

Home Digital Storage Hierarchy and Consumer Storage Demand

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About the Presenter

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Dr. Coughlin is the Founder and President of Coughlin Associates. Tom has over 30 years of experience in the data storage industry as a working engineer and high level technical manager. In addition to regular technical and management consulting projects he is the publisher of reports on digital storage in consumer electronics as as content creation and distribution. He is the author of the recently published *Digital Storage in Consumer Electronics: The Essential Guide* from Newnes (a division of Elsevier). Tom has many published reports and articles on digital storage and its applications. He has 6 patents on magnetic recording and related technologies. Tom is the founder and organizer of the annual Storage Visions Conference, a partner to the International CES. Tom is a senior member and was 2007 chairman of the Santa Clara Valley IEEE Section and San Francisco Bay Area Council and was chairman of the Santa Clara Valley IEEE Consumer Electronics Society in 2006 and past chairman of the SCV IEEE Magnetics Society more than once. Tom is a member of the IEEE CE Society Adcom. He is also a member of APS, AVS, IDEMA, SNIA, AAAS, TCG and SMPTE.

Tom received a B.S. in Physics and an M.S.E.E. from the University of Minnesota (Minneapolis) and a PhD in Electrical Engineering from Shinshu University in Nagano, Japan.

EMBEDDED TECHNOLOGY™ SERIES



Digital Storage in Consumer Electronics

The Essential Guide

Thomas Coughlin



Newnes

Available in
March 2008
from Newnes
(a division of
Elsevier
Publishing)

IDEMA



Outline



- Consumer market and drive trends
- Consumer digital storage hierarchy
- Getting hard disks designed into more consumer products
- Conclusions

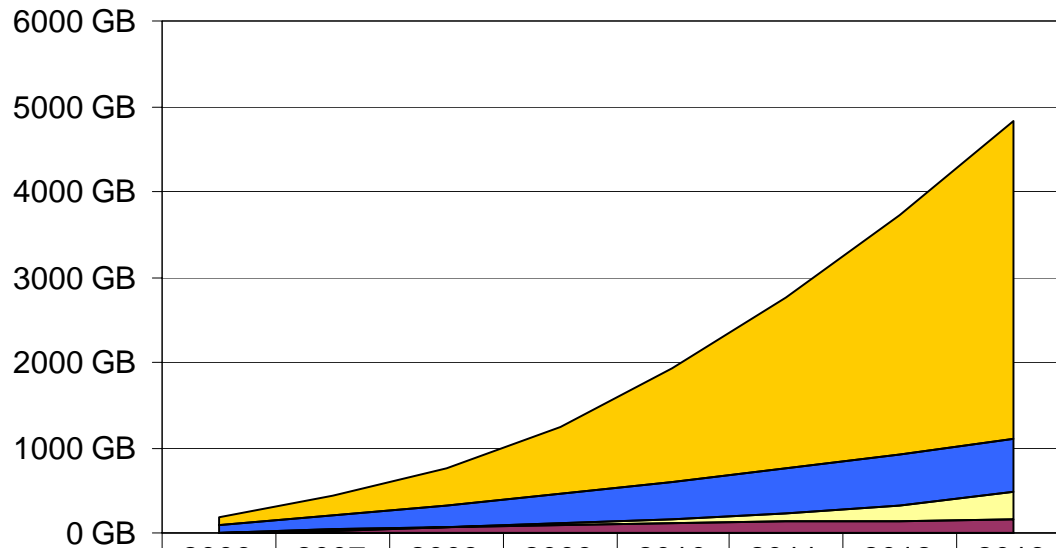


Consumer Market and Drive Trends

New Drivers of Digital Storage

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

Home Entertainment Accumulated Digital Content per Average Household

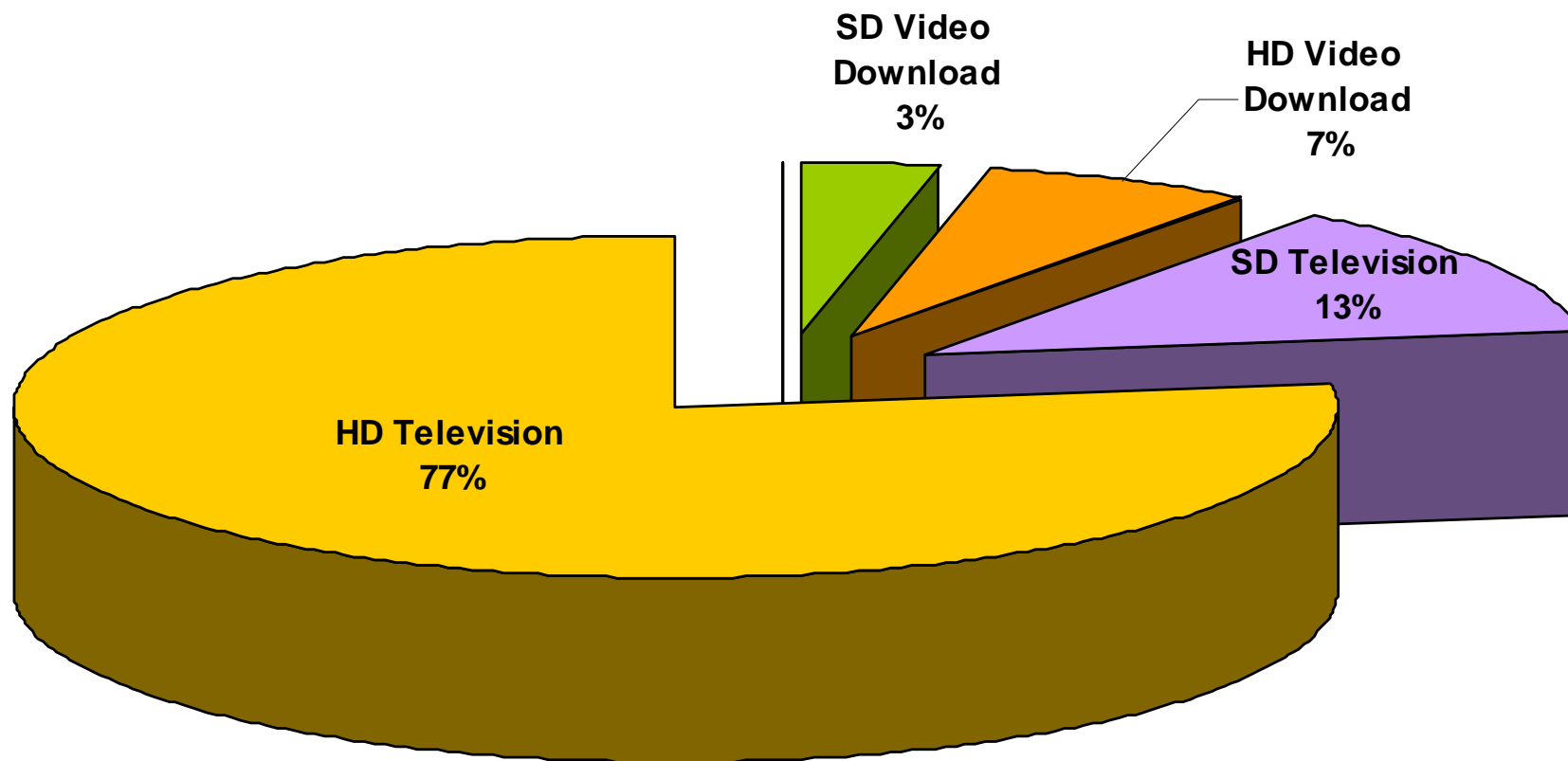


	2006	2007	2008	2009	2010	2011	2012	2013
■ HD Television	106.36	234.00	433.75	779.00	1,336.	2,008.	2,806.	3,728.
■ SD Television	78.07	164.66	257.80	353.80	447.65	524.29	582.30	621.69
■ HD Video Download	-	2.28	8.80	22.89	49.08	96.15	186.22	330.32
■ SD Video Download	6.71	32.74	58.37	83.19	106.62	127.60	143.34	152.49
■ Music	0.58	0.88	1.19	1.50	1.82	2.13	2.45	2.76

- Even an average household will have Terabytes of commercial data in the next decade
- As content resolution increases the required storage capacity must increase as well

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

Accumulated Digital Content in 2013 Per Average Household



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

Estimated growth of personal and commercial content in CE devices

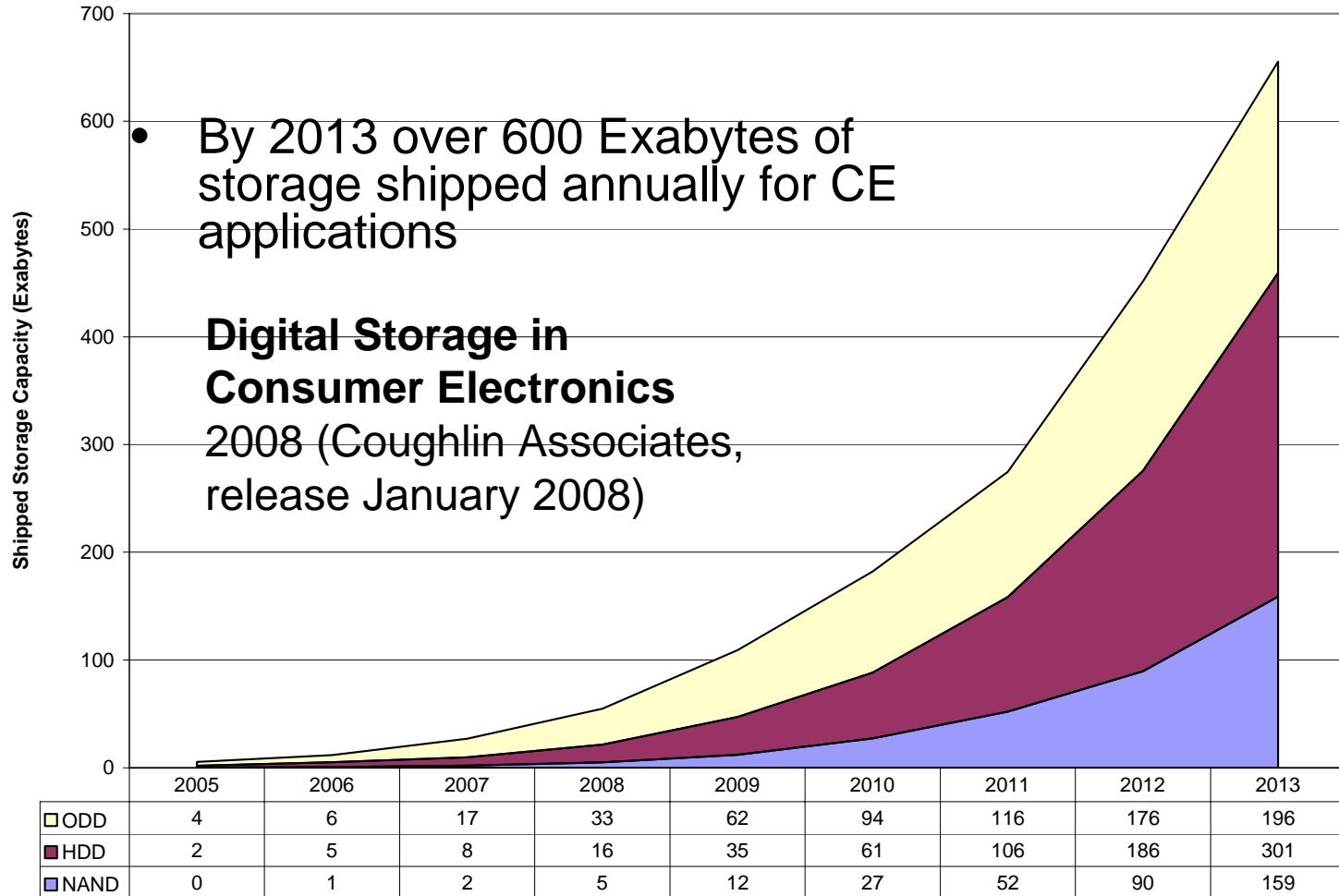
(storage units in exabytes)

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

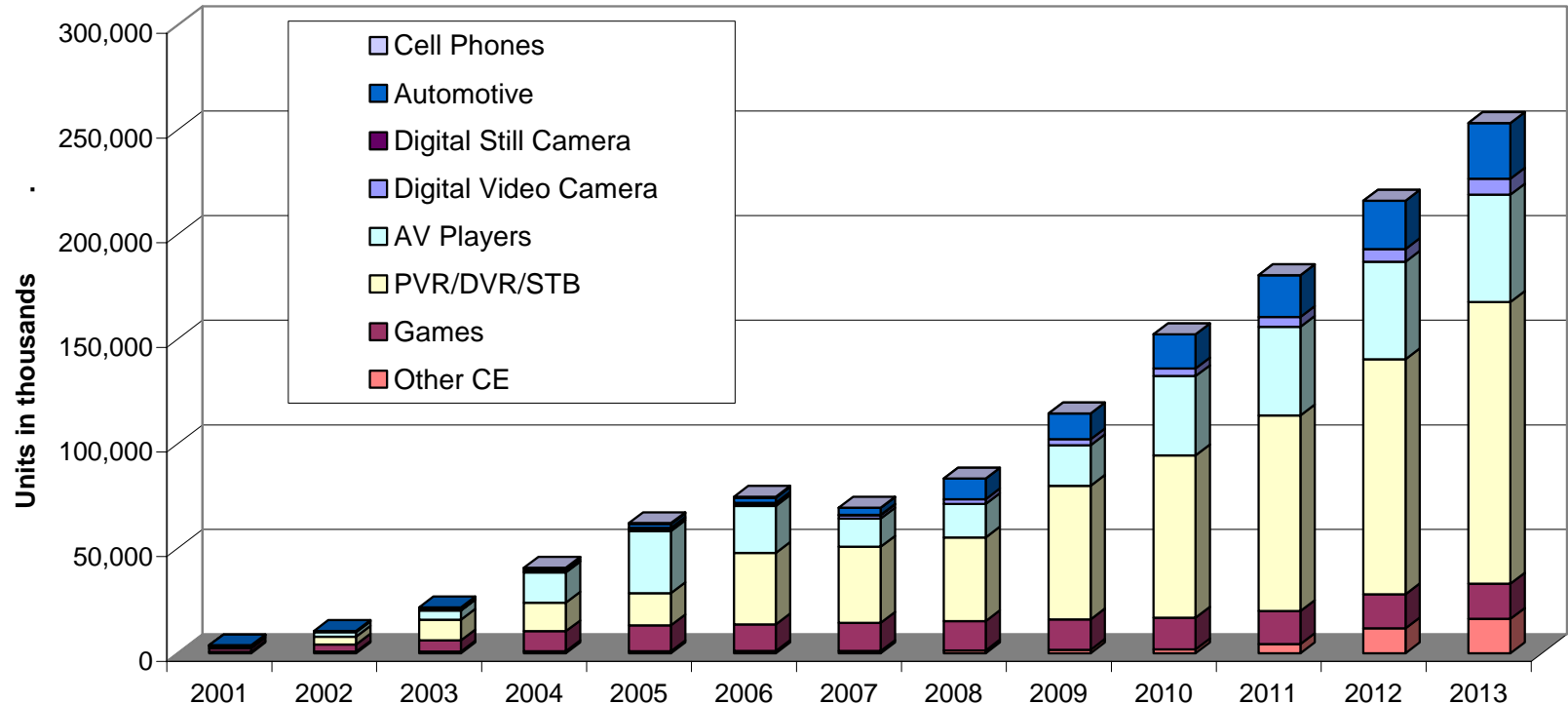
Digital Storage in Consumer Electronics, Thomas Coughlin, Newnes, March 2008

EXEBYTES SHIPPED FOR CONSUMER APPLICATIONS

(OPTICAL DISK, HDD AND FLASH MEMORY)



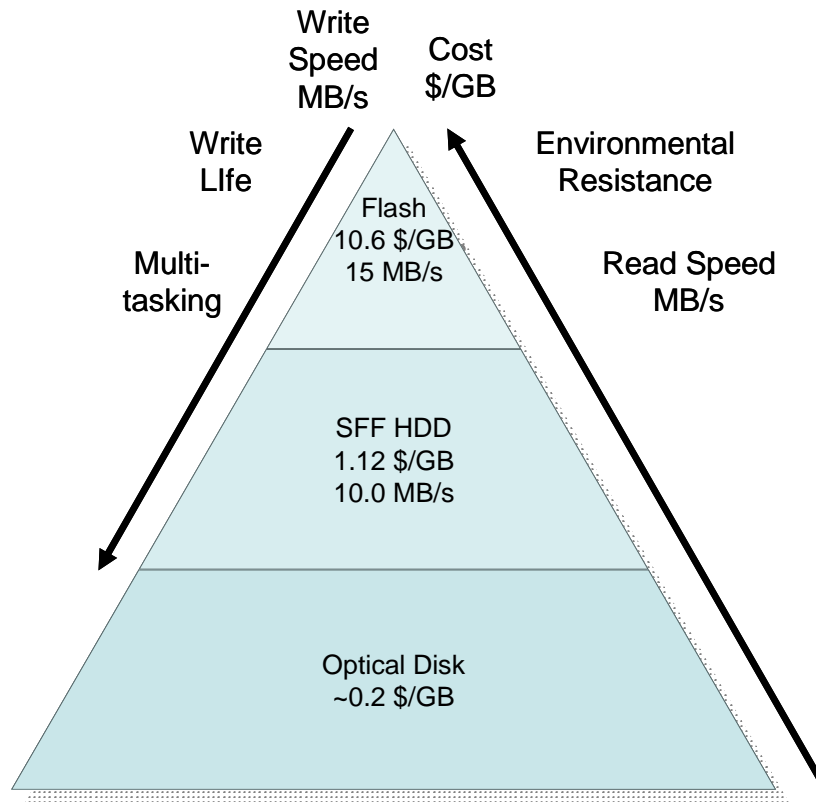
Hard disk drives in CE applications



- Decline in 2007 vs. 2006—particularly in mobile CE market—short term or long term trend?
- In 2007 majority HDDs in static storage with some mobile applications

Consumer Digital Storage Hierarchy

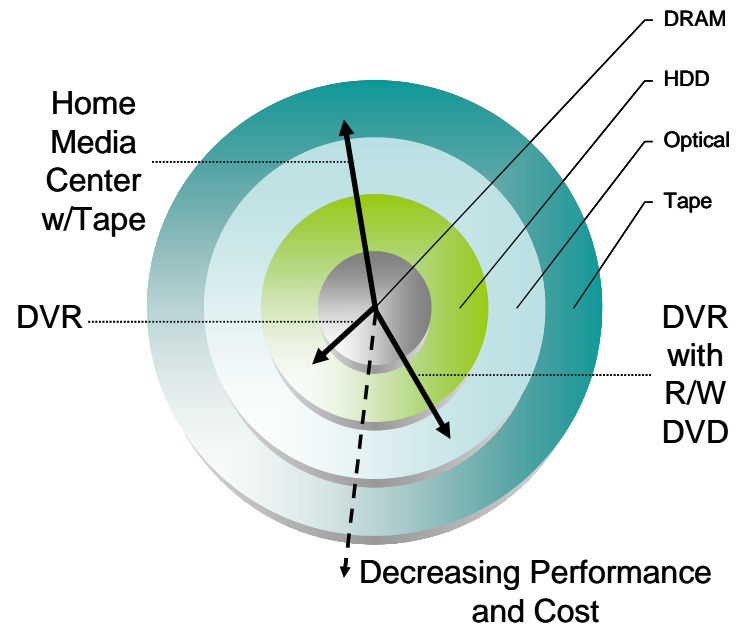
Mobile consumer electronics storage hierarchy



- 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

Static consumer electronic storage hierarchy showing a performance or data access speed hierarchy.

- The devices used for static consumer storage include hard disk drives, flash memory and optical storage.
- There may also be some digital magnetic tape used in older consumer products.
- In this view we show performance and general usage of digital storage devices for several consumer electronics applications using elements of the storage hierarchy.



After S. R. Hetzler, The Evolving Storage Hierarchy, Presented at the INSIC Alternative Storage Technologies Symposium, Monterey, CA 2005.

More synergy than competition between flash and HDDs

- Most of flash memory used in CE applications where content is first downloaded to HDDs and then “temporary” copy loaded on flash memory for playout
- Many flash memory applications such as digital cameras usually reuse the flash memory, downloading the captured content to HDDs
- Both commercial and personal content (such as photographs) are often backed up requiring even more HDD content
- Thus most CE applications help grow both flash and hard disk drive volumes

Where will Flash Dominate?

Where will HDD's Dominate?

- Flash
 - Digital still cameras
 - MP3 players (very compressed content fits into needed capacity point for lowest price)
 - Other cache storage applications
 - Laptop computers where ruggedness is premium and storage capacity is limited
 - Low cost laptop computers—one computer per child
 - Removable computer storage (such as USB drives)
- HDDs
 - Rich media players (Personal Video Players)
 - Rich media cell phones (could be wireless access of a local NAS device)
 - Life-logs or other high resolution continuous capture devices
 - All applications requiring high resolution content such as higher quality music and higher resolution video
 - Majority of computer mass storage
 - Long term storage applications such as content delivery and backup

Getting Hard Disks Designed into More Consumer Products



Why did HDDs for CE drop off in 2007?

- Biggest loss was in mobile products
- Flash memory is making inroads on these applications because storage requirements aren't increasing fast enough
- HDDs are growing for DVR and external storage applications
- HDD companies need to rethink their strategy in the mobile space—where can they add value?

Importance of Supporting the 1.8-inch Drive Form Factor

- The history of the HDD industry has favored evolving smaller form factor drives over time because of the physics of scaling for higher areal density—smaller drives are the future!
- The 3.5-inch drive may be in the minority after 2010
- 1.8-inch drives now have capacities as high as 160 GB, which will increase in time—the capacity is there but we need applications that will use it!
- 1.8-inch drives enable new CE applications and high capacity sub-notebook computers
 - Wireless NAS Storage (PANS)
 - Life logs and other high resolution capture and use devices

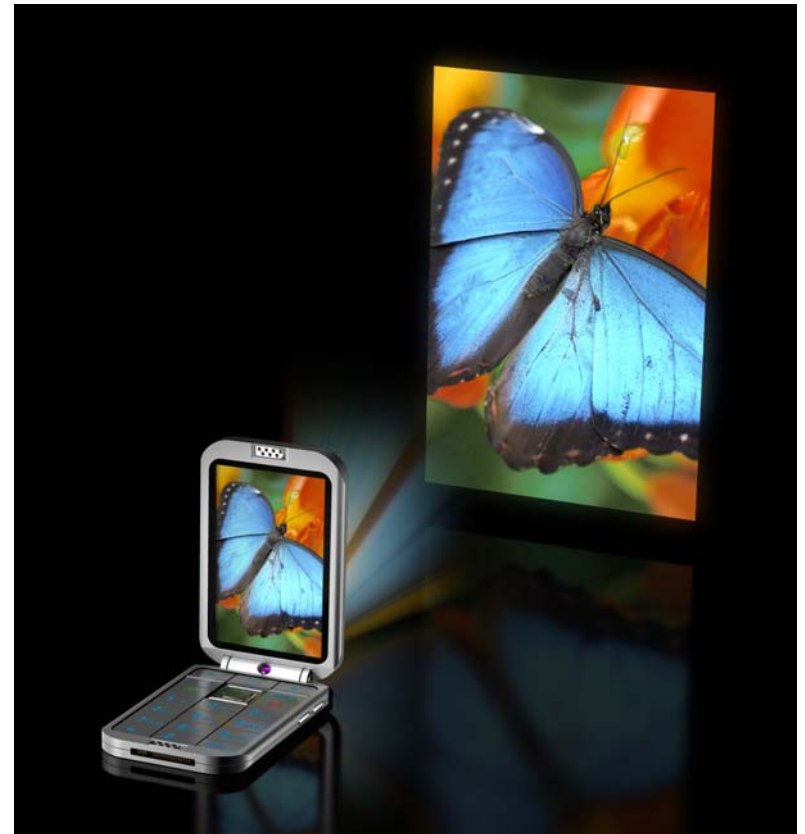
IMPORTANT FACTORS TO PROMOTE FOR USE OF HDDS IN MOBILE DEVICES

- Focus on applications that can benefit from large amounts of inexpensive storage
- Support the development of new longer lasting power sources or wireless power to enable higher performance devices
- Support the development of improved human interfaces, many of these such as speech recognition could require significant amounts of digital storage (several GBs or more)
- Promote technologies for automatic metadata generation since this will make the data more useful and require storage itself—potentially quite a bit of it
- Support the development of hard disk drive external mobile devices including wireless PANS (Personal Area Network Storage) devices

Power in CE devices

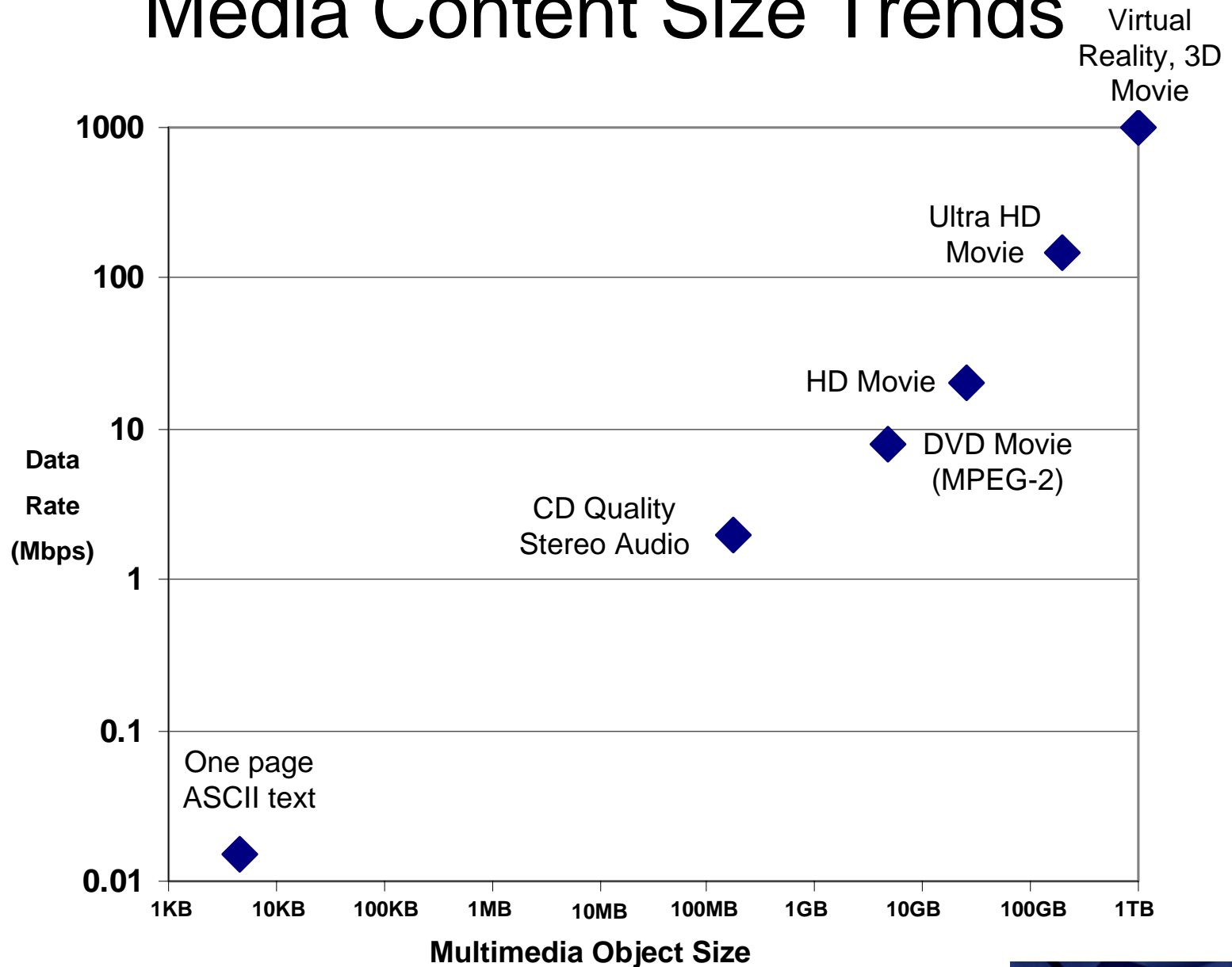
More power means more storage!

- In mobile devices power is a serious design parameter. All the components in a mobile player require power.
- Power brings a mobile device “POWER”
 - Personal projectors
 - Wireless communication
 - More time for capturing higher resolution content

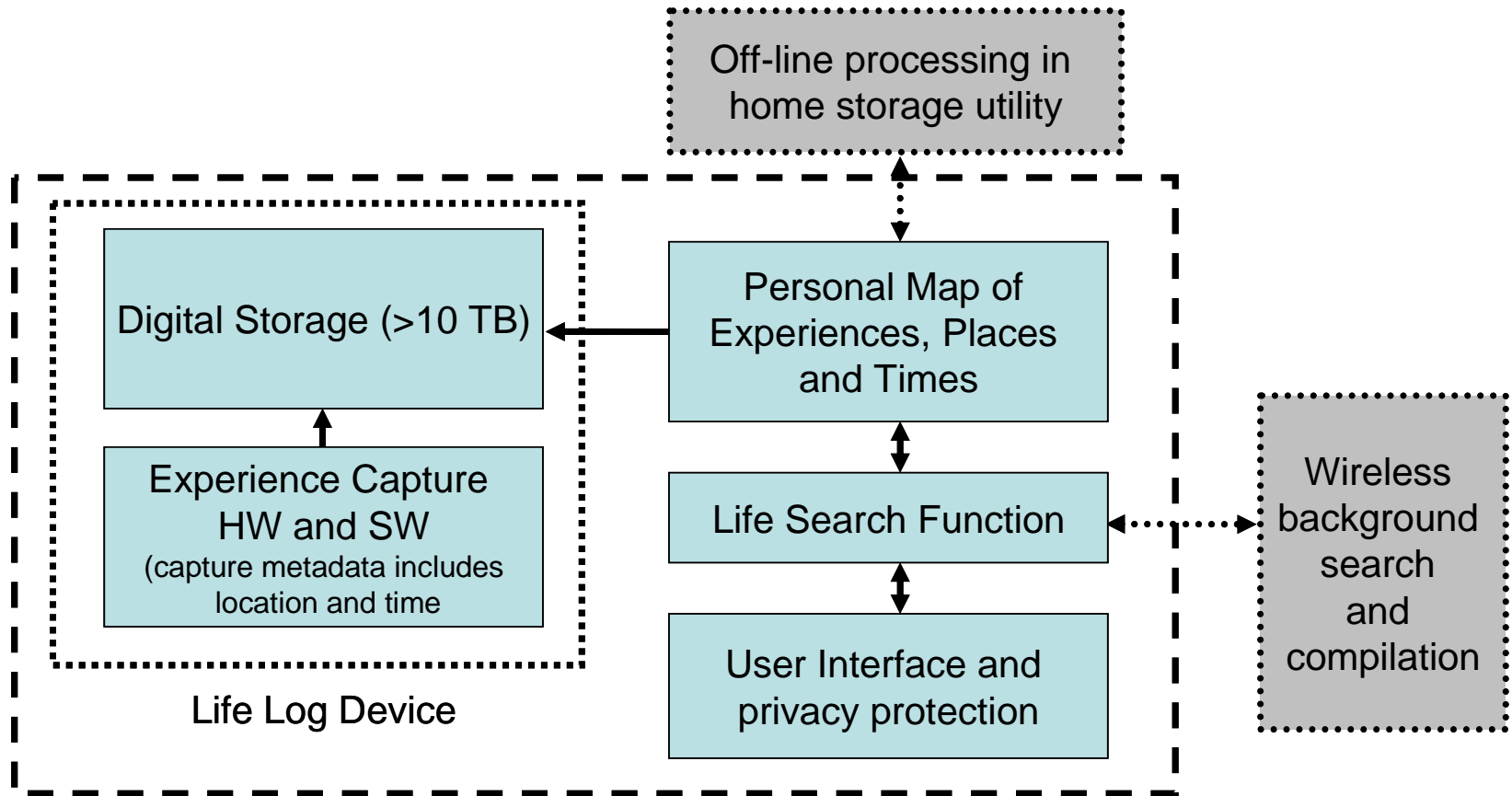


Potentially power hungry personal projector (Novellus)

Media Content Size Trends



Block diagram of personal memory assistant showing major component functions



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

Life Log 2008



PVR-PRO WEARABLE VIDEO TECHNOLOGY

Have you ever felt like you were missing out on an event because you had to concentrate on filming?

Have you ever wanted to video record a meeting or interview?

Have you ever needed documentation of an important event?

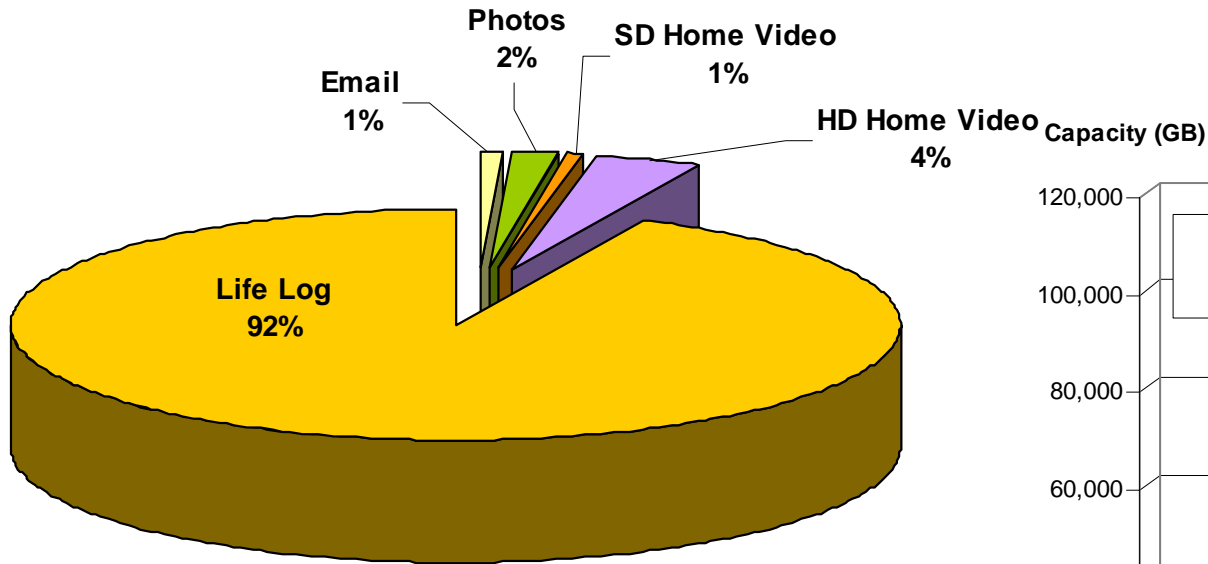
MEET **VIEVU**.

We make **WEARABLE** personal video recording devices that allow you to capture all the details of your daily life while you concentrate on what's important. Consider it your own personal **VIDEO DIARY**.

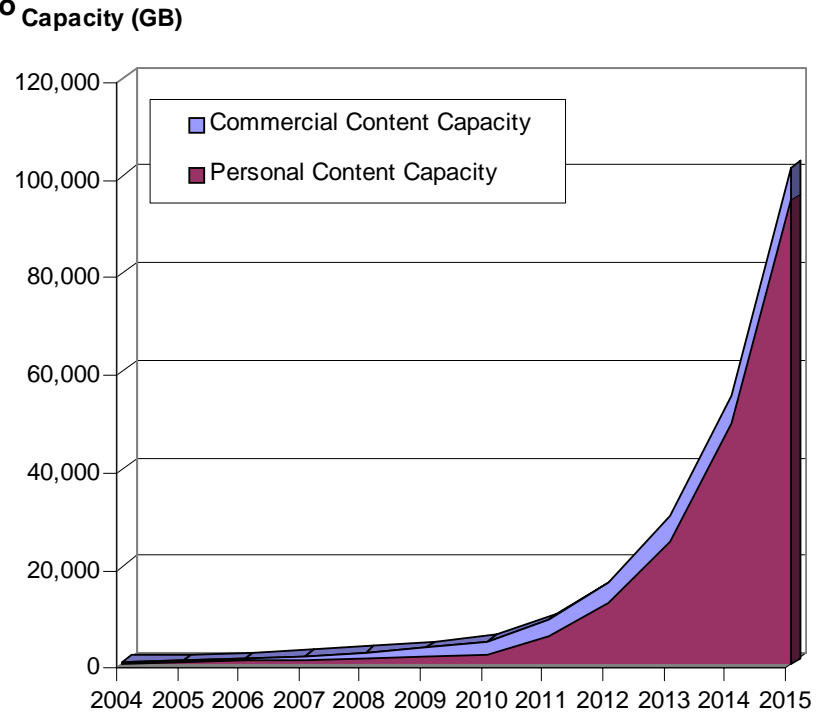
- This device only has 4 GB of flash memory at present
- This device “wants” a high capacity hard drive so it can capture higher resolution content
- Plenty of room for evolution of these types of products

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)



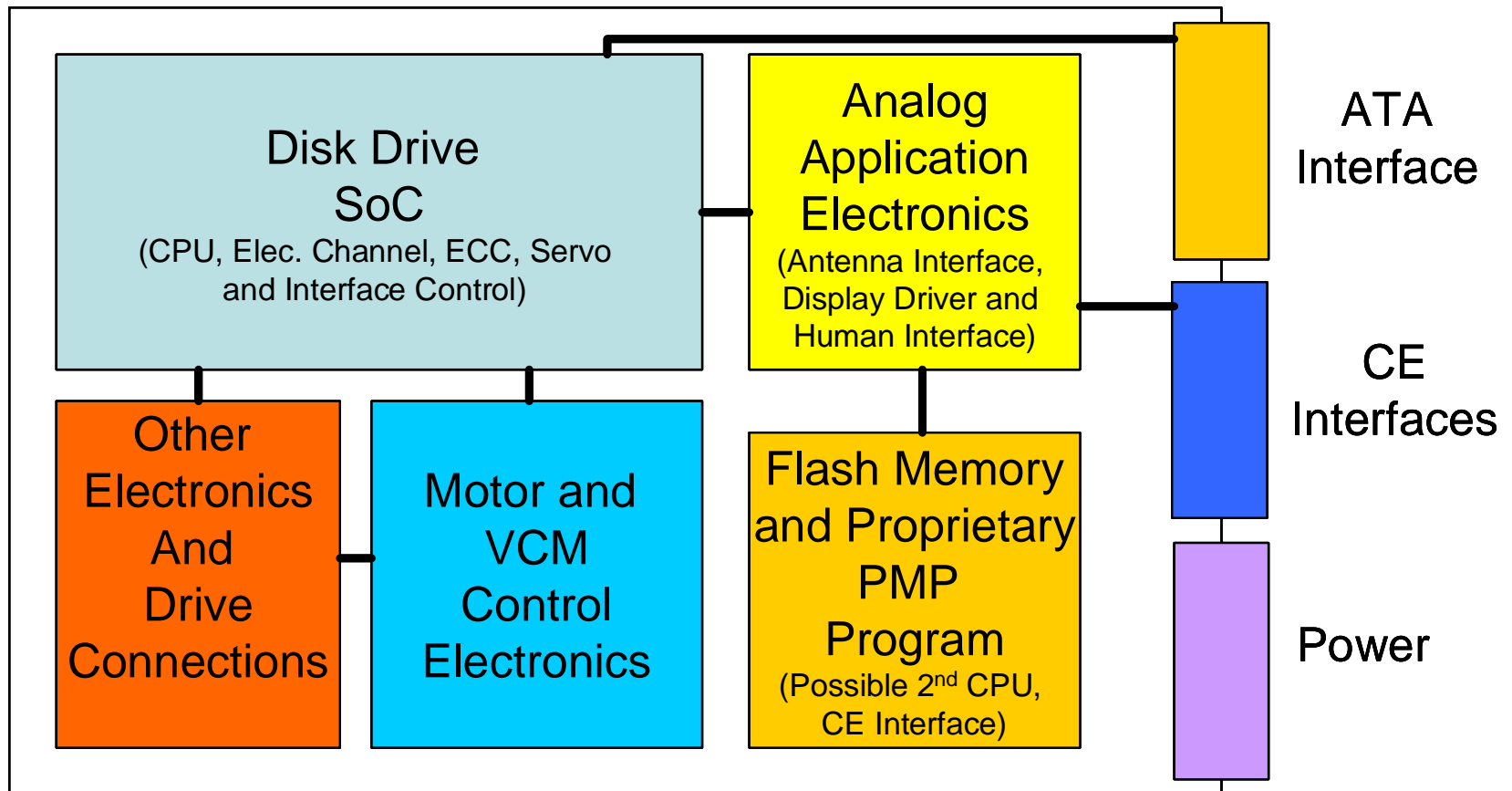
Personal Area Network Storage (PANS)



Seagate's DAVE

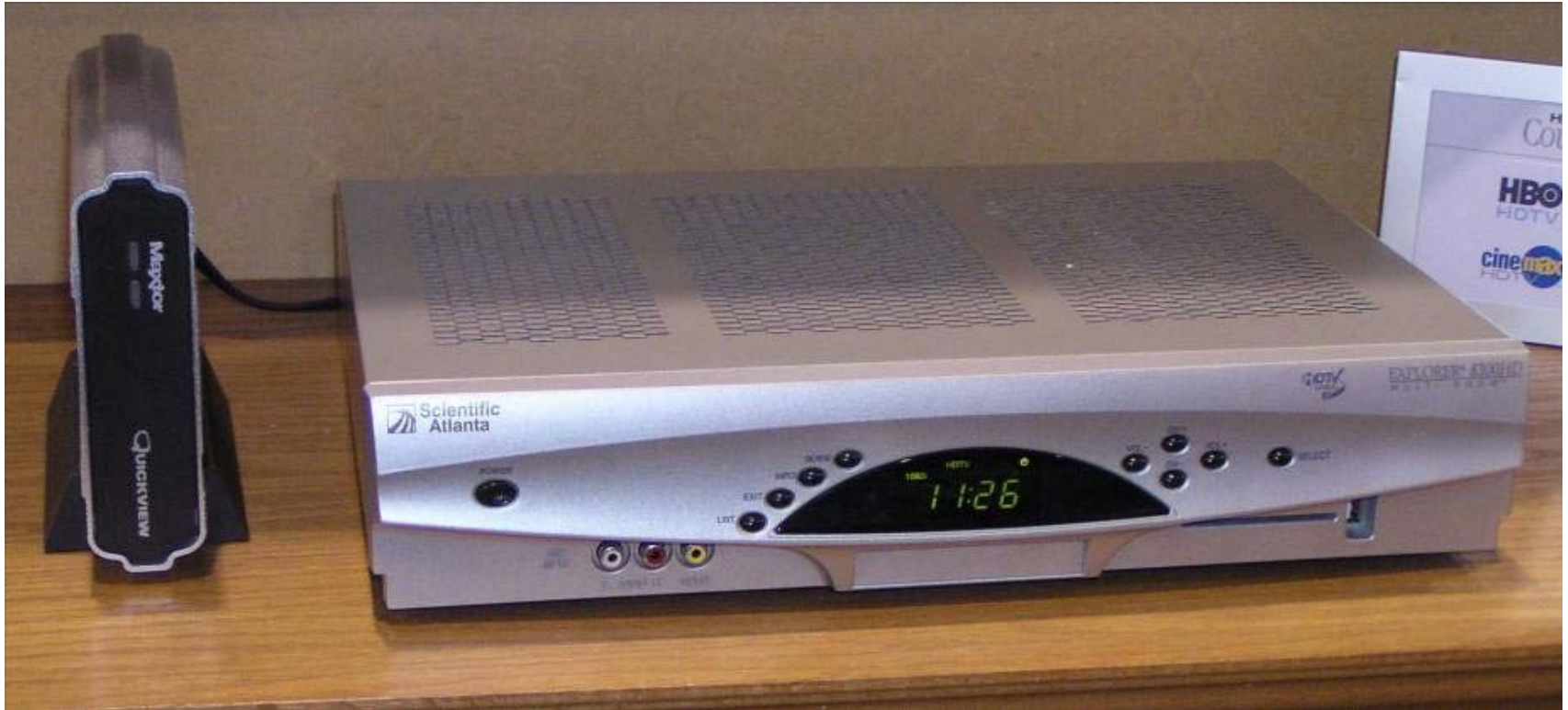
- A hard disk drive-based external storage device with wireless connectivity allows storage expansion, streaming and content aggregation

Example of a Personal Media Player (PMP) implemented on a Hard Disk Drive



Give designers new ways to improve performance and save money!

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

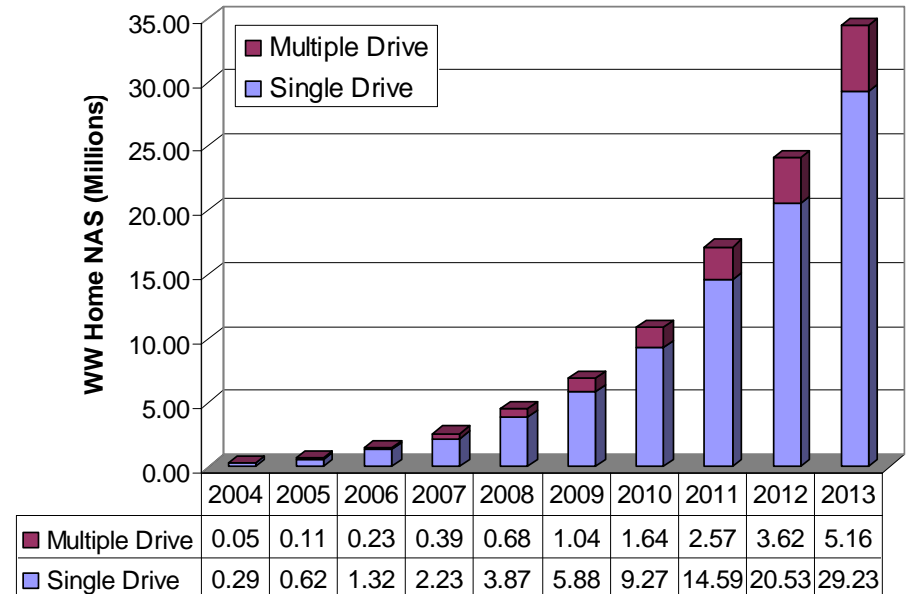
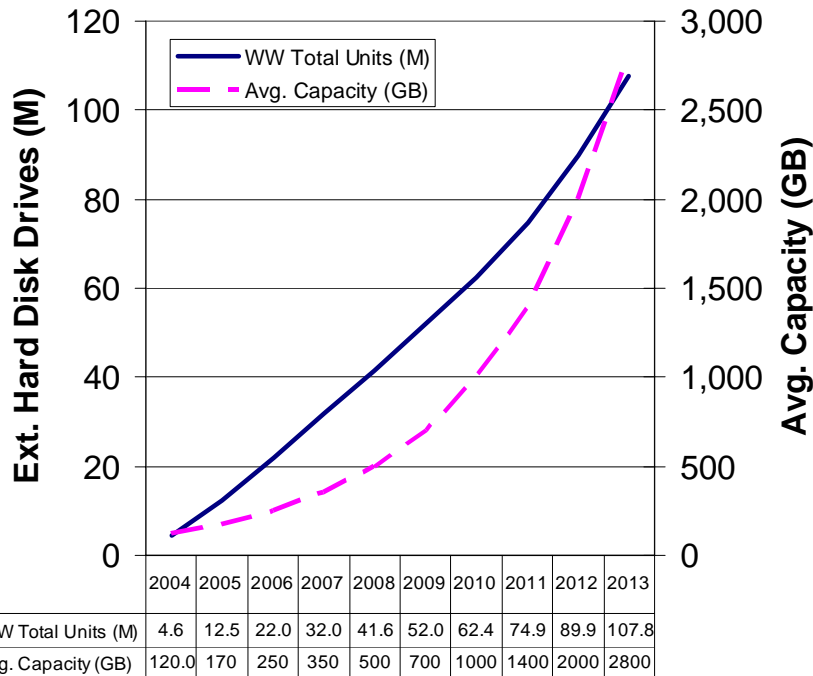


DVR storage requirements over time (combination of internal and external storage)

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

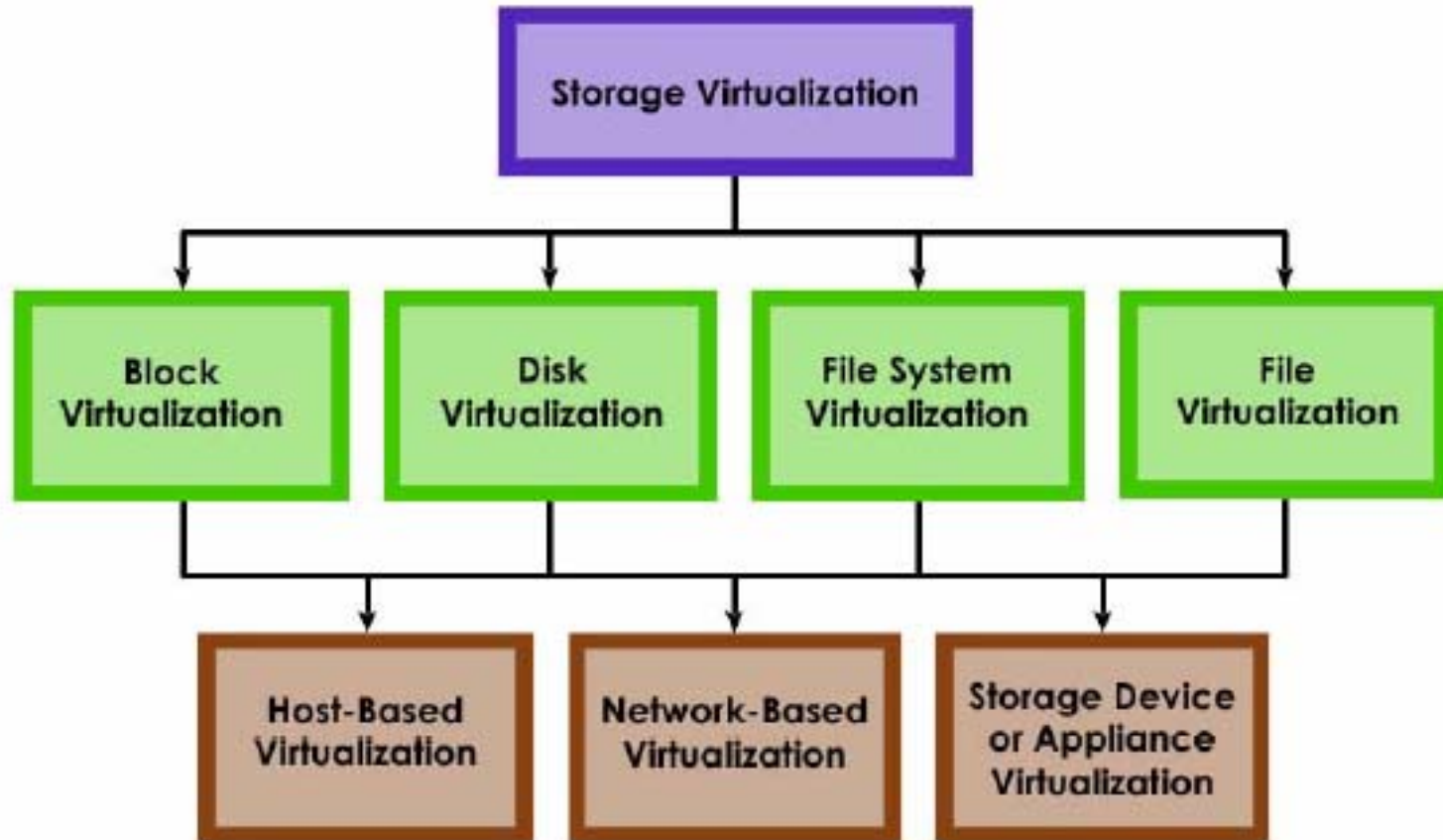
Digital Storage in Consumer Electronics, Thomas Coughlin, Newnes, March 2008

Projections for external storage and home NAS



- By 2013 over 100 M external storage devices and over 34 M NAS in home and small office environments

Paths to home storage virtualization





Conclusions



- The demand for storage for CE applications is very elastic—if they 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.
- Disk drives in consumer applications declined in 2007 but with the right initiatives and approach to the market this growth can be rekindled.
- 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.



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

A photograph of two young boys playing in a river. The boy on the left is standing on a rocky bank, leaning forward and splashing water towards the boy on the right. The boy on the right is sitting in the water, smiling and looking back at the first boy. The background consists of a rocky riverbank and a large log. The word "Thanks" is written in a large, black, cursive font over the right side of the image.

Thanks