Storing Your Life

Consumer Digital Storage—Personal, Shared, Hierarchical and Virtual

Thomas Coughlin

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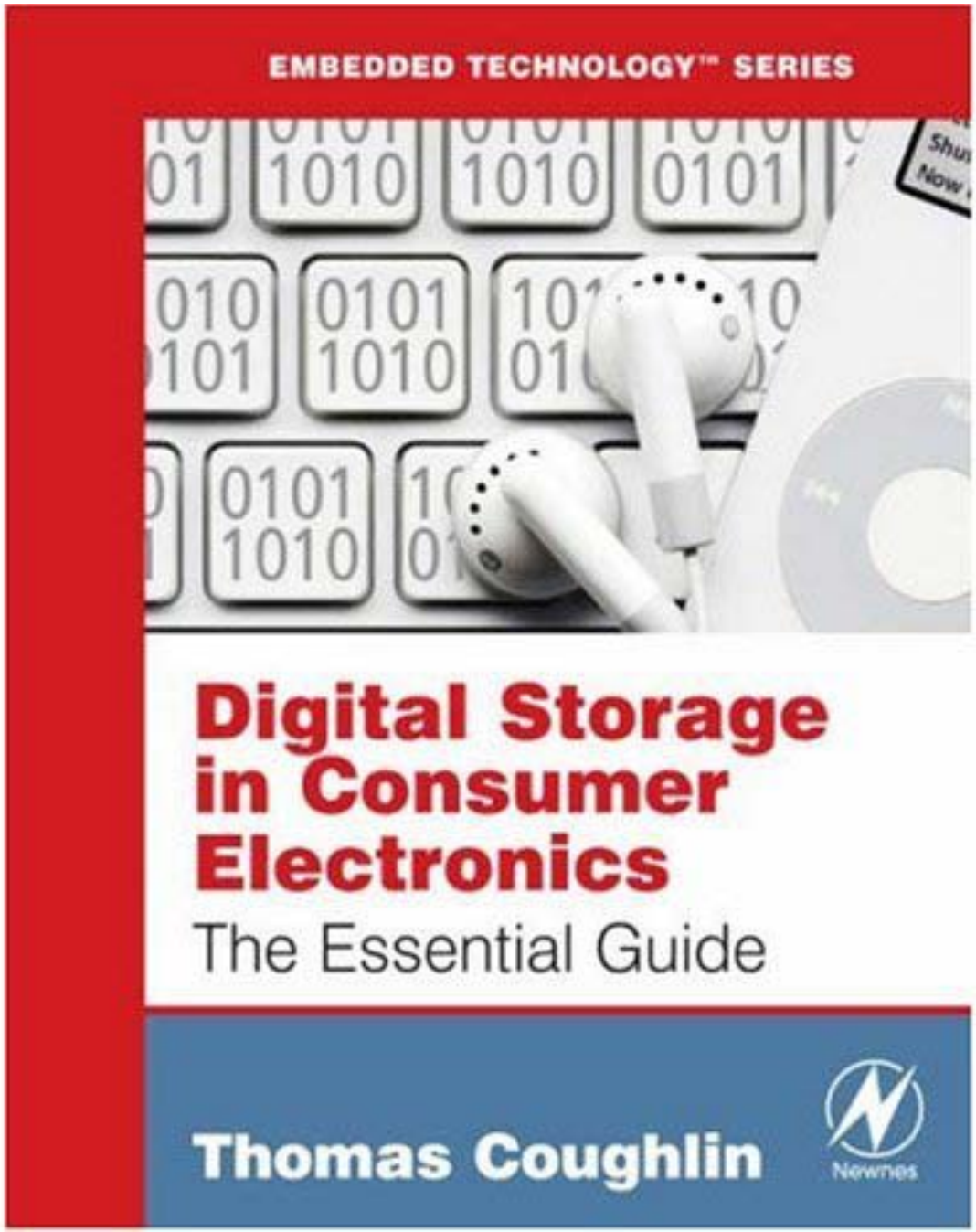


Published by Newnes Press (a division of Elsevier Publishing)

Outline

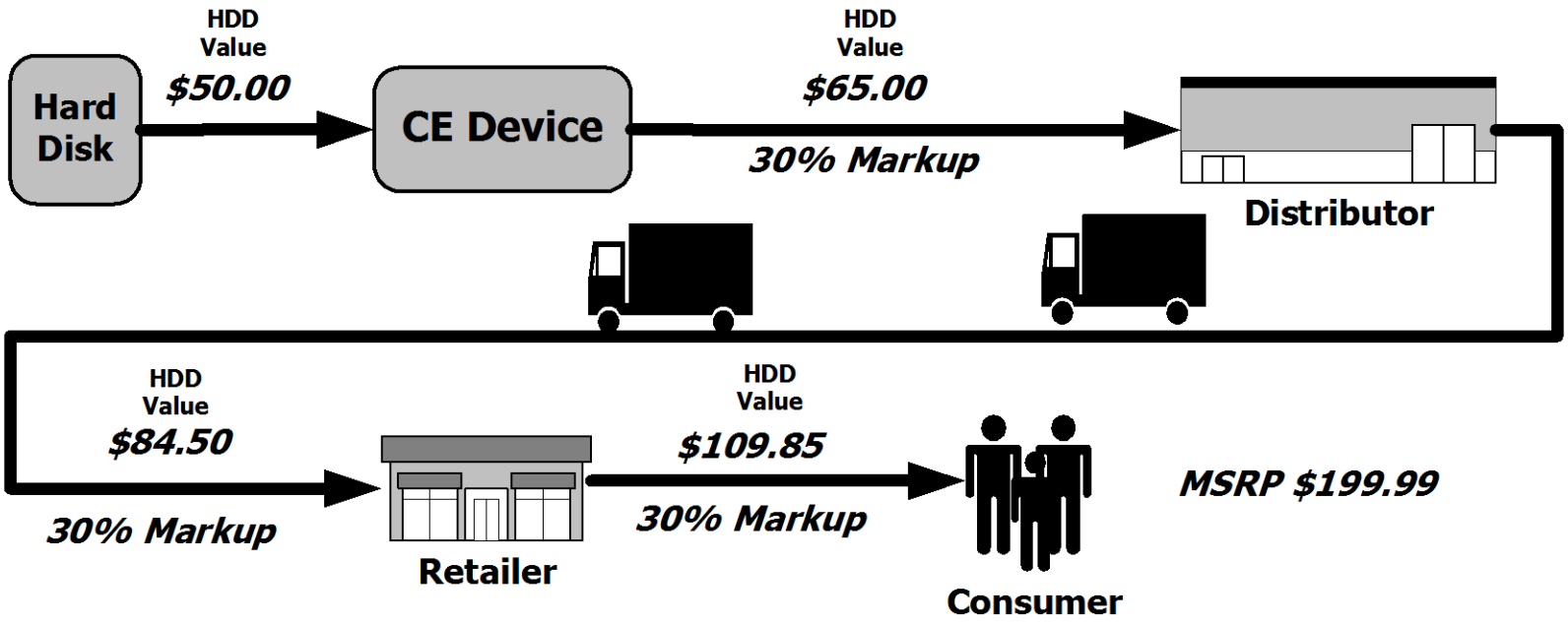
- Drivers for Digital Storage in the Home
- The Consumer Electronics Storage Hierarchy
- New and Emerging Digital Storage Applications
- Intelligence in CE Storage Devices
- Connecting Everything in the Home and Home Virtualization
- Conclusions

Drivers for Storage in the Home

The Cosmic Wheel of Storage Karma

Content Creation
Content Editing
Content Archiving
Content Distribution
Content Reception

Consumer Storage Mark-up Through the Retail Distribution Chain



(1.30 X 1.30 X 1.30) = 220%

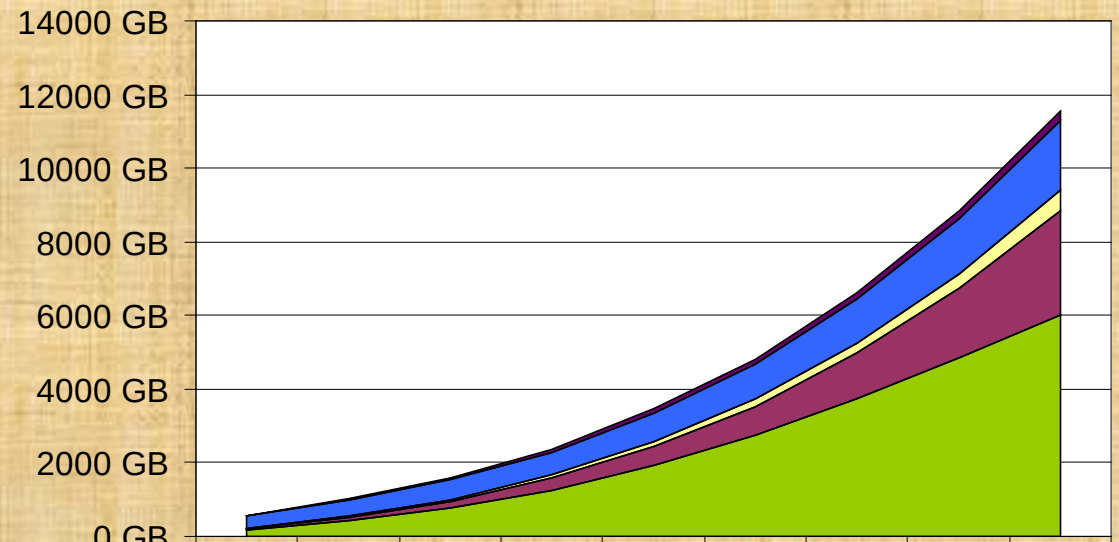
$199.99/220% = $90.90 BOM Cost

$50.00/$90.90 = HDD is 55% of BOM

Storage and streaming bandwidth for music and video formats

Format	*Bandwidth (Mbps)*	*Storage Capacity/Hour (GB)*
MUSIC FORMATS		
MP3	~0.128	~0.057
CD Quality	1.400	0.630
DVD Audio	9.600 (max)	4.320
VIDEO FORMATS		
iPOD (MPEG-4)	~0.750	~0.337
DVD (MPEG-2)	11.080	2.700
SD TV	~8.000	~2.000
HD TV	~19.300	~8.890
Blu-ray Disc	36.550	~12.500
Ultra-HDTV (8K X 4K)	~195.000	~133.000

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
- Of this amount ~26 Exabytes are user generated content

Drivers of Consumer Digital Storage

- Ease of content viewing/capture/creation: Being built into many modern consumer devices e.g. cameras, digital recorders—
- Growth of User Generated Content (UGC)
- Content Sharing: Easy to multiple digital content 1,000 or more through on-line sharing.
- New methods of creating metadata automatically so content can be used easier.
- New ways to share and coordinate data around the home.
- Multitasking

IEEE Spectrum, 10/09

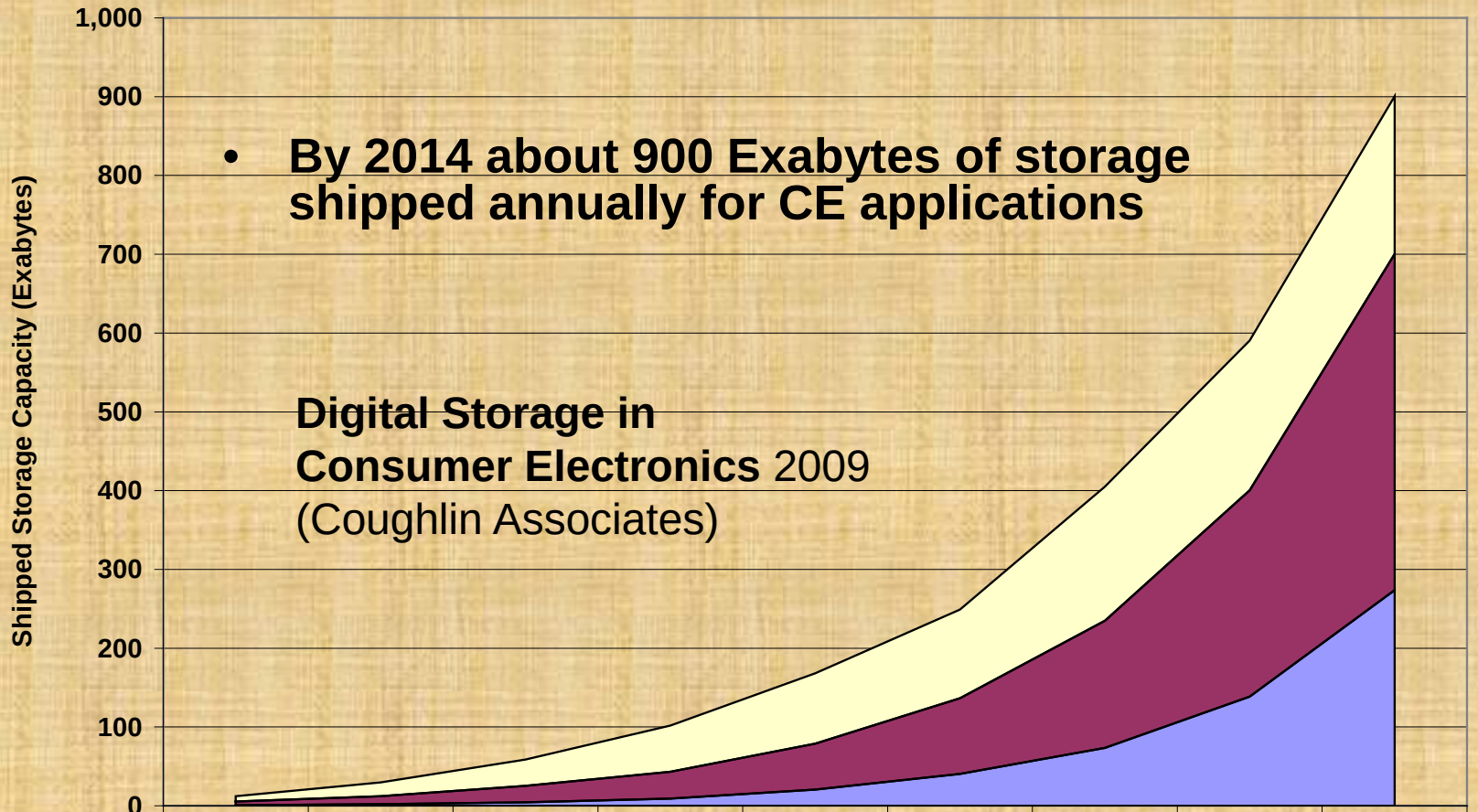
Estimated growth of personal and commercial content in CE devices

(storage units in exabytes)

Year	Commercial Content	Self Generated Personal Content	Personal Cloud Shared Personal Content	Total
2006	4	5	0	9
2007	8	9	0	17
2008	16	13	0	29
2009	30	24	1	55
2010	48	35	3	86
2011	69	113	7	189
2012	93	274	17	384
2013	120	603	39	762
2014	150	1,279	88	1,517
2015	184	2,664	194	3,041

Digital Storage in Consumer Electronics, Thomas Coughlin, Newnes, March 2008

Exabytes Shipped for Consumer
(OPTICAL DISK, HDD AND FLASH MEMORY)



	2006	2007	2008	2009	2010	2011	2012	2013	2014
ODD	6	17	33	59	89	113	170	190	200
HDD	5	10	21	34	58	96	162	262	427
NAND	1	2	4	9	21	41	73	138	274

Threats to long-term assets

- Large-scale disaster
- Human error
- Media faults

Long-term content suffers from more threats than short-term content

- Component faults
- Economic faults
- Attack
- Organizational faults

- Media/hardware obsolescence
- Software/format obsolescence
- Lost context/metadata

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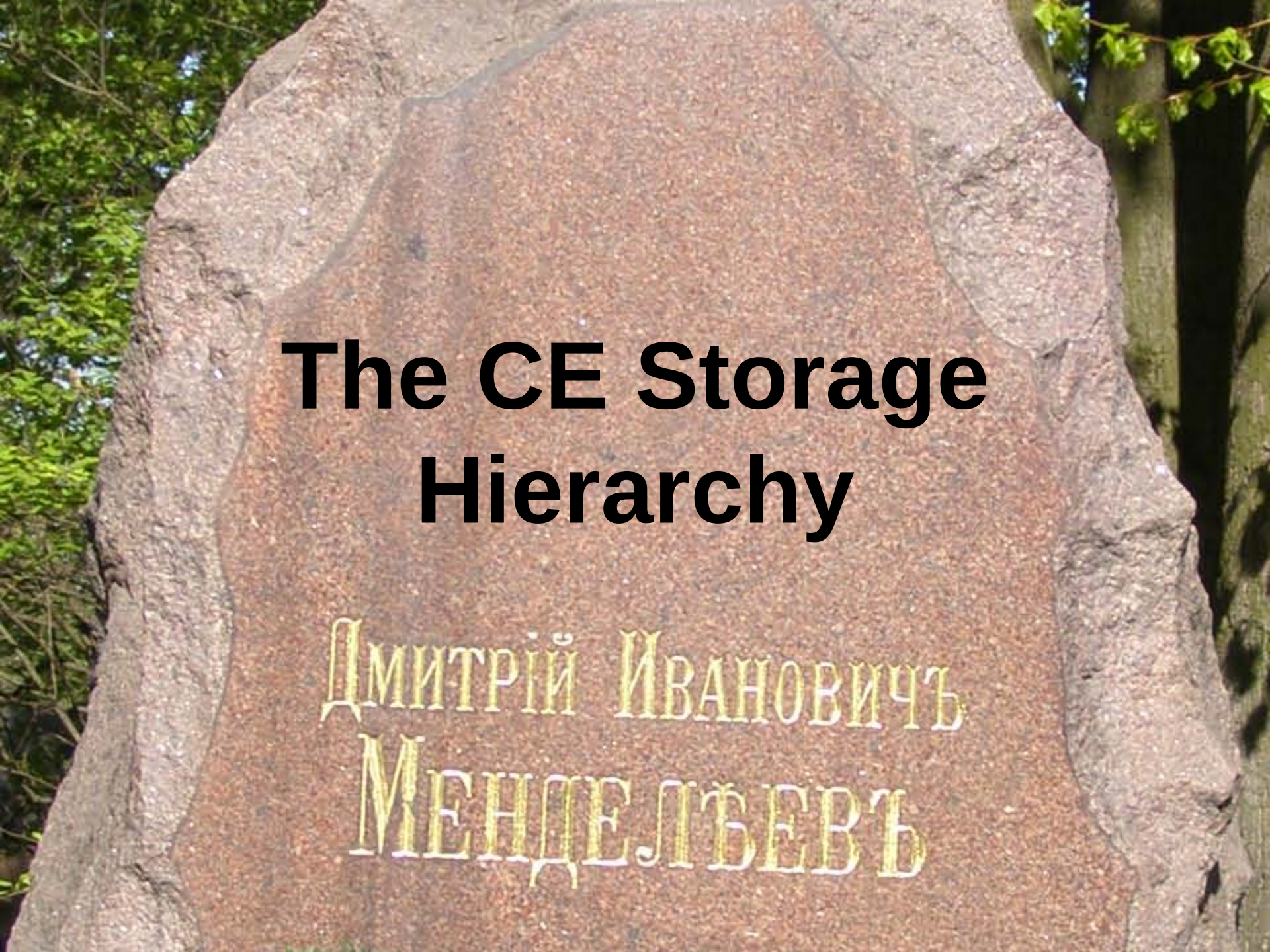
The CE Storage Hierarchy



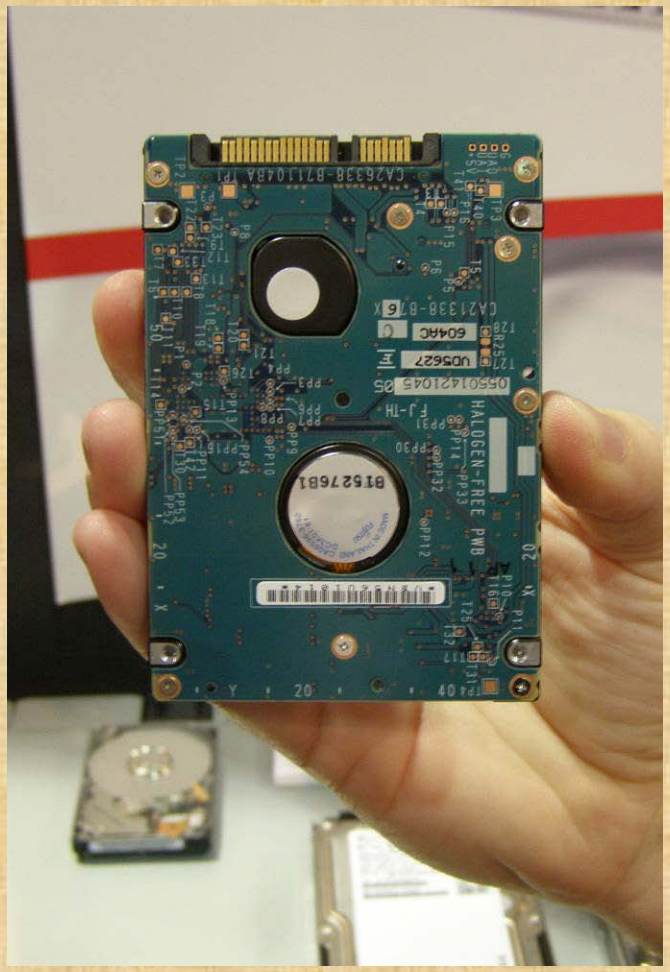
Storage Devices Used in CE

- Hard disk drives
  - Capacity drives (SATA)
- Optical Discs
  - CD, DVD, Blu-ray
- Flash Memory
  - Card formats
  - SSDs

Hard Disk Drives

Fujitsu

HDD Advances



- 1.5 TB 2.5-inch drive introduced by Seagate (not notebook format)
- Toshiba introduced a 320 GB 1.8-inch drive
- Hitachi, Seagate, Western Digital and Samsung producing 3 TB 3.5-inch drives (over 4 TB in 2011?)

External Storage and Backup

Clickfree Backup

Wireless USB Drive

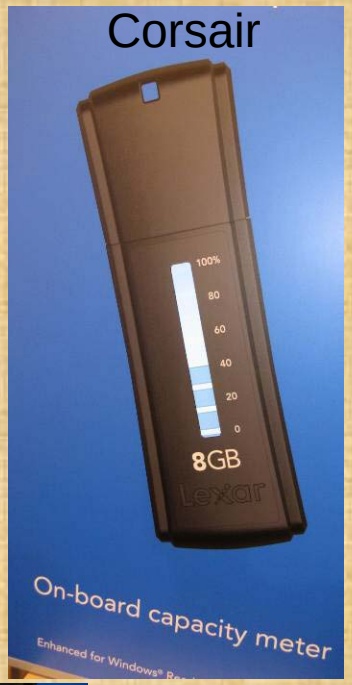
HP Media Server, V2

iVDR external storage

Plug Computer: Any storage device becomes networked storage

Flash Memory

Sandisk Ducati



Inexpensive PCs

Intel Z-P140

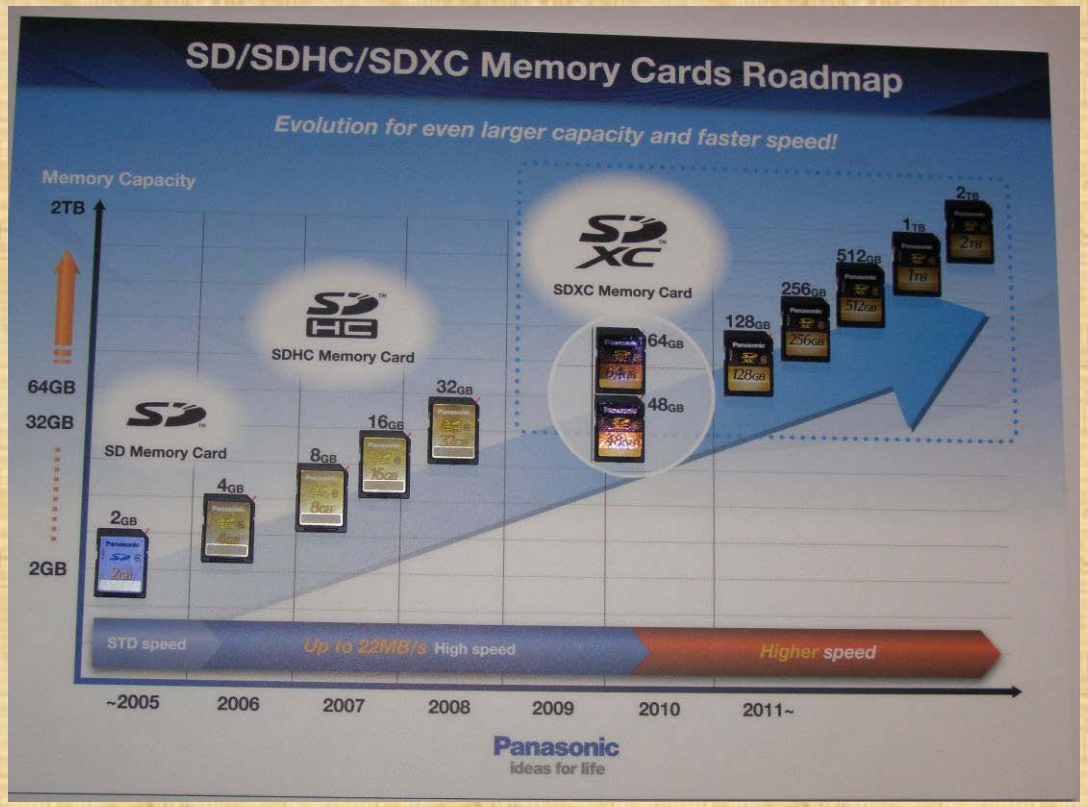
SanDisk

Samsung

Increasing Flash Storage Density

- Line width reductions with semiconductor process development
- Multi-level cells increase storage capacity
  - However wear out faster with MLCs by a factor of 10X per doubling of per cell capacity
  - Smart flash controllers with wear leveling can hide most of this wear from the user (gradual degredation rather than catastrophic failure)
- Flash can also be stacked allowing denser volumetric storage

Higher Capacity, Higher Speed SD Cards



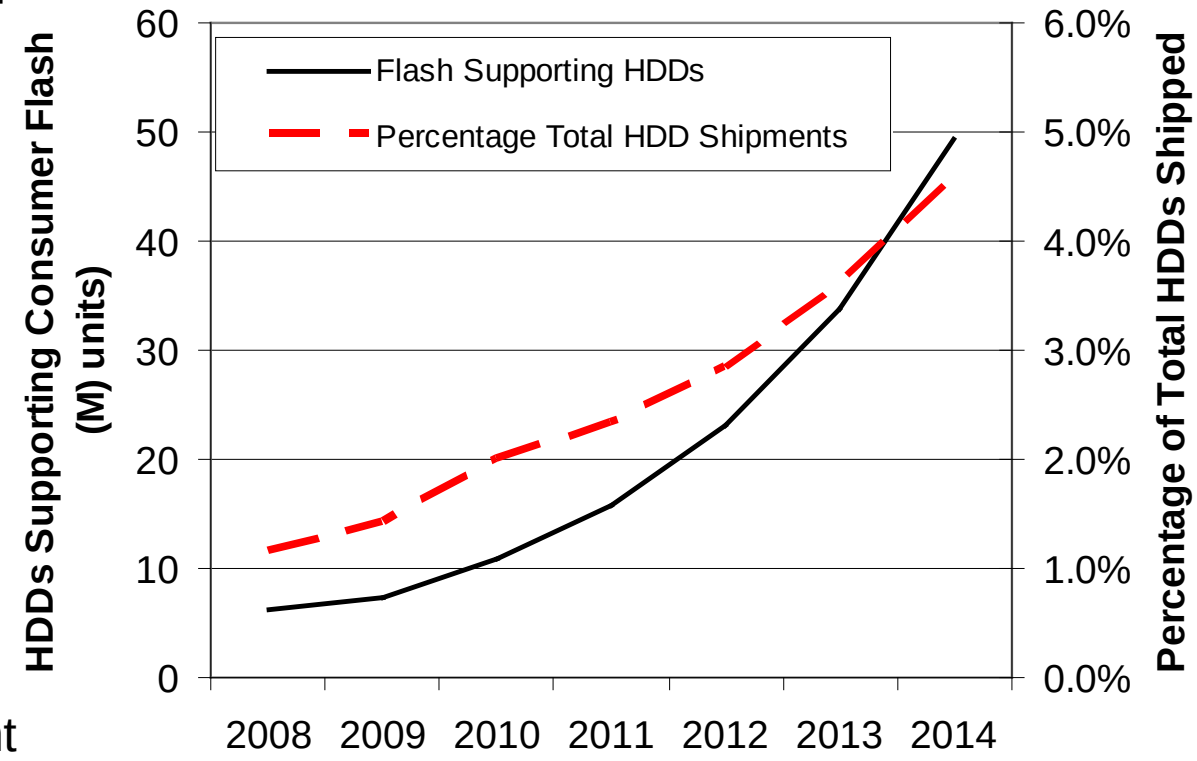
- In 2009 the SD card association announced the SDHC format (up to 2 TB and 300 MB/s)
- In 2010 Toshiba was showing product
- CE Devices using this available by 2011

Flash Memory for Content Distribution

- Optical discs are disappearing from laptop computers—content distribution on-line or with flash devices such as USB drives or cards
- Will flash memory displace optical media for physical content distribution?

Symbiotic Relationship Flash and HDDS

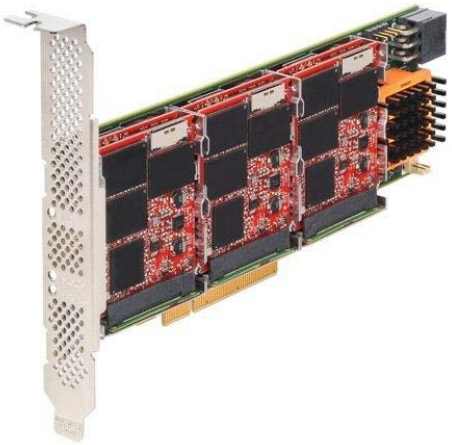
- Almost all consumer flash applications require HDDs
  - Music and video players
  - Cameras
- Consumer flash applications have created greater demand for HDDs
  - Downloads
  - Uploading photos and videos
  - Backup of Consumer Content

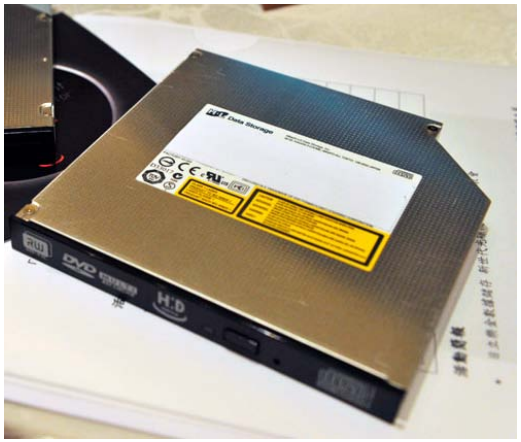


White Paper: Flash and HDD: Symbiosis or Survival of the Fittest? (Coughlin Associates & Objective Analysis)

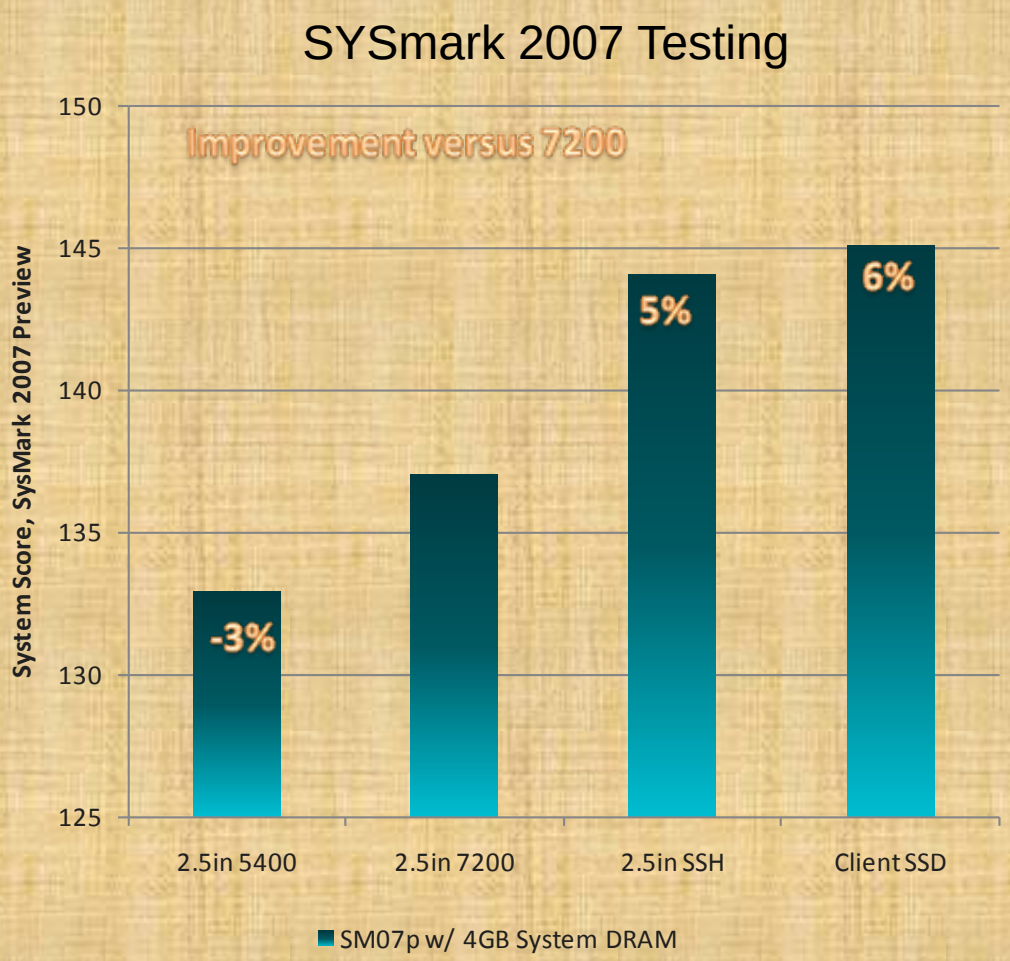
Dual Drive and Hybrid HDD Approaches

- Dual Drive/Storage Tiering
  - Marvell HyperHDD
  - Hitachi-LG HyDrive
  - Intel dual drive
  - Other companies potential dual storage products
- Hybrid solid state HDD
  - Seagate Momentus XT





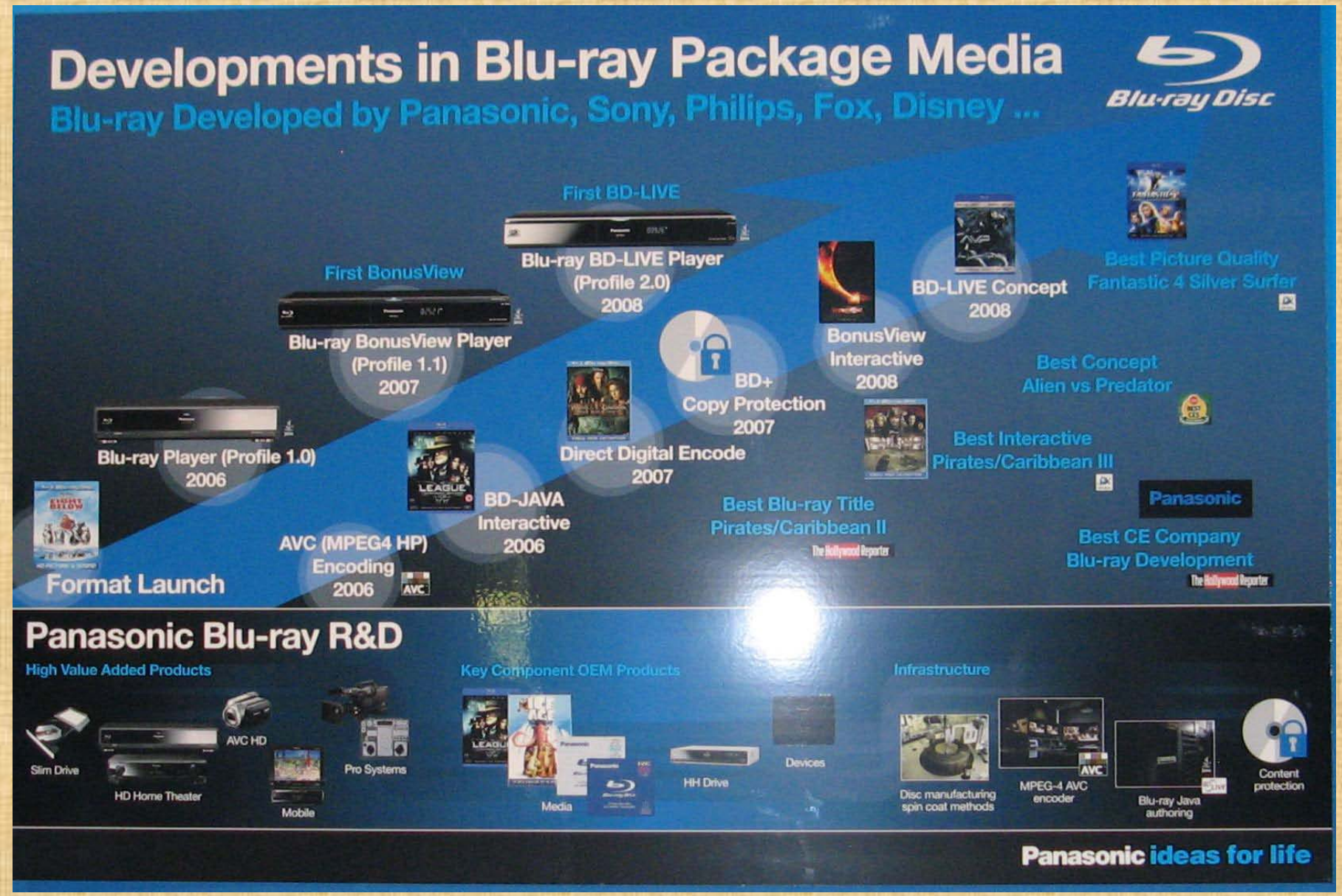
Hybrid Flash Memory/HDD
(Seagate's Momentus XT)



- Adaptive Memory™
  - Algorithms monitor data access transactions
  - Qualified data is placed in the SSD
  - Maintains frequently used data vs. not used data
- Dynamically improves response time and application load times based on usage
- Customizes system performance to the user
- Maximizes the performance and minimizes the amount required

Seagate Momentus XT Introduction Presentation, 2010

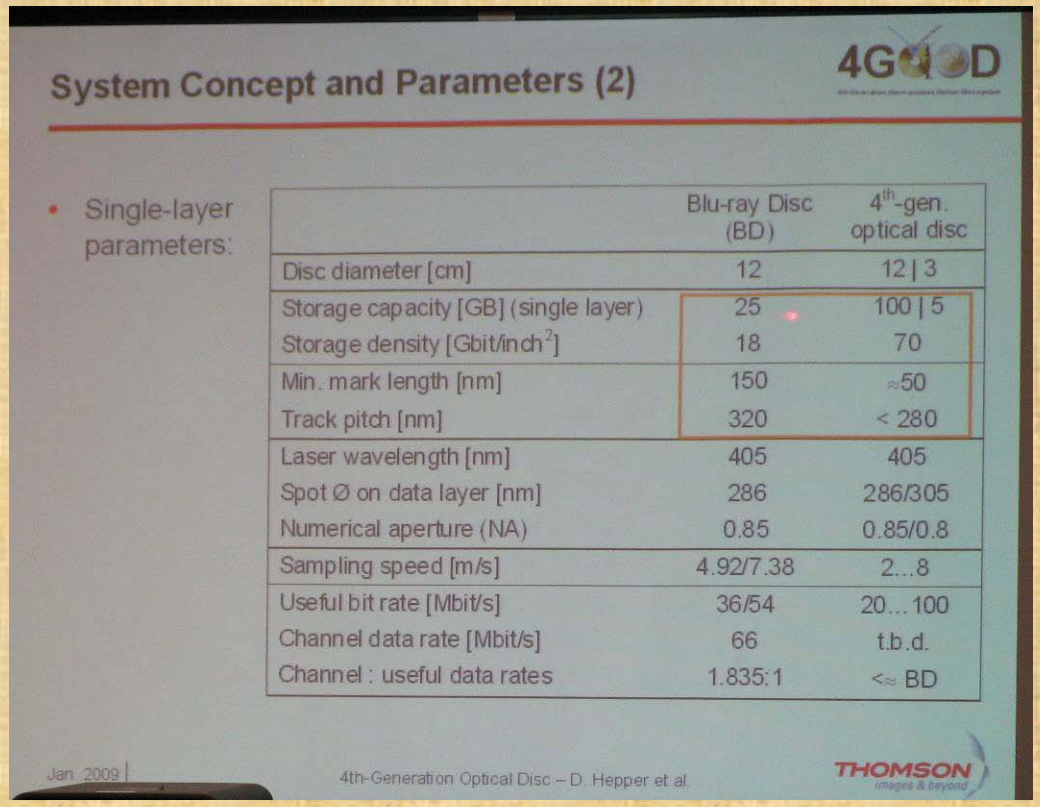
Optical Discs



Optical Disc Storage Development

Maxell Writable Blu-ray Media

Ritek Writable Blu-ray Media



- 100 GB Blu-ray Disc with SuperRENS
- Holographic storage: 1 TB/disc (???)

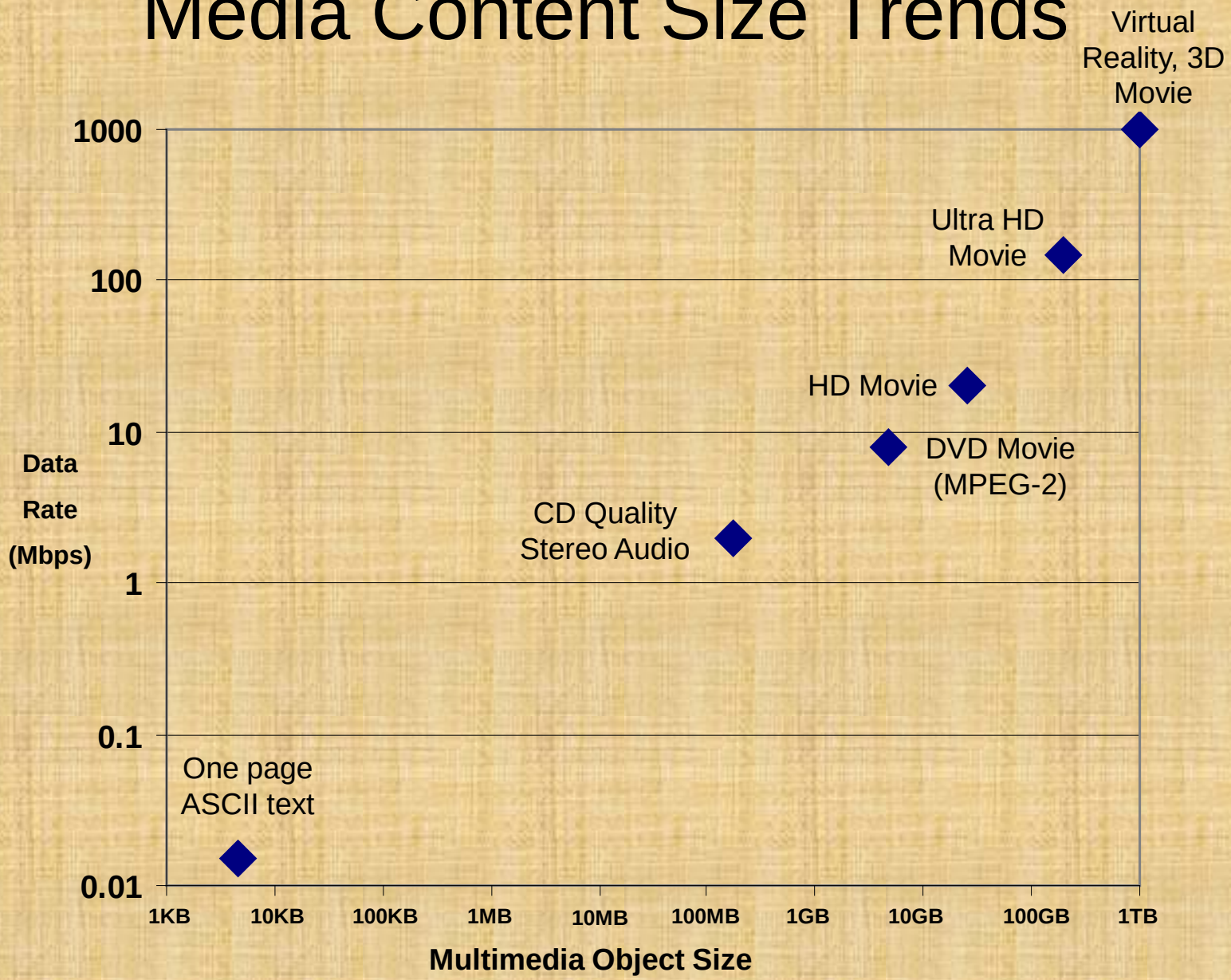

New and Emerging Digital
Storage Applications

Technology Enablers

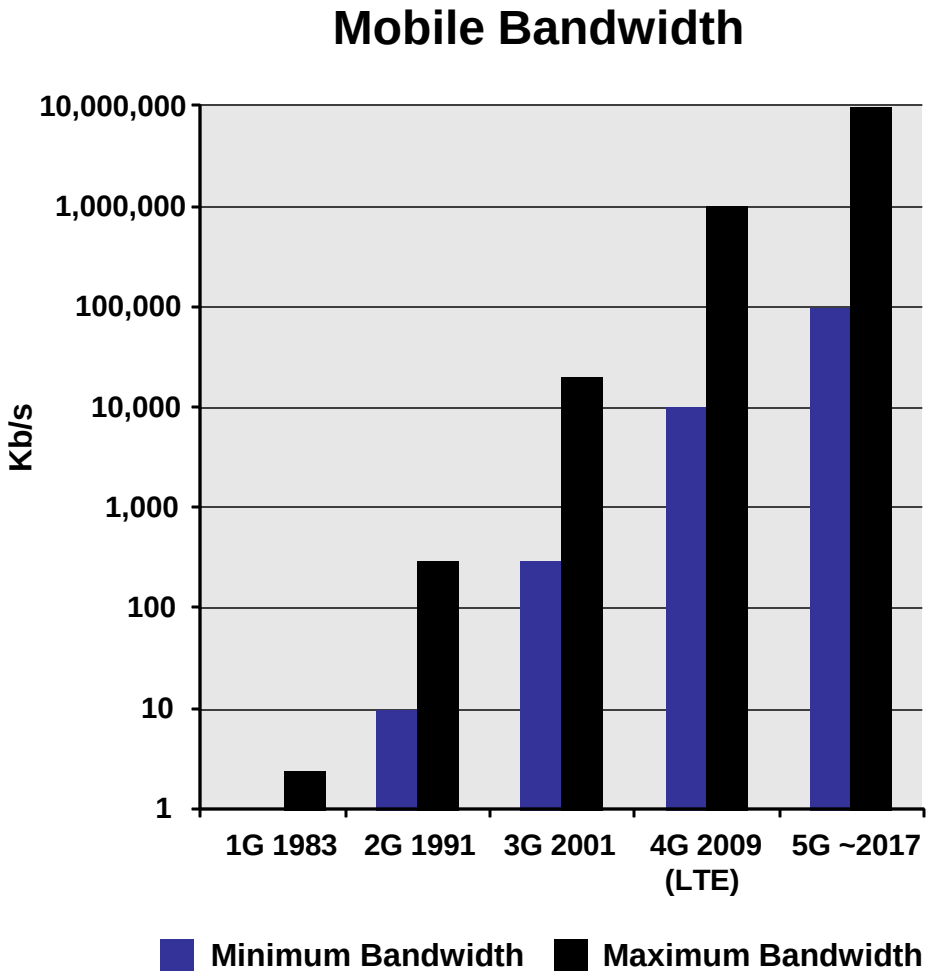
- Longer lasting batteries, easier recharging or power sources, e.g. as fuel cells
  - Microprojectors (even HD content)
  - Constant connectivity
  - Continuous content capture
- Lower power and flexible displays
  - Use products longer and in more places

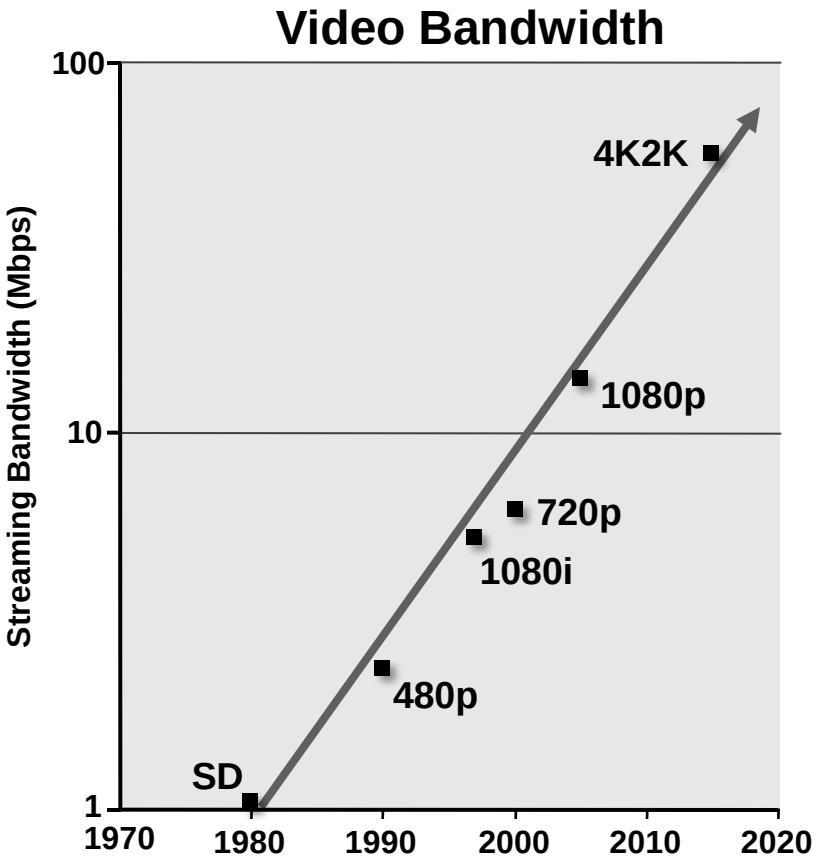
- More immersive experiences (displays, sound and other senses)
  - Drives demand for richer content—which requires greater storage capacity (and greater bandwidth requirements)
- Greater access to data both locally and on-line
  - Larger (or smaller) built-in storage
  - More content from the cloud
  - Faster direct attached interfaces and internet BW (such as USB 3.0)

Media Content Size Trends



Driving Factors—Mobility and Video



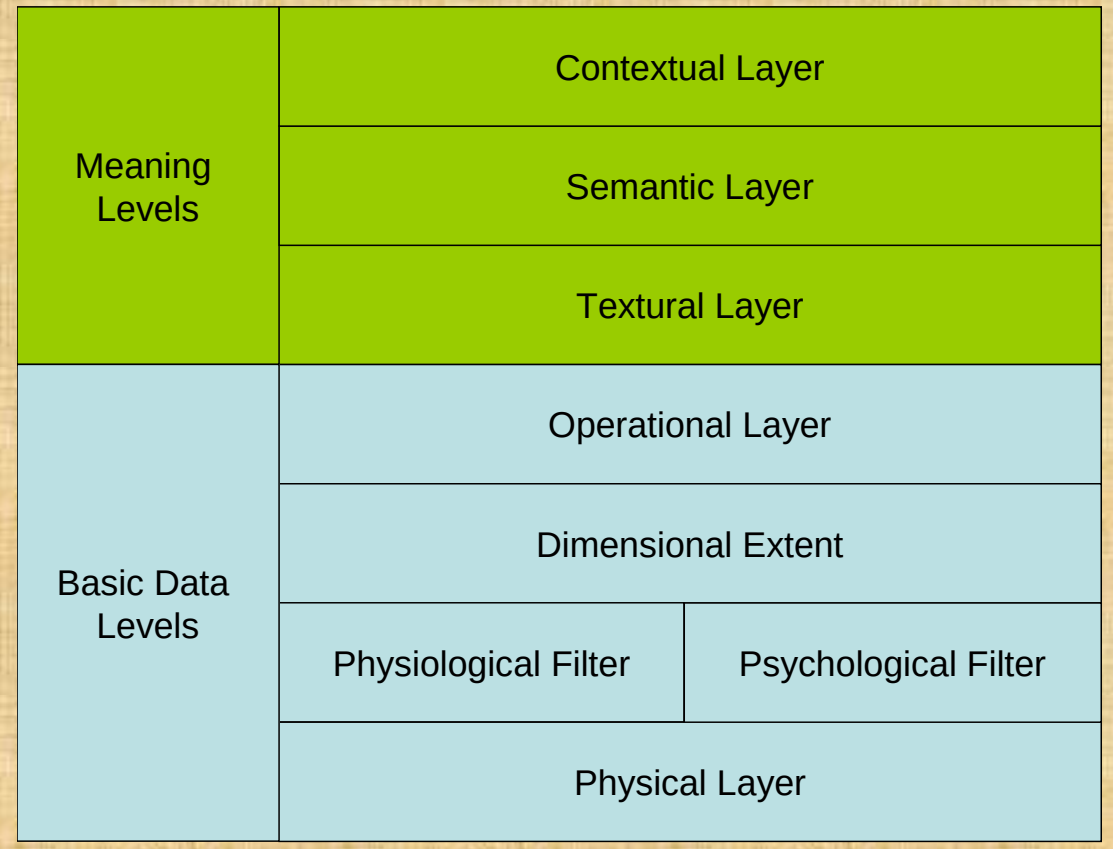


2010 Designcon Keynote, Vincent Hu, Altera

Metadata

- Metadata--information about a file or data object that allows easier search and use of the content
- Currently most metadata is entered manually
- Automated generation of metadata using content robots and sensors
- With inexpensive storage, metadata could become unlimited,

Metadata Layer Model



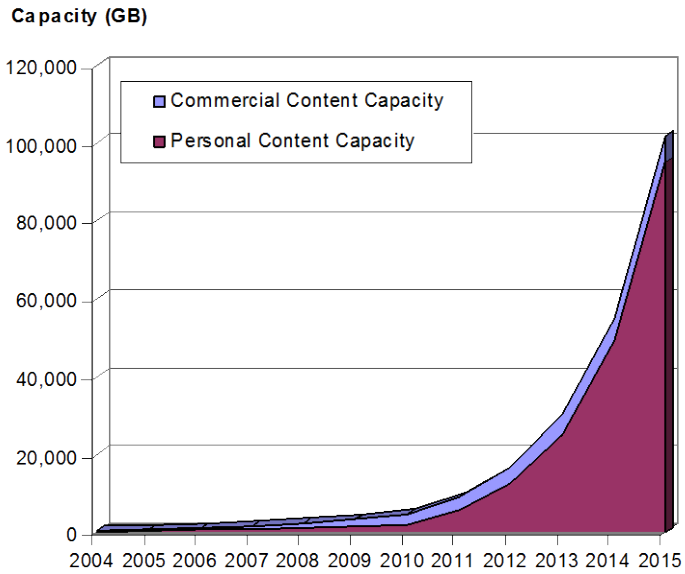
- We need a consumer metadata standard that obeys 4 criteria:
  - Flexible
  - Scalable
  - Upgradable
  - Simple
- Plus something that can also integrate the professional standards

T. M. CoughLIn and S. L. Linfoot, a *Novel Taxonomy for Consumer Metadata*, Presented at 2010 ICCE Conference

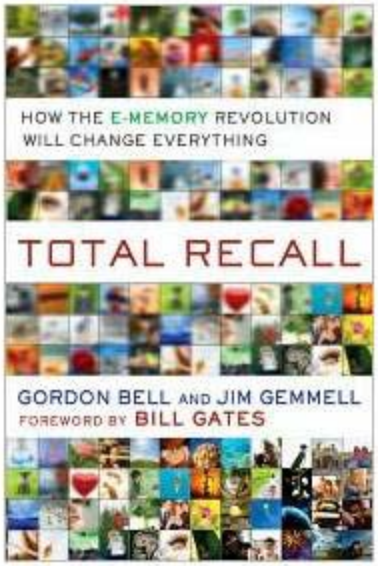
Our children will be capturing their lives on digital storage

- My kids text their friends all the time.
- They also send pictures to each other
- They watch YouTube Videos
- It's only a matter of time before we have the technology for them to record what they do every day
- When it is available I know that they will use it and share their daily experiences
- This will use a lot of storage and combined with other user generated and commercial content will result in petabyte homes in the next decade

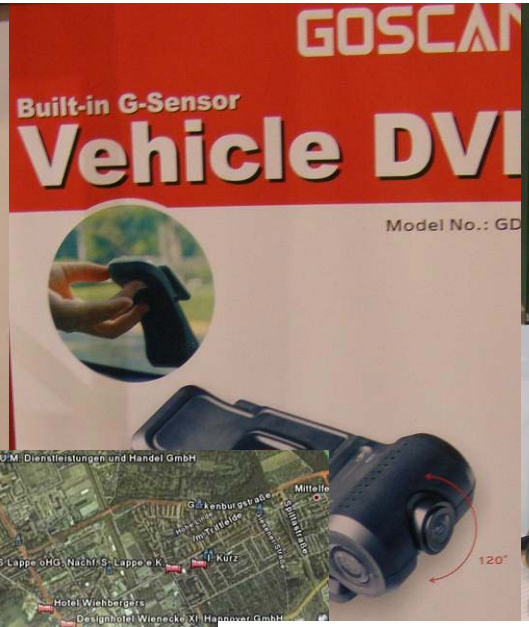
Total Recall!



Publish Date
September
2009



Everything a Recording Device



Built-in Camera of the Laptop

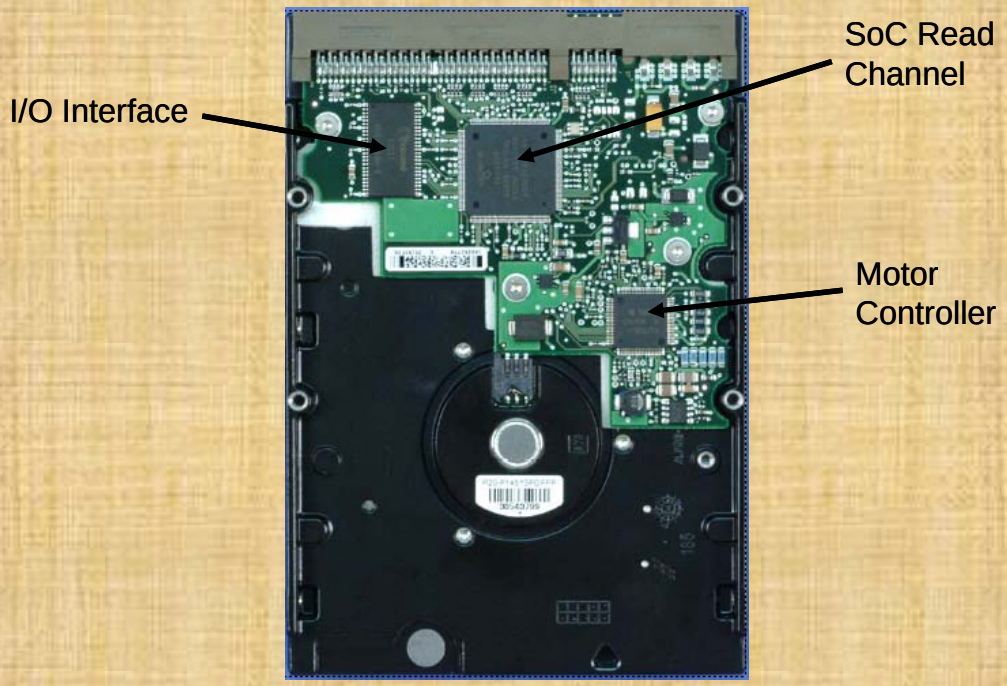
Personal Cloud Storage

- Much of the content consumers will access in the future will come from the Internet and other remote sources (the Cloud)
  - According to In-Stat by 2014 US On-Demand Revenues will be great than $10 B
- Some of this content will stay on the cloud with access through streaming or temporary buffering
- Many consumer devices are play only and are limited on local storage—these rely on cloud storage
- Other consumer devices create content—e.g. cameras and thus require larger local storage (User Generated Content--UGC)
- Some of this UGC may end up in the cloud but how much and would this really be the only copy?


Intelligence in
CE Storage
Devices

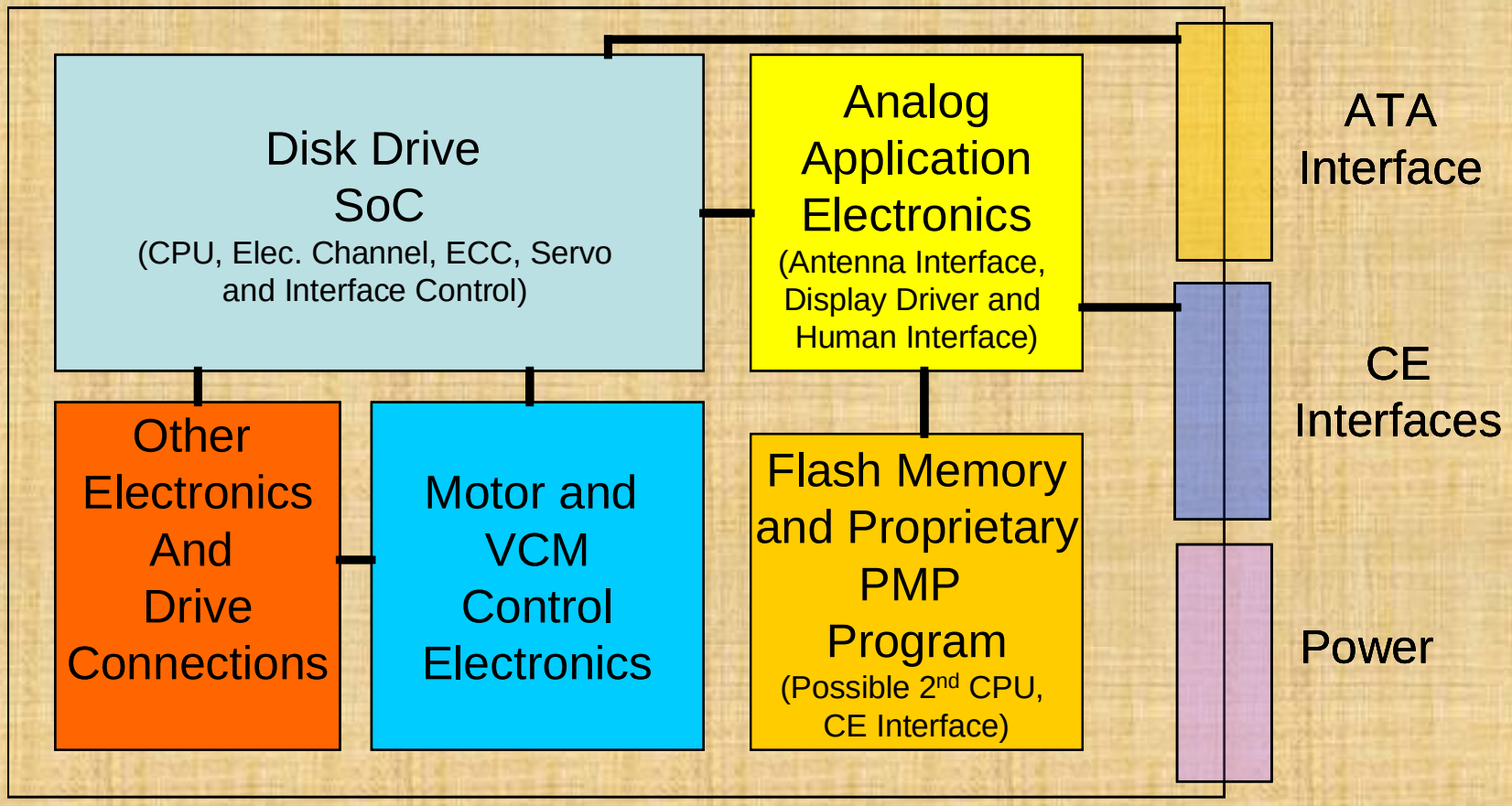
Putting Applications on Storage Devices

- For many applications the digital storage device is highest cost items in the BOM
- Many CE applications are reaching a level of maturity that they could be implemented as a sequence of standard command calls in the hard drive electronics
- Reduced cost of CE products by eliminating second circuit board and integrating product test into drive test



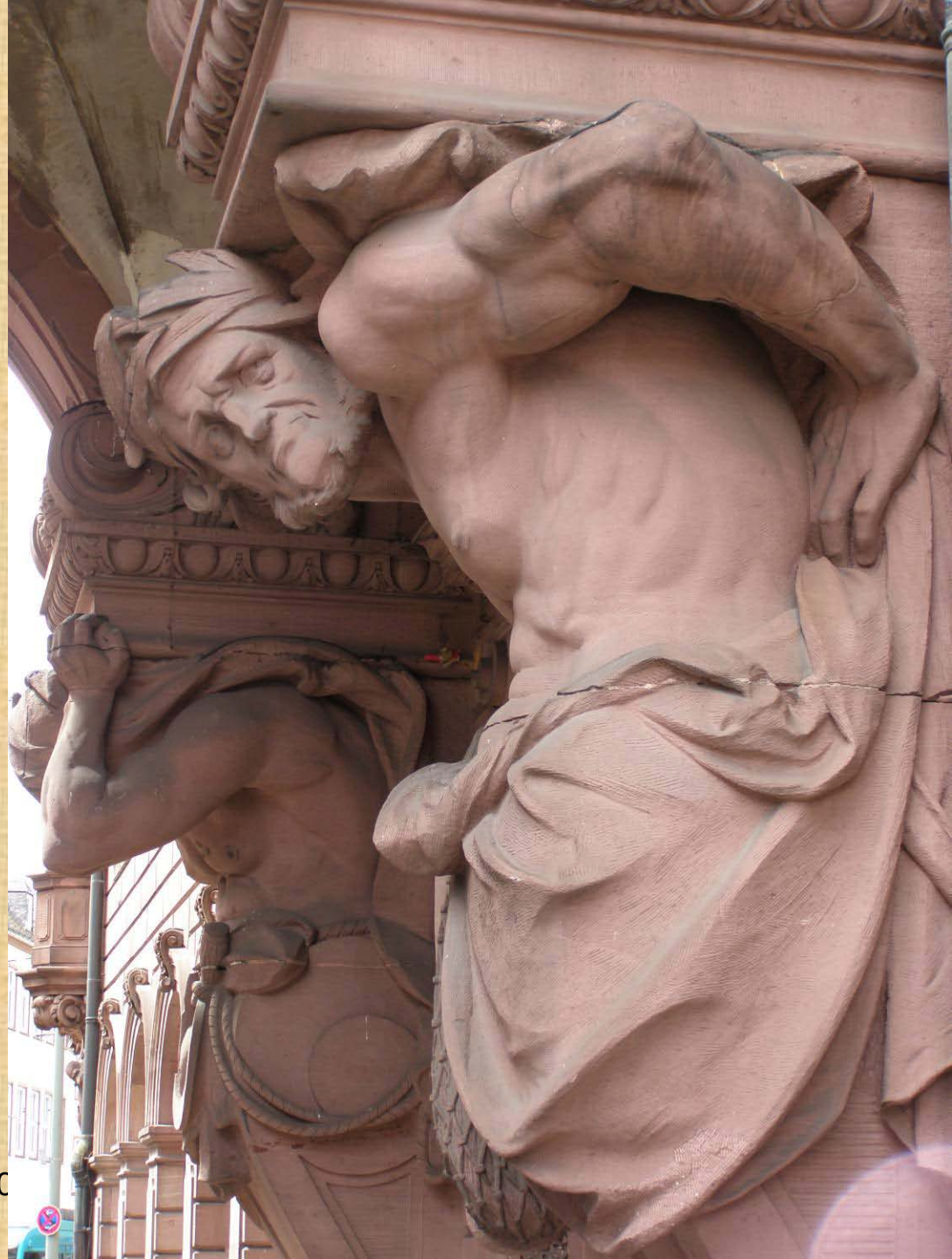
•Modern hard disk drive printed circuit assemblies (PCAs) are much smaller, typically occupying only a fraction of one side of a 3.5-inch hard disk drive.

Example of Applications on a Hard Disk Drive



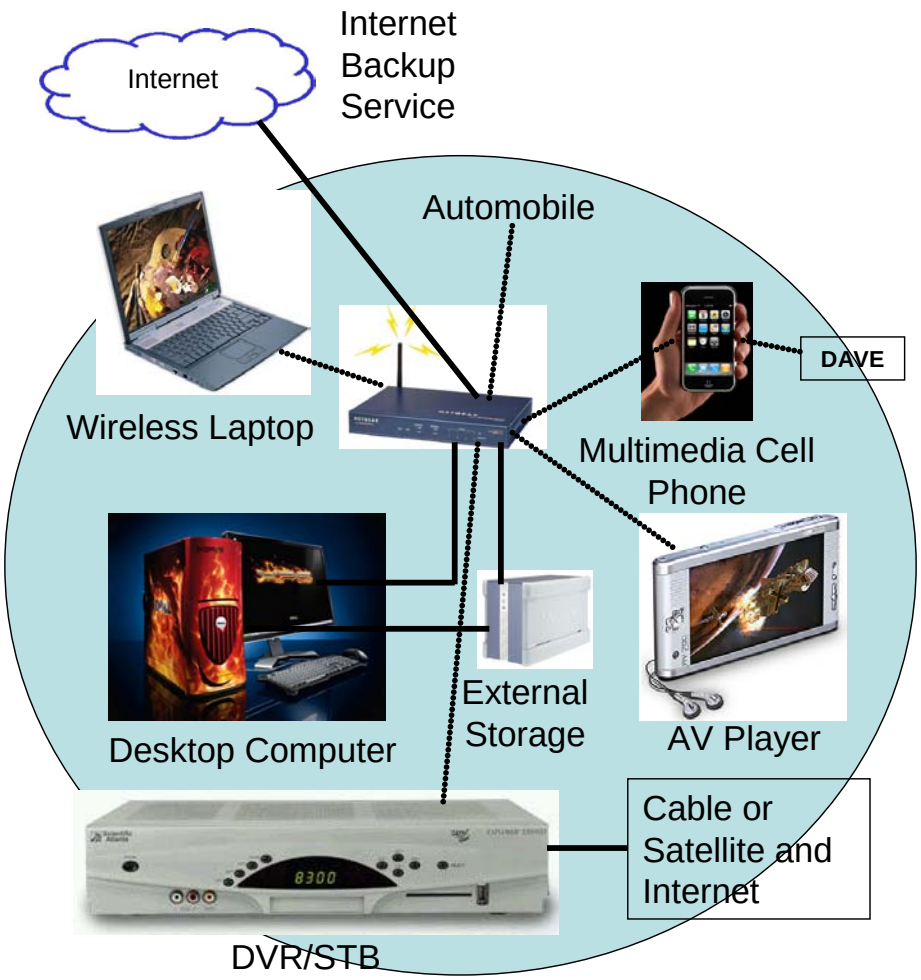
Give designers new ways to improve performance and save money!

Home Virtualization: Connecting and Managing Everything in the Home

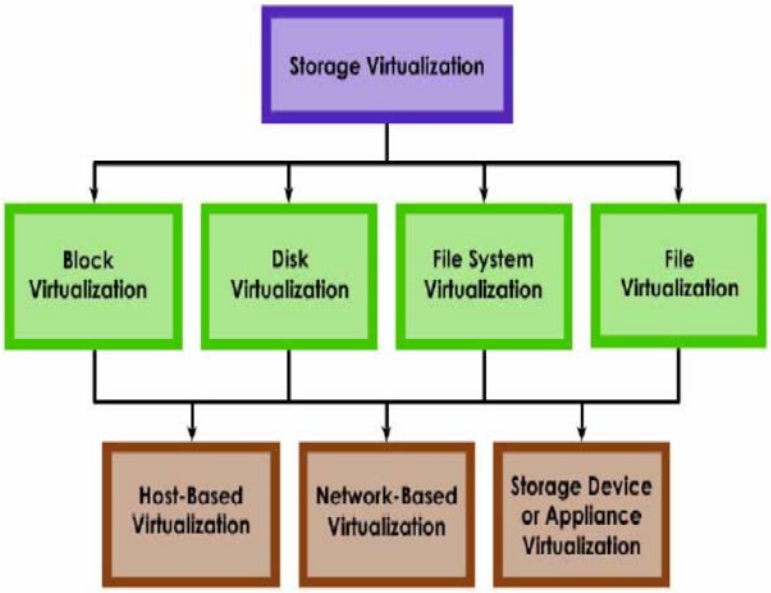


Home Storage Utility

- Things won't look like they do now
- Everything will be connected
- Content and storage will be shared and there will be many copies—storage is cheap and capacities are large
- Content is managed, indexed and automatically backed up



Home storage virtualization (user freed from storage devices)



The home storage utility should provide the following basic functions:

- content backup and deduplication in the home
- content backup outside the home (in the cloud, to provide home disaster recovery)
- content sharing in and around the home with optimal use of network resources
- indexing and organizing home content
- synchronization of content as needed
- Automatic management and control of storage and network resources

In the next decade

- A terabyte in your pocket
- A petabyte in your home
- Exabytes in datacenters
- Zetabytes in the world

Conclusions

- The demand for storage for CE applications is very elastic—if people have more storage they will use it!
- The modern storage hierarchy is more complex than in the past and includes more storage options depending upon performance and storage economics.
- Digital storage enables new applications for mobile and home devices that should make managing, organizing, preserving and using content easier.
- With the growth in personal content and content sharing through social networking, the growth of digital storage for consumer applications is virtually unlimited.
- It remains to be seen what the ultimate balance of on-line vs. local storage will be in CE.
- Managing, organizing and protecting home content will lead to new concepts applied to virtualize and aggregate digital storage in the home.

Sources

- **Digital Storage in Consumer Electronics: The Essential Guide**, Newnes a division of Elsevier Press (March 2008)
- **Digital Storage in Consumer Electronics Report 2009** , Coughlin Associates
- **Consumer Survey on Digital Storage in Consumer Electronics 2008,** Coughlin Associates
- **2010 Digital Storage for Media and Entertainment Report**, Coughlin Associates
- Presentations at **2007, 2008 2009 and 2010 Storage Visions Conferences** (www.storagevisions.com) **and CES**

For more information go to the tech papers section of www.tomcoughlin.com

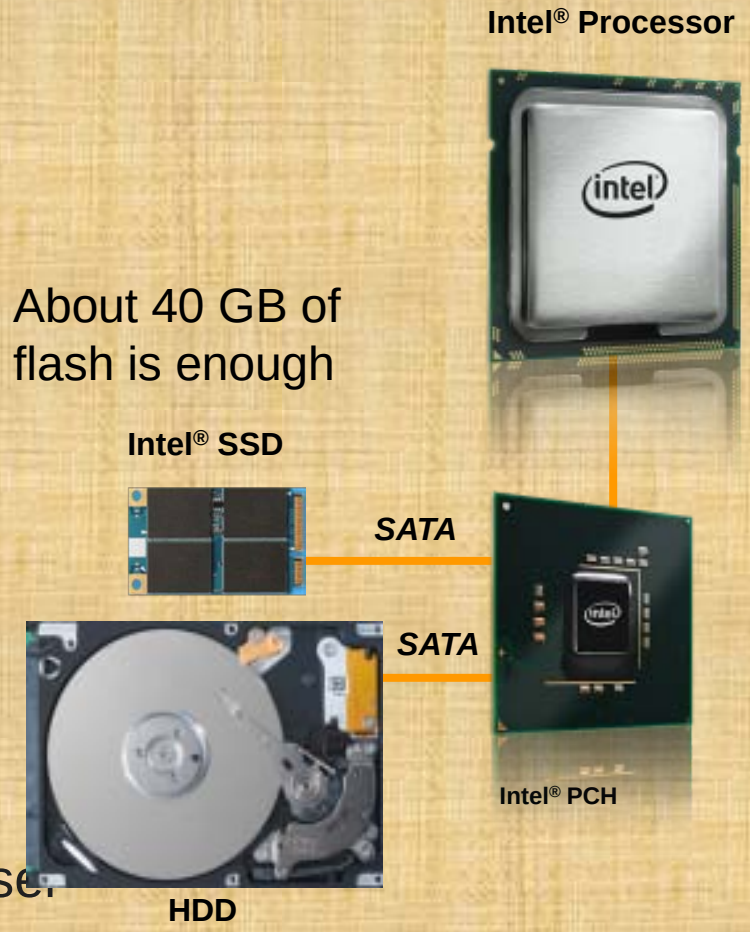

Thanks

Plug Computers

- Build networked computers into everything…
- www.plugcomputer.org

Capacity Scaling - Dual Drive

- What is Dual Drive?
  - Intel® Solid-State Drive (SSD) combined with a Hard Disk Drive (HDD)
  - Intel® SSD for performance
  - HDD for capacity
- Software Configuration
  - SSD: Operating System and key applications
  - HDD: General applications and user personal data



Shahed Ameer, Intel, IDF 2010

USB 3.0