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Home Networking and Digital Living Networking Alliance

Pat reaches his apartment and swipes a Smart Card at the door. The door unlocks and the lights automatically turn on as he enters the room. The room has a couch in the center, facing a wall with a large LCD screen. The other walls have two smaller digital photo frames displaying images of aquatic animals glowing in the dimly lit room. The images change periodically. Pat holds his cell phone near the screen. The images of the party Pat has just attended start appearing on the screens. He sits on the couch and reaches for a touch-screen console on a side-table.

The console shows that his favorite program on the Discovery Channel that was scheduled during the day has been recorded on his Home Storage System. One tap on the screen and the program starts playing on the LCD. The program is interrupted as Pat's friend Sam appears on the screen, standing at the door. Pat moves his hands on the console and the door opens to let Sam in. Sam would like some copies of the party pictures. Through the same console, Pat prints the pictures for Sam.

This may appear like a digital home from a Hollywood sci-fi movie, but it's not! Such homes having networked interoperable systems will be a reality in the near future, thanks to guidelines like DLNA and standards like UpnP, HomePNA and ZeroConf.

This paper provides an insight into the digital home and the technologies involved in home networking, with a specific focus on DLNA.

About the Authors

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Introduction

The nature of data stored in different storage devices has undergone a major change in the last few years. Information, entertainment and personal content that used to be physically stored in CDs or DVDs are now stored as MP3 songs, movies, and digital photographs on the hard disk. This transition has been initiated by advances in Storage Technology like miniaturization, low costs and continuously increasing capacities of hard disk drives. The future of entertainment is digital and the following facts speak for themselves.

- Apple iTunes is the No. 1 retailer of music in the United States. Physical sellers of CDs and DVDs like Wal-Mart and Amazon come second and third.
- Netflix, the largest DVD rental company in the United States, is repositioning itself as a video download service company, shifting from providing physical DVDs.
- Digital cameras are gaining popularity as compared to film-based cameras.

A modern home, today, essentially has digital devices like High Definition Televisions (HDTVs), media players, music players, digital cameras, digital photo frames and mobile phones. The consumer is facing increasing complexity in configuring these devices to enjoy digital content. There is a need to have all these devices communicate and work with each other, preferably, without involving a PC or a Laptop.

The market opportunity in home networking products has resulted in companies forming alliances to enable interoperability amongst devices. The alliances in the home networking arena include:

- **Home Phone-line Networking Alliance (initiated by Telecom service providers and vendors):** for the distribution of triple-play solutions at home using co-axial cable or phone lines.
- **Universal Plug and Play Forum (UPnP Forum):** alliance among consumer electronics and appliances companies.
- **Digital Living Network Alliance (DLNA):** alliance of consumer electronics, appliances and mobile device companies.

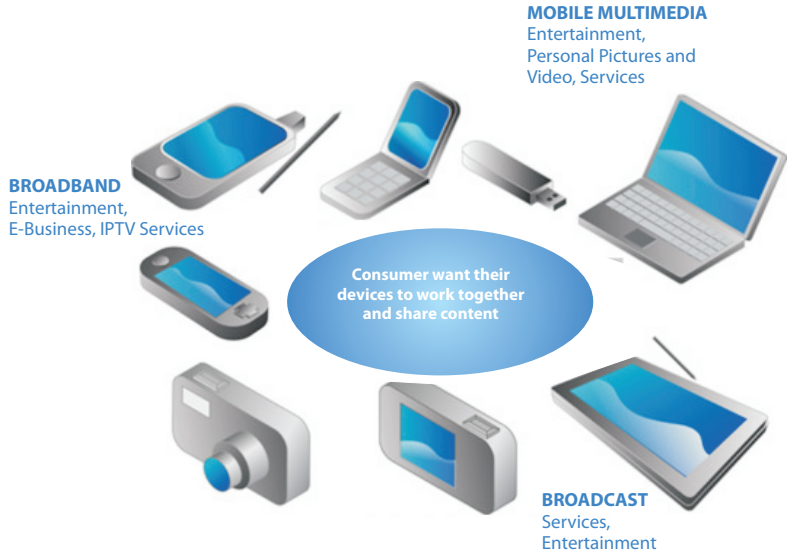

Figure 3. Home Entertainment network

The DLNA alliance includes leading electronic companies of the world. They have come up with standards that allow consumer devices to inter-operate in a seamless environment. This revolution will empower the consumer to create, manage and enjoy digital content from a variety of digital content sources.

Issues affecting the Market and Industry

A modern home, which has multiple digital appliances requires complex technical configuration. This section provides an insight into issues that affect the consumer and vendors of devices in the home and home office segment.

2.1 Home and SOHOs

There is an increase in the number of devices used by consumers for entertainment, office work and 'on the go'. The consumer needs to configure each, so that they interoperate. For example, to view content stored on a mobile phone on the TV, the user needs to transfer the content to the PC and connect the PC to the TV. In the future, home lighting and climate control, refrigerator and home security system will also be networked with other devices at home. Configuring each device separately can be time consuming and may drive down sales of these devices. DLNA guidelines enable these devices to work seamlessly together, without user configuration. This will also enable vendors to focus on improving consumer experience.

2.2 Multiple Devices and Formats

Consumers generally use multiple devices for entertainment, office work or surveillance. A well-stacked digital home will have the following devices:

- HDTV or HD Projector
- DVD/ Movie Format Player
- Home Theater System or a separate music system
- Network Storage Drive/ NAS Device
- Cable and Internet Modem or Satellite Set-Top Box
- Printer and/ or Photo Printer
- PC and/ or Laptop
- Hand-held devices/ mobile phones
- Game Console
- Wireless Router
- Digital Network Media Player
- Digital Photo Frame
- Digital Camera
- Video Surveillance System

It is becoming increasingly difficult to seamlessly view and manage content from different devices, given the wide array of technologies and formats used. Consider for example:

- Movies are available in different formats: DVD, HD-DVD
- Music is distributed in various formats: iTunes, Zune Marketplace, MP3, Real Player (.ram), WMV (from Microsoft)
- Games do not have compatibility across vendors: Xbox, PS3, Wii
- The security of digital content is applied in multiple ways
- Broadcast technology varies from continent to continent: NTSC, PAL

The use of PCs and mobile devices to download, view, and share digital content, such as photographs, music, and videos has grown in the last five years. In order to exchange this multimedia content, different media formats, codecs, transmission protocols and display technologies must be interwoven. Also, with the advent of digital music and video download services, content companies are restricting their use with the help of Digital Rights Management (DRM). DRM prevents commercial premium content from being illegally accessed, copied, listened to or viewed, as required by the commercial content owners. This adds to the complexity of a simple movie download by the consumer.

Therefore, diverse devices must connect and talk seamlessly with each other. Consumer should face a simple system where user can share multimedia data seamlessly without the need to setup and configure devices manually

2.3 Usage of Home Networks

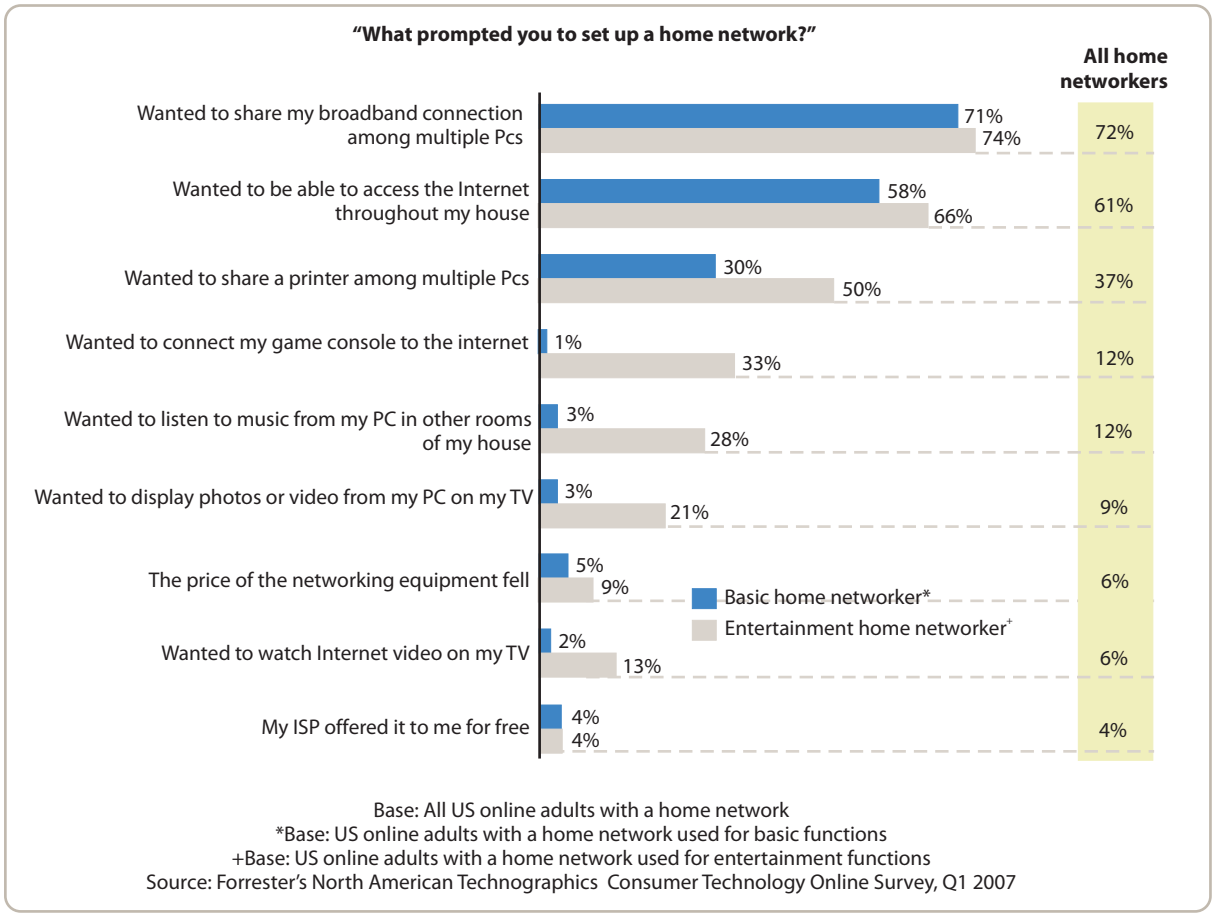

Figure 1. Reasons for Usage of Home Network in US Households

The major areas of a home network include:

- Home Entertainment
  - Interoperability of TV, PC, laptop, set-top box, audio system
- Home Servicing
  - Local information services
  - Everyday information
- Home Communication
  - Pushing photographs from mobile/ PDA to the home server

- Home Management
  - Control of home appliances, lighting, cooling and so on
  - Remote control of appliances using PDAs
- Home Security
  - Intrusion detection, visitor notification, viewing home images
- Community Management
  - Package delivery notification, vehicle arrival notification, common area monitoring

2.4 Manufacturer's Challenges

Consumers can choose from a variety of devices offered by multiple vendors for entertainment or home office. Vendors, however, face the following challenges while designing their products:

- Compliance to standards related to home networking (Example: DLNA)
- Increasing role of software
- Video display and broadcast
- Evolution of standards/ codecs and their adherence
- Implementation challenges
- Interoperability of applications with other vendor's software in home networks (formats, video codecs, content security)
- Interoperability of consumer electronic devices and PDAs (for home monitoring/ control)
- Interoperability and compliance testing
- Network security (inbound/ outbound)
- Shortening product life
- Shortening development cycle
- Increasing development costs

Vendors are collaborating to tackle these challenges. One example of collaboration is development of alliances like DLNA, UPnP forum, HomePNA and DSL forum. One specific example of a collaboration is the alliance between Amazon and TiVo to provide music or movies directly to consumer devices like a music player or TV.

Interoperability Standards and Solutions

The devices and software used in a home network must be interoperable. Therefore, vendors and manufacturers need to conform to a single standard to achieve this. DLNA is that common set of guidelines for a home network. DLNA compliant devices and software are guaranteed to seamlessly integrate with minimal or no configuration. DLNA started as Digital Home Working group in 2003 and was renamed DLNA in 2004. It is led by Promoter Member Companies consisting of AMD, Broadcom, Cisco, Comcast, HP, Intel, IBM, LG, Microsoft, Motorola, Nokia, NXP, Samsung, Sharp, Sony, Texas Instruments and Toshiba.

The DLNA guidelines do not really create a new set of standards, but re-use existing popular standards, namely UPnP (Universal Plug and Play).

3.1 DLNA Guidelines – Enabling Plug and Play

The DLNA organization provides enabling standards for home networks and home server functionality. The goal of the organization is to standardize interaction between devices at home/ small office such that the devices are interoperable and communication (between home devices) is transparent to the user.

The DLNA protocol suite is drawn from PC and Internet standards; they include support for wired Ethernet and wireless LAN, IPv4, UPnP, JPEG, LPCM and MPEG-2 as the baseline image, audio and video formats. Figure 2 illustrates the protocol suite.

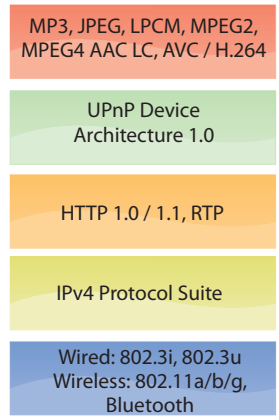

Figure 2: DLNA Guideline Building Blocks

The DLNA guidelines specify three device categories (listed in Table 1).

Home Network Devices Category	Mobile Handheld Devices Category	Home Interoperability Devices Category
Digital Media Server (DMS)	Mobile Digital Media Server (M-DMS)	Mobile Interoperability Unit (MIU)
Digital Media Player (DMP)	Mobile Digital Media Player (M-DMP)	Mobile Network Connectivity Function (M-NCF)
Digital Media Renderer (DMR)	Mobile Digital Media Uploader (M-DMU)	
Digital Media Controller (DMC)	Mobile Digital Media Downloader (M-DMD)	
Digital Media Printer (DMPr)	Mobile Digital Media Controller (M-DMC)	

Table 1: DLNA Device Classes and Categories

Home Network Devices consist of:

- **Digital Media Server (DMS):** a component capable of storing and sourcing media. A DMS may be implemented in a Set-Top Box, Digital Video Recorder or a PC.
- **Digital Media Player (DMP):** can acquire media from a DMS and play it to the user. For example, a TV or a network media player.
- **Digital Media Renderer (DMR):** has the ability to display content to the user. Content is provided to it by another device (in a way, it is a 'passive DMP').
- **Digital Media Controller (DMC):** can initiate activities as a third-party controller. For example: to start a display of media from a DMS to a DMR.
- **Digital Media Printer (DMPr):** is able to print the media sent to it. For example: photo-printer or a normal printer.

Mobile Hand-held Devices category includes devices for server, controller and player, with similar functionality as in the Home Network Devices category. Additionally, the class contains::

- **Mobile Digital Media Uploader (M-DMU):** sends content to the server from a mobile device.
- **Mobile Digital Media Downloader (M-DMD):** receives content from the server to a mobile device.
- **Mobile Network Connectivity Function (M-NCF):** is used to connect the home network with the mobile hand-held device (could be Wi-Fi – 802.11).
- **Media Interoperability Unit (MIU):** required to provide media content format conversions (if required) between home and mobile device classes.

It is evident from the naming convention that DLNA guidelines are targeted specifically to provide interoperability/ connectivity for a home network. Hence, no other application areas are considered.
The DLNA organization uses UPnP standards as a major building block for its guidelines.

3.2 UPnP: Universal Plug and Play

UPnP is a protocol that enables hiding the discovery and control configuration of other devices in the network from the user. UPnP uses peer-to-peer network topology where devices discover each other and use a common mechanism to communicate their status and abilities to each other. The underlying communication mechanism between devices may be of any type that allows exchange of IP packets.

This condition is much broader in scope and may use Ethernet, Wi-Fi, Bluetooth, coax, phone lines, or any other near-field communication/ proximity network.

UPnP is divided into six parts based on functionality—addressing, discovery, description, control, eventing, and presentation. The UPnP protocol aims to provide flexibility in device service offerings and formats used. Re-negotiation and handshake may occur based on the functionality. As the UPnP protocol has been in existence since October 1999, it has gained a good number of member companies and a large number of products.

3.3 Other important Protocols

ZeroConf

ZeroConf or Zero Configuration Networking is a set of protocol suites that enable creation of a usable IP network without configuration or a specific software (DHCP, DNS and service discovery). This allows home users to connect PCs, Laptops, Media Players, Storage Drives, Network Printers and Digital Photo Frames together, and expect them to start communicating automatically.

Features of ZeroConf:

- Uses RFC 3927 (IPv4 link local addressing) enabling peer devices to automatically allocate IP address without use of DHCP server.
- Enables translation between Hostname and IP address without using a DNS server, but the multicast DNS protocol (mDNS). The mDNS protocol allows a network device to choose a domain name in the 'local' namespace and announce it by using multicast to connected devices.
- Allows the use of services such as the printer without a directory server. It uses DNS-Service Discovery (DNS-SD) for this purpose. With this, the peer devices may advertise the services they offer and enquire services available in the network.

Home Phone-line Networking Alliance (HomePNA)

Home Phone-line Networking Alliance (HomePNA) is an alliance of Telecom network service providers and Telecom network manufacturers for home networking. This organization also seeks to establish home networking standards for compatibility between telecom, computer and home entertainment products. The major proposition that HomePNA makes is—utilization of existing telephone wiring across a home for networking devices. This is reflected in HomePNA's slogan—'No new wires'.

Features of HomePNA:

- Computers may be networked as in a LAN using HomePNA certified hub (or RJ11 to RJ45 converter) and existing telephone wiring at home.
- HomePNA certified devices require no new wires, no configuration and provides easy installation.
- Internet access may be shared among devices using the HomePNA certified router.
- It uses a frequency range higher than the range of frequencies used by DSL and voice/ fax calls.
- Co-axial or two-wire interface may be used for HomePNA devices.
- Multiple Television (HDTV), voice and data content streams may be broadcast to all rooms using the telephone line network at home. This results in ideal application for the hotel industry.
- It supports up to 63 devices in the home network (using phone line), with data rates up to 320 Mbps.
- The HomePNA organization seeks to co-work with other home networking organizations like the DLNA and DSL forum so that HomePNA is not isolated..

The future aim of HomePNA organization is to have:

- Transparent Installation.
- Remote diagnostic, management and expedited fixes (allowing operators to manage glitches remotely from their operation center).

3.4 Open Source Projects in Home Networking

Open source projects are being carried out on DLNA, UPnP and ZeroConf. These open source projects provide fledged media servers, device implementations or libraries handling specific components of the standard.

Following is a list of currently known open source projects in a home networking protocol:

DLNA

- **uShare:** UPnP AV v1.0 and DLNA compliant media server. It uses a built-in HTTP server and libupnp. uShare does not provide a UPnP media adaptor (only serves content, but cannot transcode streams to fit client requirements).
- **Libdlna:** aims to be the reference open source implementation of DLNA standards.

UPnP

- **CyberMediaGate:** UPnP audio-video media server implementation of UPnP standards. It is developed using 'Cyberlink' open source package for UPnP development.
- **GMediaServer:** UPnP compliant media server from the GNU organization.
- **GMediaRender:** UPnP compliant media renderer for UNIX (Linux) systems. It provides the software component to render media content (movies, music, images) from a UPnP media server.
- **MediaTomb:** another UPnP compliant media server based on libupnp/pupnp.
- **Libupnp:** provides an API for building control points, devices and bridges that are compliant with UPnP v1.0.
- **Pupnp:** pure Perl based UPnP control point implementation.

ZeroConf

- **Avahi:** open source implementation of ZeroConf. It consists of mDNS, IPv4 link-local (RFC 3927), and DNS-SD protocols.

Conclusion

The home networking domain is expected to expand exponentially. Most consumer electronics, software and PC vendors are therefore jostling to provide devices and solutions for this market. Consumers in the US and Europe are increasingly buying into the home networking story. It is just a matter of time before the rest of the world starts following.

5.1 Need for a Single Standard

The DLNA organization and UPnP forum have gained acceptance with vendors, but it remains to be seen which standard goes on to become the de-facto standard for home networking.

While DLNA is based on UPnP standards, which are a loose set of specifications that are slightly broader in scope, DLNA provides a much stricter specification allowing only a set of transport technologies and formats. DLNA started as an organization of vendors for home and small office products, aiming to provide seamless compatibility between their products. The 'DLNA Certified' product is an assured guarantee for less configuration and perfect integration with other 'DLNA Certified' products in the home or office.

Telecom vendors and operators initiated the HomePNA standard. It focuses primarily on IPTV roll-out and distribution within a home. It also seeks to utilize the existing phone-line network in homes. A disadvantage of HomePNA is that it is based on co-axial or two-wire transport technology (though this is touted as an advantage). Unfortunately, most network devices are based on Ethernet or wireless (Bluetooth or Wi-Fi) network technology. Hence, a HomePNA user has to buy a number of Ethernet converters or bridges to make the existing devices work with two-wire/ co-axial cables.

5.2 Future Roadmap for DLNA

DLNA organization is expanding its scope. It has increased the device classes supported from two to twelve; added new media format profiles, and included Real Time Protocol (RTP) for media streaming. It includes QoS across the entire DLNA network, added support for MPEG-4 video and Bluetooth transport technology.

In future, DLNA is expected to focus on increasing capabilities for mobile devices such as – control of home network, control of media content, and playback. DLNA is also working to enable the consumer's enjoy their home content, when they are on the road. Other features which are being developed in the future DLNA guidelines include playlist synchronisation for consumers from their personal computer to their mobile media player and synchronization of multiple media servers: for example synchronization of home media server with car audio system.

It appears that with new releases of products complying with DLNA every passing day, DLNA is set to become the force behind home networking.

Conclusion:
Consumer electronics vendors are creating devices which connect the internet directly to the TV. Mobile and handheld vendors and service providers are also converging to provide live broadcast on your handheld. The mobile/handheld is also being used as a controller of content at home. These evolutions shall compel manufacturers to standardise the protocol and communication guidelines for devices at home. DLNA is already providing this protocol and communications glue for devices at home. Many vendors have already adopted DLNA guidelines and are releasing products regularly in the market. In the next 5 years, sales of DLNA certified products shall prove the potential of DLNA alliance.

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Acronyms

Abbreviation	Description
AAC	Advanced Audio Coding (specified for MPEG2 and MPEG4)
AC3	Adaptive Transform Coder – 3
ARP	Address Resolution Protocol
ATRAC	Adaptive Transform Acoustic Coding
AV	Audio Video
DHCP	Dynamic Host Configuration Protocol
DLNA	Digital Living Networking Alliance
DNS	Domain Name System
DRM	Digital Rights Management
DTH	Direct to Home
DVD	Digital Video Disc
GIF	Graphics Interchange Format
HD	High Definition
HDTV	High Definition Television
HPNA	Home Phone-line Networking Alliance
HTTP	Hyper Text Transfer Protocol
ICV	Independent Certification Vendor
IETF	Internet Engineering Task Force
IP	Internet Protocol
ITU	International Telecommunication Union
LCD	Liquid Crystal Display
LPCM	Linear Pulse Code Modulation
MP3	MPEG-1 Audio Layer 3
MPEG	Moving Pictures Expert Group
NAS	Network Attached Storage
NTSC	National Television System Committee
PAL	Phase Alternating Line
PDA	Personal Digital Assistant
PNG	Portable Network Graphics
RTP	Real Time Protocol
SSDP	Simple Service Discovery Protocol
TIF	Tagged Image File Format
UPnP	Universal Plug and Play
URL	Universal Resource Locator
VC1	Video Codec evolved from Discrete Cosine Transform. This is an alternative to MPEG-4 AVC from Microsoft.
WMV	Windows Media Video

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