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Abstract

The trends for networked storage in consumer environments continue to indicate that more and more data is finding its way into the home. While most home/consumer external storage implementations were stand-alone/direct-attached, 2009 saw more and more networked storage begin to appear in residential environments and we expect this trend to continue in 2010 and beyond. What are the implications as consumers want more storage servers, home servers, and "networking" in their home storage?

Learning Objectives

- To survey the growing market for home/consumer storage, home storage servers, and to understand the drivers for continue growth in this market.
- To understand what technologies are being implemented in this area, and look at future developments and technologies that will exist in the "HAN" (Home Area Network), including commerce, e-government, entertainment, security, and energy management.
Presentation Outline

- The Trends and Drivers in Home Networking/Consumer Storage
- Consumer Storage: The Same Challenges as Enterprise Networked Storage in the Early Days
- A Look at the Home Storage Technology Landscape
- Consumer Storage, UPnP, and the Home Area Network (HAN) Specification
- Testing Performance in the Home Network
- The Implications for Digital Home Storage, the Home Area Network, and the Industry
- What is the role of SNIA in this technology space?
Trends and Drivers in Consumer Storage

- Digital Media: The Child of an Increasing Number of Devices
  - The volume is growing more rapidly than we imagine
  - Digital “islands” are becoming increasingly frustrating to consumers
  - Safety and Security growing concerns as financial, medical, and other personal information is stored on home digital storage
- Most home storage is one disk failure away from complete and total loss; backup to alternative modalities & sites is still a work in progress
- Performance will begin to differentiate offerings as more consumers buy “their second box” (the one that actually works with their needs)
- DRM technology does not have an elegant and fair method of aggregating personal digital content in a fungible manner
- Conclusion: Storage in the Digital Home is broken, and organizations that can fix it will make a lot of money
Trends and Drivers in Home Networking

- The number and breadth of products connected to home networks continues to increase.
- 35 million households in the US have data networks, and the figure is expected to grow by 50 million by 2012. Just 10 years ago there were only 2.8 million households with data networks.
- Research shows the market opportunity for home servers is significant, with over 60 million homes having the prerequisites, including multiple PCs installed, a home network, and a broadband Internet connection. The number of homes meeting these criteria is expected to grow through 2012 to nearly 100 million.
- Service providers will play a major role in expanding the penetration of home networks and multimedia- or entertainment-oriented networking products centered on the delivery of Web-based content, primarily video.
- There will arise a highly abstracted “home storage utility” that will hide the complexity of storage in consumer devices, handle data transfers and backup and indexes and automatically generates appropriate metadata for that content.
- Total digital storage device capacity for all storage devices shipped into the home could reach 650 exabytes by 2013. At the same time expected accumulated consumer data by 2013 is expected to be about 760 exabytes.

Cumulative Networked Home Devices

Cumulative Home Data

Growth of Commercial and Personal Content Continues Unabated

Estimated growth of personal and commercial content stored or associated with consumer static and mobile consumer 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>
</thead>
<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>
<td>9</td>
<td>0</td>
<td>17</td>
</tr>
<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>


CONSUMER & SOHO STORAGE: Small Boxes in a Massive Market

© 2009 Storage Networking Industry Association. All Rights Reserved.
Digital Storage Technology Newsletter, Coughlin Associates, July 2009
Survey was 43% male, 57% female, age breakdown 26% (18-25 years), 30% (26-35 years), 24% (36-45 years) and 20% (46-55 years). Most households had 2 to 3 members and less than 13% had 5 or more members.

Participants owned many common CE devices using storage, saw the ability to record content as extremely important.

More than 50% of participants thought that storing TV content long term was important or very important.

47% thought that it was important or very important to share content with other CE devices.

48% thought it important to transfer content to permanent removable storage (more data on backup slides).

By 2015 overall consumer content, including commercial, personal as well as shared content could add up to about 760 Exabytes worldwide.

Home based businesses number 20 million in US at present, expected to grow 10% per year, plus added IT demands for telecommuters, will also impact.

Projections based up on a consumer survey show that we could expect over 2.2 TB of new content in an average home in 2013 including backups (if people make them!).

By 2013 total content in an average home could total almost 9 TB. 5 TB of this is commercial content.

Projections for the upper 10% most active users of content in the home could easily see their storage capacity requirements double those of the average user.

Initiatives to digitize medial records (required by 2014) will cause households to hold archives/originals of records, increasing storage volume to even greater magnitude.
Home Networking is easy, except…

- Ad hoc networks don't have resources just for the sake of the network
  - E.g., DHCP, DNS, directory, …
- Alternative: Running a full domain is a lot of work
- Network is unreliable
  - Nodes added / removed unpredictably
- Programs need to talk to programs
  - But software is heterogeneous
  - One size doesn't fit all
- Must upgrade system piece at a time
- Conclusion: digital chaos, limited integration, and logarithmic growth

JUST LIKE THE STORAGE NETWORKING INDUSTRY IN THE 1990’S
• More drive capacity has shipped to support 'Personal' storage than 'Enterprise' storage
• The Capacity gap is increasing
• More sales, more customers, more production, but more opportunities

The Reality

Simplicity  Connectivity

Tough problems…

Reliability

Privacy

Community

Convenience

Communication

What does the consumer want?

Personal/Information Security
Management of heterogeneous nodes on the network
Appliances versus intelligent devices/servers
Not just cheap NAS, but where is the intelligence?
  - Explicit or opaque?
  - Has to be simple to manage
Security
Protection
Remote Access
46% said that either they didn't know how often they backed up their data or did it less than once per year.

Majority of participants didn't backup their commercial or user generated content.

53% of participants said that it was somewhat important or very important to store backups out of their homes and 67% said that it was important to be able to back up quickly.

64% said that it was somewhat important or very important to have fast online backups. 71% thought it was somewhat or very important to have data privacy in online backup. 74% said that security in online backup was somewhat or very important.

Solutions to Customer Challenges

▷ Storage Appliances
  ✷ NAS box/head
  ✷ Limited intelligence or application awareness
  ✷ Portable devices in growing complexity

▷ Storage as Service (“Digital Lockbox”)
  ✷ Management performed by experts
  ✷ Leverages broadband growth
  ✷ Commercial Storage/Services (aka “Cloud Computing/Storage”)
  ✷ Scalability, Growth, Security concerns

▷ Embedded Storage on Device (“Direct Attached”)
  ✷ Easy to deploy, no need to interoperate
  ✷ Variety of form factors & storage technologies
  ✷ DRM for commercial content more easily managed
  ✷ Consumer not interested in home storage networking?
Combing Local and Online Backup/Storage

- Personal Storage: easy to use, performance acceptable, affordable
- Key Weakness: does not protect important data in the case of theft, a virus, fire, flood or other natural deserter
- Online Storage: opportunity, but some challenges:
  - But, <2% of users are actually using Online storage frequently
  - Almost all Online backup services have not been integrated with other (local) backup; seamless integration still a ways off (but with a few exceptions)
- This will become an important feature to differentiate SOHO/Con storage vendor offerings, with bundling and other discounting providing incentives to move some storage into online locations
Online Storage: Who Would You Trust?*

Q: Who would you trust to back up your computer data for you?

- PC OEM
- Internet-based (e.g., Google)
- Broadband provider
- Component OEM (e.g., Seagate, WD)
- Software OEM (e.g., Norton)
- Local Telco

“Currently, to what type of device do you use most often back up your data?”*

Home Storage Networking: Phases of Development*

0. Internet Sharing Network
1. File and Peripheral Sharing Network
2. Backup Network
3. Home Media Sharing Network
4. Integrated Home Storage Network
5. Home Storage Utility

Requirements for the Home Storage Utility

- Content backup internally, including de-duplication
- Content backup externally (DR & secure remote access)
- Integration of personally-produced digital content with commercially-produced digital content
- Content sharing in and around the home with optimal use of network resources
- Indexing and organizing home content so that it can be found and used when needed (particularly there needs to be a home automated metadata generation facility)
- Synchronization of content as needed (e.g. delivering music and video to A/V players)
- General management and control of storage and network resources (e.g. it should automatically identify and troubleshoot problems, letting the owner know how to solve problems in a way s/he can understand)

What else?
A small office/home office (SOHO)/home server is a centralized computer system designed to perform services for typical networked consumer or small office/home office clients. They run an operating system and serve as a platform to deliver a variety of services either in the home/small office or remotely. These services can be integral to the server operating system, layered on top of the operating system by the operating system vendor or hardware OEM, or installed after purchase by the user.

Servers must have networking capabilities, CPUs, memory, and a general-purpose operating system capable of hosting applications that can be used by client systems. Examples of SOHO/home servers include products built using Windows Home Server and other similar products.
The Consumer, Not the Industry, Drives this Market

- Products must be easy, convenient and yes, fun, to use.
- More intuitive design rules, whether software or hardware.
- Consumers want to share information, music, videos ideas with people they know, and sometimes with strangers.
- We're heavily influenced by our peers; therefore electronics should look good so that we can show them rather than hide them.
- Professional/personal lives more inter-connected than ever before.
- Infotainment — the merging of entertainment and information is now the norm.
- More socially/environmentally aware and increasingly concerned about environmental issues, recycling, clean energy and climate change.

Source: 5 Tech Trends to Watch: The Consumer Electronics Horizon, by Mark Chisholm and Carolyn Slater
The Current State of the Art

MY NEW HOME THEATER IS AMAZING.

IT'S GOT A DVD, HD, DVR, FM, SATELLITE DISH, MP3, WIDESCREEN TV, SEVEN SPEAKERS AND A UNIVERSAL REMOTE.

IT'S FUN TO INVITE PEOPLE OVER SO THEY CAN SHOW ME HOW TO TURN IT ON.
Example: My Dad & Networked Storage

- Not a geek, but too much disposable income meets digital photography, video, genealogy, and church work
- 4 computers (2 desktops, 2 notebooks), 3 HD televisions, 1 DVR, 2 iPODs, 2 scanners, 3 printers, additional external disk drives (about 3.5 GB) and too much free time

- Solution: Home Storage Server
  - Visible across home LAN segments
  - Transparent backup/RAID
  - Sharing of audio, video, photography via web
  - Installed with no techie assistance by an 80-year old

- Response: Bought One for his Church
Charlie Bauer, 80 year-old SAN Manager

- No assistance from geek son
- No consultation of manual during initial install
- Initial configuration completed in 40 minutes
- All notebooks and desktops configured in less than 2 hours
- Backups configured and taking place first day (~10 minutes/machine)
- Family website deployed on 2nd day
The Relevant Specifications

- Nascent: The Home Area Network (HAN)
- Universal Plug and Play (UPnP)
  - Variants and mixes of UPnP
  - Simple Service Discovery Protocol (SSDP)
- X11 (1970’s)
- DLNA: Digital Living Networking Alliance (consortium of orgs)
Controlling home security, lighting, heating/cooling, printers and scanners.

UPnP Device Control Protocols (DCPs) have now been released for a wide variety of device classes including Internet Gateway Device, Media Server, Media Renderer, Printer Device, Scanner, HVAC, WLAN Access Point, Device Security, Lighting Controls, and Remote UI Client and Server.

Runs on any medium that supports IP networking, including phone line, power line, Ethernet, RF, wireless and 1394.

Vendors use any operating system and any programming language to build UPnP products.

UPnP technology is built upon IP, TCP, UDP, HTTP and XML, among others.

Common base protocols: Vendors agree on base protocol sets on a per-device basis.

Extendable: Each UPnP product can have value-added services layered on top of the basic device architecture by the individual manufacturers.
UPnP Device Categories & Specifications

- **Audio/Video**
  - MediaServer V2.0 and MediaRenderer V2.0
  - MediaServer V1.0 and MediaRenderer V1.0

- **Basic**
  - Basic Device V1.0

- **Home Automation**
  - Digital Security Camera V1.0
  - HVAC V1.0
  - Lighting Controls V1.0

- **Networking**
  - Internet Gateway V1.0
  - WLAN Access Point V1.0

- **Printer**
  - Printer Enhanced V1.0
  - Printer Basic V1.0

- **Remoting**
  - Remote UI Client V1.0 and Remote UI Server V1.0

- **Scanner**
  - Scanner V1.0

- **Add-on Services**
  - Device Security V1.0 and Security Console V1.0
  - Low Power V1.0
  - Quality of Service V1.0
  - Quality of Service V2.0
DLNA Specifics

- Network and Connectivity
  - Pervasive use of IPv4 and IPv6

- Device and Service Discovery and Control
  - UPnP™ Device Control Protocol Framework (DCP Framework)

- Media Format and Transport Model
  - (Next slide)

- Media Management, Distribution and Control
  - UPnP Audio/Video (AV)

- Digital Rights Management and Content Protection
  - DLNA Networked Device Interoperability Guidelines

- Manageability
  - Development of Best Practices
### DLNA Media formats for Home Devices

<table>
<thead>
<tr>
<th>Media Formats</th>
<th>Required Formats Set</th>
<th>Optional Formats Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging</td>
<td>JPEG</td>
<td>GIF, TIFF, PNG</td>
</tr>
<tr>
<td>Audio</td>
<td>LPCM (2 channel)</td>
<td>MP3, WMA9, AC-3, AAC, ATRAC3plus</td>
</tr>
<tr>
<td>Video</td>
<td>MPEG2</td>
<td>MPEG1, MPEG4, WMV9</td>
</tr>
</tbody>
</table>

### DLNA Media formats for Mobile/Handheld Devices

<table>
<thead>
<tr>
<th>Media Formats</th>
<th>Required Formats Set</th>
<th>Optional Formats Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging</td>
<td>JPEG</td>
<td>GIF, TIFF, PNG</td>
</tr>
<tr>
<td>Audio</td>
<td>MP3 and MPEG4 AAC LC</td>
<td>MPEG4 (HE AAC, AAC LTP, BSAC), AMR, ATRAC3plus, G.726, WMA, LPCM</td>
</tr>
<tr>
<td>Video</td>
<td>MPEG4 AVC (AAC LC Assoc Audio)</td>
<td>VC1, H.263, MPEG4 part 2, MPEG2, MPEG4 AVC (BSAC or other for Assoc.Audio)</td>
</tr>
</tbody>
</table>
Disparate benchmarks leave wide variety of results

Used several benchmarks when evaluating

Very useful: Intel® NAS Performance Toolkit

- Uses workloads home users will care about
- Records system response
- Organizes results
- Various options for controlling traffic generation
- Simple statistics
  - Throughput, Bytes Transferred, Transfer sizes, Service times (Average, Maximums)

Recorded in log files
### Realistic Application-Based Workloads

<table>
<thead>
<tr>
<th>Test</th>
<th># files</th>
<th>% seq.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD Video Play</td>
<td>1</td>
<td>99.5%</td>
<td>720p HD stream from Windows Media Player* 256kB reads</td>
</tr>
<tr>
<td>2HD Video Play</td>
<td>2</td>
<td>18.1%</td>
<td>2x playback</td>
</tr>
<tr>
<td>3HD Video Play</td>
<td>3</td>
<td>6.6%</td>
<td>3x playback</td>
</tr>
<tr>
<td>4HD Video Play</td>
<td>4</td>
<td>9.6%</td>
<td>4x playback</td>
</tr>
<tr>
<td>HD Video Record</td>
<td>1</td>
<td>99.9%</td>
<td>720p HD stream, 256kB writes</td>
</tr>
<tr>
<td>HD Video Play &amp; Record</td>
<td>2</td>
<td>17.8%</td>
<td>1 playback, 1 record simultaneously</td>
</tr>
<tr>
<td>2HD Video Play &amp; Record</td>
<td>3</td>
<td>3.0%</td>
<td>2x playback, 2x record</td>
</tr>
<tr>
<td>Directory Copy From NAS</td>
<td>126</td>
<td>91.9%</td>
<td>64kB reads</td>
</tr>
<tr>
<td>Directory Copy To NAS</td>
<td>126</td>
<td>52.49%</td>
<td>Predominantly 64kB writes, wide scattering under 16kB</td>
</tr>
<tr>
<td>File Copy From NAS</td>
<td>1</td>
<td>99.9%</td>
<td>4GB file copy, 64kB reads</td>
</tr>
<tr>
<td>File Copy To NAS</td>
<td>1</td>
<td>100%</td>
<td>64kB writes</td>
</tr>
<tr>
<td>Photo Album</td>
<td>169</td>
<td>80%</td>
<td>All reads – wide distribution of sizes</td>
</tr>
<tr>
<td>Office Productivity</td>
<td>607</td>
<td>81.3%</td>
<td>Reads &amp; writes; small, 1kB &amp; 4kB reads; Mostly 1kB writes</td>
</tr>
<tr>
<td>Content Creation</td>
<td>99</td>
<td>39.1%</td>
<td>95% writes; 1k, 4k &amp; little reads; Writes up to 64kB</td>
</tr>
<tr>
<td>Backup</td>
<td>1</td>
<td>99.9%</td>
<td>30GB backup using Windows* built-in utility; 8kB writes</td>
</tr>
<tr>
<td>Restore</td>
<td>1</td>
<td>99.6%</td>
<td>30GB restore from above backup, 1MB reads</td>
</tr>
<tr>
<td>HD Play with Office Apps</td>
<td>608</td>
<td>53.2%</td>
<td>Playback concurrent with office productivity</td>
</tr>
<tr>
<td>HD Play with Backup</td>
<td>2</td>
<td>65.3%</td>
<td>Playback concurrent with backup</td>
</tr>
</tbody>
</table>
Convergence is coming!

Companies who can leverage storage networking experiences (“lessons learned in the last 10 years”) and who can deploy light, easily managed, application aware, networkable digital storage will be winners.

Adoption will be consumer>SOHO replacing Enterprise>SOHO as a pattern (solving more problems for more people at less cost/TB)

Products still spotty and uneven in performance, but no clear differentiating factors exist.

Challenges in digital rights management across a home network:
- “Family Domain Model” for commercial digital media content
- Something akin to “Fair Use” clause in DMCA will have to be written to apply to family networks
- Mobility will be a challenge
What is the role of SNIA in this technology space?

- SNIA member companies entering the consumer space in a big way
  - Products
  - Services (storage on demand, backup on demand, storage server operating systems, etc.)
- Standards development for the management of storage in the Home Area Network is nonexistent
  - Perhaps some variant of SMI that leverages the XML basis of UPnP (“SMI Lite”) with limited profiles and functionality
- Can’t find success by moving challenges to the customer!
- Work with Consumer Electronics trade associations, standards bodies to smooth transition to the connected Digital Home
SNIA working to aggregate manufacturers

Presentation on Energy Star®

Drobo, EMC, Intel as participants

Plans for 2010

SOHOCON ACTIVITIES INCLUDE:
• Full participation in the CIFS/SMB/SMB2 Plugfest. Companies MUST plugfest to above protocols in order to participate.
• Presentation: “SOHOCON Storage: Building A Global Market”, by Rick Bauer, manager of SNIA’s SOHOCON Storage Practice
• Presentation: “The EPA ENERGY STAR® Program for SOHOCON Storage: Preparing Your Company for the U.S. Government Standard”, delivered by members of SNIA’s Green Storage Initiative and Technical Workgroup
• ADDITIONAL ACTIVITIES INCLUDE:
  o Integrated home storage environments: issues and solutions
  o The special events will conclude with discussions about ways that the SOHOCON member companies can collaborate further on plugfesting.
Please send any questions or comments on this presentation to trackstorage@snia.org

Many thanks to the following individuals for their contributions to this tutorial.

- SNIA Education Committee

William Bulkeley  Jason Oxman
Mark Chisholm  Carolyn Slater
Tom Coughlin  Gary Shapiro
Consumer Electronics Association  Cindy Loffer Stevens
Charlie Kindel  UPnP Forum
DNLA  Chris Lionetti
Frank Hady  Tony Bock
Kelly Woods  Steve Murtha
Recommended Resources

Digital Storage in Consumer Electronics
The Essential Guide
Thomas Coughlin

Windows Home Server Bible
Get your household connected and your data protected
Greg Kettell, Jennifer Ackerman Kettell

Create a home office network at home
Back up, store, and secure your data
Stream media easily and share files

The book you need to succeed!
Texts & Articles

- Coughlin, Tom.
- Demand Response and Home Network Solutions Providing Integrated DR and AMI, 2007 Trilliant Networks

Groups

- UPnP Forum  
  - www.upnp.org
- Allegro Software  
  - www.allegrosoft.com
- Gatespace  
  - www.gatespace.com
- Intel  
  - www.intel.com/ial/upnp
- Metro link  
  - www.metrolink.com
- Microsoft  
  - www.microsoft.com/hwdev/upnp  
  - www.microsoft.com/homenet
- Virata  
  - www.virata.com/products/upnp.htm
<table>
<thead>
<tr>
<th>Device</th>
<th>Device</th>
<th>Raw Capacity</th>
<th>Utilization</th>
<th>Net Capacity</th>
<th>First Instance Commercial Capacity</th>
<th>First Instance Personal Capacity</th>
<th>Copied Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop Computer</td>
<td>1</td>
<td>500.00</td>
<td>70%</td>
<td>350.00</td>
<td>170.00</td>
<td>180.00</td>
<td></td>
</tr>
<tr>
<td>Desktop Computer</td>
<td>2</td>
<td>300.00</td>
<td>70%</td>
<td>210.00</td>
<td>110.00</td>
<td>100.00</td>
<td></td>
</tr>
<tr>
<td>Laptop Computer</td>
<td>3</td>
<td>160.00</td>
<td>70%</td>
<td>112.00</td>
<td>40.00</td>
<td>72.00</td>
<td></td>
</tr>
<tr>
<td>Smartphone</td>
<td>4</td>
<td>8.00</td>
<td>70%</td>
<td>5.60</td>
<td>1.00</td>
<td>0.60</td>
<td>4.00</td>
</tr>
<tr>
<td>Regular Mobile Phone</td>
<td>5</td>
<td>4.06</td>
<td>60%</td>
<td>2.44</td>
<td>0.40</td>
<td>2.04</td>
<td></td>
</tr>
<tr>
<td>Regular Mobile Phone</td>
<td>6</td>
<td>1.03</td>
<td>20%</td>
<td>0.21</td>
<td>0.06</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Regular Mobile Phone</td>
<td>7</td>
<td>1.03</td>
<td>20%</td>
<td>0.21</td>
<td>0.06</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Mobile AV Player</td>
<td>8</td>
<td>4.00</td>
<td>60%</td>
<td>2.40</td>
<td>2.40</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td>Mobile AV Player</td>
<td>9</td>
<td>4.00</td>
<td>60%</td>
<td>2.40</td>
<td>2.40</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td>Digital Still Camera</td>
<td>10</td>
<td>2.00</td>
<td>10%</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Digital Still Camera</td>
<td>11</td>
<td>2.00</td>
<td>10%</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Digital Video Camera</td>
<td>12</td>
<td>160.00</td>
<td>10%</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
<td></td>
</tr>
<tr>
<td>DAS Ext. Storage Device</td>
<td>13</td>
<td>750.00</td>
<td>70%</td>
<td>525.00</td>
<td>175.00</td>
<td>350.00</td>
<td></td>
</tr>
<tr>
<td>DAS Ext. Storage Device</td>
<td>14</td>
<td>500.00</td>
<td>70%</td>
<td>350.00</td>
<td>140.00</td>
<td>210.00</td>
<td></td>
</tr>
<tr>
<td>DAS Ext. Storage Device</td>
<td>15</td>
<td>200.00</td>
<td>70%</td>
<td>140.00</td>
<td>28.00</td>
<td>112.00</td>
<td></td>
</tr>
<tr>
<td>NAS Storage Device</td>
<td>16</td>
<td>1,500.00</td>
<td>73%</td>
<td>1,087.50</td>
<td>393.00</td>
<td>695.00</td>
<td></td>
</tr>
<tr>
<td>DVR</td>
<td>17</td>
<td>80.00</td>
<td>100%</td>
<td>80.00</td>
<td>80.00</td>
<td>80.00</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>4,176.13</strong></td>
<td></td>
<td><strong>2,884.15</strong></td>
<td><strong>401.00</strong></td>
<td><strong>1,105.51</strong></td>
<td><strong>1,378.14</strong></td>
</tr>
</tbody>
</table>
33% said that they downloaded 2 or more songs per week with 9% saying they downloaded 10 or more songs.

36% had 100 or more downloaded songs in the household with 10% having 1000 or more songs.

38% had purchased 3 or more games in the last two years with 12% purchasing more than 8 games over that time.

Most people wanted to have one or more videos stored on a single disc.

57% wanted to permanently store entire TV series.

63% wanted to keep copies of their medical records.

66% wanted to store their entire music collection.

Source: Digital Storage in Consumer Electronics 2008, by Tom Coughlin
58% recorded 3 hours or more of TV per week with 23% of that number recording 10 hours or more.

45% recorded at least one movie a week.

Convenience cited as greatest reason to make recordings of TV but 35% of participants wanted a library of TV content.

While most people delete old content from their DVR/PVRs 17% said that they keep everything that they record.

45% of participants had more than 200 photographs on their computers and 17% had more than 1500 photographs.

46% took more than 100 digital photographs annually with 25% taking over 400 photographs annually.

### Example: Overcoming Obstacles

<table>
<thead>
<tr>
<th>File Extension</th>
<th>Video/Picture Codecs</th>
<th>Audio Codecs</th>
<th>DRM Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photos</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.jpg</td>
<td>JPEG</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>.png</td>
<td>PNG</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>.bmp</td>
<td>BMP</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>.tif</td>
<td>TIF</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>.gif</td>
<td>GIF</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Music</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.m4a</td>
<td>N/A</td>
<td>AAC</td>
<td>No Fairplay</td>
</tr>
<tr>
<td>.mp3</td>
<td>N/A</td>
<td>MP3</td>
<td></td>
</tr>
<tr>
<td>.wma</td>
<td>N/A</td>
<td>WMA, WMA Pro</td>
<td>Yes</td>
</tr>
<tr>
<td>.wave</td>
<td>N/A</td>
<td>LPCM</td>
<td></td>
</tr>
<tr>
<td>.ogg</td>
<td>N/A</td>
<td>Vorbis OGG</td>
<td></td>
</tr>
<tr>
<td>Audio/Video</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.avi</td>
<td>Divx, xvid (MPEG-4, ASP)</td>
<td>MP2, MP3, Dolby Digital (2ch, 5.1ch)</td>
<td>Divx DRM</td>
</tr>
<tr>
<td>.divx</td>
<td>Up to rev. 6.0 (MPEG-4 ASP)</td>
<td>MP2, MP3, Dolby Digital (2ch, 5.1ch)</td>
<td>Divx DRM</td>
</tr>
<tr>
<td>.dvr-ms</td>
<td>MPEG-2 video</td>
<td>MP2, Dolby Digital (2ch, 5.1ch)</td>
<td></td>
</tr>
<tr>
<td>.mp4</td>
<td>MPEG-4, part 2, H.264 (BP@L3) up to 720p 30 MP@L4 up to 720p 60</td>
<td>AAC, MP2, MP3</td>
<td>No Fairplay</td>
</tr>
<tr>
<td>.mov</td>
<td>MPEG-4, part 2, H.264</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.mpg</td>
<td>MPEG-1, MPEG-2 (up to MP@HL)</td>
<td>MP2, LPCM, Dolby Digital</td>
<td></td>
</tr>
<tr>
<td>.wmv/ASF</td>
<td>WMV9, VC-1</td>
<td>WMA, WMA Pro</td>
<td>MS DRM</td>
</tr>
<tr>
<td>m2t/TS</td>
<td>MPEG-2 (TS) (up to MP@HL)</td>
<td>MP2, LPCM, Dolby Digital</td>
<td></td>
</tr>
</tbody>
</table>

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Flash

- Digital still cameras (HDDs still used for very highest resolution)
- MP3 players (very compressed content fits into needed capacity point for lowest price)

Hard Disk Drives

- Rich media players (Personal Video Players)
- Rich media cell phones
- All applications requiring high resolution content such as higher quality music and higher resolution video
Deep Dive: UPnP in Action
Steps to UPnP Networking

1. Addressing
   - Control point and device obtain an address to participate in the network

2. Discovery
   - Control point finds all devices and device advertises its availability

3. Description
   - Control point learns about device capabilities

4. Eventing
   - Control point invokes actions on device

5. Presentation
   - Control point listens to state changes of device

6. Control
   - Control point controls device and/or views device status using an HTML UI
UPnP Architecture

Discovery: SSDP (Simple Service Discovery Protocol)

1 Discovery
2 Description
3 Control
4 Eventing
5 Presentation

Search Request
Device Reply
Discovery: SSDP (Simple Service Discovery Protocol)
Description: XML

0 Addressing
1 Discovery
2 Description
3 Control
4 Eventing
5 Presentation

UPnP Architecture

Device Description XML Document

Get Description

UPnP Network

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How UPnP Works

UPnP Architecture

Control: SOAP

0 Addressing
1 Discovery
2 Description
3 Control
4 Eventing
5 Presentation

Action: SetPowerOn

Action Result

VCR Turns On

UPnP Network

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UPnP Architecture

Eventing: GENA (General Event Notification Architecture)
UPnP Architecture

Eventing: GENA (General Event Notification Architecture)

Action: SetPowerOn

Notify: PowerOn = True

VCR Turns On

UPnP Network

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**UPnP Architecture**

**Presentation: HTML**

1. **Discovery**
2. **Description**
3. **Control**
4. **Eventing**
5. **Presentation**

**UPnP Network**

- **Web Browser**
- **HTML UI**
- **Get Presentation**

Web Browser

Get Presentation

HTML UI
Anatomy of a UPnP Device

- Networking stack
- Discovery server
- Description server
- Presentation server
- Control & Eventing Services
UPnP Protocol Stack

Vendor-specific API above

Vendor-specific OS below

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UPnP Residential Gateway Example

Ip telephony application listens for incoming calls

End User Benefits:
- Automates real-time setup and configuration of Internet applications
- Multi-player gaming, streaming audio/video, VoIP
- Enables software to automatically setup and configure the NAT and Firewall
- End user no longer needs to configure network

Service Provider Benefits:
- Eliminates support calls for NAT, firewall, gaming configuration
- Enables customer self-provisioning for enhanced services
- Reduces barriers to deploy voice, video, gaming, etc.
Business Opportunities

Audio & Video Example

1. Discovery of devices and services
2. Browsing of content
3. Selection of streaming protocols
4. Streaming and Playback (out of band*)

CDs, DVDs, Flash Cards

Internet Content

Local Content

Media Server

TV

Picture Frame

Stereo

Remote Control

End User Benefits:
- Discover A/V content on all UPnP devices and PCs and share across home network
- Stream content easily from any device to any device on home network
- Control point offers rich, easy to use interface for creating and managing media
- Supports DVD, CD, play list, photo album, live broadcast, etc

Manufacturer and Service Provider Benefits:
- Highly extensible – any data type, any transfer protocol, any combination of server, render, and control point
- Highly scalable – ultra low resource devices (cameras, EPF) up to high-end servers (PCs, media servers, Internet, broadcasts, PVR). *Out of band = not UPnP Constrained
**End User Benefits**

- No need to install or share printer on the PC or and manually connect all devices to the network (no networking knowledge needed)
- Automatically discover printer/scanner and no need to search for new imaging devices added to the network.

**Manufacturer and Retailer Benefits**

- Reduce customer and service support with driver questions and how to network printer on home network
- Ability to print and scan from an extended range of devices not support previously (Pocket PCs, Cell Phones, Web Tablets)
End User Benefits

- Customizable and easy control of heating, venting, AC unit, motion sensors, lighting and security (personal environment presets)
- Save money on energy bills (set temperature automatically from occupancy or depending on outside temperature)
- Synchronize home settings with PC programs (Outlook calendar, Internet weather)
- Enable secure remote access into the home via the Internet and control UPnP devices.

Manufacturer and Retailer Benefits

- UPnP enabled automation systems add much more functionality over existing proprietary control panels (more desirable over existing technology)
- New opportunities for manufacturers to extend additional features available to the PC, Internet, or other devices (more revenue with new business models, software and service offerings)
### Home Networking/Storage to Change Business Models

#### Digital Entertainment Consumer vs. Electricity Consumer

<table>
<thead>
<tr>
<th>Passive</th>
<th>Active</th>
<th>Participatory</th>
</tr>
</thead>
</table>
| • Passive receipt of content  
  • Limited sources of content generation  
  • Major media companies exclusively control content  
  • Provider-customer relationship one-to-many, driven by demographics and geography | • Consumer interest drives new and more targeted choices in content  
  • More interest in and leverage of information on quality indicators for content (e.g., TV program rating systems)  
  • Broader choice of providers drives more active role in provider selection  
  • Consumer does not control content, but has stronger influence via choices  
  • Introduction of time-shifting technologies enables more active selection and management of content at individual level | • Interactivity and involvement with content and service providers increases  
  • Consumers active in producing content and influencing content distribution  
  • Rapid creation of new content types as technology change causes explosion in capabilities  
  • Dynamic, value-based pricing of content  
  • Provider-customer relationship dynamic is increasingly customized to specific entertainment and information interests, with consumer analytics a key driver |
| • Passive receipt of power  
  • Limited sources of power generation  
  • Incumbent utilities exclusively control power generators  
  • Provider-customer relationship one-to-many, driven by demographics and geography | • Consumer interest drives new and more targeted choices in power supply  
  • More interest in and leverage of information on quality indicators for content (e.g., green energy standards)  
  • Broader choice of providers drives more active role in provider selection  
  • Consumer does not control generation, but has stronger influence via choices  
  • Introduction of residential time-of-use programs and green power options enables more active selection and management of generation deployment at individual level | • Interactivity and involvement with generation and service providers increases  
  • Consumers active in generating power and influencing generation planning decisions  
  • Rapid creation of new power supply options as technology change causes explosion in capabilities  
  • Dynamic, value-based pricing of power (e.g., time-of-use)  
  • Provider-customer relationship dynamic is increasingly customized to specific energy management goals, with consumer analytics a key driver |

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*Source: “The end of television as we know it,” IBM Institute for Business Value, January 2006; IBM Institute for Business Value analysis.*
The Product Space

- **Buffalo TeraStation Live**
- **Intel® Entry Storage System SS4200-E**
- **The D-Link DNS-323**
- **Niveus Storage Server**
- **Linksys NAS200 Network Storage Enclosure**
- **The Iomega® Home Network Hard Drive**
- **The D-Link DNS-323**
- **Apple Time Capsule**
- **LaCie Network Space**
- **Intel NAS Platform**
- **ARTiGO A2000**