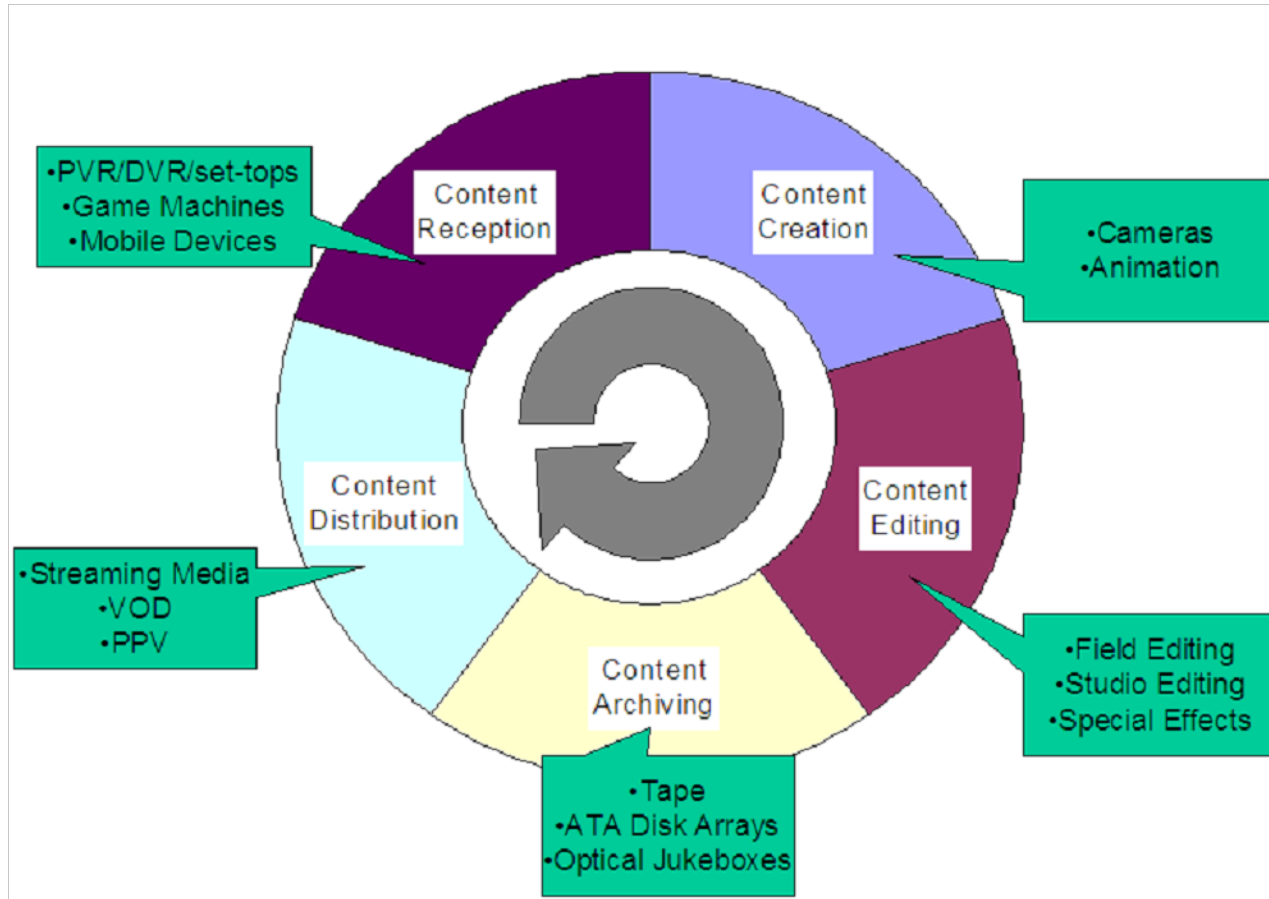


Digital Storage for Professional Media and Entertainment

Thomas M. Coughlin
President
Coughlin Associates
www.tomcoughlin.com

- ❑ 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

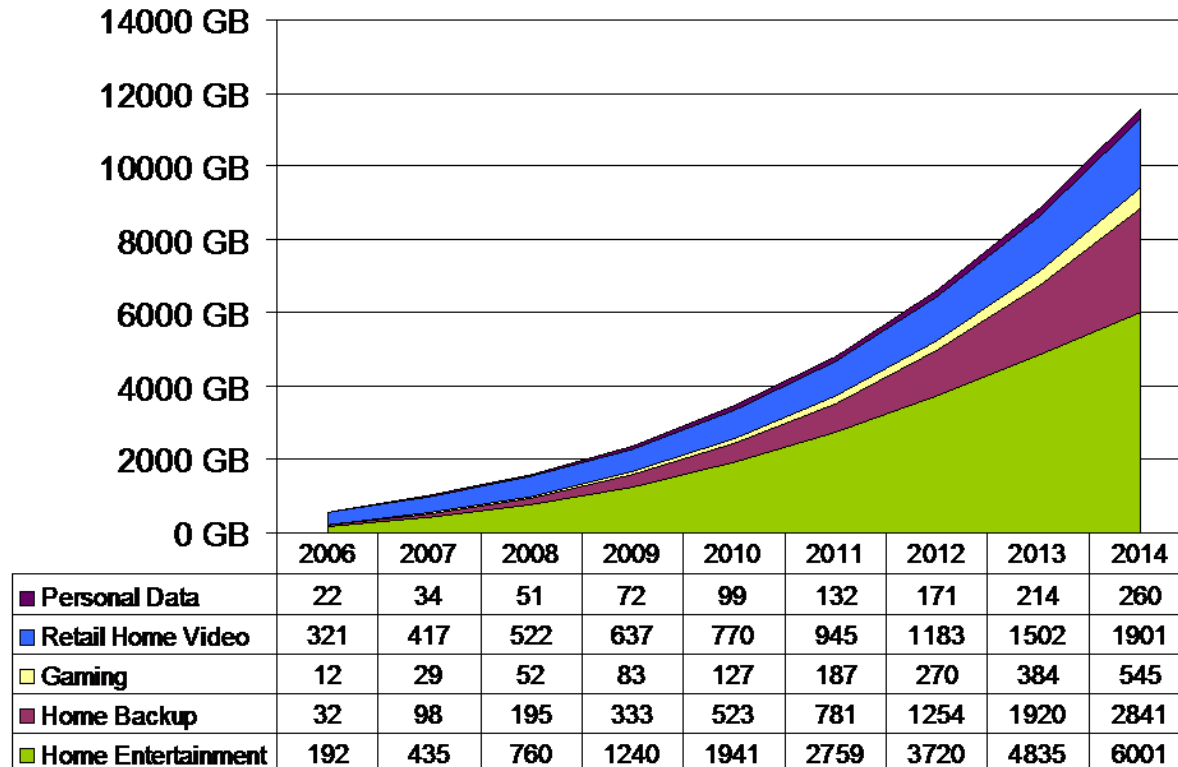
Digital Entertainment Content Value Chain (An Accelerating Positive Feedback Loop)



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 and even more in the future!
- ❑ Storage systems will be needed that make all of the different sources of 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

CE Devices are Content Devices



USB Storage in all Shapes and Colors



HP Media Server



Media Server Products

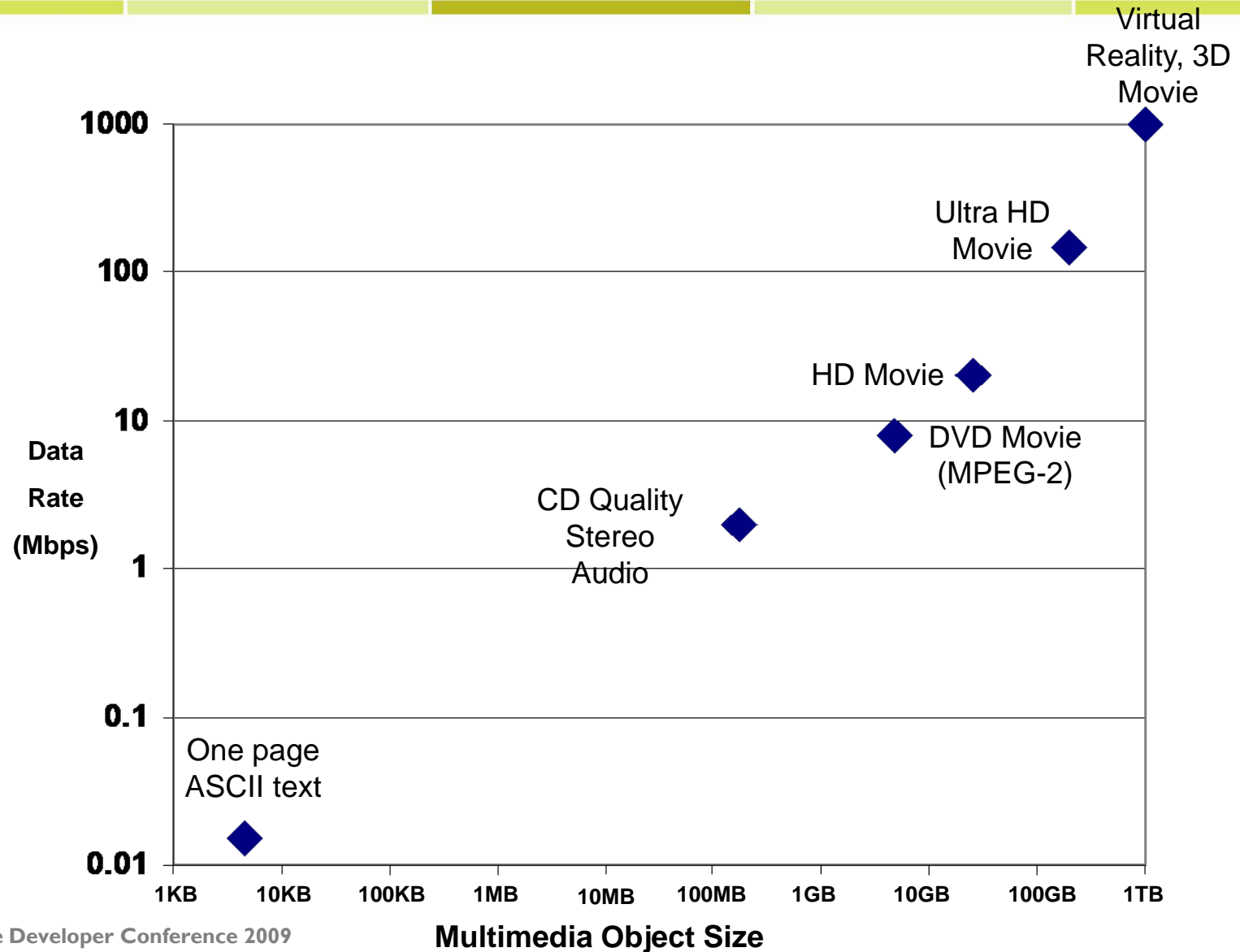


Blu-ray
Player

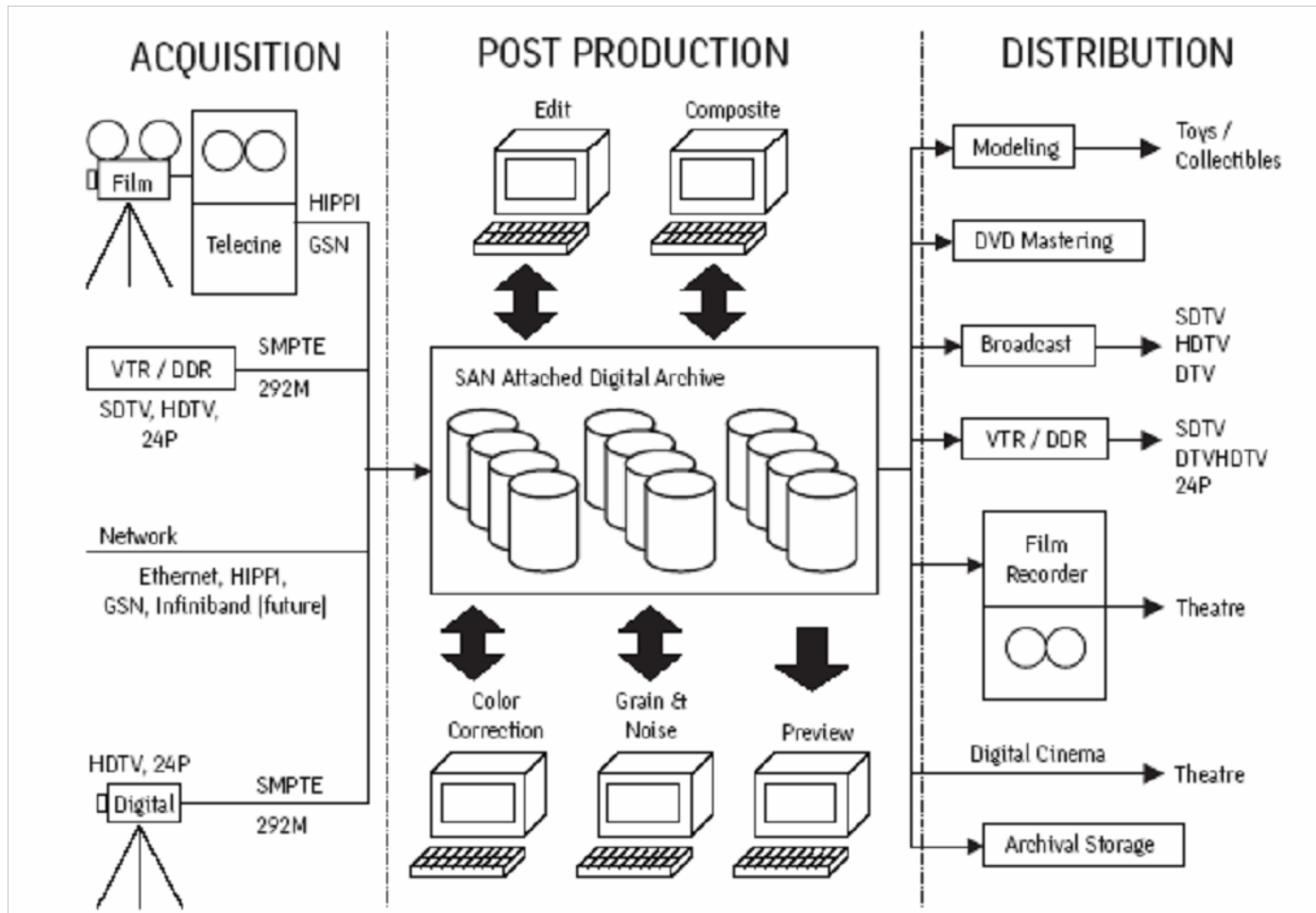


DVRs and
Expanders

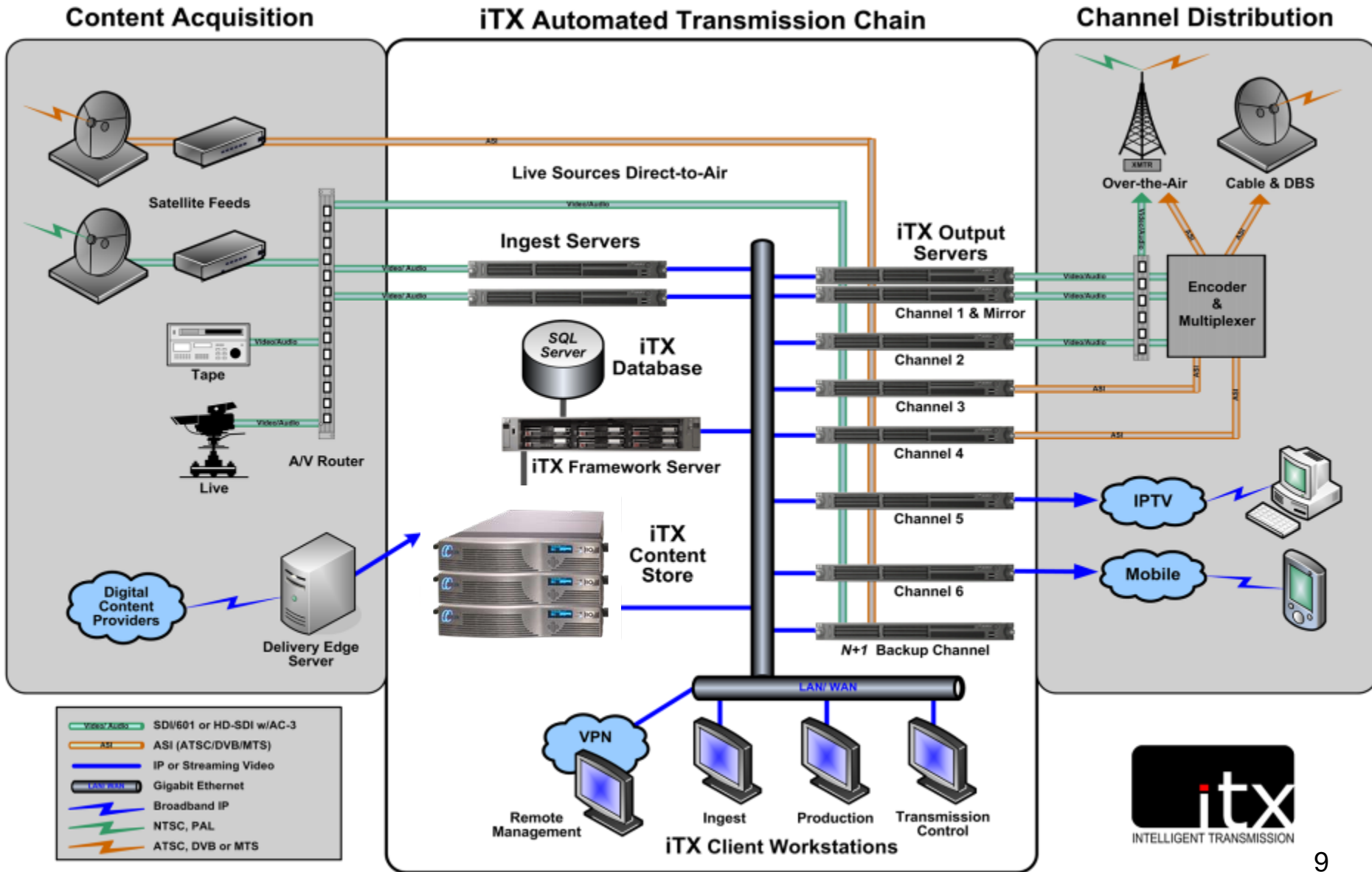
Media Content Size Trends



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

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)

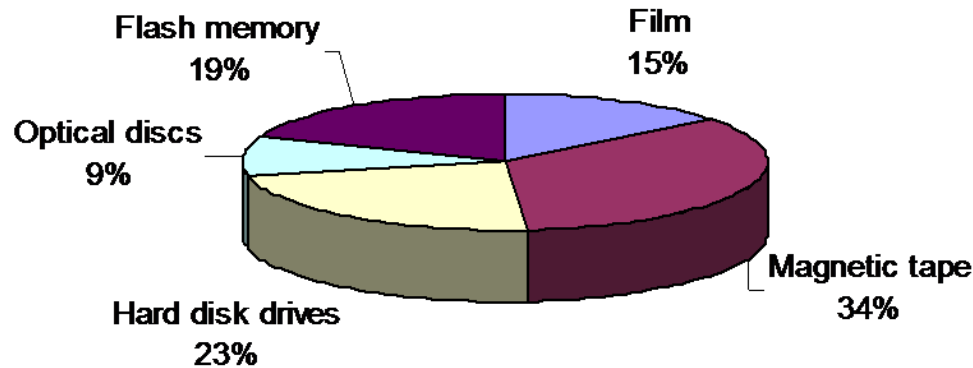
	2K Resolution	4K Resolution
Size of Single Frame	8.3 MB	53 MB
Avg. Storage Size of Finished Film	2 TB	8 TB
Data Generated During Production	100-400 TB	400-1,600 TB
Typical Data Rate for Real-Time Film Playback	200 MB/s	1,274 MB/s

- Note that 3D content can multiple the storage requirements by 1.5 X
- Ultra-HD content (8K) could increase demand by ~16 X



Content Capture, Editing and Post-Production

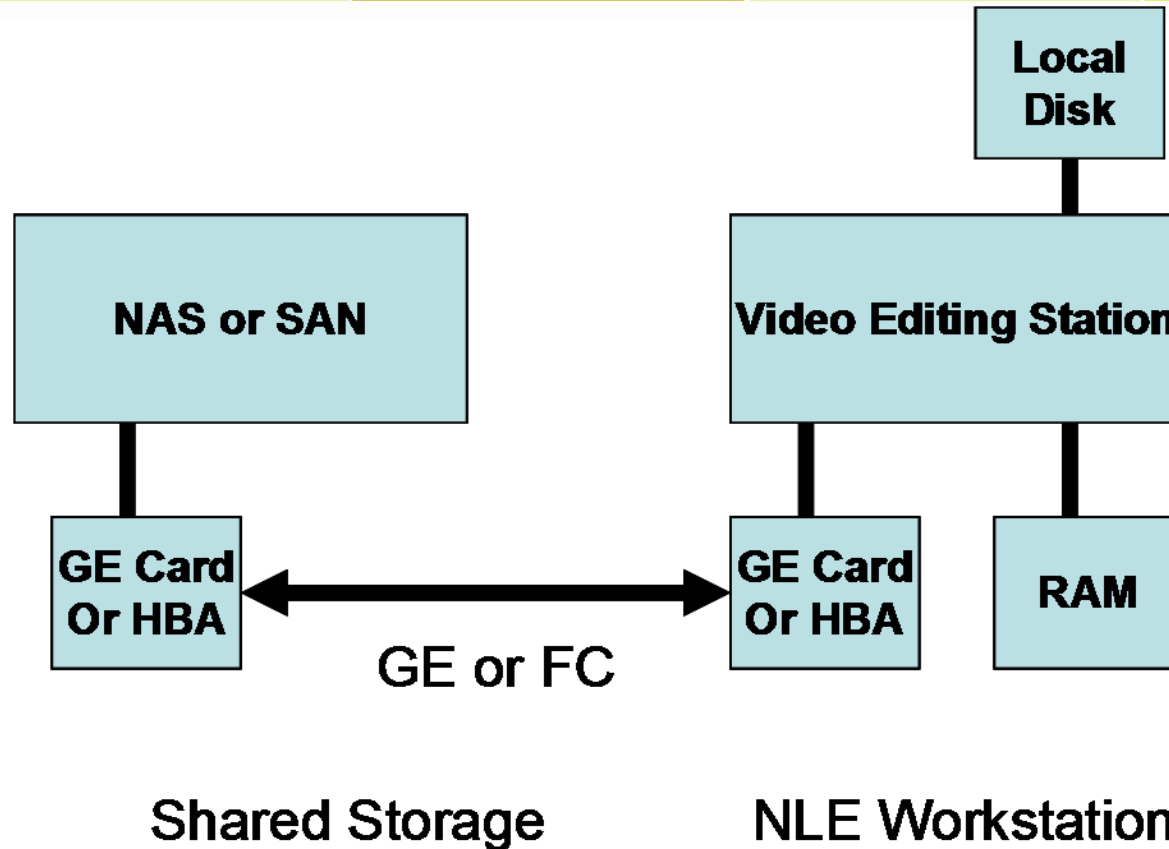
Percentage of Recording Media in Cameras



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



- 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

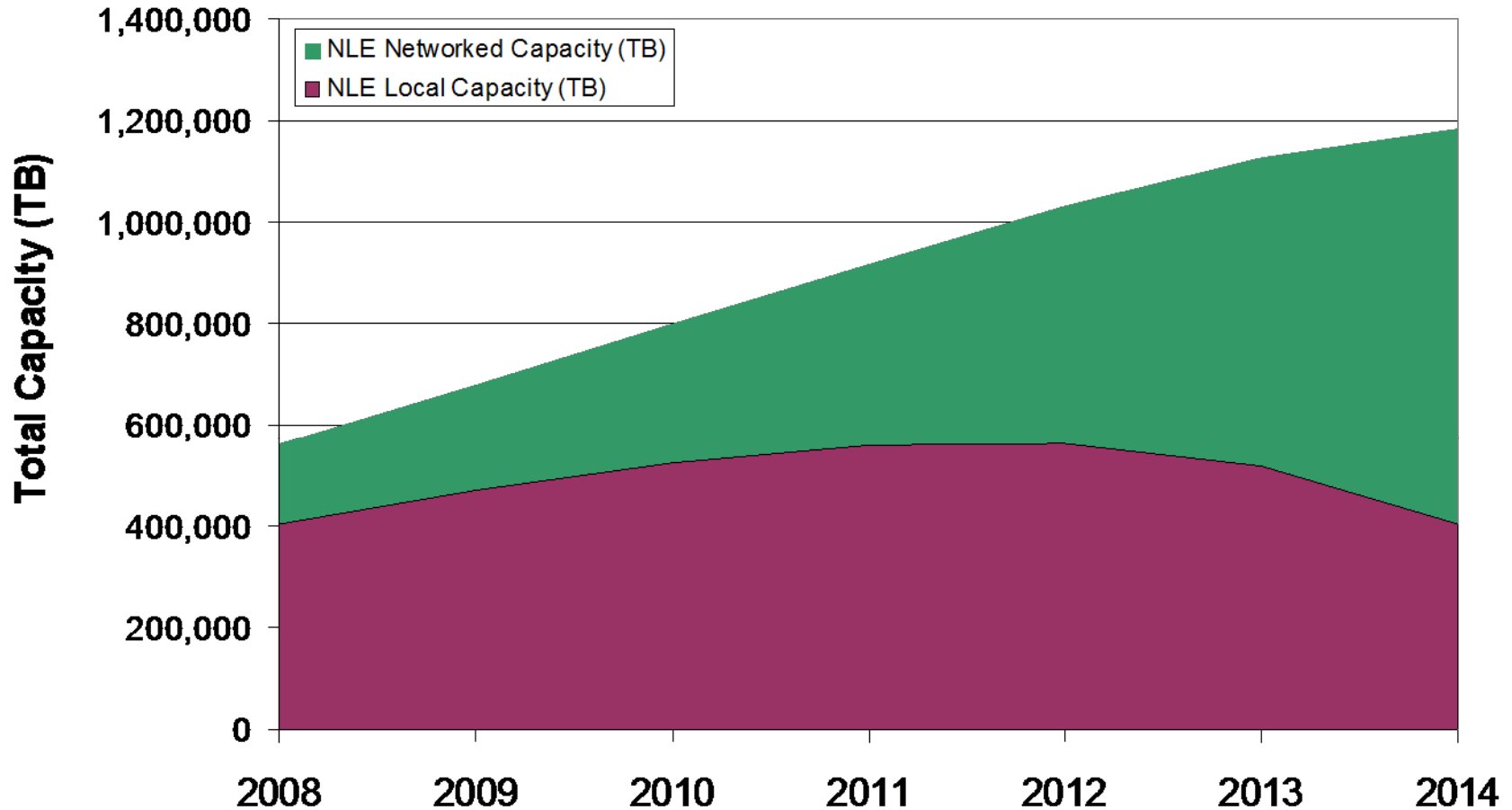
Professional NLE Bandwidth Requirements

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.

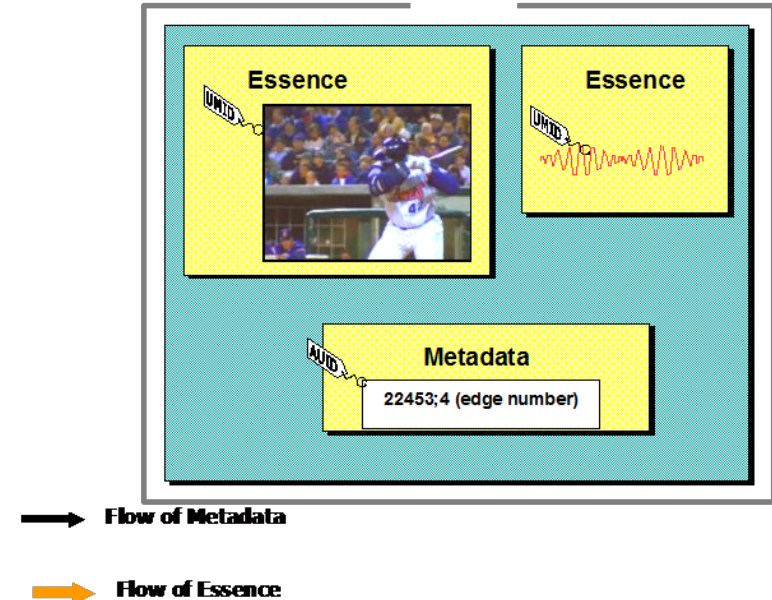
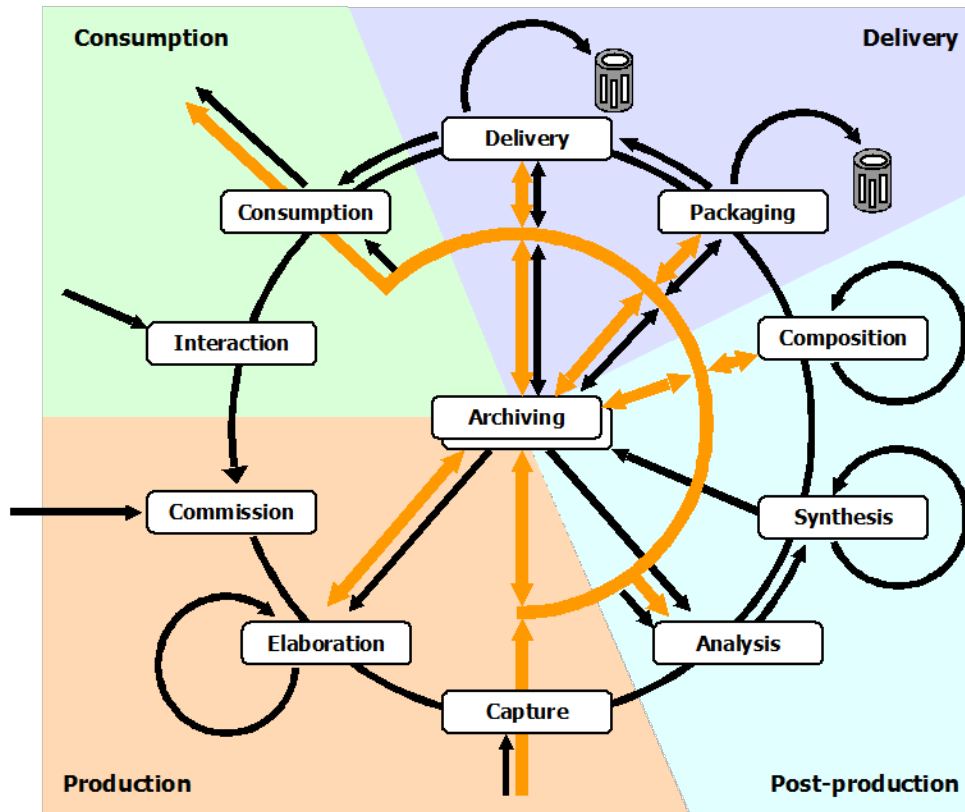
Defintion/ bandwidth requirements	Bandwidth per node	Number of workstations	Total bandwidth needed
Standard Definition (SD) at 30 Fps in RGB @10 bits def	42 MB/s	10	420 MB/s
High Definition (HD) 24P RGB @ 10bits def	199 MB/s	4	796 MB/s
2K film resolution	306 MB/s	2	612 MB/s
4K film resolution	1223 MB/s	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



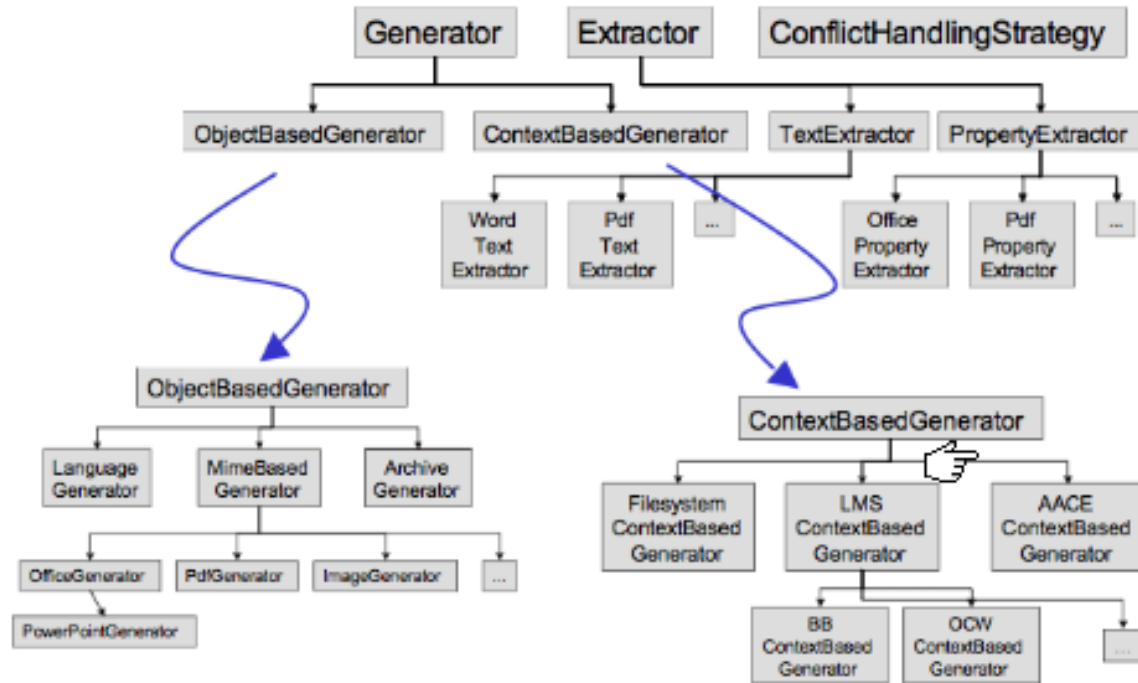
- Most metadata is manually generated
- Some automated sensor input can provide metadata (e.g. GPS in some high end cameras)

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



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

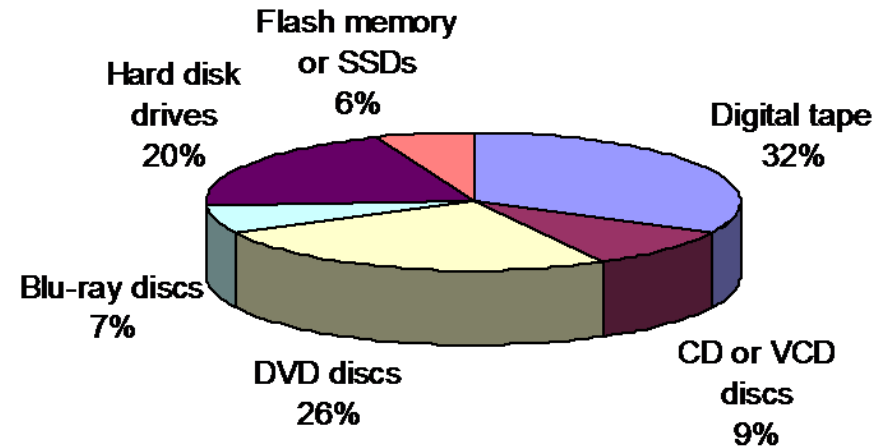
Content Delivery

A photograph of a concert stage at night. The scene is dimly lit, with several bright spotlights illuminating the stage. The text "Content Delivery" is overlaid in the center of the image in a bold, purple font. The background shows a large crowd of people, and the stage is filled with performers and equipment.

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



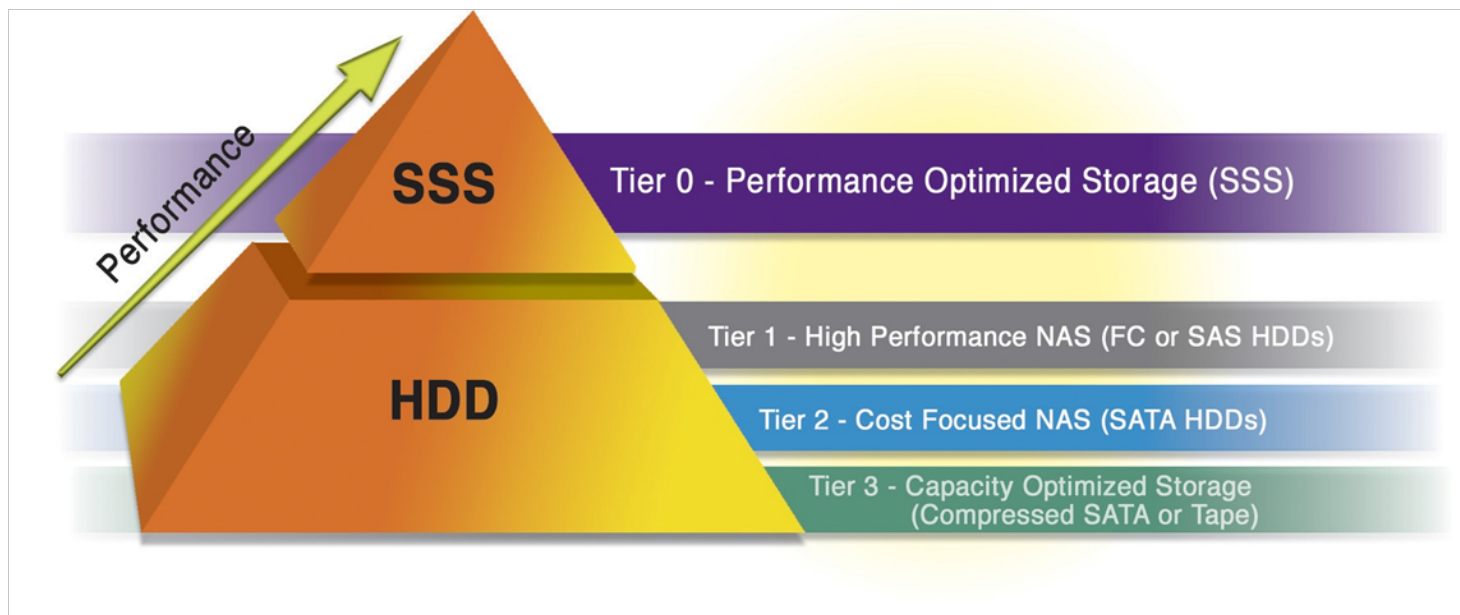
Coughlin Associates Professional M&E Survey, 2009

VOD Capacity and Bandwidth Requirements

	Monthly Ingested Capacity (GB)	Streaming Bandwidth (Mbps)	Streaming Output Capacity (GB)
Standard Definition (SD)	~100	10,125-16,875	~720
High Definition (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



- 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



SSS Play Back Demonstration (SV09)

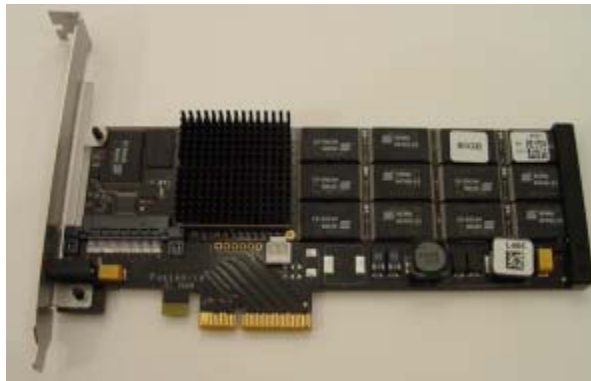
SDC 

STORAGE DEVELOPER CONFERENCE

SNIA  SANTA CLARA, 2009



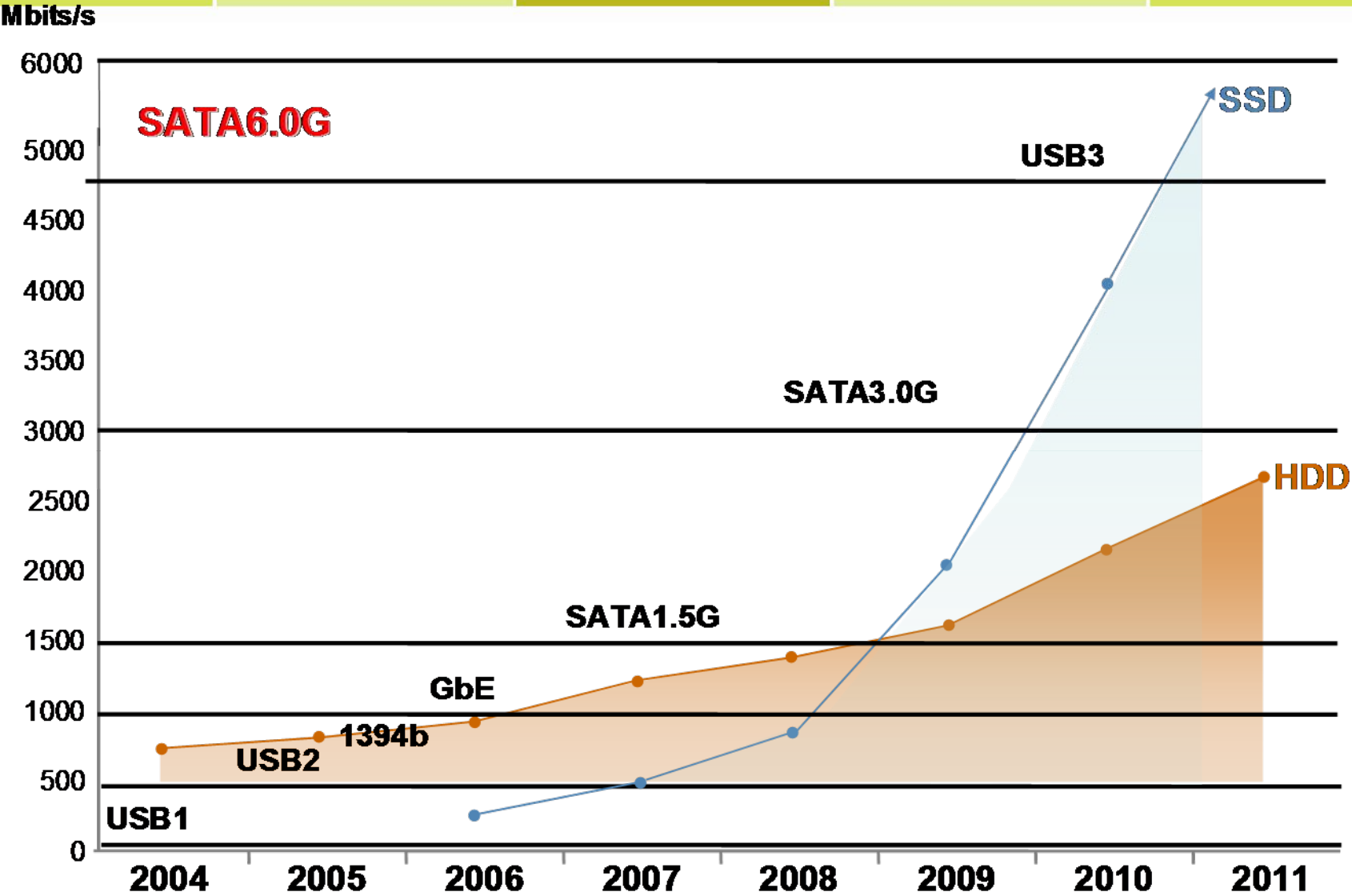
SSD Developments for Enterprise Applications



- ❑ 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

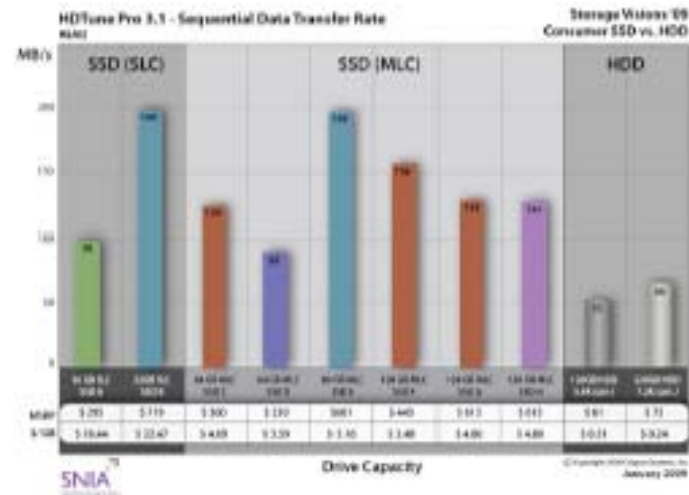
(Graph from Silicon Image, SV09)



HDTune and PCMark

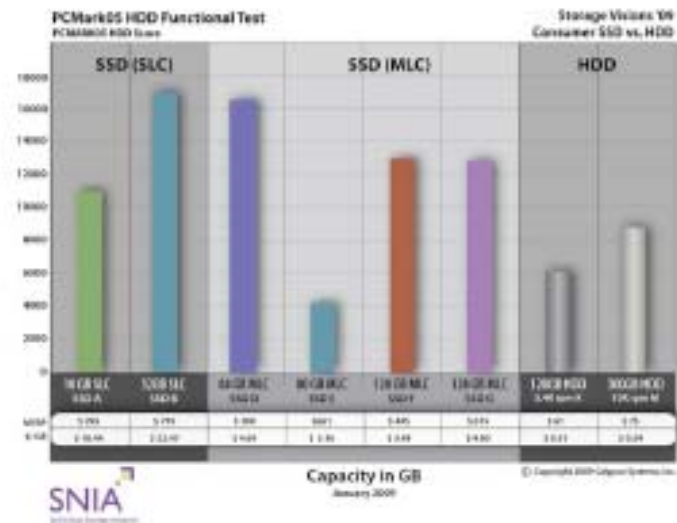
➤ HDTune Data Transfer Rate –

System Level MB/S DTR, no file size



➤ PCMark05 – System Score

System Level PCMark05 Generated Score

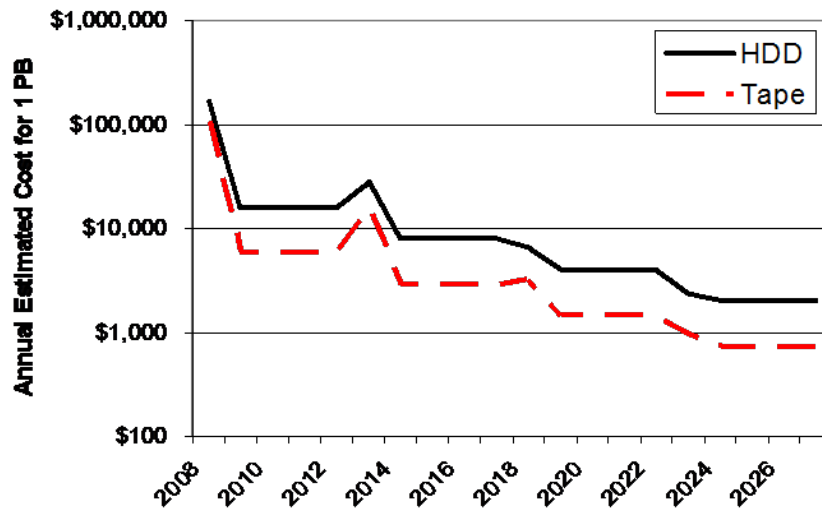
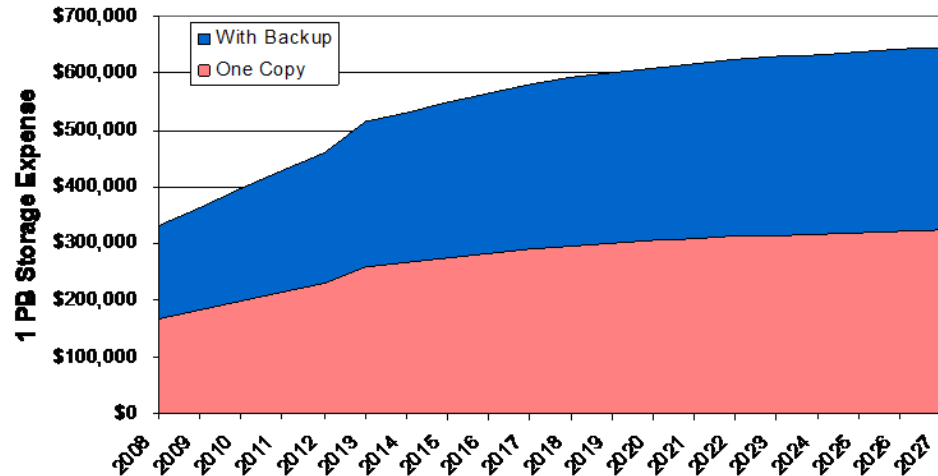


Solid State Storage Initiative

Archiving and Preservation

ΠΑΝΤΑ ΤΑ ΕΝ ΟΥΡΩΝ ΕΙΣ ΤΗΝ
ΕΓΓΕΝΕΤΟ ΟΥΔ' ΕΝ ΟΥΡΩΝ ΕΙΣ ΤΗΝ
ΚΑΙ Η ΕΥΗΗΝΤΟ ΦΩΣΤΩΝ ΑΝΘΡΩΠΩΝ
ΚΑΙ ΤΟ ΦΩΣ ΕΝ ΤΗΣ ΚΟΤΙΑΣ ΑΙΝΕΣ ΚΑΙ Η
ΣΚΟΤΙΑ ΑΥΤΟΥ ΚΑΤΕΛΑΒΕΝ
ΕΓΕΝΕΤΟ ΑΝΘΡΩΠΟΣ ΑΠΕΣΤΑΛΜΕΝΟΣ Α
ΡΑ ΟΥ ΟΝΟΜΑΤΩ ΙΩΑΝΝΗΣ ΟΥΤΟΥ Η
ΘΕΝΕΣ ΜΑΡΤΥΡΙΑ ΗΝ ΜΑΡΤΥΡΗΘΗ
ΠΡΟΤΟΥ ΦΩΤΟΣ· ΙΝΑ ΠΙΣΤΕΥΟΙΣΤΕ
ΣΩΘΗΤΕ ΑΥΤΟΥ· ΟΥΚ ΗΝ ΕΚ ΕΥΣΤΕ
ΦΩΤΟΣ ΗΝΤΟ ΦΩΣΤΩΝ ΑΝΘΡΩΠΩΝ
ΕΙΧΕ ΜΕΝ
ΕΙΣ ΤΑ ΠΑΝΤΑ ΑΝΘΡΩΠΩΝ
ΕΙΣ ΤΟΝ ΚΟΣΜΟΝ· ΕΝ ΤΩ ΚΟΣΜΩ
ΟΧΛΟΣ ΑΙΩΝΙΟΥ ΕΓΕΝΕΤΟ ΚΑΙ ΟΧΛΟΣ
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ΧΑΡΙΤΙΝ ΑΥΤΟΥ ΠΑΡΕΛΑΒΟΝ ΟΧΛΟΣ
ΔΕ ΠΟΛΥΝ ΑΥΤΟΝ ΟΔΕΥΚΕΝ ΑΥΤΟΥ
ΑΥΤΕΙΑΝ ΤΕΧΝΑΥ ΓΕΝΕΣΑΙ ΤΗΝ
ΠΙΣΤΕΥΟΥΣΤΙΝ ΕΙΣ ΤΟΝ ΟΧΛΟΝ
ΟΧΛΟΣ ΑΙΩΝΙΟΥ ΕΓΕΝΕΤΟ ΚΑΙ ΟΧΛΟΣ
ΑΥΤΟΝ ΟΥΚ ΕΓΝΑΝ ΤΗΝ ΑΙΩΝΙΑΝ

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.**

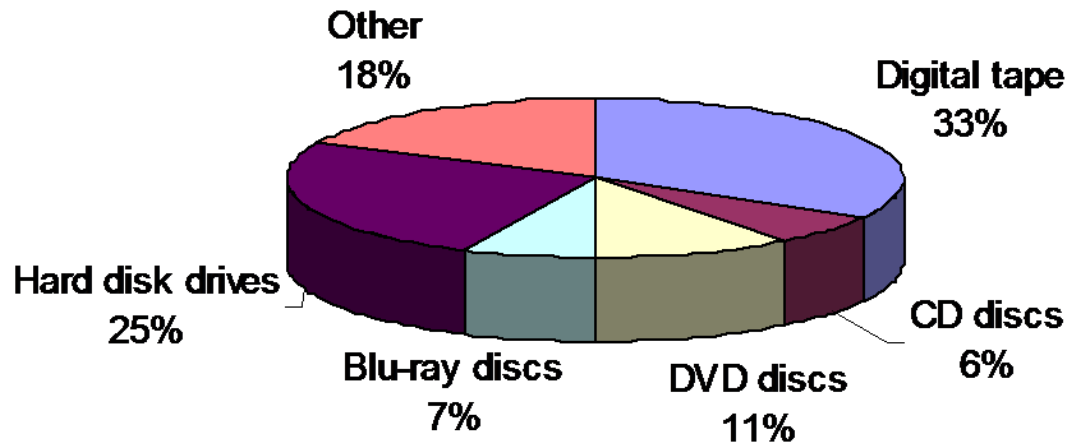
Survey Results (of those involved in digital archiving and preservation)

- ❑ 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%

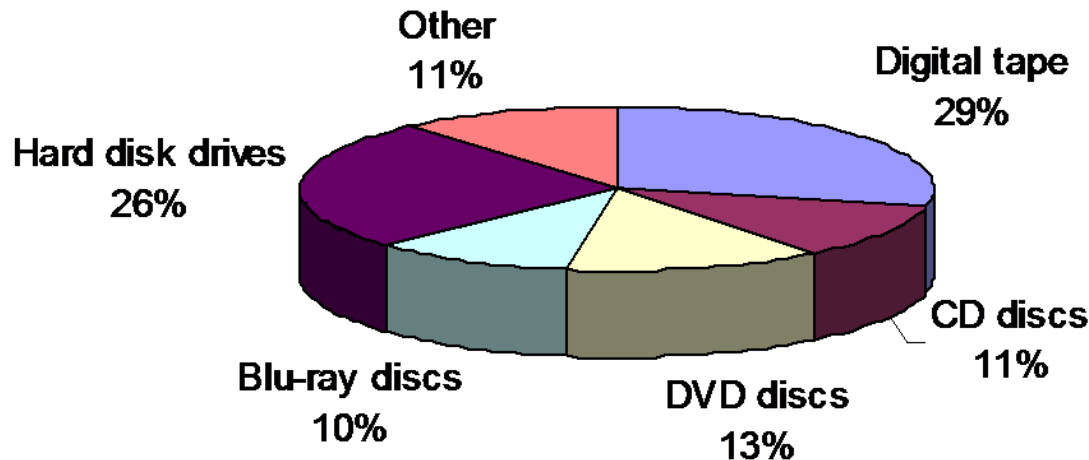
Coughlin Associates Professional M&E Survey, 2009

Long Term Archive Survey Results

Percentage of Digital Long Term Archives



Growth Rate of Archival Media



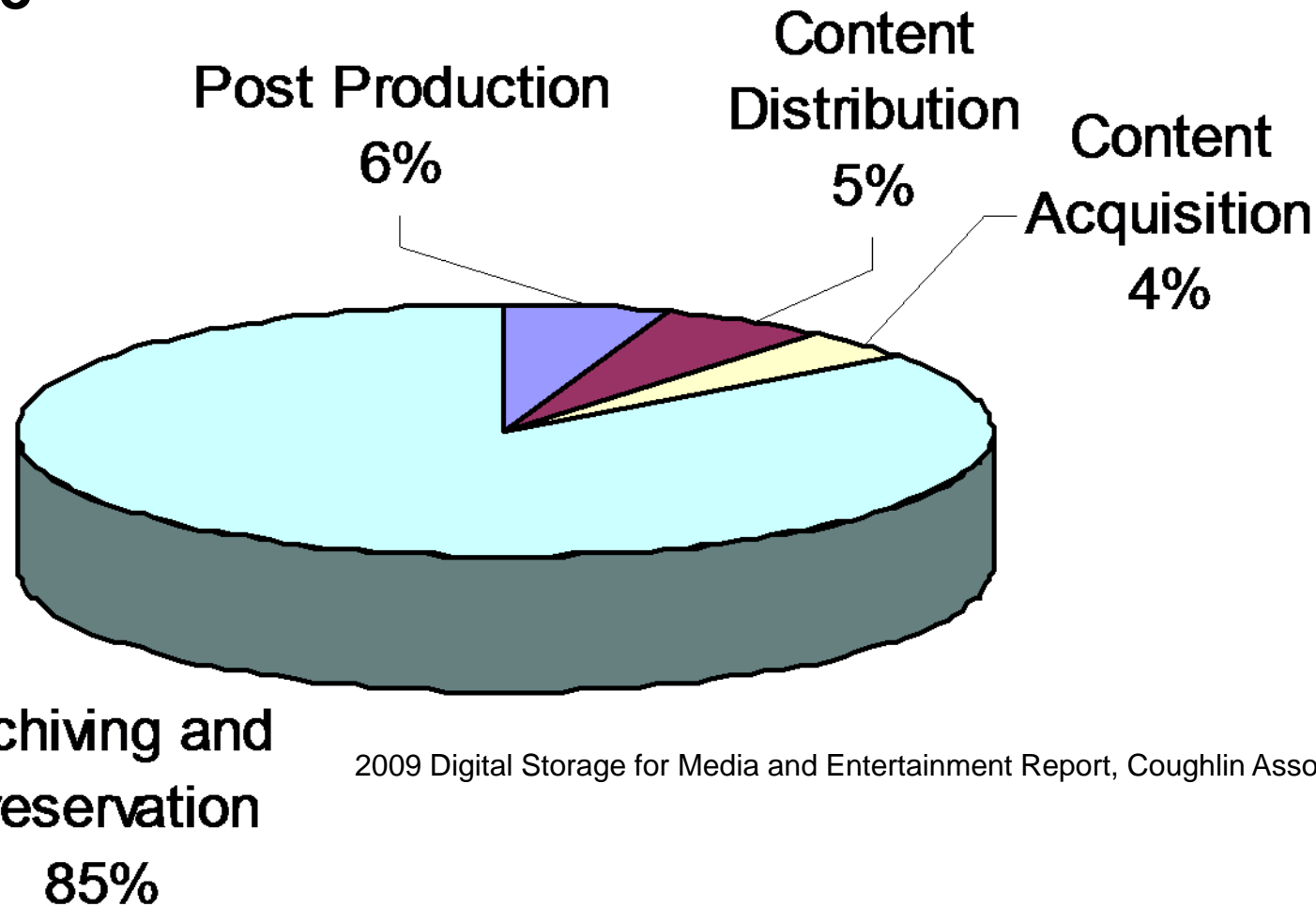
- Tape and HDDs predominate in long term archival media and are projected to show greatest growth in the future
- About 41% never update their digital archives
- 75% used different storage for archiving and working storage

Media and Entertainment Storage Trends



Distribution of Storage Capacity for Entertainment Creation, Archiving, & Distribution

In 2008



2009 Digital Storage for Media and Entertainment Report, Coughlin Associates

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

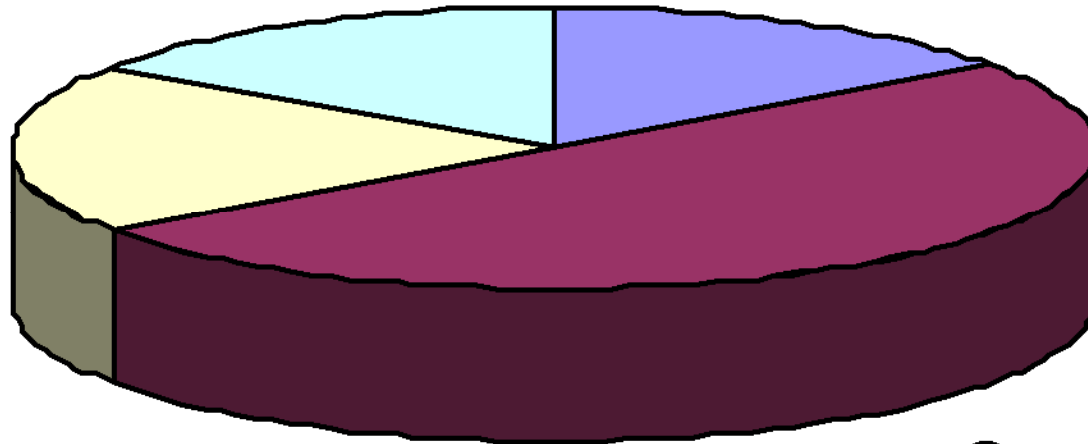
Archiving and
Preservation

15%

Post Production

15%

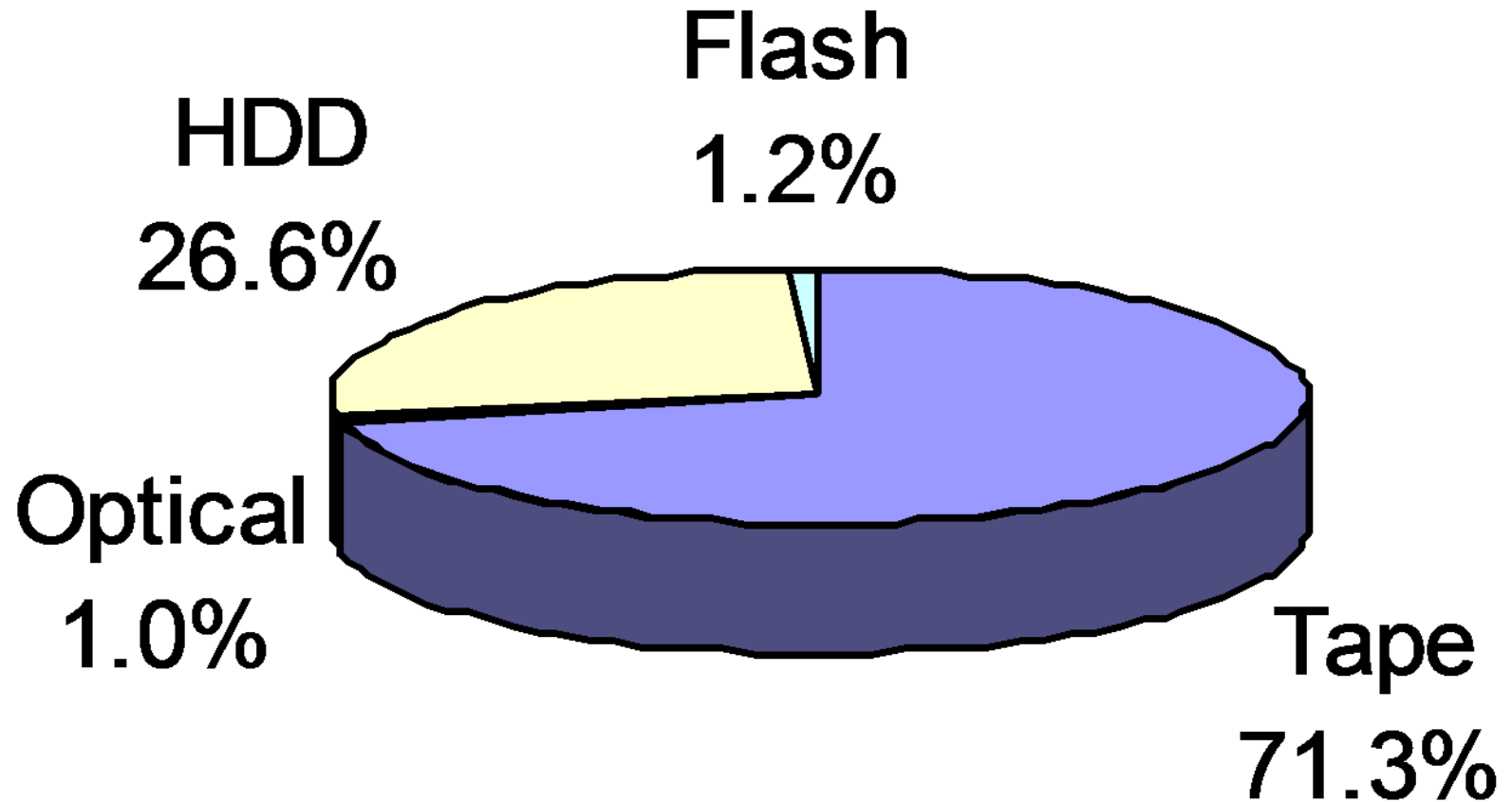
Content
Acquisition
20%



Content
Distribution
50%

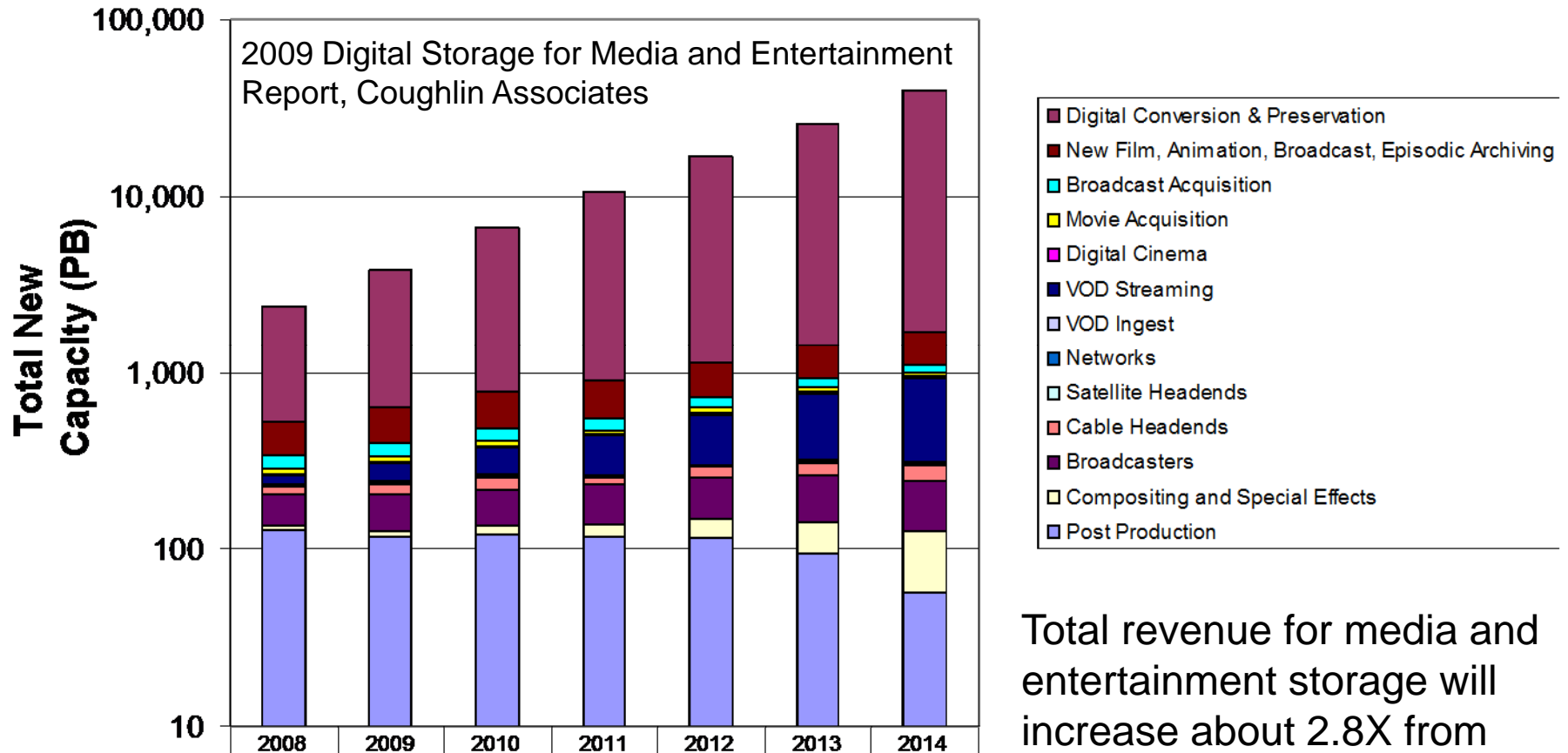
2009 Digital Storage for Media and Entertainment Report, Coughlin Associates

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



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!



- ❑ 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 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)
- ❑ SNIA SSSI: <http://www.snia.org/forums/ssi/>