Your Life in Your Pocket

The Motivation for Writing
a Book on the Technology
Behind the iPod Revolution

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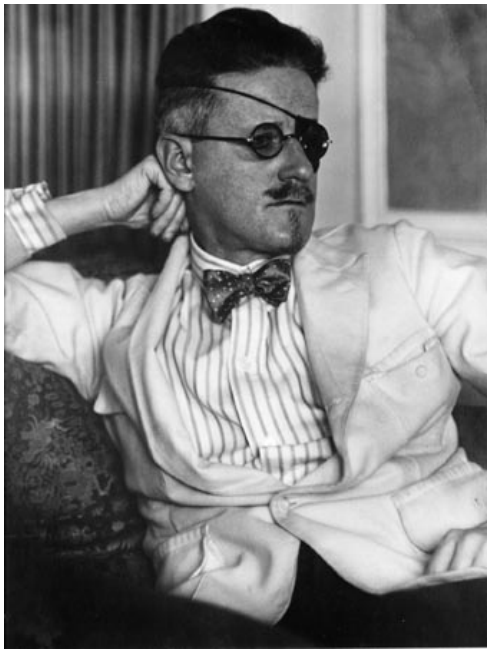
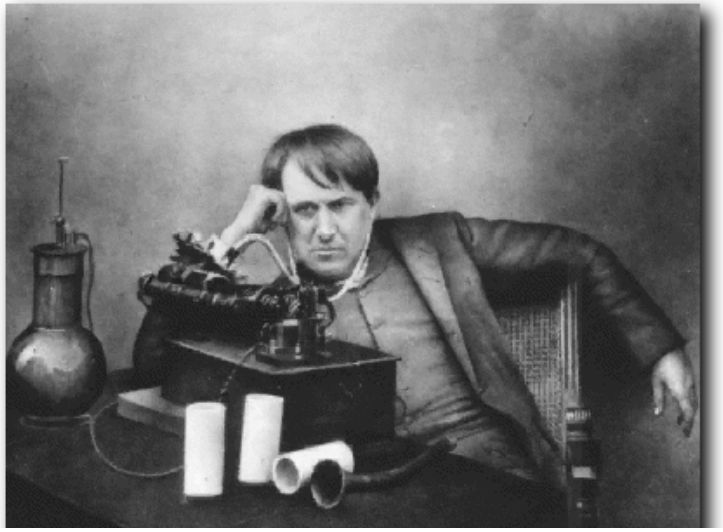
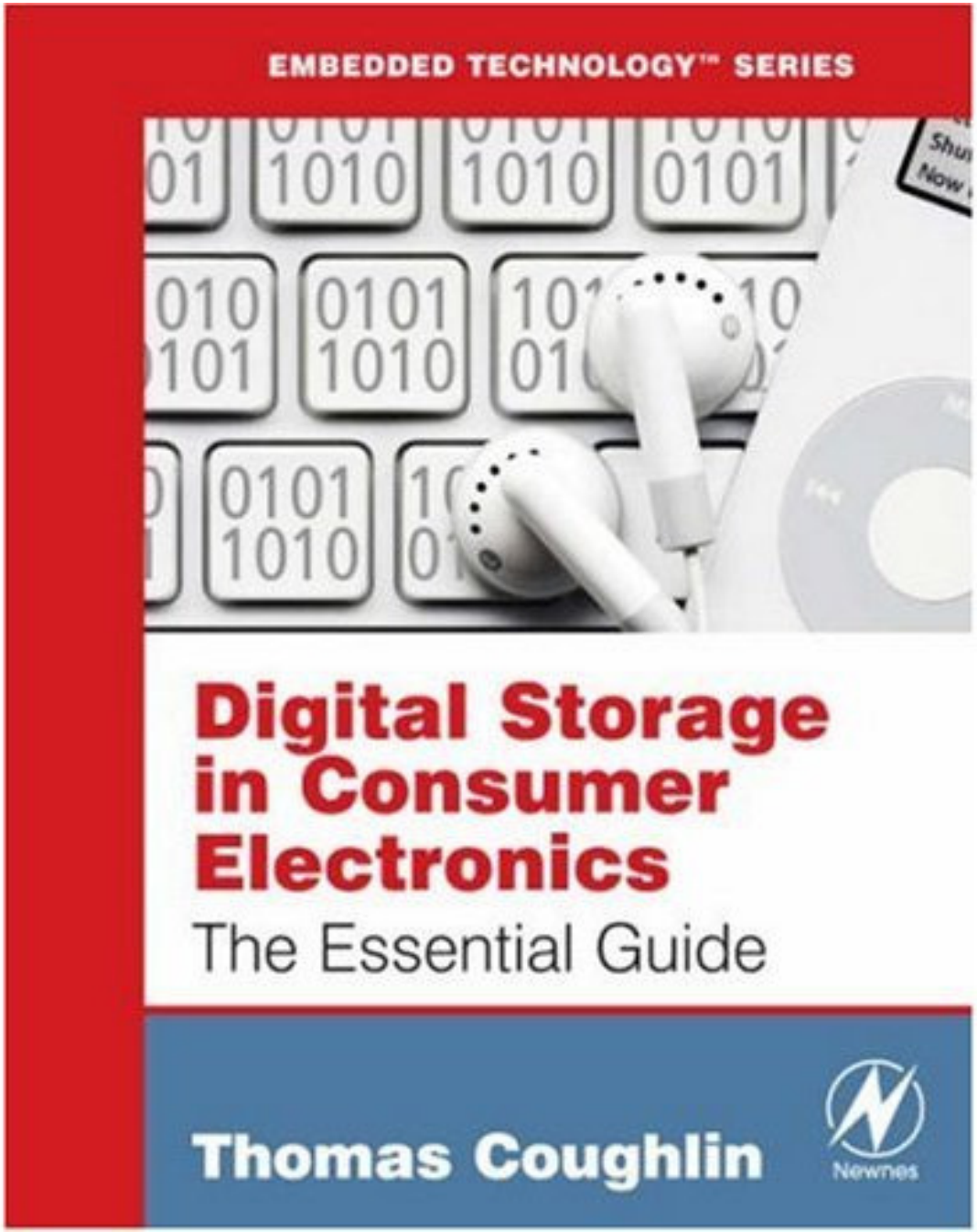
Outline

- In the Beginning
- A Bit About Me
- Prior Writing
- Fire in the Belly—Why I did this
- The Long and Winding Road
- Reviewers
- Editing
- The Final Act and Epilogue
- Conclusions



Writers and Engineers…





Now available from Newnes (a division of Elsevier Publishing)

In the Beginning

- In 2000 I attended the International CES with another colleague and realized the importance of digital storage in consumer electronics
  - I thought of organizing a conference, Storage Visions on this topic (first conference in 2002, most recent in January 2008)
- I also wrote reports on digital storage and applications and did consulting in this area
- In 2005 I started to ask about doing a book on digital storage in consumer electronics

A Bit About Me

- I am from the western mid-West: South Dakota and Iowa
- Over 20 years industrial experience
  - Engineer—designed heads and media for magnetic recording for over 20 years
  - Manager—Led technical and business groups in digital storage components and devices
- For 10 years working as consultant and entrepreneur
- Started Coughlin Associates as a company in 2001
- Worked with Dr. Al Hoagland of Santa Clara University as Adjunct Professor and helping to organize technical symposium there for many years
- Very active in IEEE, both technical and regional: SCV Section Chair in 2007 and now Region 6 Central Area Chairman, past chair of SCV Magnetics and Consumer Electronics Society
- Member of several technical organizations such as IEEE, APS, AVS, SMPTE, SNIA, IDEMA, AAAS, etc.
- Helped organize and run several conferences and started two (Storage Visions and Creative Storage)
- Written many reports and articles on technical and market topics concerning digital storage devices and applications
- Consulting of all sorts: Expert Witness, Product Design, Company Due Diligence for Investors, Product Launches, Market and Technology Analysis,
  - whatever kept food on the table…

Prior Writing

- Wrote regular company reports when at regular jobs and involved in filing several patents, 6 patents granted
- Wrote several technical and market reports on digital storage technology components, capital equipment, devices and applications since 1997 (initially with Peripheral Research and also Peripheral Concepts but now as Coughlin Associates)
- Wrote articles for trade magazines and technical journals (well over 60 of these published)
- More recently wrote regular column for Processor Magazine and blogs on Thinkernet.com and Entertainmentstorage.org

Fire in the Belly

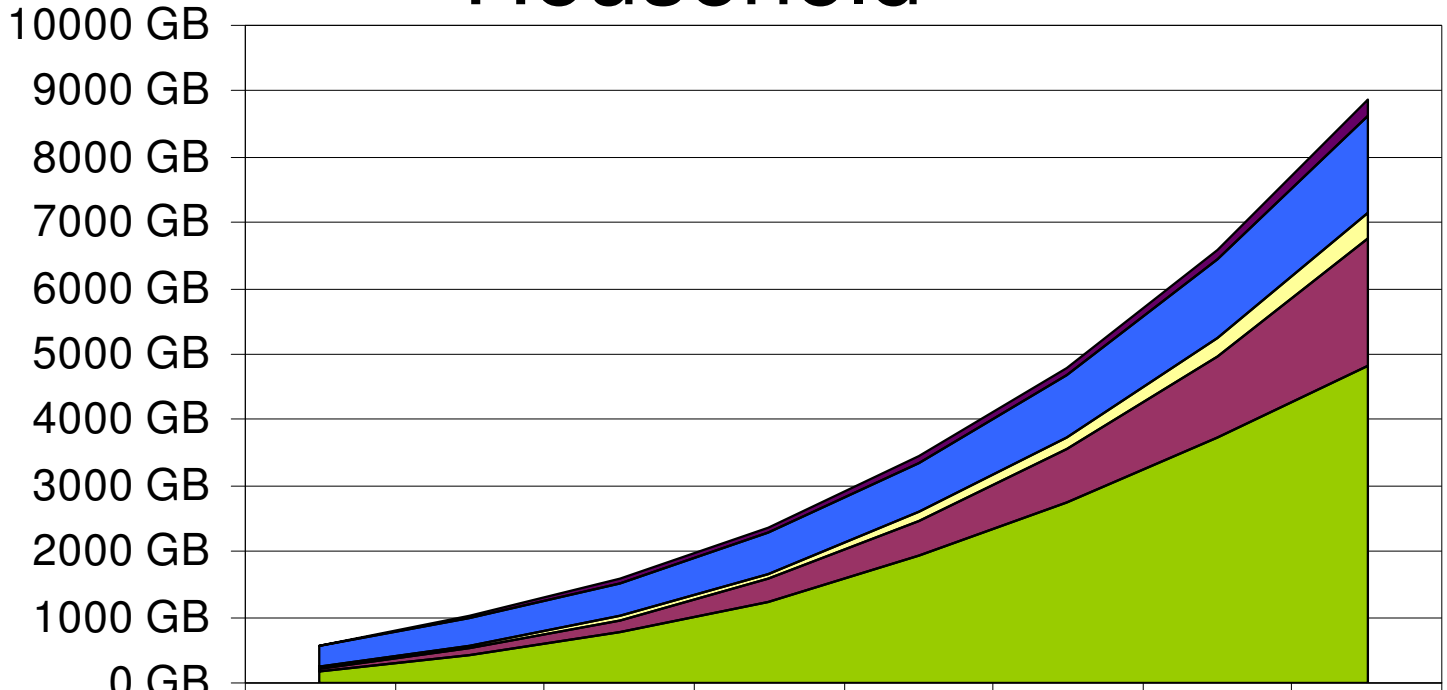
How I Chose My Topic

- I was driven by a conviction that digital storage would play a key role in the creation and operation of consumer electronic products
- I had written many technical and market reports on digital storage and applications for a limited audience and given talks on these subjects
- I had given my Storage Visions Conference for 5 years when I started the book project
- I wanted to influence and reach a larger audience with the ideas expressed in the book

The Cosmic Wheel of Storage Karma

Content Creation
Content Editing
Content Archiving
Content Distribution
Content Reception

Accumulated Digital Content Per Average Household



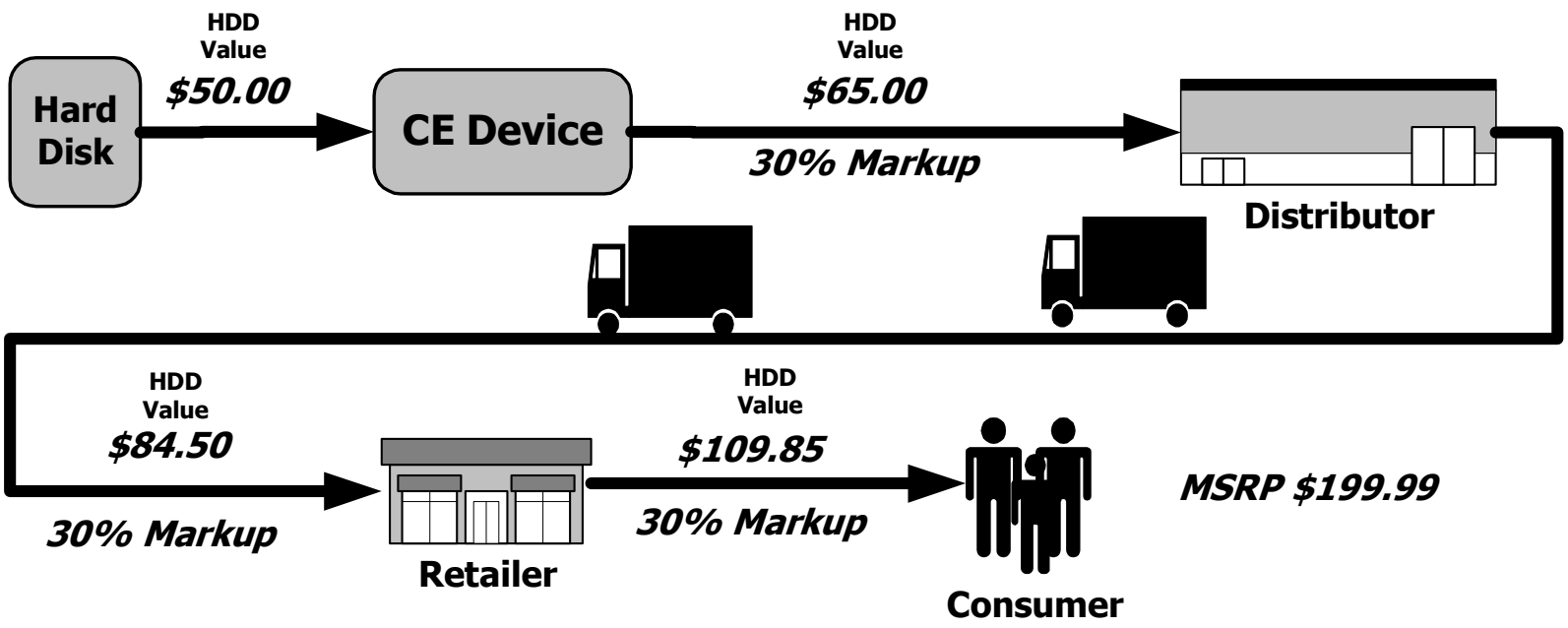
	2006	2007	2008	2009	2010	2011	2012	2013
Personal Data	22	34	51	72	99	132	171	214
Retail Home Video	321	417	522	637	770	945	1183	1502
Gaming	12	29	52	83	127	187	270	384
Home Backup	32	98	195	333	523	781	1254	1920
Home Entertainment	192	435	760	1240	1941	2759	3720	4835

•**Consumer Survey on Digital Storage in Consumer Electronics** (Coughlin Associates, January 2008)

Storage and streaming bandwidth for music and video formats

Format	Bandwidth (Mbps)	Storage Capacity/Hour (GB)
MUSIC FORMATS		
MP3	~0.128	~0.576
Loss-less Compressed CD	~0.700 min.	~0.315
CD Quality	1.400	0.630
DVD Audio	9.600 max.	4.320
VIDEO FORMATS		
Format for iPOD (MPEG-4)	~0.750	~0.337
DVD MPEG 2	11.080	2.700
MPEG 4	~1.400	~0.630
SDTV	~8.000	~2.000
Blu Ray/HD DVD	36.550	3.750
HDTV	~19.300	~8.890
Ultra-HDTV	~295.000	~133.000

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

The Storage Behind Consumer Electronics

The guts of an iPhone

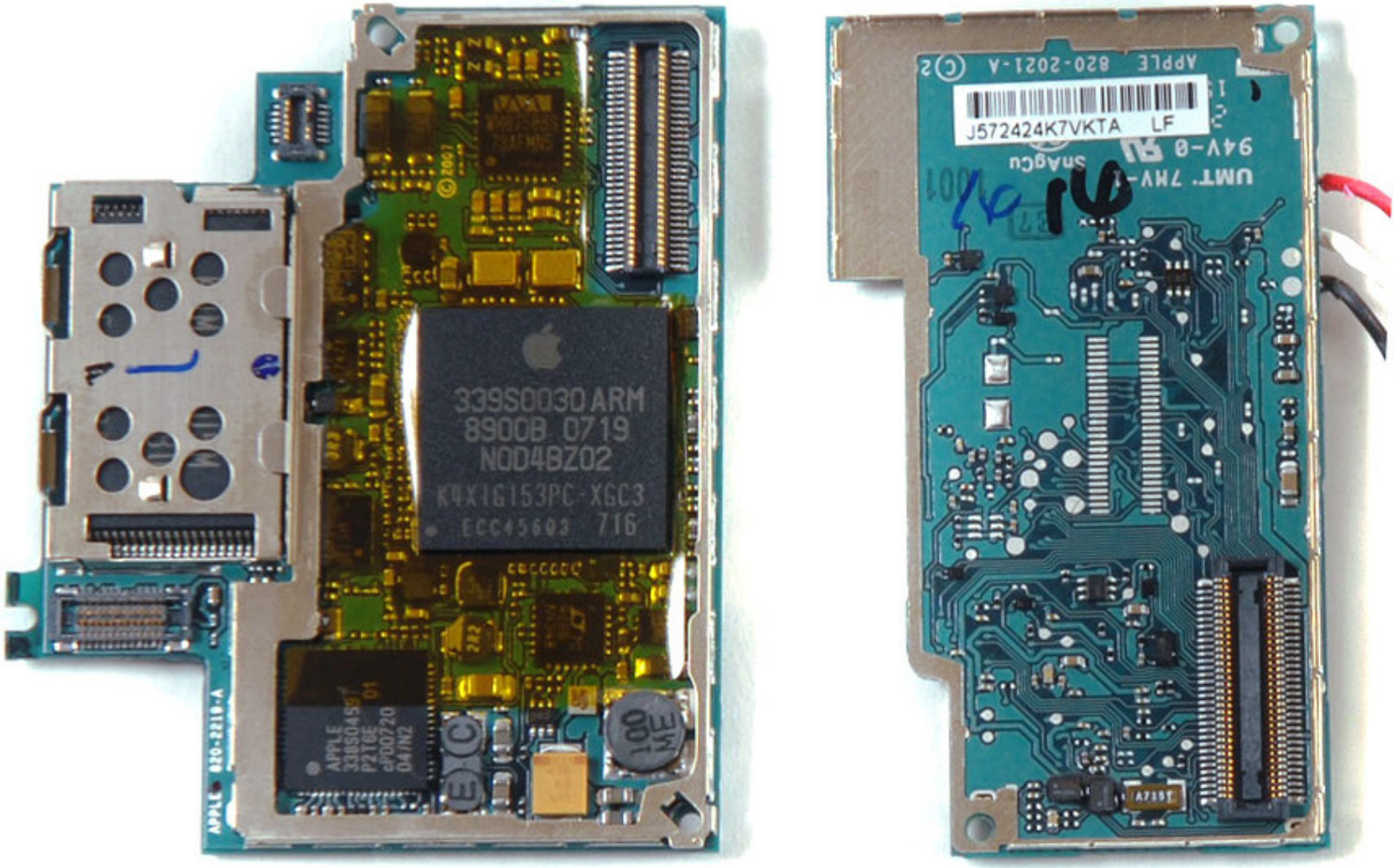
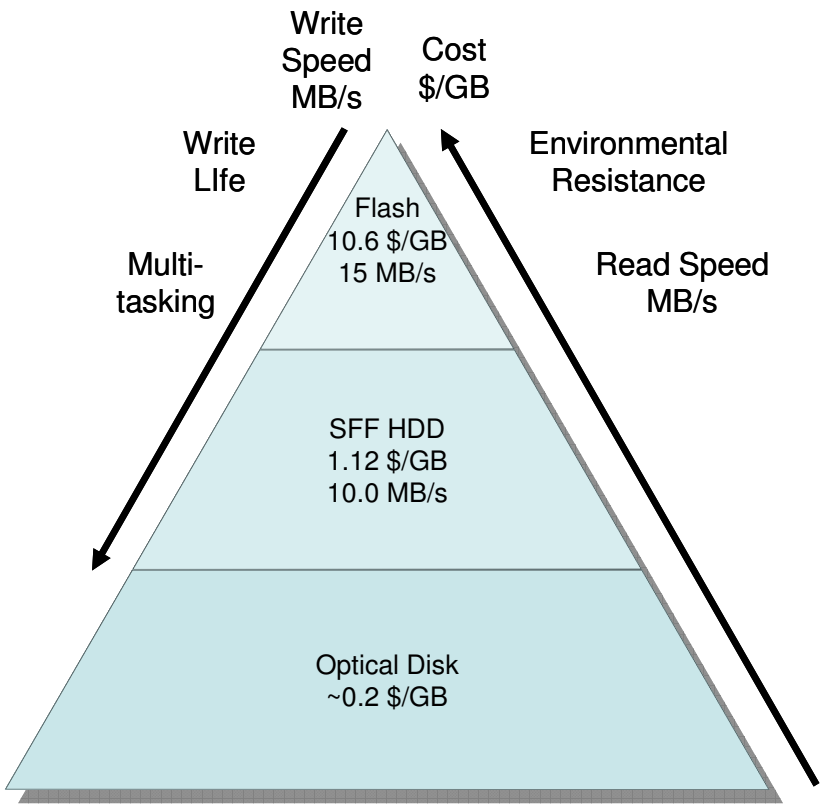


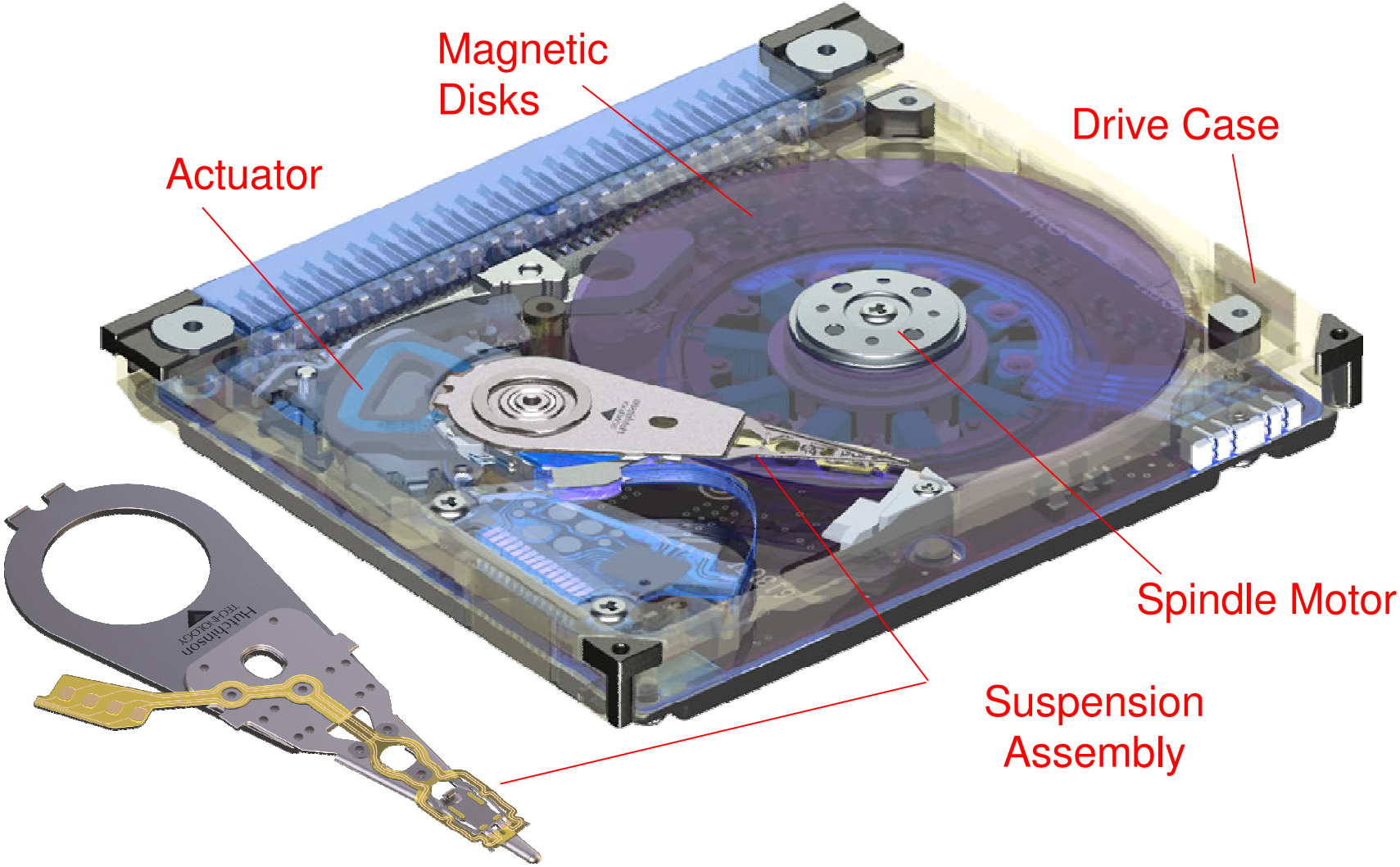
 Image from iFixit, 2007

Mobile consumer electronics storage hierarchy

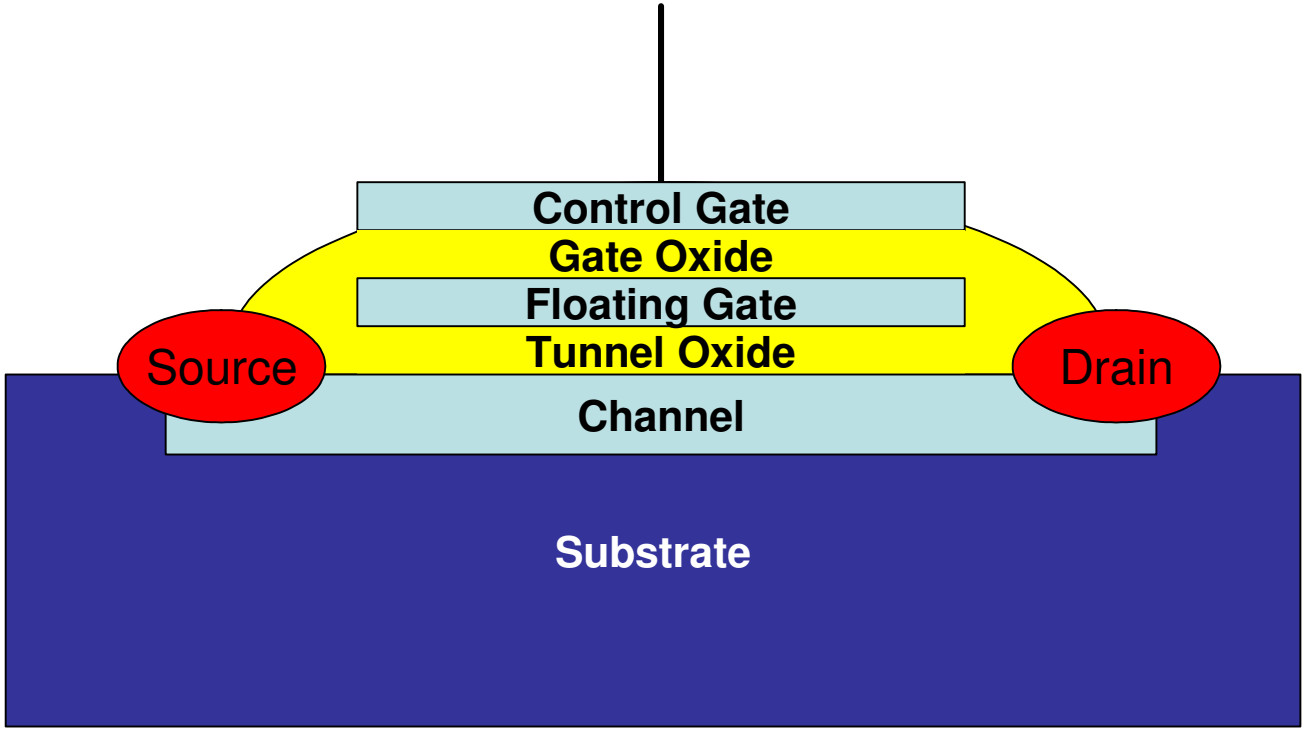


- In this figure we construct a mobile consumer electronic storage hierarchy
- We look at Flash, HDDs and optical storage as a function of importance performance and cost considerations

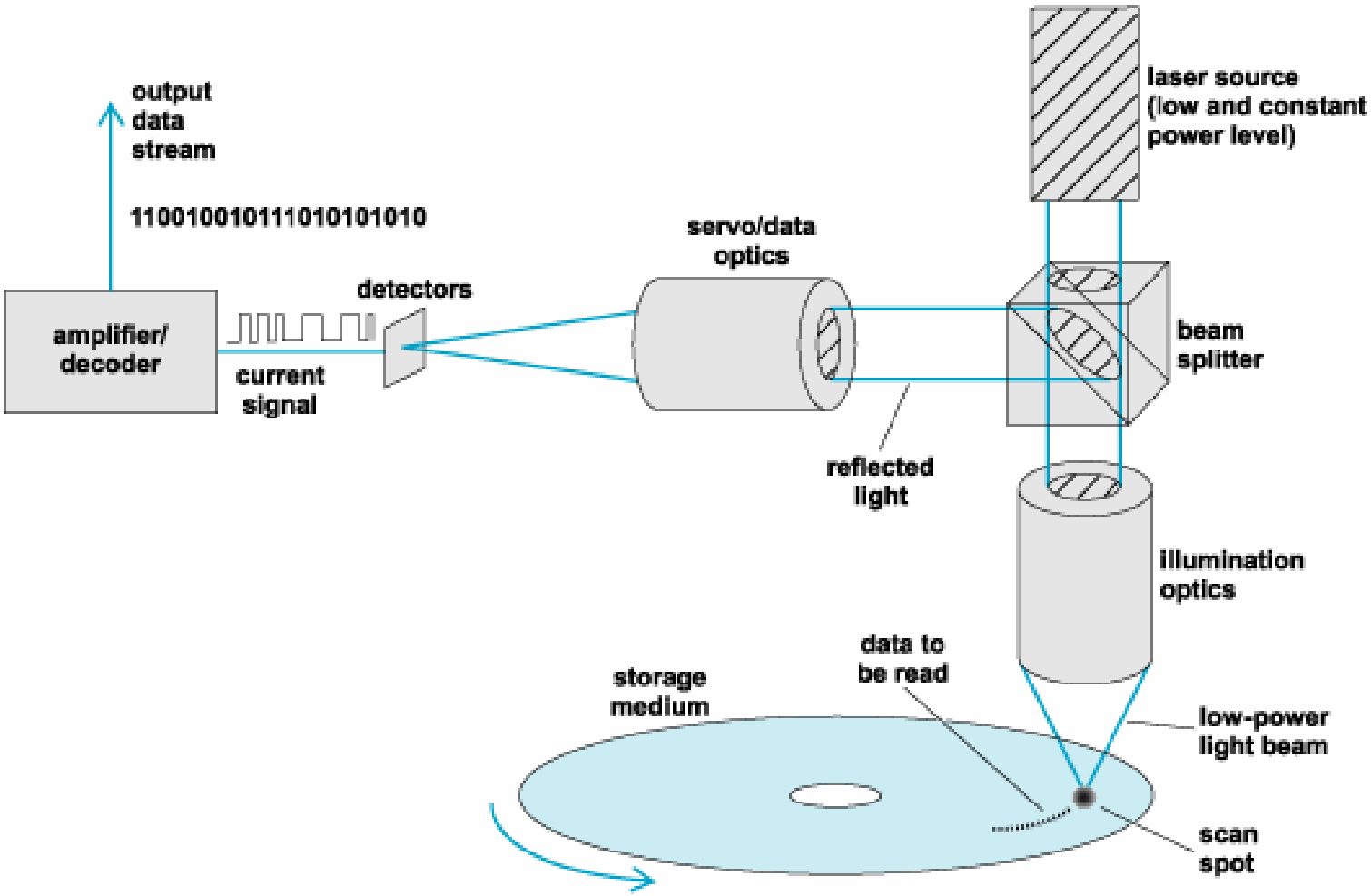
Major components of a hard disk drive (Image Courtesy of Hutchinson Technology)



Floating Gate Flash Memory Cell



Optical Storage--Playback



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
  - such as automated GPS location recording on pictures and video
  - speech recognition and translation to text
  - image and video recognition and recording of the indexing information
  - Metadata into everyday life
- With inexpensive storage, metadata could become unlimited,
  - making the original content easier to find and use
  - enabling enormous capability to create single frame content analysis
  - also cross-correlation information between frames or even between many types of content and across multiple files
  - Enables analyzing the use of content by an individual to create unique tailored metadata

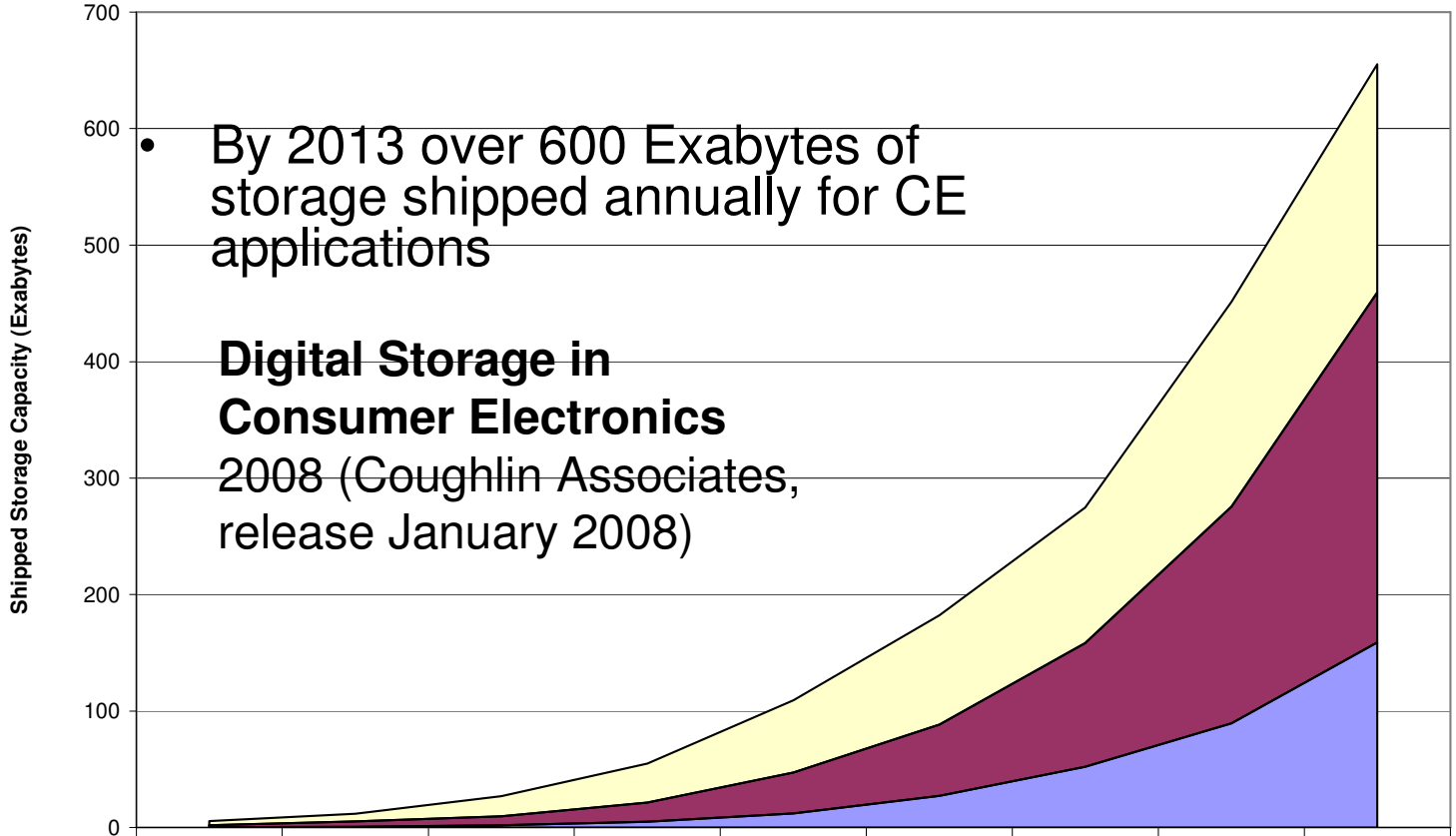
Estimated growth of personal and commercial content in CE devices

(storage units in exabytes)

Year	Commercial Content	Self Generated Personal Content	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)

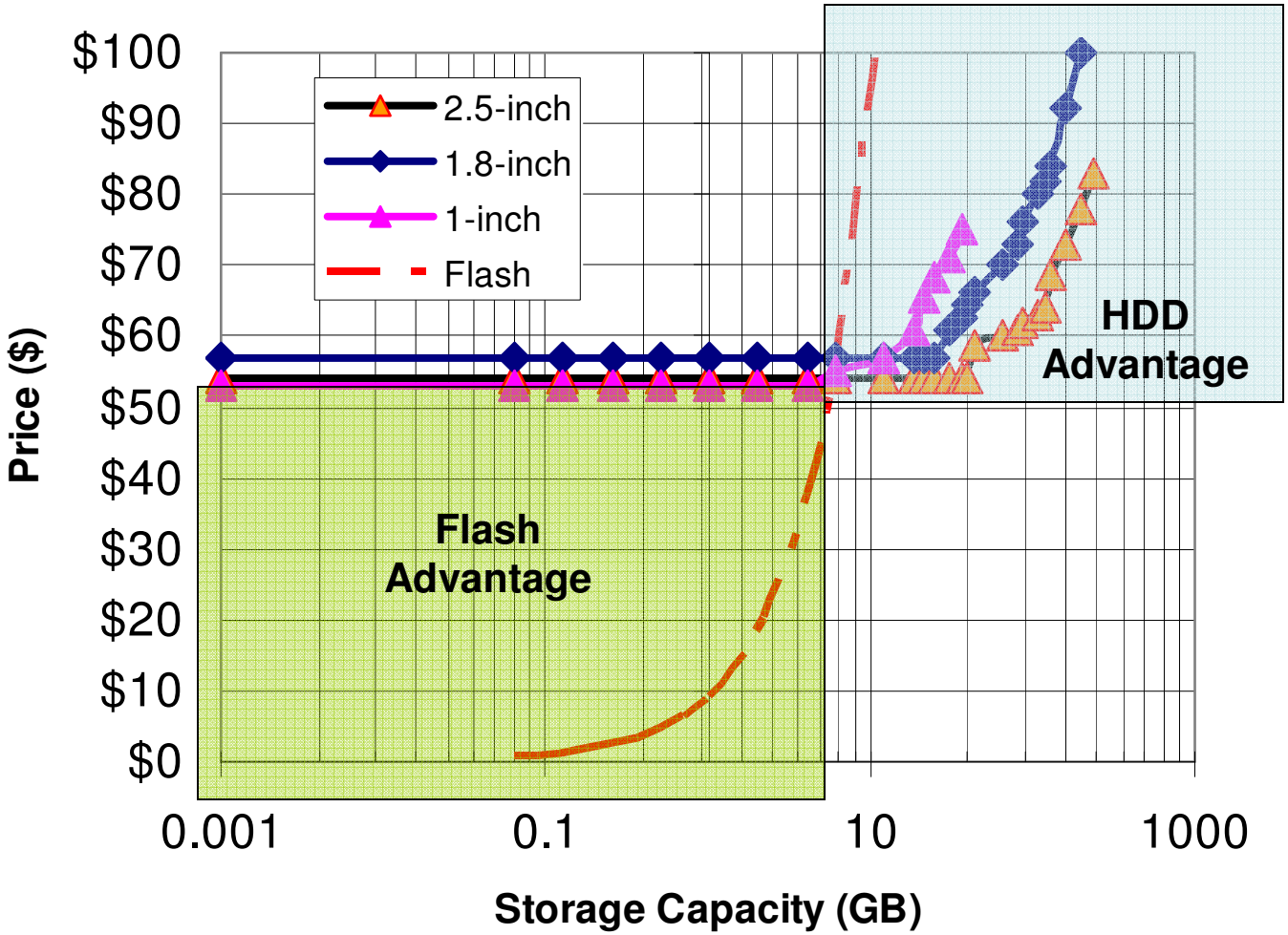


- By 2013 over 600 Exabytes of storage shipped annually for CE applications

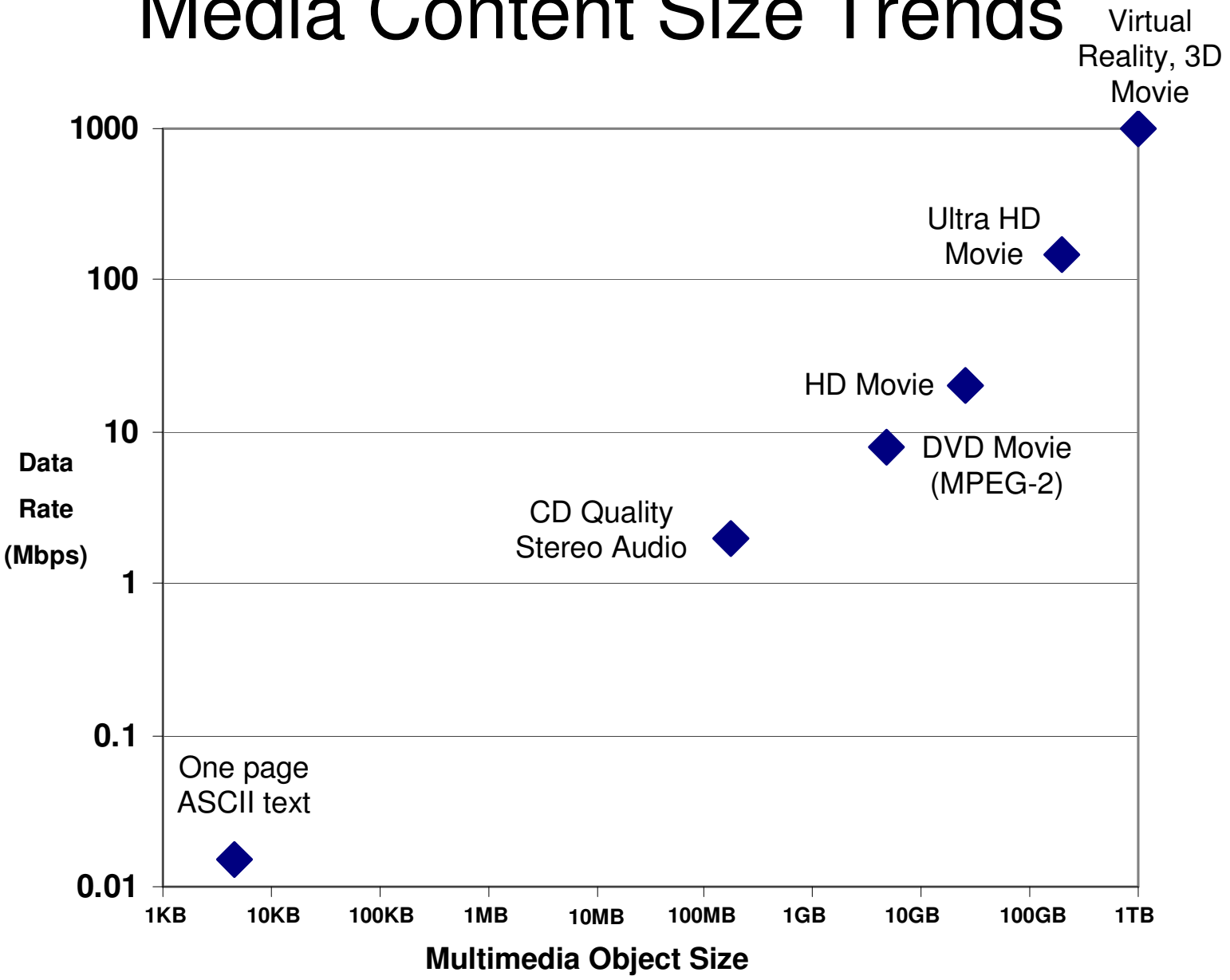
Digital Storage in Consumer Electronics
2008 (Coughlin Associates, release January 2008)

	2005	2006	2007	2008	2009	2010	2011	2012	2013
ODD	4	6	17	33	62	94	116	176	196
HDD	2	5	8	16	35	61	106	186	301
NAND	0	1	2	5	12	27	52	90	159

Comparison of price and storage capacity of flash memory and hard disk drives in mid-2007



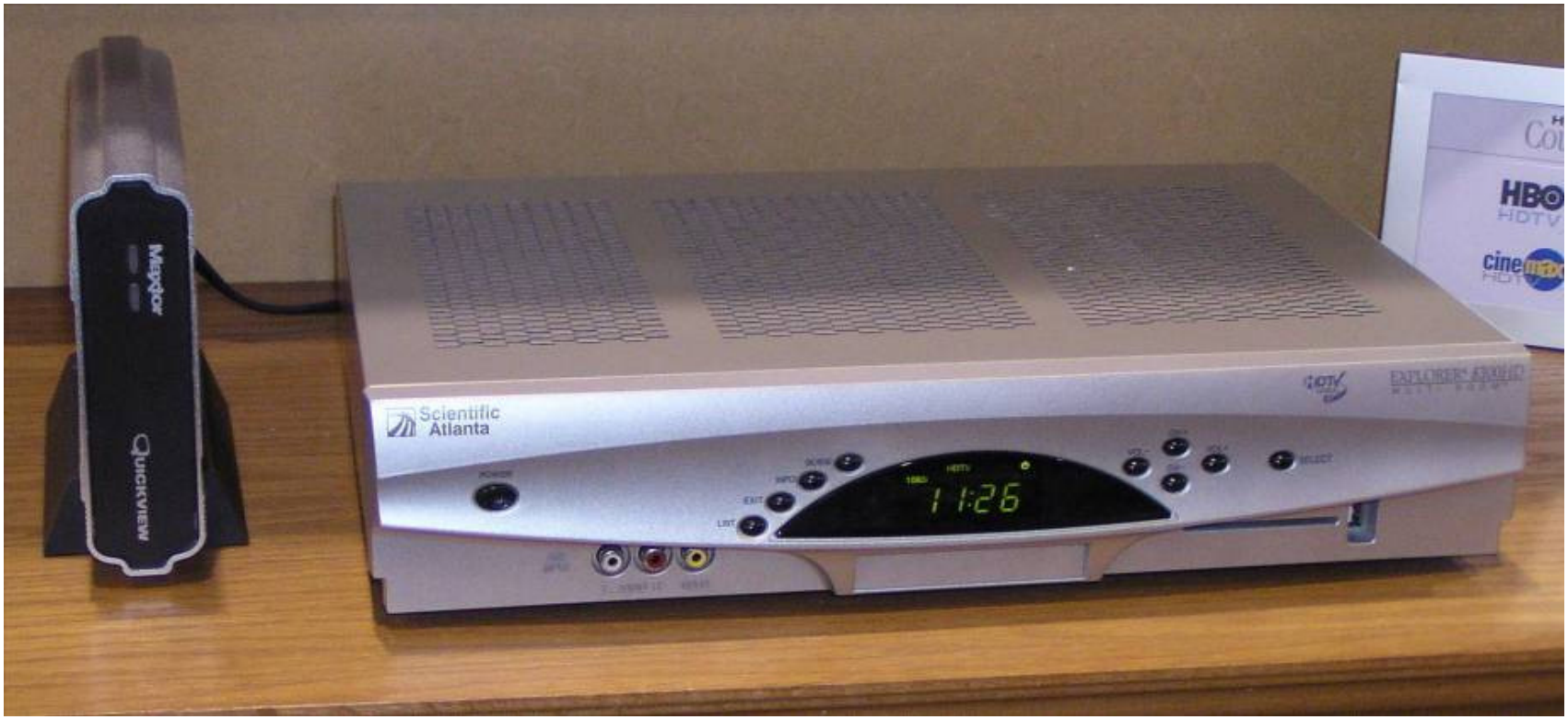
Media Content Size Trends



Rules for Storage Design

- Use the most cost effective storage component(s) that provide enough capacity for the application.
- Never design a product where you intentionally limit the available storage capacity to the customer—always allow a means of storage capacity expansion.
- If appropriate, incorporate the advantages of multiple types of digital memory to achieve some of their individual advantages—a hybrid is often more capable than a device with a single memory technology.
- Protect the customer's content and battery life.
- Give consumers a way to protect their personal content and privacy—encryption and backup.
- Make storage management and organization automatic—for instance protect data and prevent replication of corrupt data.
- Design the components, including storage, to provide lowest total product cost--storage integration concepts could help here.

eSATA storage expansion box attached to an digital video recorder enabled set-top box.



DVR storage requirements over time (combination of internal and external storage)

Year	Internal Storage	External Storage	Comments
2006	40 GB	0	No valid ext. storage options
2010	80 GB	1 TB	Ext. storage options available
2014	160 GB	10 TB	Assumes able to retain considerable recorded programming
2018	320 GB	100 TB	Lots of stuff—some non-commercial
2024	640 GB	1 PB	Huge capacity anticipated

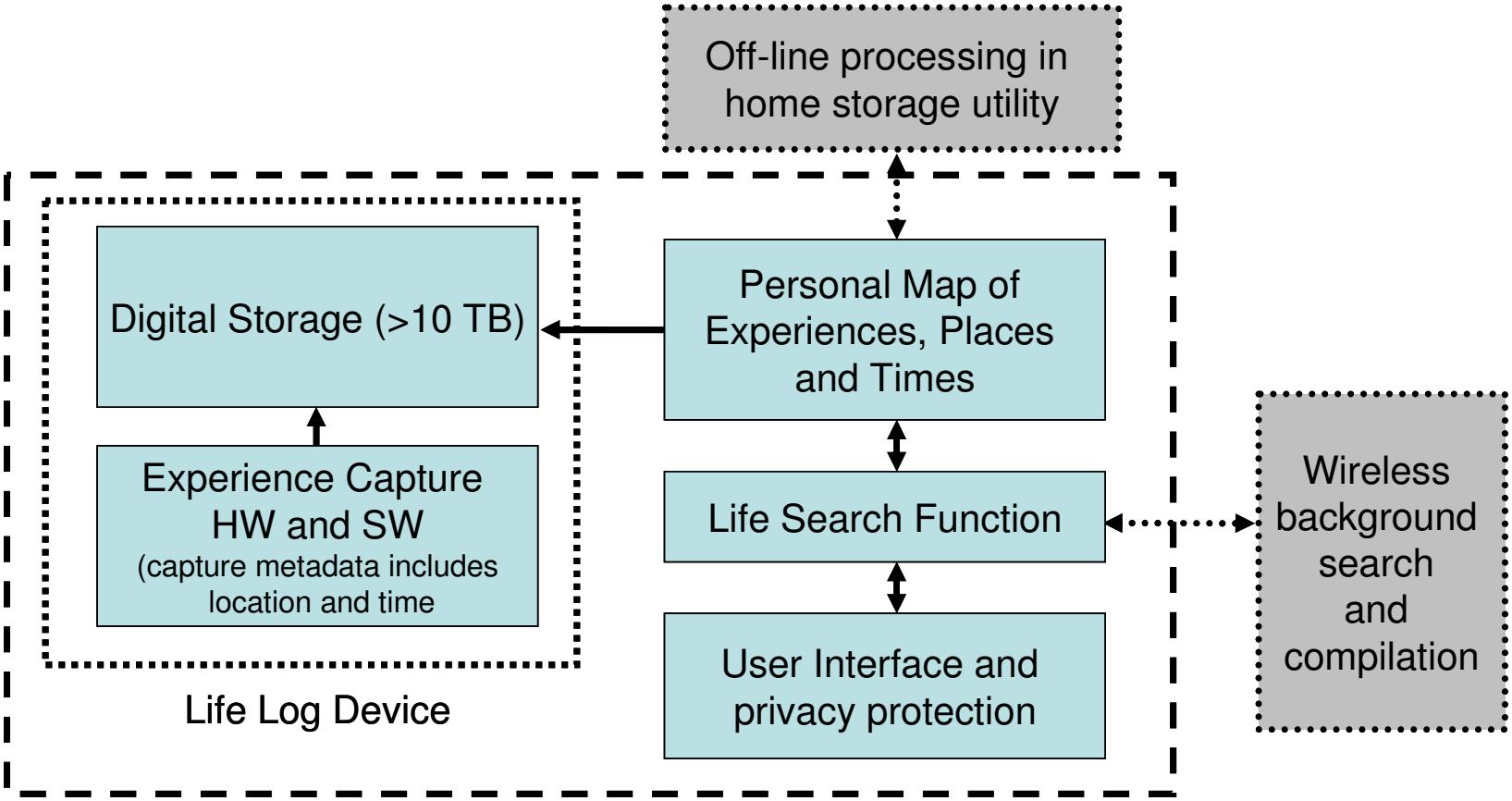
Digital Storage in Consumer Electronics, Thomas Coughlin, Newnes, March 2008

Personal Area Network Storage (PANS)

Seagate's DAVE

- A hard disk drive-based external storage device with wireless connectivity allows storage expansion, streaming and content aggregation

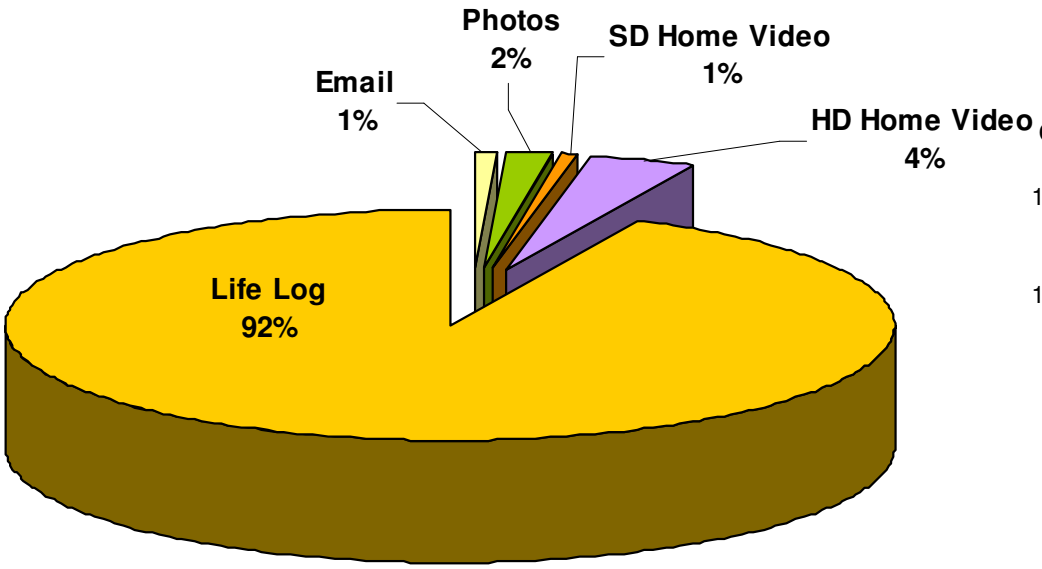
Block diagram of personal memory assistant showing major component functions

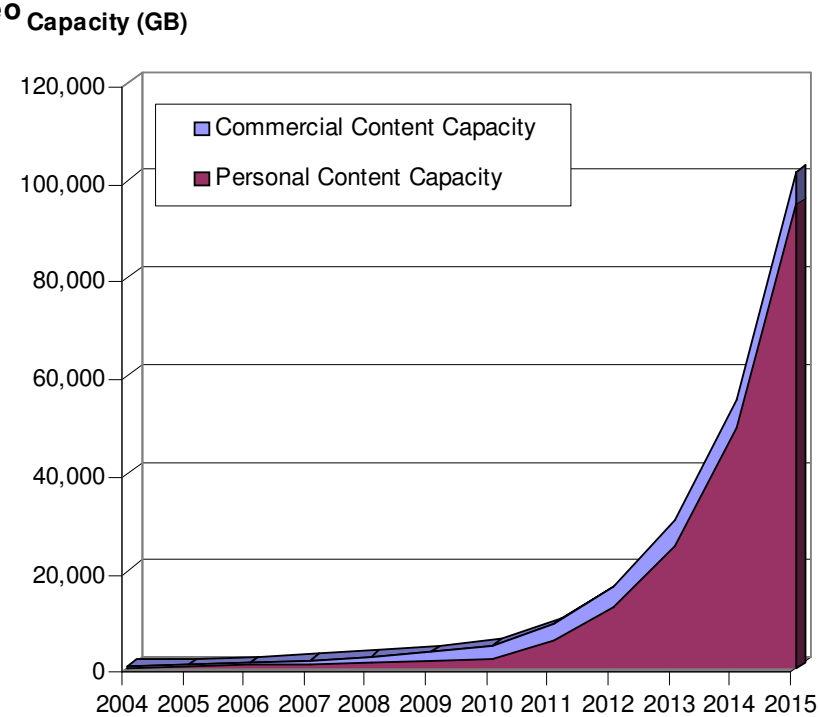


Such a device could require 10 TB of storage capacity on-board!

Affect of Personal Recording on Home Storage Demand

Accumulated Personal Digital Content in 2015
Per Top 10% Household with 1 life-log



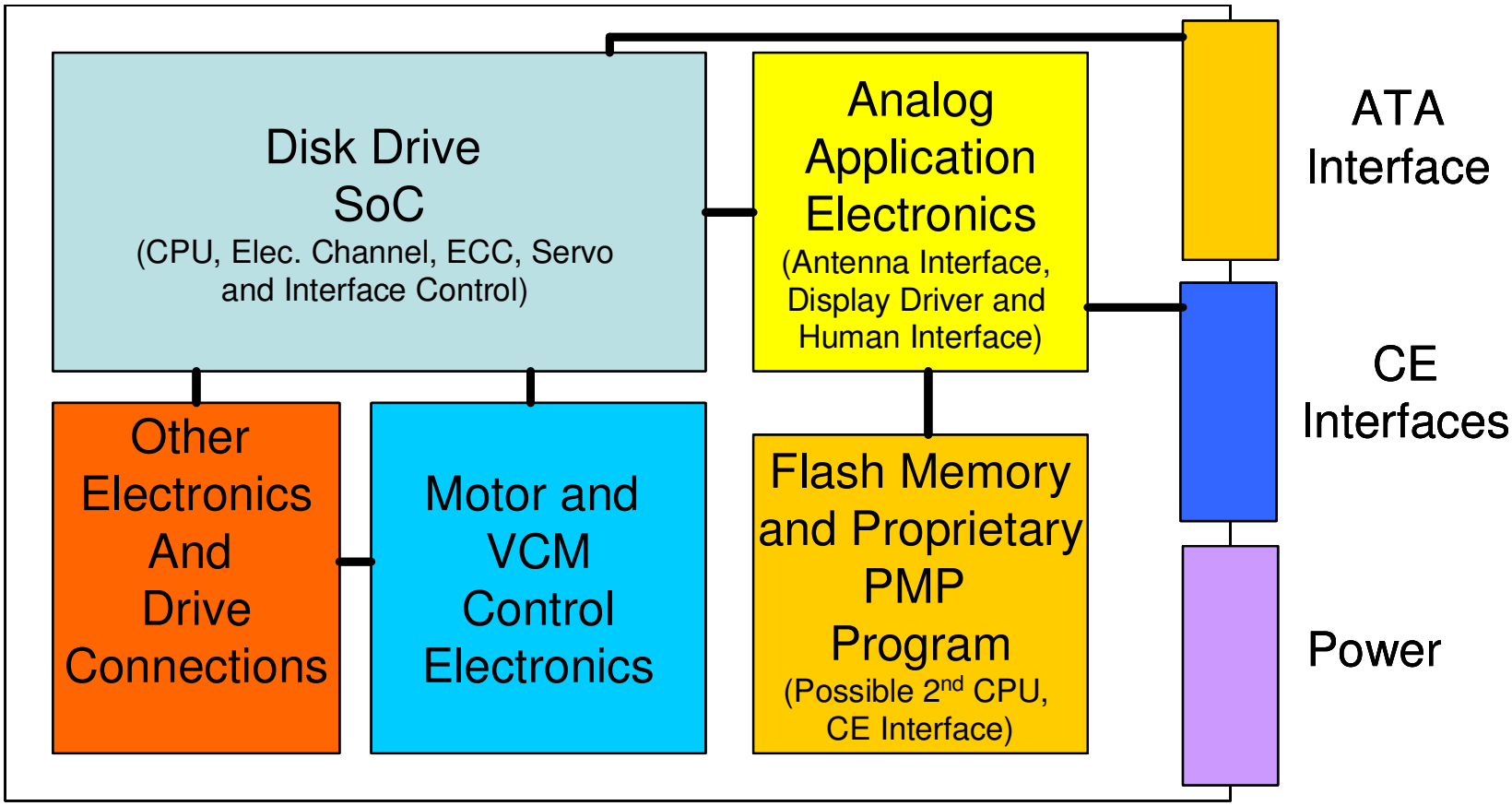


Digital Storage in Consumer Electronics 2008
(Coughlin Associates, release January 2008)

Digital Storage is a Signficant Fraction of Total Product Cost

Product	Capacity (GB)	Avg. Prod. Price ($)	Est. Prod. Cost ($)	Est. Cost of Storage ($)	Ratio Storage & Prod. Cost	Type
DVR	250	$450	$200	$80	40%	HDD
Game System Ext. Storage	20	$90	$80	$65	89%	HDD
Personal Video Player	60	$390	$195	$130	67%	HDD
MP3 Player	4	$240	$190	$140	74%	Flash

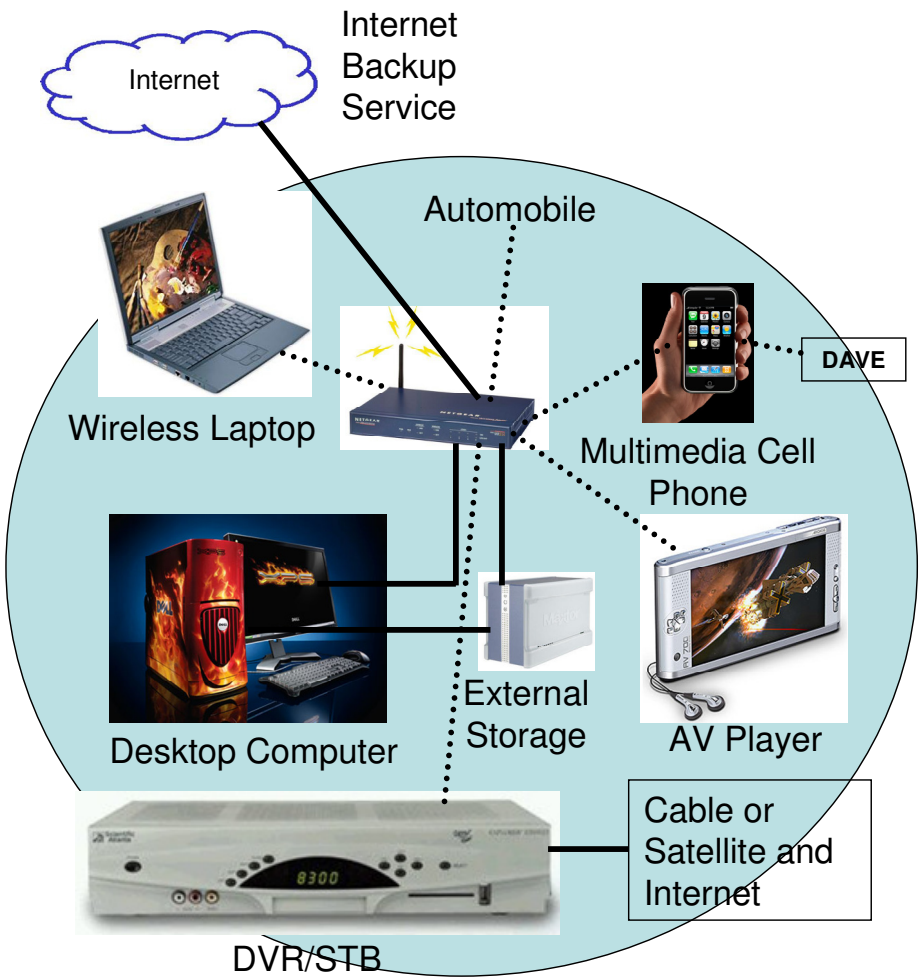
Example of Applications on a Hard Disk Drive



Give designers new ways to improve performance and save money!

Typical Home in 2017
Home Storage Virtualization

- 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



The Process—Making an Book Proposal

- Lance Leventhal, a fellow conference organizer, told me that he worked with McGraw Hill in finding them new technical books. He said that he would help me put together a proposal for a book and get it in front of them.
- I worked for several months in 2005 and 2006 putting the outline together.
  - When the document was done in 2006 it was pretty comprehensive at 24 pages in length

The Book Proposal

The Essential Guide to Digital Storage in Consumer Electronics
by
Thomas M. Coughlin
Proposal Date: 8/23/06

PROPOSAL

- Overview
- Intended Audience
- Competition
- Production Information
- Schedule
- Outline (bulk of document)
- Book Preface
- Organization of the Book
- Who the Book is For
- How the Reader will Benefit
- Author Biography

The Process—Finding a Publisher

- Even with Lance's help the book proposal was rejected by McGraw Hill and with Lance's blessing I approached another fellow I knew that helped bring books to other publishers.
- This fellow got me in front of Elsevier who decided that they would sign me up to write this for their Embedded Systems division in Fall of 2006.
  - I was to get my initial draft of the entire book to them by September 2007
  - They agreed to help me with some of the illustrations
  - I had to get permission for any illustrations or photos from other sources
- I submitted chapters of the book (10 total) to Elsevier starting in March 2007 and ending in September 2007, these included illustrations
- At the same time I got permission from several sources of illustrations and material to include things from them in the book
- Overall it took me about a year to get a publisher from when I started the project

The Long and Winding Road—Doing the Work

- I started writing the book after my Storage Visions Conference ended in January 2007
- I had a plan of writing a chapter a month and started to do this in March 2007—I sent these to Elsevier as they were finished
- I had to split my original chapter 2 into three chapters that covered HDDs, flash memory and optical discs separately
- By August I had finished the first draft of all the chapters
- I had to make changes for the submitted “final” draft due towards the end of September 2007
- In order to finish the book I had to cut myself off from the world to focus on writing and editing. So during 3-4 months for 2-3 hours on most days I shut the door, turned off the phone and didn’t answer email, otherwise I would never have been able to finish the project
- Over October and November I got back revisions of text and figures that I had to review and correct and get back to the publisher
- By mid-December the project was basically done and the book was scheduled for printing in March 2008

Reviewers and Contributors

- I was encouraged in writing the book by Tom Clark who also was one of my reviewers
- I had help with content and reviews during the process by several people including:
  - Rick Wietfeldt
  - Brian Berg
  - Dick Zech
  - Jim Handy
  - Bert Haskell
  - Michael Willett
- I also received permission to use photos and material from several sources including Portelligent, Peek Inside, iFixit and Pat Hanlon
- Tom Clark and Rick Wietfeldt wrote comments for the back cover of the book

Editing

- I submitted chapters roughly monthly to Elsevier
- I had an editor assigned to me who gave me feedback on material as I sent it to her
- When my first complete draft was sent to Elsevier in September 2007 a production editor worked with me on the photos and setting up the book
- In November I received the draft of the book which I reviewed and corrected
- I had one more chance to see the “galleys” in December, just before the CES and Storage Visions

The Final Act

- Publicity Plans
  - Questionaire from Elsevier on various approaches for publicity and promotion
  - Writing articles for magazines on the book
  - Giving presentations at conferences and elsewhere
  - Make flyers on book and make available at events
  - Get book part of reading lists—SNIA added this to their recommended reading list

Epilogue

- Whirl Tour
  - Signed on as distinguished lecturer for the IEEE Consumer Electronics Society to give presentations based upon material in the book
    - Presentations in 2008 in Singapore, Hong Kong, Germany, Russia, UK and Republic of Ireland
  - Book signings being set up
    - Digital Guru in Bay Area
    - At CES or other events (with Elsevier?)
    - At Flash Memory Summit
    - At Storage Visions 2009 (January 2009)
  - Elsevier
    - Made poster and featuring book at events they attend such as Embedded Systems Conference

Conclusions

- Writing a book required motivation to let people know about my thoughts and ideas on digital storage use in consumer electronics
- The process required a fair amount of concentrated effort to complete
- You never catch all the possible problems and mistakes no matter how often you go over the material—entropy rules!
- Finishing the book was very satisfying and it has given me excuses to talk with more people about a subject that I enjoy

Sources

- **Digital Storage in Consumer Electronics: The Essential Guide**, Newnes a division of Elsevier Press (March 2008)
- **Digital Storage in Consumer Electronics Report 2008** , Coughlin Associates
- **Consumer Survey on Digital Storage in Consumer Electronics 2008,** Coughlin Associates
- **2007 Entertainment Creation and Distribution Digital Storage Report**, Coughlin Associates
- Presentations at **2006, 2007 and 2008 Storage Visions Conferences** (www.storagevisions.com) **and CES**

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


Thanks