DLNA for HD Video Streaming in Home Networking Environments

With the proliferation of digital content and the expanding variety of connected and IP-enabled consumer electronics (CE) devices, consumers are increasingly seeking ways to efficiently stream high definition (HD) video among their home networking devices. The connected home is on the road to convergence, enabling exciting new applications and easy digital media sharing between CE devices, mobile handsets, set-top boxes (STBs), and personal computers (PCs) that will change the way people interact and share HD video in the next-generation digital home.

This emerging "connected home" ecosystem comprises a variety of connectivity technologies – including Wi-Fi, Ethernet and MoCA – as well as a host of different file formats and incompatible software applications that can lead to consumer confusion. With so many ways to implement the sharing of digital video throughout the home, there are nearly as many ways for users to experience incompatibility and frustration. In order to eliminate this confusion and to enable as seamless a user experience as possible, devices need to interoperate transparently.

The key means for enabling these connectivity technologies to work together is to bring together proven and established network and multimedia standards into a single consistent and reliable framework that serves developers, consumers and service providers alike. To this end, Digital Living Network Alliance (DLNA) has developed robust, technical guidelines defining device classes and networked home use cases which, when built into digital TVs, STBs, Blu-ray players and other devices allow high-quality streaming of multimedia content over wireless and wired connections.

Shortcomings of the Home Network

Today, the home network is primarily used by consumers for a very short list of purposes. For many reasons, the home network fails to provide the universal connectivity and ease-of-use required to facilitate high-bandwidth HD video streaming. As a result, the home network is used in many cases only to share an Internet connection.

Consider the problems consumers face with printer sharing. While consumers could purchase a single printer to service an entire household, the complexity of initially configuring printers and later troubleshooting subsequent networking issues leads many users to connect multiple printers directly to individual PCs and laptops. For digital audio, complexity of setup and lack of universal connectivity makes using independent docking stations a preferred alternative to streaming audio over the home network from a central storage location. If sharing printers and audio wasn't complicated enough for consumers, then sharing digital video, particularly HD video, can present an even more

daunting task. Most video content is stored on a PC or a digital STB. Not only must the PC or STB be turned on to access content, but they could be located in a different room than where consumers wish to sit, relax and watch.

The reality is that sharing digital content including streaming HD video is feasible using today's home networks. Reliable, quality streaming requires a high-bandwidth infrastructure, and many consumers – not just the "prosumers" with large budgets – already have an extensive home network infrastructure comprised of a variety of proven technologies:

Wi-Fi: Wireless networks, running at 802.11n speeds, provide more than enough bandwidth to support Internet data transport in addition to streaming audio and multiple HD video streams.

Ethernet: PCs, laptops and access points all support Ethernet. In addition, higher-end audio and video equipment is beginning to offer Ethernet ports to support reliable wired connectivity. Blu-ray players, for example, will use an Ethernet port to support BD-Live which augments recorded content with additional content available off the Internet.

MoCA: Coax is the connectivity cable of choice for televisions and STBs. Many homes already have an extensive coaxial cable framework that provides high-bandwidth wired connectivity to rooms where users intend to be able to watch video. The MoCA standard exploits this existing infrastructure to bring televisions, STBs and receivers into the home network.

While these technologies enable powerful wired and/or wireless connectivity, connectivity involves so much more than just a physical infrastructure to route data. Across this infrastructure flows a myriad of content, link, transport, management, discovery, control and content protection protocols. In and of themselves, digital pipelines only move data and do little else to directly facilitate the sharing of content between connected devices.

Redefining Seamless Interoperability

With so many protocol and technology choices available, the biggest hurdle preventing consumers from streaming any kind of video or other digital content throughout their homes is incompatibility between devices. Consider the case where a consumer wants to share a short video of her daughter taken on her mobile phone (see Figure 1a). In order to display the video on her widescreen TV, she needs to first email the video to herself. Then, leaving her guests, she must turn on her PC, download the email, then open the video and save it as a file. After hunting for a thumb drive or memory card, she copies the file. Carrying the drive back into the living room, she must plug it into the TV or digital receiver and then use the device's interface to locate the video on the thumb drive or memory card and display it.

In addition to disrupting the conversation that sparked wanting to share the video, this type of content transfer process simply consumes too much time, even when it goes smoothly. As a result, the casual sharing of video on multiple screens is not often thought of as a reasonable option.

This is the value proposition that DLNA offers consumers: seamless and effortless sharing of content. Products designed following the guidelines laid out by DLNA share video in just a single step: streaming a copy of the video wirelessly from the phone to the TV (see Figure 1b). The consumer can even freeze-frame the video using a "remote control" menu on the phone, as well as fast-forward and replay the video.

Simplifying the sharing process means freeing consumers from having to be aware of where and how content is stored. Consumers will no longer view their home network as a chaotic collection of different devices scattered throughout every room in the house that is complex to configure and use. DLNA's vision is that each device has access to all appropriate content, no matter where it resides on the network. It's like every device is a window onto a consumer's entire library of digital content. And when accessing content becomes a matter of seconds rather than minutes, and when it doesn't matter if the video is stored on a phone, hard drive or streaming off the Internet, consumers can effortlessly enjoy their digital content whenever and wherever they please.

DLNA Guidelines

DLNA was formed in 2003 to enable cross-industry convergence of multimedia content in home networks. At its core, its goal is to enable a wired and wireless interoperable home network where digital content in the form of images, music and video can be easily and seamlessly shared across personal computers, consumer electronics and mobile devices.

DLNA achieves this by defining a platform of interoperability guidelines based on open and established industry standards. In addition to defining a manageable framework of standards and protocols, DLNA guidelines also outline several device classes, carefully constructed usage cases for networked homes, and additional functions which enhance the content sharing experience.

There are a total of twelve Device Classes spread across Home Network and Mobile Handheld device categories.. A single multi-functional product may fall under multiple categories. In general, servers acquire, record, store and protect content, as well as source content for players or printers. Renderers playback content from servers after being configured by a controller; renderers cannot configure themselves to find and play content. Uploaders copy content to servers while downloaders copy content from servers. Devices may also bridge and/or transform content between home network and mobile handheld devices.

DLNA guidelines also outline a wide range of practical usage models that effectively capture the ways in which consumers would like to be able to seamlessly manage the acquisition, storage, transfer and playback of all forms of digital content.

Example use cases include:

Send: Transfer video or images captured on a digital camera or mobile phone to a PC
Push: Display video or images captured on a digital camera or mobile phone directly on a TV without having to go through a PC
Find and Play or "Play to…": Use a mobile phone to locate a video or song stored on a PC, external disk drive or network-attached storage (NAS) device and stream or transfer it to a stereo or home theatre for playback
Pull and Print or "Print to…": View a photo stored on a media server on a TV and print it using a networked printer

Using Standards to Simplify Design

DLNA guidelines can be thought of as an umbrella standard that defines how the home network interoperates at all levels. In addition to defining how different standards will interoperate and how data will be handled at each level, it also narrows down the number of standards a device must support. DLNA guidelines define both mandatory and optional standards for each of the different networking layers (see Table 1). Devices must support all mandatory standards to be compliant.

Table 1: DLNA Layer standards
Caption: DLNA guidelines define standards for each of the connectivity layers that devices should support to be compliant.

Layer	Function Defined	Standards
Link Protection	How commercial content is protected on the home network	DTCP/IP
Media Formats	How media content is encoded and identified for interoperability	MPEG2, MPEG4, AVC/H.264, LPCM, MP3, AAC LC, JPEG, XHTML-Print
Media Transport	How media content is transferred	HTTP
Media Management	How media content is identified, managed, and distributed	UPnP AV 1.0, UPnP Print Enhanced 1.0
Discovery and Control	How devices discover and control each other	UPnP Device Architecture 1.0
IP Networking	How wired and wireless devices physically connect and communicate	IPv4 Protocol Suite
Connectivity		Wired: Ethernet 802.3, MoCA Wireless: Wi-Fi 802.11, Wi-Fi Protected Setup

DLNA's focused approach to standards is critical to the cost-effective implementation of content sharing. Rather than bogging down cost and increasing device

complexity by requiring devices to support myriad standards – both in terms of engineering effort and licensing investment – DLNA has defined a small set of mandatory standards that devices must support. This not only simplifies development, it ensures that consumers will be able to share all of their content among all of their devices.

The importance of this last aspect to the effectiveness of DLNA's approach cannot be overestimated. The plethora of formats in which digital media can be downloaded or purchased can leave consumers with content, for example, that can be played back on a portable media device but not a home stereo. For the digital sharing experience to be complete, consumers need to be able to transparently access, transfer and playback content without having to know what format it is encoded in or with which devices it can used.

DRM and Link Protection

Another challenge is posed by Digital Rights Management (DRM) systems. Content providers secure digital media with a variety of DRM mechanisms. DLNA understands the need to prevent sharing of commercial content across devices with different DRM technologies unless there is a robust interoperability mechanism to facilitate the transfer. Given the complexity of implementing DRM interoperability, it will be some time before content providers arrive at an approach on which they all agree. In order to prevent the lack of DRM interoperability from overtly restricting content streaming, DLNA has outlined DLNA Link Protection to protect content in flight between source and display devices. While consumers are currently not able to copy protected content, they will be able to view and enjoy commercial content on devices within the home network.

Flexible Access

An essential aspect of DLNA usage models is allowing consumers not only to access content stored anywhere in the network, but to access it in the most convenient way. Originally the home network was thought to have a PC serving as a centralized controller, and all management of content had to pass through the PC portal. The home network as envisioned by DLNA allows consumers flexible access to content, whether they want to work from a PC, mobile phone, STB or stereo receiver.

The concept of flexible access is key to understanding how consumers will adopt content-sharing technology. Rather than having to replace all of their computer and entertainment equipment at one time to enable content sharing, DLNA's vision of the home network builds up as consumers bring in new receivers, speakers, monitors and players. Any two pieces of equipment can make up a network; e.g. a camera can talk directly to a widescreen TV. In fact, with the pervasiveness of equipment designed to DLNA guidelines – to date, over 5,000 products have been DLNA-certified – many consumers have already begun building their network without knowing. And as they add more pieces over time, their network becomes more powerful.

Connecting equipment to home networks is also becoming simpler through more universal wireless access. Wi-Fi has been an integrated component of DLNA guidelines since its inception with support for 802.11 n/b/g/a, Wi-Fi Multimedia (WMM) QoS and Wi-Fi Protected Setup. Many vendors are choosing to implement Wi-Fi in their products even when target home networks also use a wired infrastructure because of the added flexibility of connecting mobile devices.

Extensive Ecosystem

Enabling the sharing of HD video and other multimedia content across the home requires a firm foundation based on mature and proven standards, compelling consumer benefits, a solid certification program and an extensive ecosystem. DLNA is made up of over 200 members including manufacturers of PCs, consumer electronics, and mobile devices, as well as semiconductor manufacturers, content owners, service providers, retail, and automotive players.

The joint development model of DLNA guidelines also offers significant benefits to manufacturers and consumers compared to more specialized standards that address limited market sectors or applications:

- Joint marketing efforts leverage smaller investments made by a large number of interested vendors to more quickly and effectively educate consumers to the advantages of DLNA-certified products while raising awareness of the existence and value of certification and logo programs. Standards supported by a smaller ecosystem take longer and require more marketing expenditures to achieve critical mass.
- The expansive ecosystem of products available to consumers results in added brand value and extensive product choices.
- Increased choice combined with simplified connectivity gives consumers the confidence to invest in and use their home network for more than just Internet sharing.
- Ongoing development investment supports new applications and value-added functionality.
- The DLNA Marketing Committee continues to raise awareness, understanding and the varying uses of DLNA-certified products.
- The DLNA Certified logo means product differentiation by telling purchasers that the product meets DLNA certification testing requirements. Devices carrying the DLNA Certified logo directly on the product, packaging or product literature have been rigorously tested and validated to interoperate with other DLNA Certified devices.

DLNA continues to expand upon its foundation to offer an ever-richer set of features and functions to ensure a quality multimedia experience for consumers. In addition to introducing a few more media formats, DLNA recently released mechanisms to support menu sharing, scheduled recording services, electronic program guide features and content (photo, video and audio) synchronization. Further ongoing work includes enhancing DRM interoperability, supporting automotive applications, expanding remote

access functionality, and adding new features such parental controls, closed captioning and emergency alert notifications.

DLNA has also expanded its certification program to include “Print to” and “Play to” capabilities which add a controller element to existing server and player models. For example, users are able to use a mobile handheld device to push content from a remote NAS to a printer or digital photo frame in another room.

Streaming HD video throughout the home is no longer just a possibility. The standards and technology required to support high-quality HD video already exist. What has been lacking is a focused approach to achieving interoperability between the myriad devices that can populate a home network. With its robust, technical guidelines, members of DLNA have created a coherent model for the next-generation networked home built on mature standards, proven silicon and a clear understanding of what consumers want out of the content-sharing experience.

For many, the home is the center of family life as well as the center of social life. The ability to “Find, Share and Enjoy” content, whether streamed off the Internet or from a camera, disk drive, PDA or mobile phone, enables consumers to enjoy high-quality video, photos, and music on any device they choose, anywhere they like.

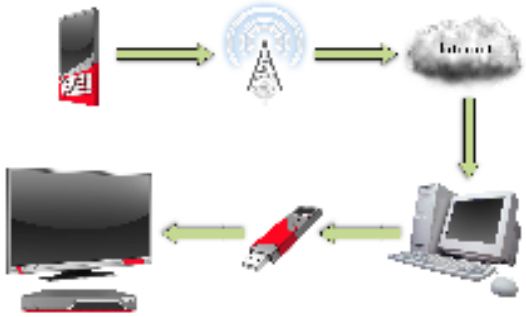

Figure 1a

Figure 1b

Figure 1a) Traditionally, displaying a video or photo from a mobile phone on a TV involves such a tedious and time-consuming process that consumers rarely attempt it.

Figure 1b) The value proposition of DLNA is seamless and effortless sharing of content, enabling consumers to send a copy of a video or photo directly to the TV in a single step.