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 Distribution Chain
From Scott Kipp’s book “Broadband Entertainment.”
Many Digital Content Revenue Streams

Formats
- HDTV (MPEG-2)
- Digital Cable (MPEG-2)
- DVD Quality (MPEG-2)
- Internet streaming

Channel
- Cable
- Telco
- Satellite
- Broadcast
- CD/DVD
- 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 DVD HD-DVD Blu-ray

0.7 0.7 4.7 4.7 15 30 20 25 50 50

200GB+ Roadmap

50-10x Capacity of DVD

67 - 150% more capacity than HD-DVD

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89x58
Optical Content Distribution Trends

Holographic Disks

- Upper Limit for Conventional Optical Technology
- Next Gen DVD Technology
- Broadcast-quality movie (MPEG-2)
- Consumer HDTV-quality movie (compressed)
- Professional HDTV-quality movie (compressed)
- Digital Cinema and VR

Target Area

Data Rate (mbps)

Multimedia Object Size

Source: Telcordia 3/03
Flash Memory

14 formats and growing…

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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

Areal Density in Gbpsi

Technology: $y = 51.252e^{0.0717x}$

Product: $y = 14.778e^{0.108x}$
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 2\textsuperscript{nd} 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 2\textsuperscript{nd} 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

$1
$10
$100
$1,000
$10,000
$100,000
$1,000,000

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

Total Cost

Flash
HDD

10x
100x

Jim Handy, Semico, 2005
Storage Visions Conference

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# 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>Capacity</td>
<td>1.5 / 2 / 4GB</td>
<td>512MB / 1GB</td>
<td>512MB / 1GB</td>
<td>Scalable</td>
</tr>
<tr>
<td>Cost (estimated)</td>
<td>$50 to $90</td>
<td>$27 to $42</td>
<td>$25 to $40</td>
<td>Best cost</td>
</tr>
<tr>
<td>NOR-less enable</td>
<td>No</td>
<td>No</td>
<td>Yes – saves cost</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>32mm / 42.8mm</td>
<td>21.5mm</td>
<td>18mm</td>
<td>Smallest</td>
</tr>
<tr>
<td>Width</td>
<td>24mm / 36.4mm</td>
<td>20mm</td>
<td>12mm</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>3.3mm / 5mm</td>
<td>1.4mm</td>
<td>1.4mm</td>
<td></td>
</tr>
<tr>
<td>DRAM read buffer</td>
<td>Yes – adds power</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Power consumption</td>
<td>1000mW and up</td>
<td>140mW</td>
<td>20mW</td>
<td>Best Power cons.</td>
</tr>
<tr>
<td>Temp range</td>
<td>0 to 65°C</td>
<td>-40 to 85°C</td>
<td>-40 to 85°C</td>
<td>Rugged</td>
</tr>
<tr>
<td>Drop test</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

#### Products available in 2004

<table>
<thead>
<tr>
<th>Measurements in mm</th>
<th>36.4</th>
<th>42.8</th>
<th>24.0</th>
<th>32.0</th>
<th>20.0</th>
<th>21.5</th>
<th>15.0</th>
<th>11.0</th>
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<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>5.0</th>
<th>2.1</th>
<th>1.4</th>
<th>1.0</th>
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<tbody>
<tr>
<td>Volume (mm³)</td>
<td>7790</td>
<td>1613</td>
<td>605</td>
<td>165</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity* (min)</th>
<th>1 GB* (~$60)</th>
<th>32 MB (~$8)</th>
<th>16 MB (~$6)</th>
<th>16 MB (~$6)</th>
</tr>
</thead>
<tbody>
<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></td>
<td>20-50 mW</td>
<td></td>
</tr>
<tr>
<td>Shock</td>
<td>Risky</td>
<td></td>
<td>Excellent</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

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

- Portable Consumer Digital Devices
- MP3 player
- Handheld Game
- PDA
- Mobile phone
- Digital still camera
- Game Console
- Automotive
- Camcorders
- Video player
- MP3 jukebox

Current and future

Hitachi GST, 2005 Storage Visions Conference

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Or is it Mutual Admiration?
A Mobile Storage Hierarchy

Not included here: power and size or optical storage

Nobody wants to be here!

Flash Memory

Environmental Performance

Capacity

Data Rate
$/GB Advantage of HDDs Less for Smaller Drives

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
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!

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Two Extreme Poles of CE Disk Drive Integration
--Driven by Cost--

- Total Integration into the Host
- Total Integration onto the Drive

*Disk Drive Becomes A Chip*

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

Today

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

The Diffusion Group, 2005
Storage Visions Conference

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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

Units (in thousands)

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

Years: 2001 to 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

2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
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…