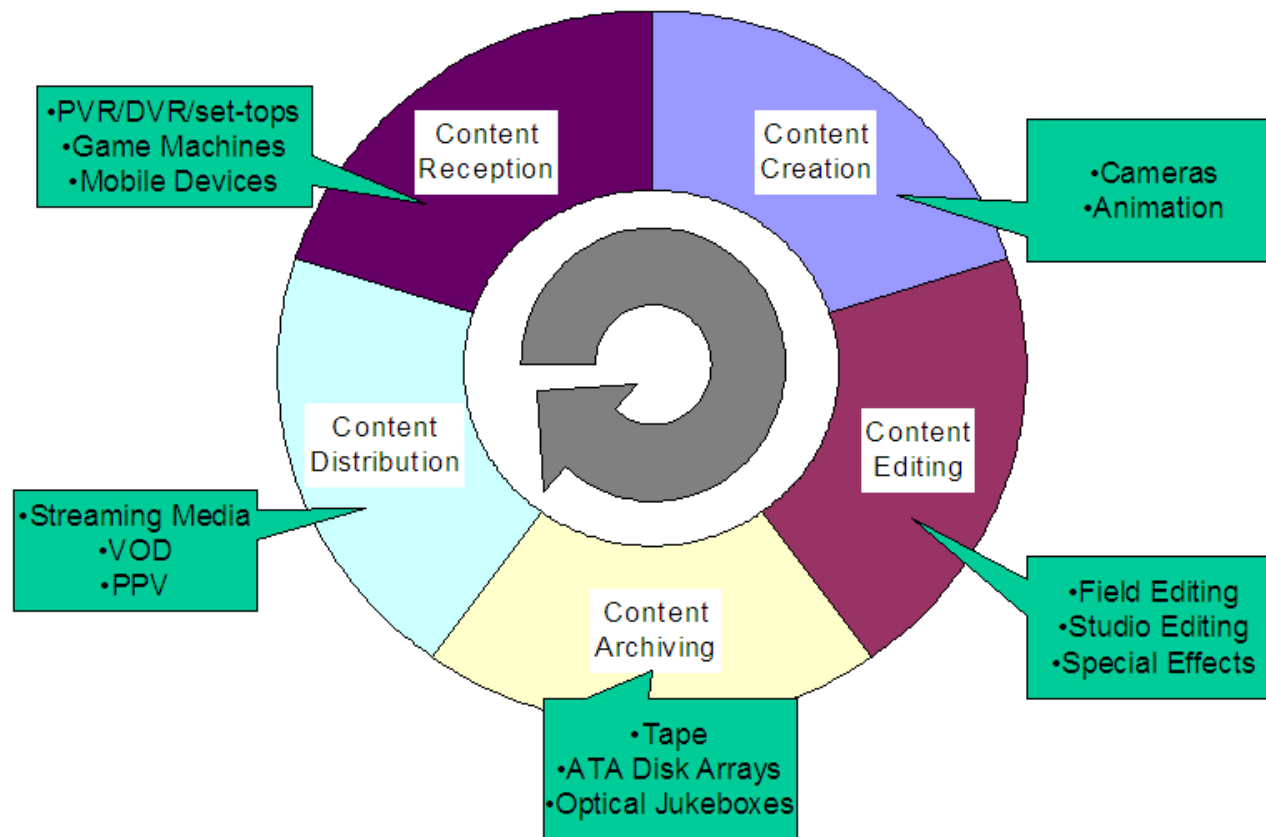# Digital Storage for Professional Media and Entertainment

Thomas M. Coughlin
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Coughlin Associates
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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
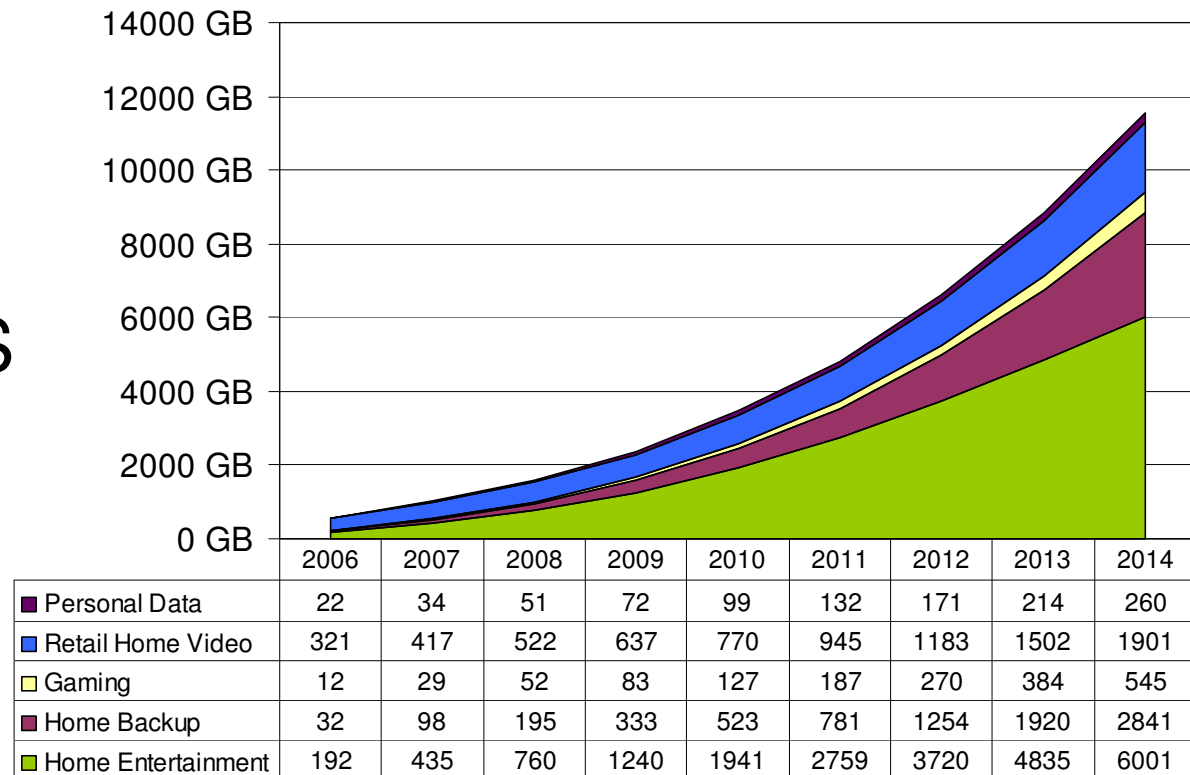- Conclusions
- Sources

Digital Entertainment Content Value Chain (An Accelerating Positive Feedback Loop)

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

Content Creation
- Cameras
- Animation

Content Distribution
- Streaming Media
- VOD
- PPV

Content Editing
- Field Editing
- Studio Editing
- Special Effects

Content Archiving
- Tape
- ATA Disk Arrays
- Optical Jukeboxes

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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

	2006	2007	2008	2009	2010	2011	2012	2013	2014
■ Personal Data	22	34	51	72	99	132	171	214	260
■ Retail Home Video	321	417	522	637	770	945	1183	1502	1901
□ Gaming	12	29	52	83	127	187	270	384	545
■ Home Backup	32	98	195	333	523	781	1254	1920	2841
■ Home Entertainment	192	435	760	1240	1941	2759	3720	4835	6001

•**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

CE Devices are Content Devices

HP Media Server

USB Storage in all Shapes and Colors

Blu-ray Player

Media Server Products

DVRs and Expanders

Media Content Size Trends

Virtual Reality, 3D Movie

Ultra HD Movie

HD Movie

DVD Movie (MPEG-2)

CD Quality Stereo Audio

One page ASCII text

Data Rate (Mbps) — y-axis: 1000, 100, 10, 1, 0.1, 0.01

Multimedia Object Size — x-axis: 1KB, 10KB, 100KB, 1MB, 10MB, 100MB, 1GB, 10GB, 100GB, 1TB
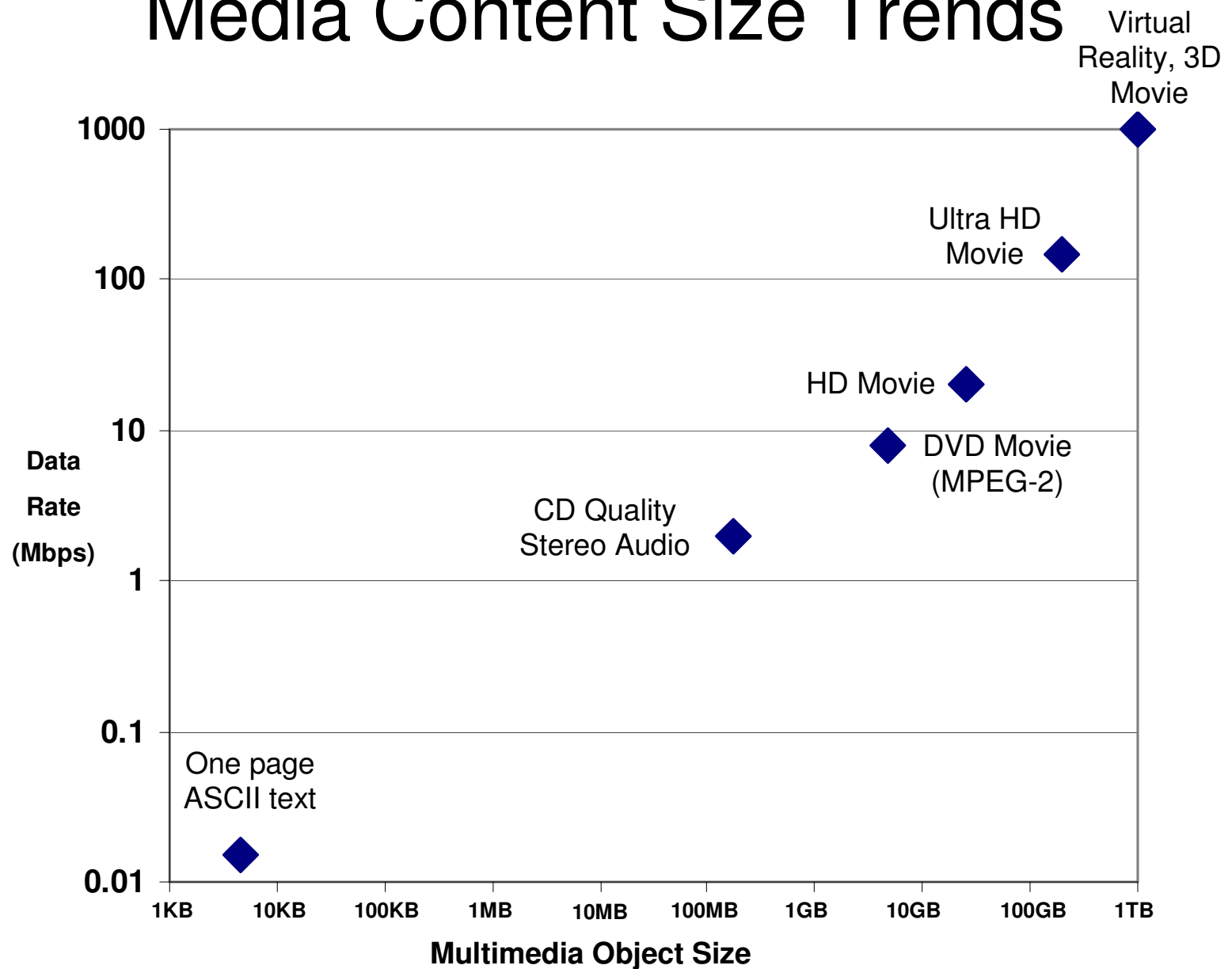
© 2009, Coughlin Associates

Acquisition, Post-Production, and Distribution Workflow.
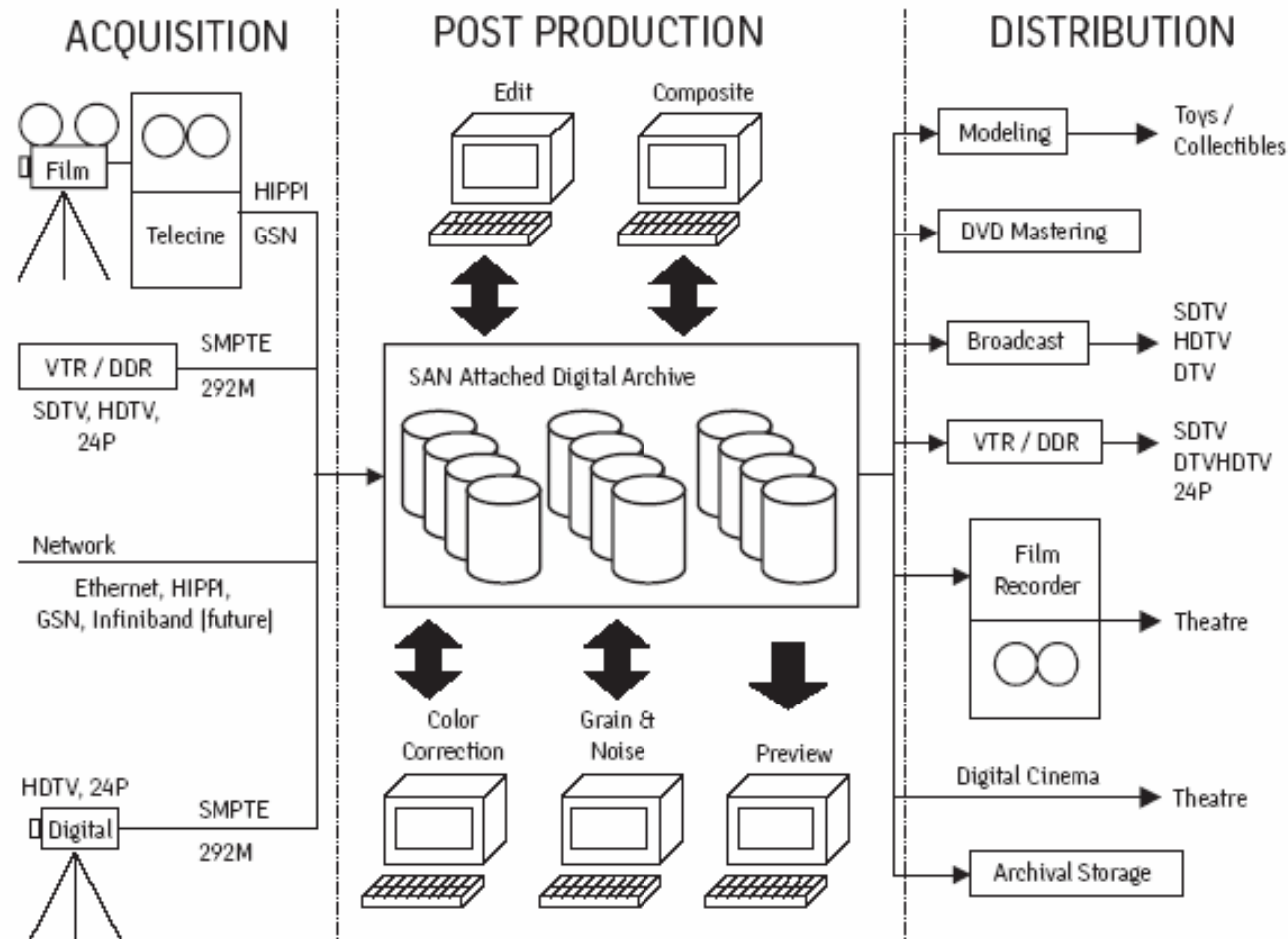
Example: Omnibus iTX System Architecture
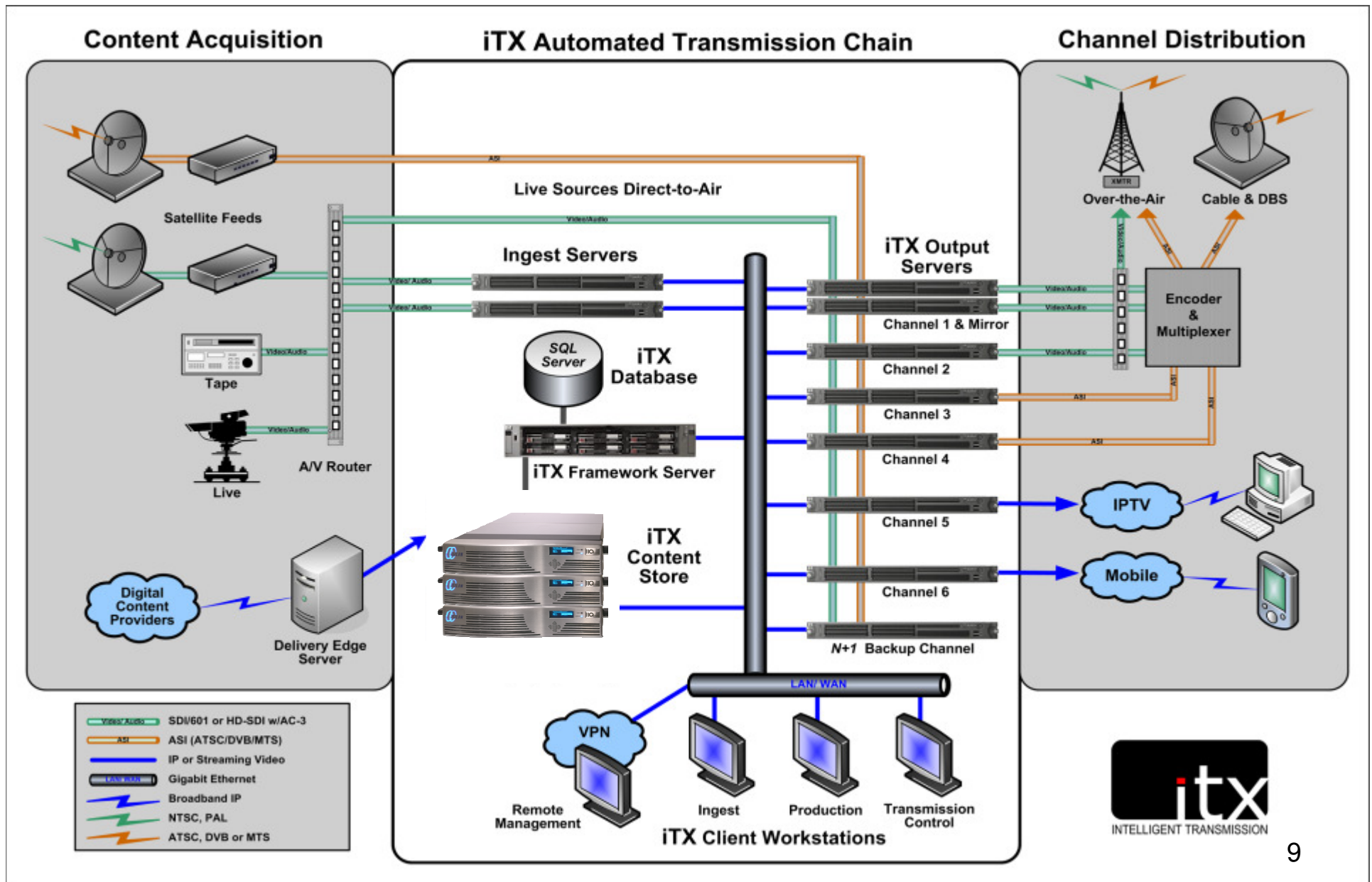
Unique Features of Profession Media and Entertainment Work Flow

- 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

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

Feature Film Metrics (24 fps, 10-bit deep, 3-color file assumed)

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

- 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%
Film 15%
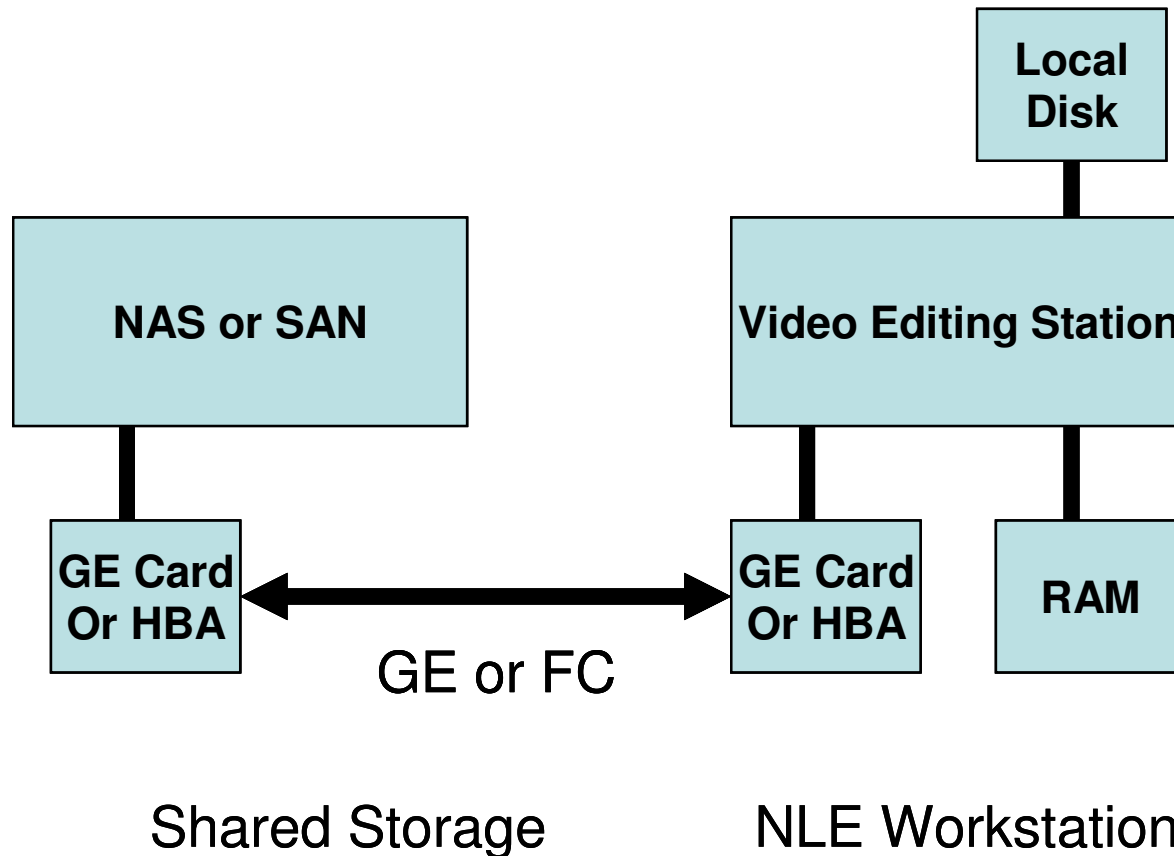Optical discs 9%
Magnetic tape 34%
Hard disk drives 23%
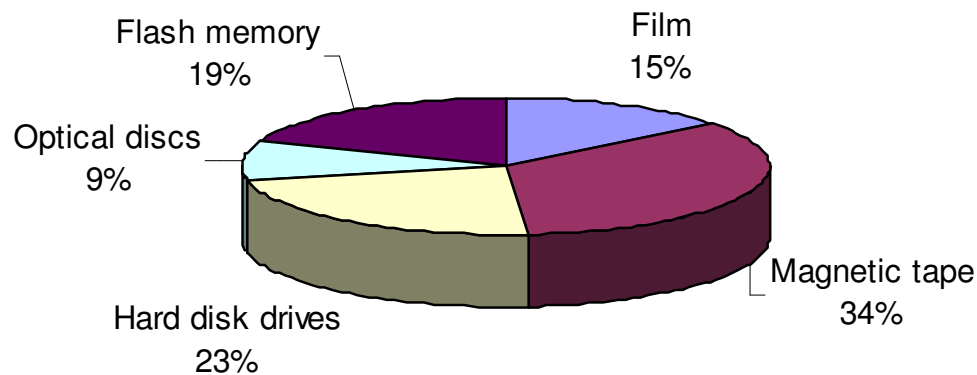
Coughlin Associates Professional M&E Survey, 2009

- 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

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Professional Non-Linear Editing Model System

- 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

Uncompressed Format	Real Time Bandwidth
2K NLE Bandwidth	300 MBps
4K NLE Bandwidth	1,200 MBps

# Bandwidth Requirements for an Example High End Editing Facility.

| Definition/ bandwidth requirements	Bandwidth per node	Number of workstations	Total bandwidth needed
Standard Definition (SD) at 30 Fps in RGB @10 bits def	42 MB/s	10	420 MB/s
High Definition (HD) 24P RGB @ 10bits def	199 MB/s	4	796 MB/s
2K film resolution	306 MB/s	2	612 MB/s
4K film resolution	1223 MB/s	1 scanner and 1 station running on local storage	1223 MB/s
Unqualified applications doing I/O	Less than 10 MB/s Average 5MB/s	30	~ 150MB/s total
		Bandwidth Grand Total	3201 MB/s

Post Production Storage Capacity Annual Demand (TB)
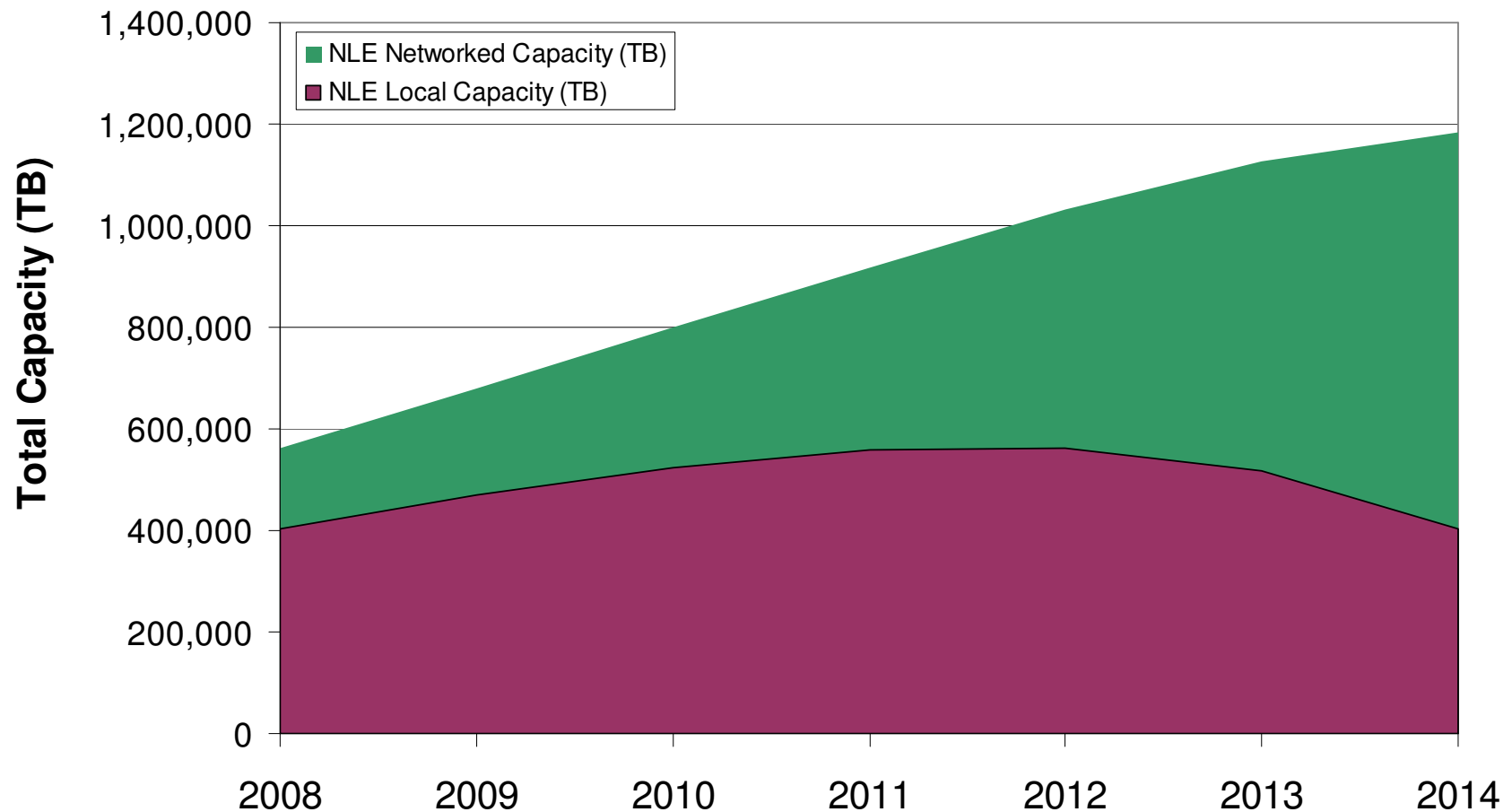
2009 Digital Storage for Media and Entertainment Report, Coughlin Associates

Uses and Flow of metadata in the entertainment content process

- Flow of Metadata
- Flow of Essence
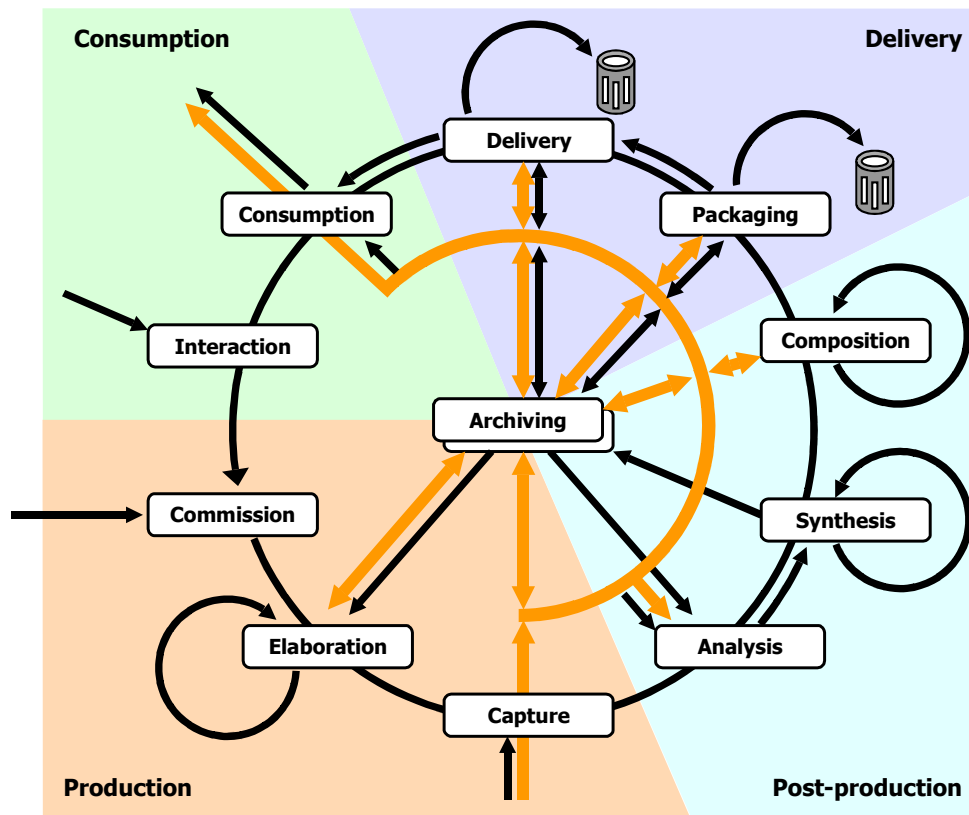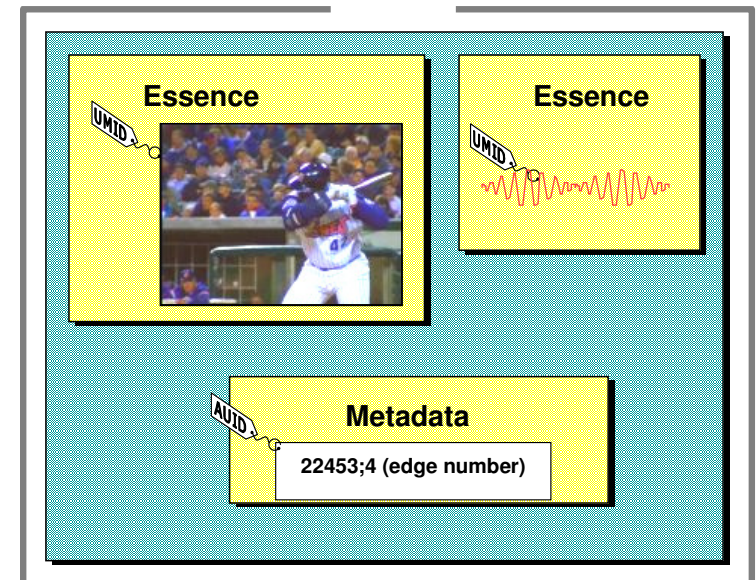
- Most metadata is manually generated

- 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

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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
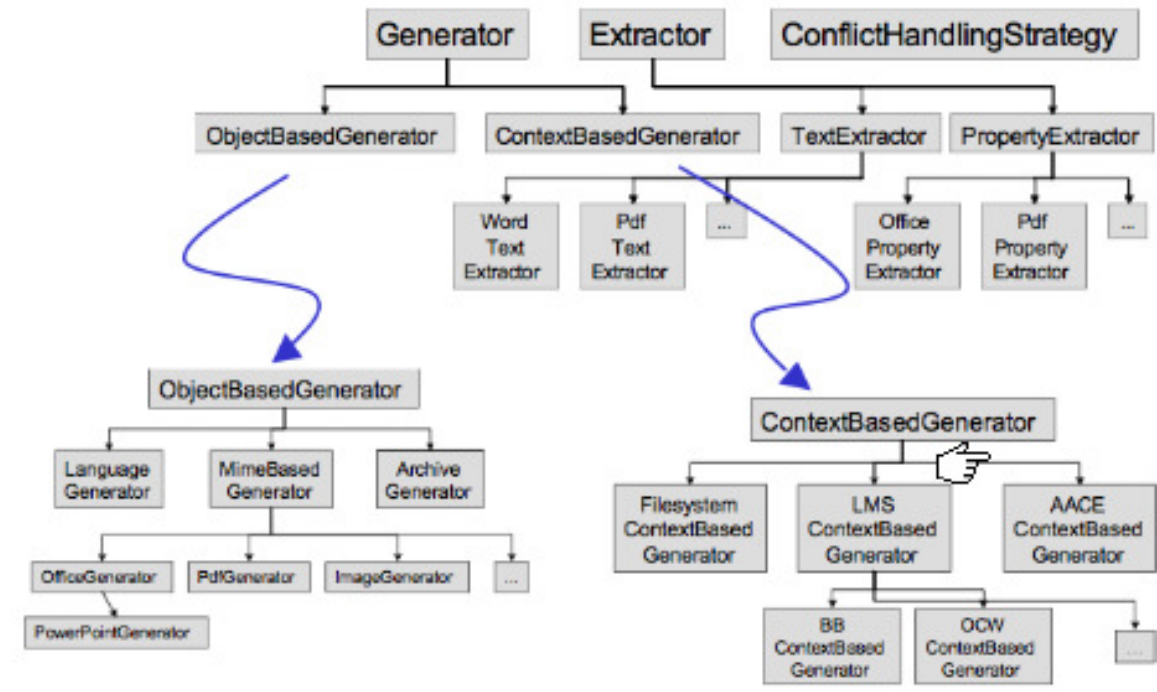
- SAmgI Automated Metadata Generation
- MeGA (Automatic Metadata Generation Applications) Project (Report from 2005)

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
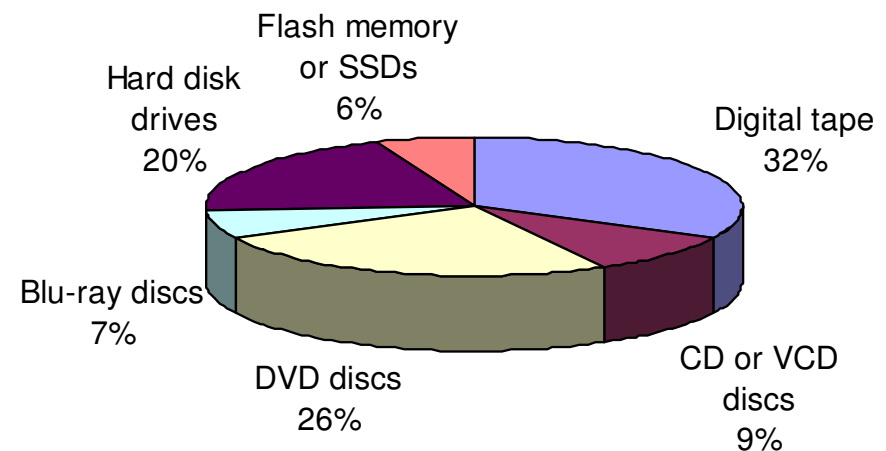
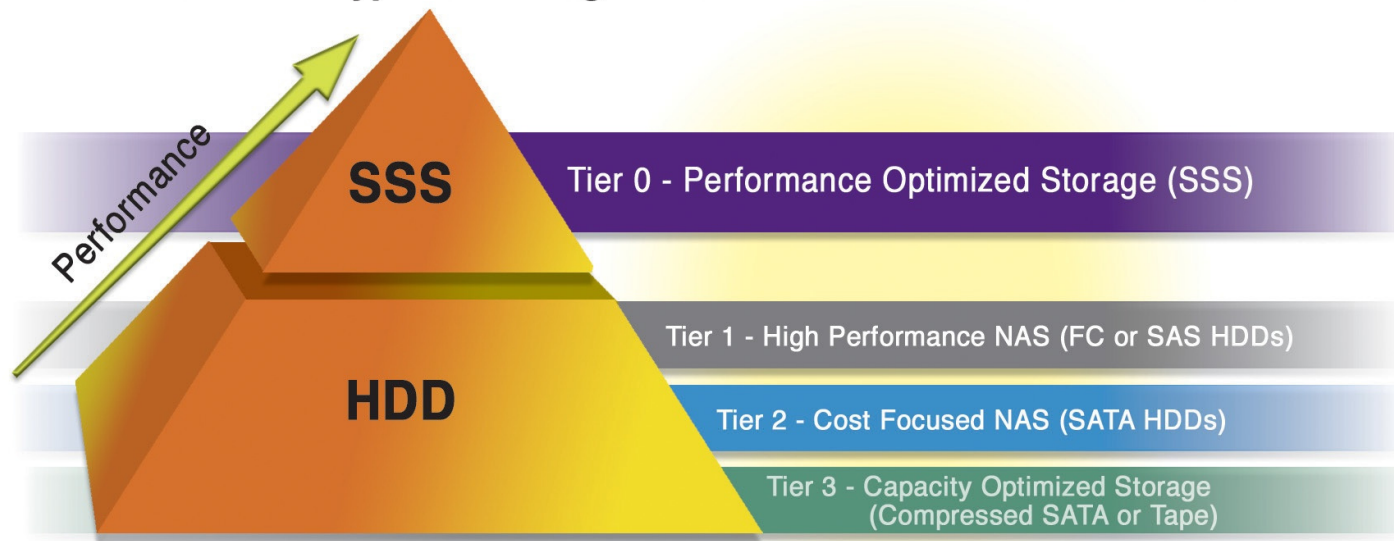Coughlin Associates Professional M&E Survey, 2009

VOD Capacity and Bandwidth Requirements

	Monthly Ingested Capacity (GB)	Streaming Bandwidth (Mbps)	Streaming Output Capacity (GB)
SD	~100	10,125-16,875	~720
HD	~900	91,125-151,875	~6,480
Y (Future Formats)	~10,800	1,081,500-1,822,500	~77,760

2009 Digital Storage for Media and Entertainment Report, Coughlin Associates

Speed and Power Driving New Storage Hierarchy

- Tier 0 - Performance Optimized Storage (SSS)
- Tier 1 - High Performance NAS (FC or SAS HDDs)
- Tier 2 - Cost Focused NAS (SATA HDDs)
- Tier 3 - Capacity Optimized Storage (Compressed SATA or Tape)

• 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

Solid State Storage 101, An introduction to Solid State Storage, SNIA-SSSI, January 2009

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
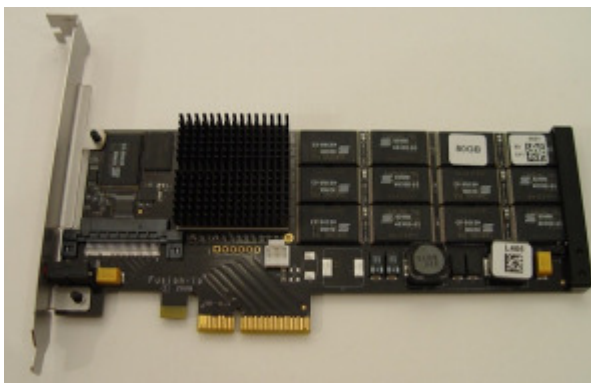
Flash Based Content Delivery

- In 2008 we saw
edge and central
delivery products
from several
companies using
flash memory
including
  - SeaChange
  - Sun

SeaChange
MFL-200

Sun Storage 7110
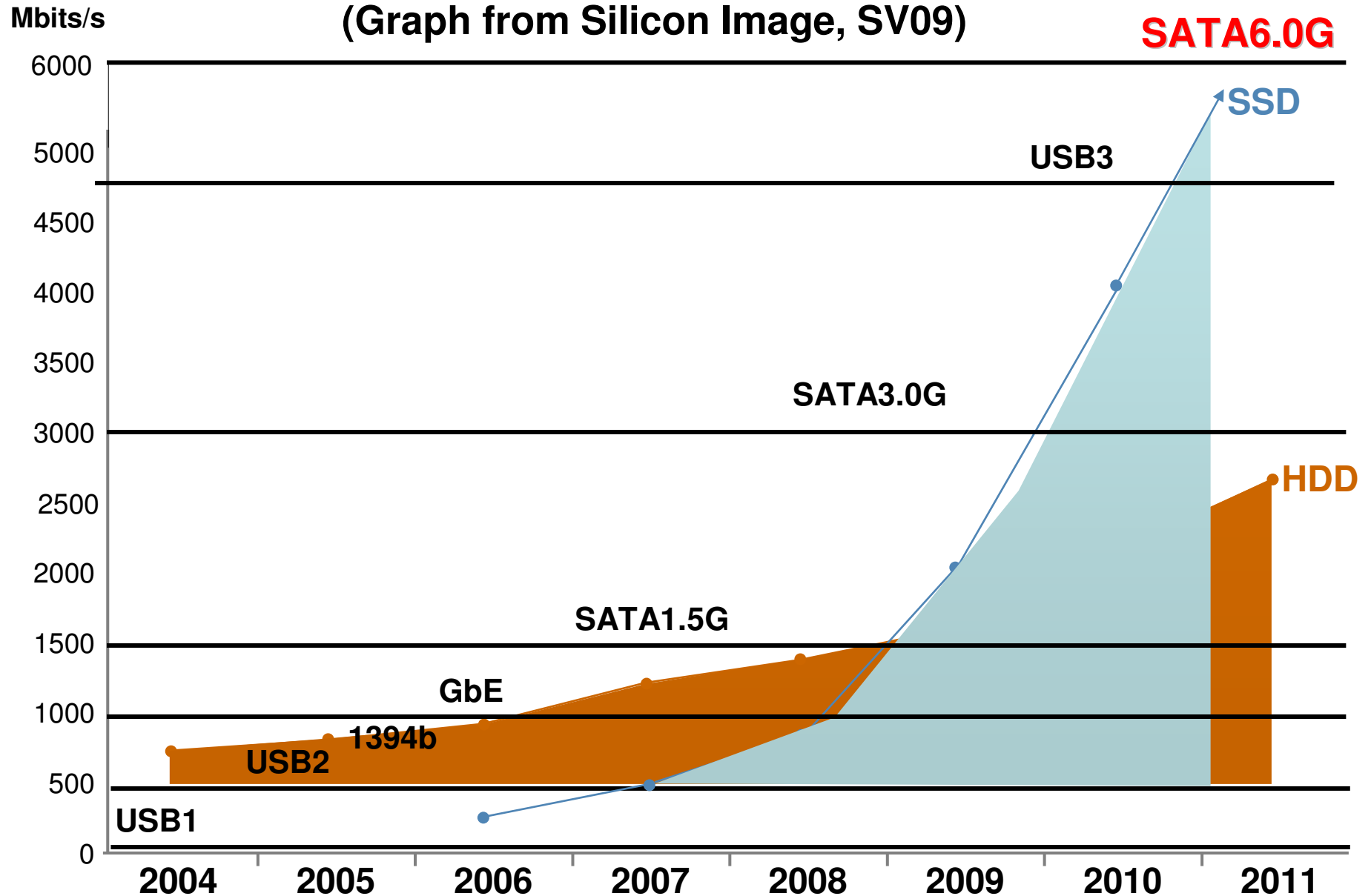
SSS Demonstration (SV09)

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)

Mbits/s

SATA6.0G

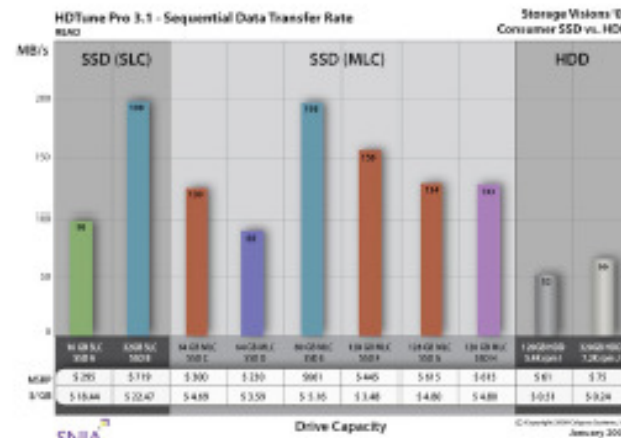SSD

USB3

SATA3.0G

HDD

SATA1.5G

GbE

1394b

USB2

USB1

6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0

2004　2005　2006　2007　2008　2009　2010　2011

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HDTune & PCMark
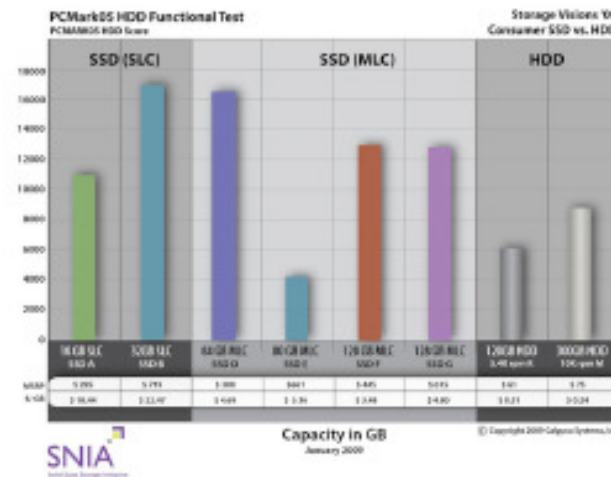
SNIA
Advancing storage & information technology

◆ **HDTune Data Transfer Rate –**

System Level MB/S DTR, no file size

◆ **PCMark05 – System Score**

System Level PCMark05 Generated Score

9

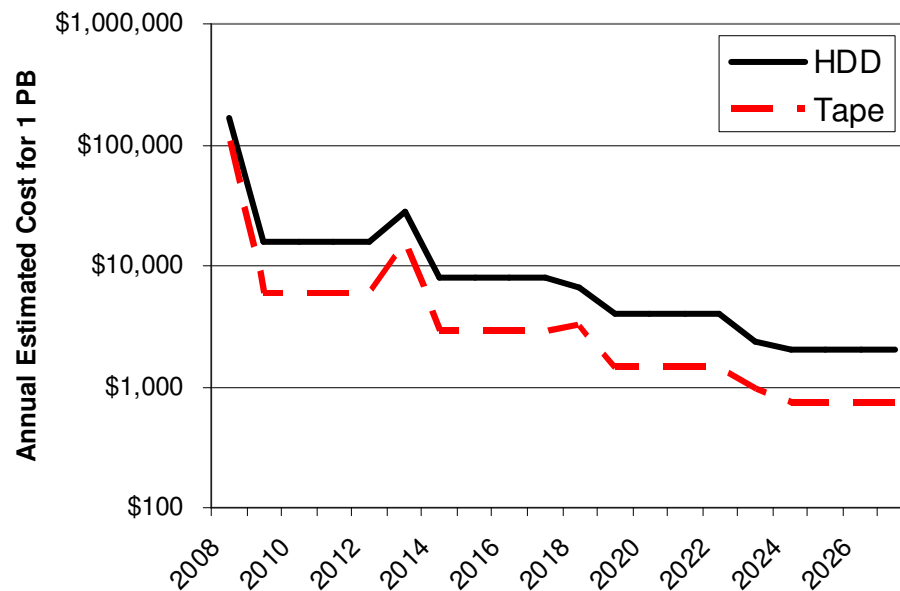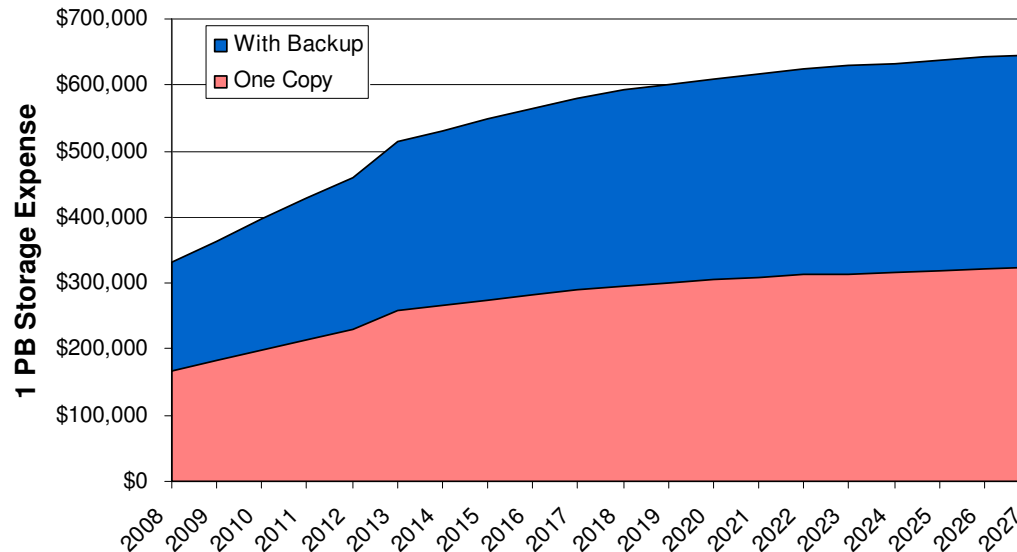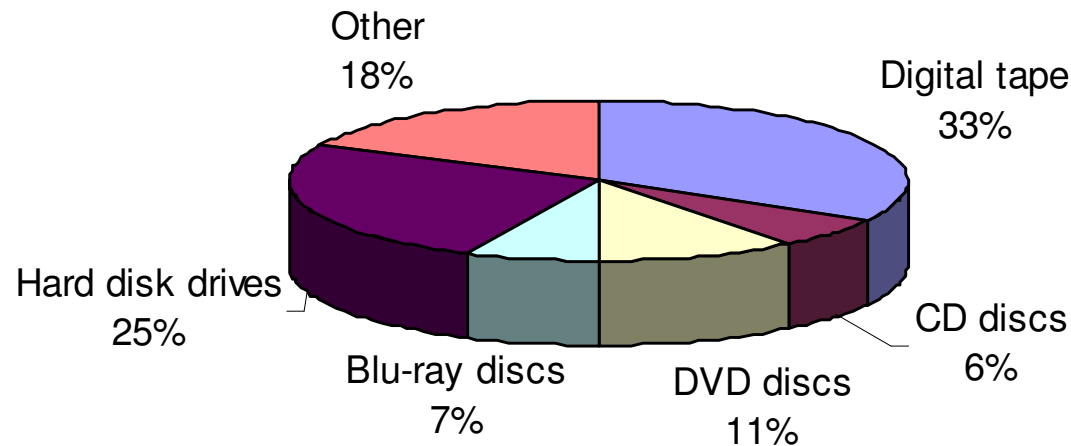# Archiving and Preservation

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

Percentage of Digital Long Term Archives

Other
18%

Digital tape
33%

Hard disk drives
25%

CD discs
6%

Blu-ray discs
7%

DVD discs
11%

Growth Rate of Archival Media

Other
11%

Digital tape
29%

Hard disk drives
26%

CD discs
11%

Blu-ray discs
10%

DVD discs
13%

- Tape and HDDs predominate in long term archival media and are projected to show greatest growth in the future
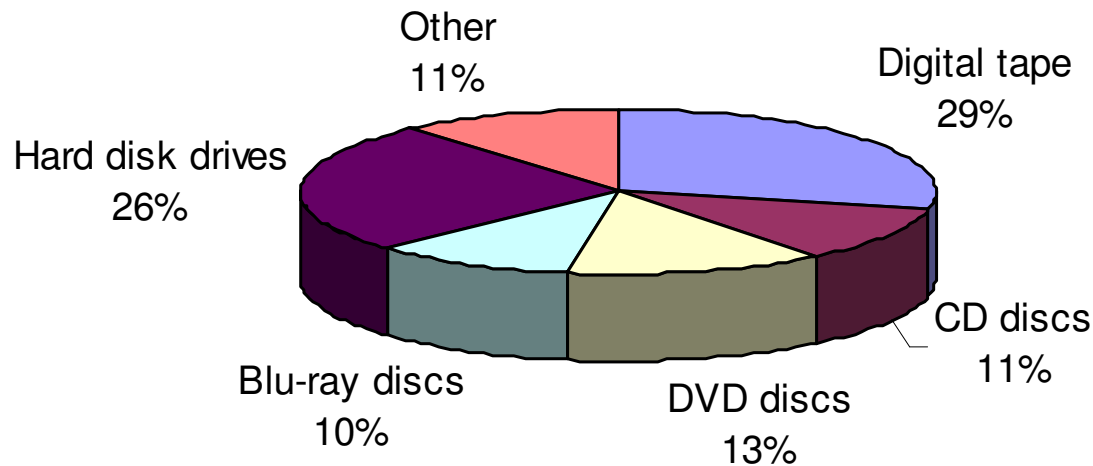
- About 41% never update their digital archives

- 75% used different storage for archiving and working storage
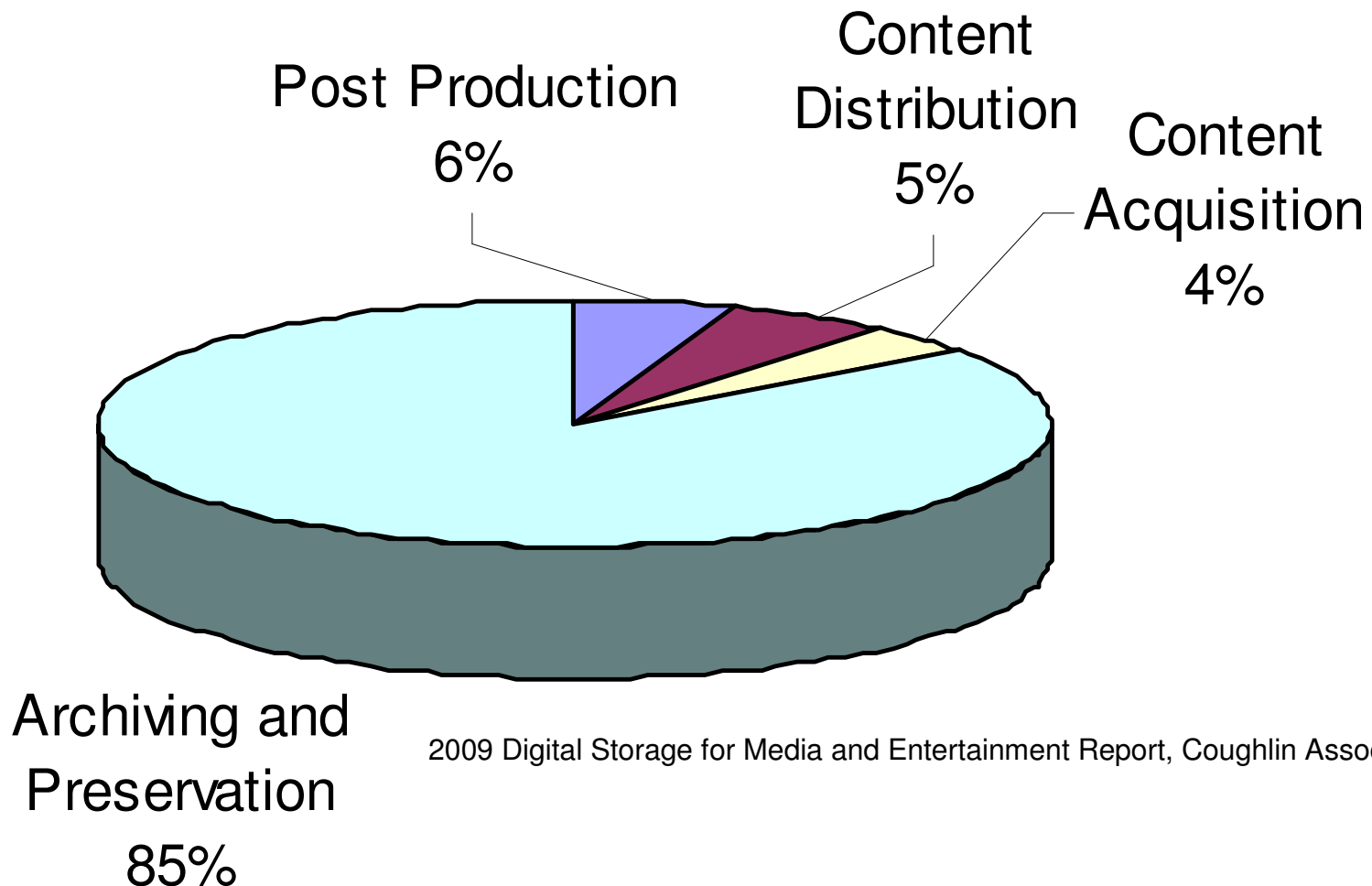
Coughlin Associates Professional M&E Survey, 2009

Media and Entertainment Storage Trends

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

Post Production
6%

Content Distribution
5%

Content Acquisition
4%

Archiving and Preservation
85%

2009 Digital Storage for Media and Entertainment Report, Coughlin Associates

Media and Entertainment Market Storage Revenue Share by Segment (2008)

Archiving and Preservation 15%

Post Production 15%

Content Acquisition 20%

Content Distribution 50%
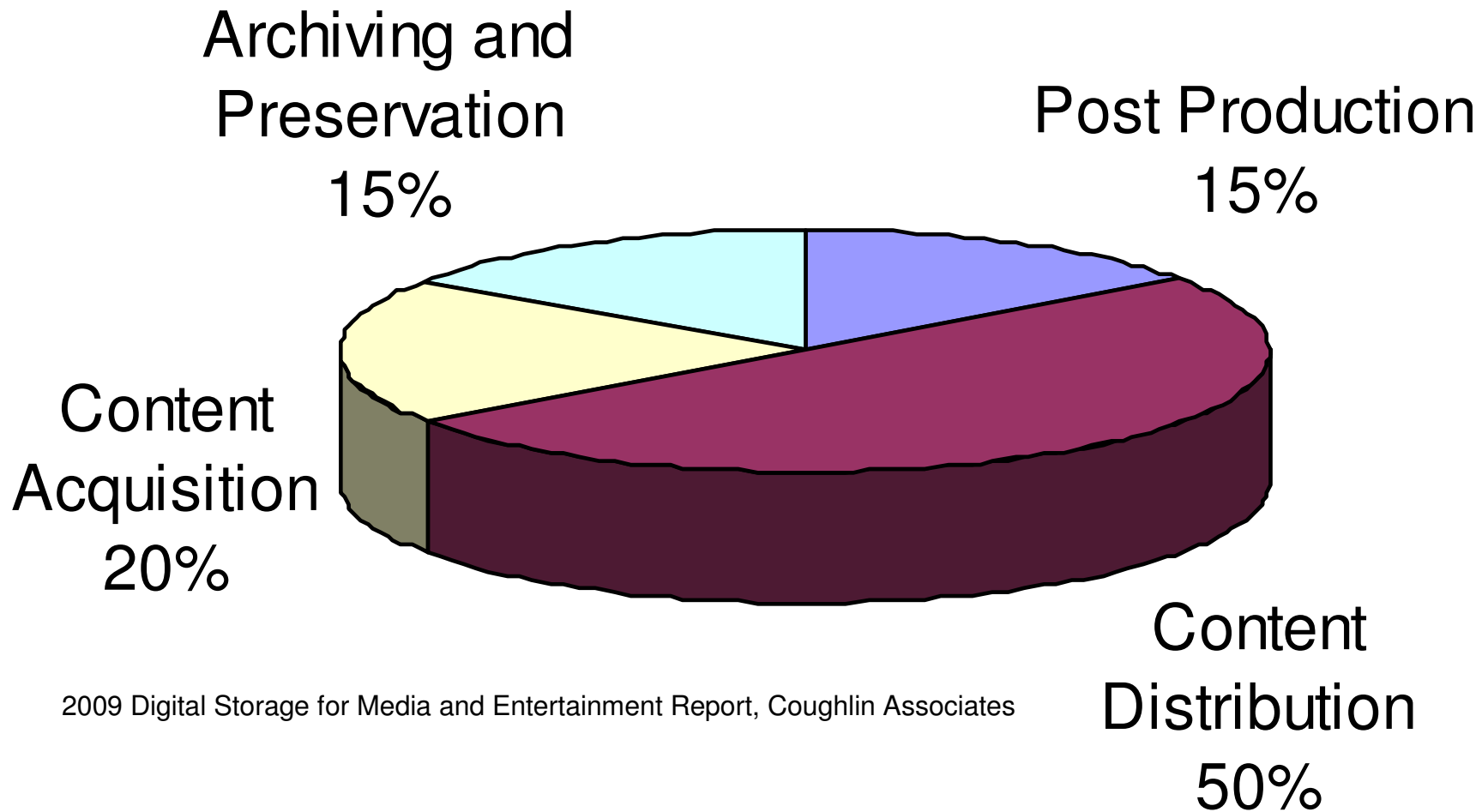
2009 Digital Storage for Media and Entertainment Report, Coughlin Associates

Market Share of Storage Media by Storage Capacity Shipped (2014)

Flash
1.2%

HDD
26.6%

Optical
1.0%

Tape
71.3%
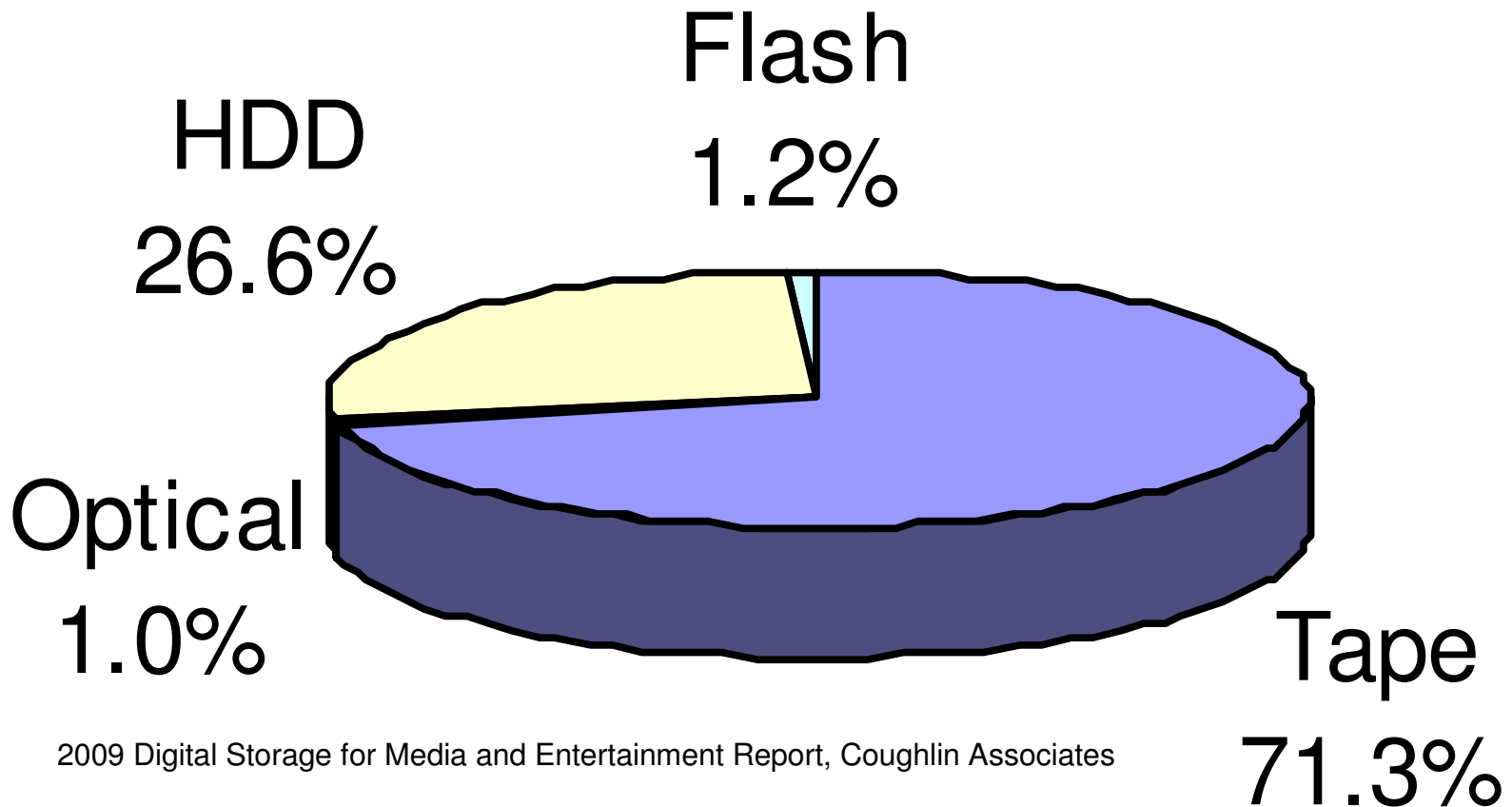
2009 Digital Storage for Media and Entertainment Report, Coughlin Associates

Total New Storage Capacity for Media and Entertainment
(over 39 Exabytes of New Storage by 2014)

2009 Digital Storage for Media and Entertainment Report, Coughlin Associates

Legend:
- Digital Conversion & Preservation
- New Film, Animation, Broadcast, Episodic Archiving
- Broadcast Acquisition
- Movie Acquisition
- Digital Cinema
- VOD Streaming
- VOD Ingest
- Networks
- Satellite Headends
- Cable Headends
- Broadcasters
- Compositing and Special Effects
- Post Production

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

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 Digital Storage in Consumer Electronics Report**, Coughlin Associates

- **2009 Survey on Storage for Media and Entertainment,** Coughlin Associates

- Go to www.tomcoughlin.com (tech papers page)