The Content of Storage

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Outline

• Content Value Chain and Revenue Streams
• Storage and Entertainment Content Creation
• Applications for Consumer Electronics
• Disk Drive Projections
• Conclusions
Digital Content Value Chain

- Content Reception
- Content Creation
- Content Editing
- Content Archiving

- PVR/DVR/set-tops
- Game Machines
- Mobile Devices

- Streaming Media
  - VOD
  - PPV

- Cameras
  - Animation

- Field Editing
  - Studio Editing
  - Special Effects

- Tape
  - ATA Disk Arrays
  - Optical Jukeboxes
Digital Content Distribution Chain
From Scott Kipp’s book “Broadband Entertainment.”
Many Digital Content Revenue Streams

**Content Applications & Services**
- Digital Cable (MPEG-2)
- HDTV (MPEG-2)
- DVD Quality (MPEG-2)
- Internet streaming
- Real
- Windows
- Quicktime
- MP3

**Formats**
- Digital Cable (MPEG-2)
- HDTV (MPEG-2)
- DVD Quality (MPEG-2)
- Internet streaming
- Real
- Windows
- Quicktime
- MP3

**Channel**
- Cable
- Telco
- Satellite
- Broadcast
- Internet

**Device**
- TV/Set-Top Box
- PC
- Consumer Electronics
- Wireless

**Applications**
- Digital Cable
- VOD
- SVOD
- Previewing
- Downloading
- Display
- Portable Playback
- PVR
- Digital Radio
- Emerging Apps

From Isilon, SV 2003
Applications for Consumer Electronics
Storage Devices for Entertainment Reception

- Flash Memory
- Hard Disk Drives
- Optical Disks
Two Primary CE Market Storage Niches

- Static or Fixed Appliances
  - Such as set top boxes, DVD Recorders/players, DVR/PVRs, etc.

Mobile Devices

  Such as MP3 Players, Personal Video Players, Cell Phones, Still and Video Cameras, etc.
What Will CE Devices look like in 2010?

• 2010 Portable Device (Jim Gray, Microsoft)
  – 100 Gips processor
  – 1 GB RAM
  – 1 TB disk
  – 1 Gbps network
  – Many form factors

• Example Mobile Communication and Intelligence Device
  – Stores millions of still photos, thousands of MP3 files, hundreds of MPEG4 movies
  – Ubiquitous mobile and fixed communication capability (all standard interfaces)
  – Carries biometric and other security features and includes all your passwords and contacts
  – With appropriate sensors this can be your life recorder to document your life (you are the entertainment)
Blue Ray Optical Disks and Drive

By end of 2005 Blu Ray and HD-DVD Disks will be available with capacities up to 50 GB!
Blu-ray Disc Delivers More Capacity

- **Single-layer**
- **Dual-layer**
- **Recordable**

HP, 2005 Storage Visions Conference

- **CD**: 0.7 GB, 0.7 GB
- **DVD**: 4.7 GB, 4.7 GB
- **HD-DVD**: 15 GB, 20 GB
- **Blu-ray**: 50 GB, 50 GB

200GB+ Roadmap

- 5-10x Capacity of DVD
- 67 - 150% more capacity than HD-DVD

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Optical Content Distribution Trends

Holographic Disks

Source: Telcordia 3/03
Flash Memory

14 formats and growing…

<table>
<thead>
<tr>
<th>Flash Format</th>
<th>Size</th>
<th>Capacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact Flash Type I</td>
<td>4.2 x 3.6 x 0.3 mm</td>
<td>32, 64, 128, 256, 512, 1024, 2048</td>
</tr>
<tr>
<td>Smart Media Card</td>
<td>4.5 x 3.7 x 0.76 mm</td>
<td>32, 64, 128</td>
</tr>
<tr>
<td>Multimedia Card</td>
<td>3.2 x 2.4 x 0.14 mm</td>
<td>16, 32, 64, 128</td>
</tr>
<tr>
<td>SD (Secure Digital) Card</td>
<td>3.2 x 2.4 x 0.21 mm</td>
<td>16, 32, 64, 128, 256</td>
</tr>
<tr>
<td>SD Expansion Card</td>
<td>3.2 x 2.4 x 0.21 mm</td>
<td>32, 64, 128, 256, 512</td>
</tr>
<tr>
<td>xD Picture Card</td>
<td>2.0 x 2.5 x 0.17 mm</td>
<td>64, 128, 256, 512</td>
</tr>
<tr>
<td>Memory Stick (Standard &amp; Magic Gate)</td>
<td>5.0 x 2.1 x 0.28 mm</td>
<td>32, 64, 128</td>
</tr>
<tr>
<td>Memory Stick Pro (Standard &amp; Magic Gate)</td>
<td>5.0 x 2.1 x 0.28 mm</td>
<td>32, 64, 128</td>
</tr>
<tr>
<td>Memory Duo Stick (Standard &amp; Magic Gate)</td>
<td>5.0 x 2.1 x 0.28 mm</td>
<td>32, 64, 128</td>
</tr>
<tr>
<td>Memory Duo Stick Pro (Standard &amp; Magic Gate)</td>
<td>3.1 x 2.0 x 0.16 mm</td>
<td>32, 64, 128</td>
</tr>
</tbody>
</table>

Capacities as of September 2003

Flash Format

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Consumer Hard Disk Drive Form Factors

3.5-Inch Drives

0.85-Inch Drives

2.5-Inch Drives

1.0-Inch Drives
HDD Quarter by Quarter Public Technology Demonstrations and Product Announcements

\[ y = 51.252e^{0.0717x} \]

\[ y = 14.778e^{0.108x} \]
Perpendicular Recording

Toshiba announced a 1.8 inch drive with perpendicular recording technology to be available in the second quarter of 2005.

- Perpendicular Recording improves thermal stability of recording, thus increasing areal density
- Development of perpendicular recording systems could cause an increase in areal density growth similar to that with the introduction of the MR head in the early 1990s
- We could find areal density growth in the next few years again exceeding 60% annually
- Not all companies will convert to perpendicular recording at once, still life left in longitudinal recording
What this means…

By 2006 or 2007 we will have
1 TB 3.5-inch Disk Drives and
20 GB 1 inch drives!
Hitachi New Drives

MIKEY
- Smallest Microdrive
- Available in 2nd half 2005
- Embedded version only
  - PATA, CE-ATA, MMC-like
- 8 – 10GB capacity
- Targeting small handheld products, including multimedia phones

SLIM
- Smallest 1.8” hard drive
- Single disk and 2-disk versions
- 60 – 80GB capacity
- Available in 2nd half 2005
- Embedded version
  - PATA, CE-ATA (future)
- Targeting handheld audio and video products
Disk Drive ASP Trends
(Weighted Average based on Seagate, Maxtor, and WD)

~12% Annual ASP Decline
~9% ASP Decline from Q3 ’03 to Q3 ’04

y = -3.7453x + 147.81
The Battle for Mobile Supremacy

Flash HDD
Mobile Storage Factors

- Size
- Capacity
- Price
- Data Rate (BW)
- Power Usage
- Environmental Factors
System Cost vs. MB

Jim Handy, Semico, 2005
Storage Visions Conference
## DiskOnChip H1 vs. Mini SD vs. HDD

<table>
<thead>
<tr>
<th></th>
<th>HDD (best case)</th>
<th>Mini SD</th>
<th>DiskOnChip H1</th>
<th>DiskOnChip H1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>1.5 / 2 / 4GB</td>
<td>512MB / 1GB</td>
<td>512MB / 1GB</td>
<td></td>
</tr>
<tr>
<td><strong>Cost (estimated)</strong></td>
<td>$50 to $90</td>
<td>$27 to $42</td>
<td>$25 to $40</td>
<td></td>
</tr>
<tr>
<td><strong>NOR-less enable</strong></td>
<td>No</td>
<td>No</td>
<td>Yes – saves cost</td>
<td></td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>32mm / 42.8mm</td>
<td>21.5mm</td>
<td>18mm</td>
<td></td>
</tr>
<tr>
<td><strong>Width</strong></td>
<td>24mm / 36.4mm</td>
<td>20mm</td>
<td>12mm</td>
<td></td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>3.3mm / 5mm</td>
<td>1.4mm</td>
<td>1.4mm</td>
<td></td>
</tr>
<tr>
<td><strong>DRAM read buffer</strong></td>
<td>Yes – adds power</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td><strong>Power consumption</strong></td>
<td>1000mW and up</td>
<td>140mW</td>
<td>20mW</td>
<td></td>
</tr>
<tr>
<td><strong>Temp range</strong></td>
<td>0 to 65°C</td>
<td>-40 to 85°C</td>
<td>-40 to 85°C</td>
<td></td>
</tr>
<tr>
<td><strong>Drop test</strong></td>
<td>Risky</td>
<td>Good</td>
<td>Excellent</td>
<td></td>
</tr>
</tbody>
</table>

### Solid state vs. rotating media cost comparison (estimated):
- 2006 - Flash is lower cost below 4GB
- 2008 - Flash is lower cost below 8GB

M-Systems, 2005 Storage Visions Conference
Small Hard Disk Drives—Not The Answer For Mobile Phones

Based on Cornice 2GB dimensions

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>5.0</th>
<th>2.1</th>
<th>1.4</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (mm³)</td>
<td>7790</td>
<td>1613</td>
<td>605</td>
<td>165</td>
</tr>
<tr>
<td>Capacity* (min)</td>
<td>1 GB* (~$60)</td>
<td>32 MB (~$8)</td>
<td>16 MB (~$6)</td>
<td>16 MB (~$6)</td>
</tr>
<tr>
<td>Capacity (*'04 max)</td>
<td>5 GB (~$70)</td>
<td>2 GB (~$140)</td>
<td>1 GB (~$70)</td>
<td>256 MB* (~$25)</td>
</tr>
<tr>
<td>Power</td>
<td>1000 mW*</td>
<td>20-50 mW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock</td>
<td>Risky</td>
<td>Excellent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SanDisk, 2005 Storage Visions Conference

*1MB = 1 Million Bytes
Portable Consumer Digital Devices

Flash implementation in CE will continue to grow
HDD is an excellent choice for high capacity applications

Current Future

Storage Requirement
32 MB 64 MB 128 MB 256 MB 512 MB 1 GB 2 GB 4 GB 8 GB 16 GB 32 GB 64 GB

Flash HDD

With multi-functions

© Coughlin Associates 2005 Hitachi GST, 2005 Storage Visions Conference
Or is it Mutual Admiration?
A Mobile Storage Hierarchy

Nobody wants to be here!

Flash Memory

Hard Disk Drives

Capacity

Data Rate

Environmental Performance

Not included here: power and size or optical storage
$/GB Advantage of HDDs Less for Smaller Drives

NAND Flash vs. Disc

- OEM NAND Flash Data Point ~ $73/GB
- ~$43/GB
- ~$24/GB
- ~$13/GB

Market Risks
- NAND flash pricing reductions to combat HDD entrance
- 3.3 mm high risk due to $/GB compared to flash
  - Need cell phone real estate to allow 5mm HDD solutions

Source: Seagate, 2005
Storage Visions Conference
SanDisk announced an 8 GB Type 1 Compact Flash.

Toshiba announced it is possible to get 6-8 GB on a 0.85 inch disk drive.
More (or maybe less) to Come…
CE Volume is Very Sensitive to Product Price

From Cornice, 2003

Storage is a significant % of the BOM Costs for CE Devices!
Two Extreme Poles of CE Disk Drive Integration

--Driven by Cost--

Total Integration into the Host

Disk Drive Becomes A Chip

Total Integration onto the Drive

Disk Drive Companies Become Contract Manufacturers for Host Companies
Methods of HDD CE Integration

Today

Tomorrow

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Source: Pat Hanlon Brief, 2004
Replay TV Teardown

--Put it on the Drive Board?--

The four-layer mainboard supports the tuner and more than 38 integrated circuits. The mainboard also provides multiple interface connections, including VGA, digital audio, infrared and S-Video, as well as the PC connection for storing and viewing photos. While virtually all devices found in the Replay TV unit are "catalog items," the architecture is certainly unique to the DVR application. Most key ICs—including TeraLogic video processors and processor/logic components from PMC-Sierra and Xilinx—are connected to a shared PCI bus. Broadcom provides MPEG encoding functions, while a Philips device supplies video decode for external S-Video.

Portelligent Teardown Report from March 24, 2003 EE Times
Integrate What Where?

- For single drive enabled applications perhaps integration on the drive board makes the most sense for the ultimate cost reduction.
- For a multiple drive application such as network storage perhaps integration of as much electronics off the drive board as possible on the system side offers the greatest cost reduction.
Network Storage in the Home

• Driven by the growth of home “reference data” such as photographs, family videos, financial records, etc.
• Need for reliable backup and preservation of this material in the home.
• Also driven by growing home entertainment networking that will require shared storage
• Need Low Cost Options for home networking
Familiarity with Network-Attached Storage Solutions
(Among Internet Households, Home Network Owners and Intenders, n = 817)

- Never heard of: 39%
- Heard of but not familiar: 29%
- Familiar with but do not own: 29%
- Own Network-Attached Storage solution: 3%

The Diffusion Group, 2005
Storage Visions Conference

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Primary Type of Content to be Stored on NAS

(Among Internet Households, NAS Intenders, n = 280)

- Music files: 13%
- Family photographs: 33%
- Duplicates of important data: 38%
- Full-length movies: 8%
- Home-created videos: 8%

The Diffusion Group, 2005
Storage Visions Conference

© Coughlin Associates 2005
Network Storage Packaging
Stealthdrive Faceplate Assembly
Network Storage Packaging
Tortured Path EMC Solutions
Disk Drive Projections
HDD Market Niche Projections

Units in thousands

- Mobile
- CE
- Desktop
- Enterprise ATA
- Enterprise

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HDD Form Factor Projections

- 1 inch or less
- 1.8 inch
- 2.5 inch
- 3.5 inch

Units (in thousands)

- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
CE Drive Applications

Units in thousands

- Cell Phones
- Automotive
- Digital Still Camera
- Digital Video Camera
- AV Players
- PVR/DVR/STB/Home Network
- Games
- Other CE
Conclusions

• Digital content creation, distribution, and Consumer Electronics require large volumes of storage

• Storage devices and requirements vary throughout the content value chain

• Choice of storage device based on several factors—storage hierarchy

• Integration of storage into consumer electronics will be a key way to lower prices and increase market penetration of storage applications

• Content Creation and Consumer Electronics represent a fast growing opportunity for storage devices and storage systems companies

Acknowledgement: Much of the material from this presentation was created while researching the forthcoming 2005 Digital Entertainment Series Reports, For more information see www.tomcoughlin.com.
The journey of a thousand files begins with a single bit...