Home Digital Storage Hierarchy and Consumer Storage Demand

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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.
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.
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)

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Accumulated Digital Content in 2013 Per Average Household

- HD Television: 77%
- SD Television: 13%
- HD Video Download: 7%
- SD Video Download: 3%


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Estimated growth of personal and commercial content in CE devices

(storage units in exabytes)

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

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

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EXEBYTES SHIPPED FOR CONSUMER APPLICATIONS
(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)
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

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Consumer Digital Storage Hierarchy

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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.

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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

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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

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Getting Hard Disks Designed into More Consumer Products

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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

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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)

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Media Content Size Trends

Data Rate (Mbps)

Multimedia Object Size

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Block diagram of personal memory assistant showing major component functions

Digital Storage (>10 TB)
Experience Capture HW and SW (capture metadata includes location and time)
Life Log Device

Off-line processing in home storage utility

Personal Map of Experiences, Places and Times
Life Search Function
User Interface and privacy protection

Wireless background search and compilation

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

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Life Log 2008

• 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

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Affect of Personal Recording on Home Storage Demand

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

- Photos: 92%
- SD Home Video: 2%
- Email: 1%
- HD Home Video: 1%
- Life Log: 4%

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

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Personal Area Network Storage (PANS)

- 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!

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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)

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

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

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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

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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.

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Sources

• 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

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Thanks