

Why broadcasters should care about

# Home networking

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**This article describes some important issues relating to home networking. It addresses the issues of interoperability and connectivity of networked devices and then discusses the standardization progress in DLNA, UPnP and DVB. It briefly lists some proprietary home networking solutions and outlines some findings of the German research project, WiMAC@home.**

**Finally, the article provides some guidance to the broadcast community, to ensure that evolving solutions adopted by the market will meet their technical and operational requirements.**

## The importance of home network connectivity

People's homes are becoming a place where members of the family use an increasingly large variety of different media devices. Traditional radio and TV sets are now being complemented by a myriad of gadgets such as iPods, mobile phones, DVD recorders, PCs, gaming consoles, storage devices and many others. All these devices used to be isolated and unaware of each other. Today, however, they are becoming connected through a home network, allowing the users to: share content regardless of where it originated or is stored; control delivery and access; allocate bandwidth ... and integrate new devices automatically.

A home network may use different physical infrastructure but generally users may like to replace their old coax cables with more modern Wireless Local Area Networks (WLAN), Power-Line Communications (PLC) or even Gigabit-Ethernet cabling. Regardless of the physical layer, Internet Protocol (IP) is used for transporting the files and streams. *Fig. 1* depicts a typical home-networking scenario with several content sources and playout devices located in different rooms. Using a simple control device, any content (live TV and pre-recorded video, radio, mp3 music, photos, EPG data, etc) could in principle be reproduced on any device in the home.

In practice however, users may experience tremendous problems with interconnecting the available commercial devices successfully. The reasons are multiple. The most obvious is that many device manufacturers commercialise their own proprietary solutions, which are not interoperable and do not comply with the Universal Plug and Play (UPnP) standard. Broadcast content is particularly disadvantaged, as very few commercially-available television and radio devices today provide IP connec-



Multimedia-over-Coax (MoCA) can be used for existing cables [2]. Although any power-line network that supports IP will generally work with DLNA, it is not yet part of the standard. The higher layers of the DLNA Stack (1.0) make use of IPv4, DTCP-IP, HTTP 1.0/1.1 and UPnP-AV 1.0.

The principal DLNA technology ingredients are given in Table 1.

Version 1.5 of “DLNA Networked Device Interoperability Guidelines” was updated in

October 2006 and introduced mobile devices and Link Layer Security (Fig. 3). The next version, 2.0, is intended to be released in the third quarter of 2009. For these guidelines, support has been announced for some important broadcast features such as electronic programme guide (EPG), AV recording, content synchronization, digital rights management and remote user interface.

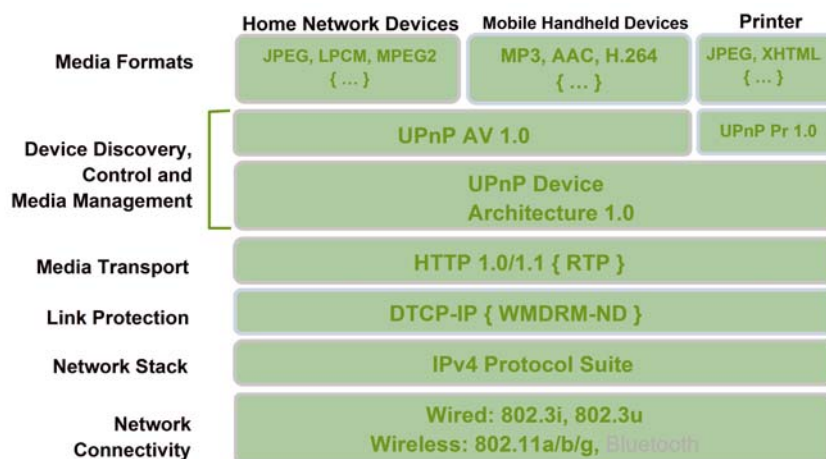


Figure 2  
DLNA device interoperability stack (Source: DLNA)

Table 1  
Principal ingredients of DLNA technology

Functional components	Technology ingredients
Connectivity	Ethernet, 802.11 and Bluetooth
Networking	IPv4 Suite
Device Discovery and Control	UPnP Device Architecture v1.0
Media Management and Control	UPnP AV v1 and UPnP Printer:1
Media Formats	Required and optional format profiles
Media Transport	HTTP (mandatory) and RTP (optional)

To benefit from the interworking of various devices, the DLNA has specified precise use cases for different scenarios. Support for all the technical requirements should be guaranteed by an international product certification programme [3]. During implementation, the compatibility can be verified at Plugfest events and with conformance test tools, offered on the DLNA homepage for members. A lower-level UPnP certification is required in advance of DLNA certification. Test certificates, indicating the functional features of each individual device, can be found in the public area of the DLNA website [4].

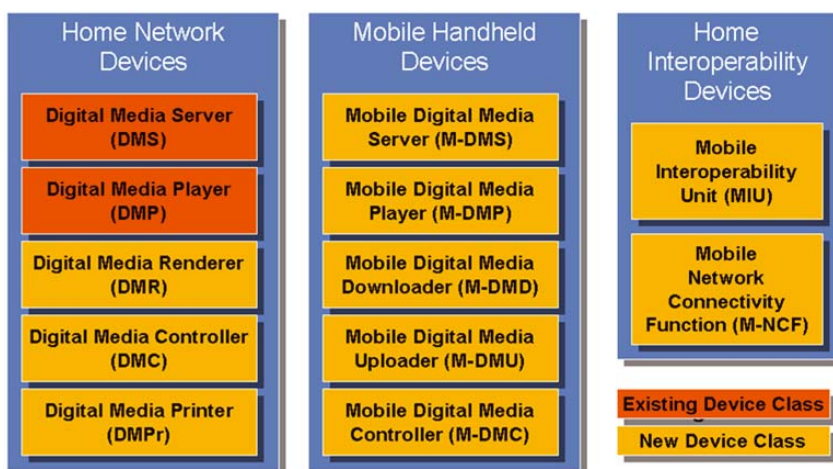


Figure 3  
Device classes in DLNA Expanded Guidelines 1.5, October 2006  
(Source: DLNA)

## Plug-and-Play networking with UPnP

In a heterogeneous home network – where many telecom, mobile, IT and broadcast devices may share audiovisual content and where new devices may come and go at any time – plug-and-play networking, embodied in the UPnP family of standards, is essential. The UPnP-enabled devices are able to communicate with each other, discover any changes in the network (for example, a new device joining the network), describe their features and expose them to the network. UPnP-based home networks are self-configurable and autonomous.

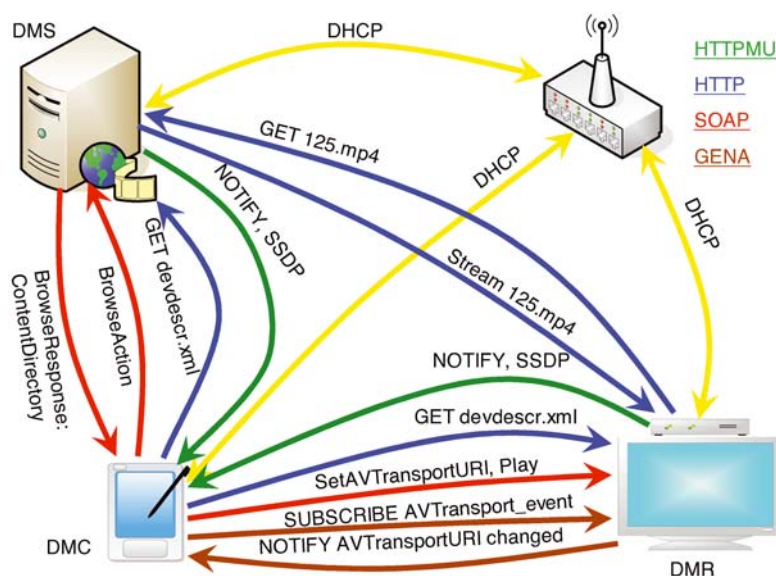
According to UPnP, networked devices are divided into categories and classes. Devices of one particular category are used within one specific usage scenario. For example, there are categories for audio/video, home automation, networking, printers, remote control and scanners. Additional categories are being regularly specified by the UPnP Forum [5].

A device class, on the other hand, represents a dedicated combination of services and functions [6]. It can, for example, be an internet gateway, a media server or lighting control.

With UPnP, the user is able to browse, search and select content and remotely control the network-attached devices. The look-and-feel of a user UPnP interface is vendor-specific and may be applied to all products of a given vendor, regardless of whether local or remote services are accessed on these devices.

The UPnP-AV architecture defines device categories such as Renderer and Server which are operated by a Control Point [7]. The Content Directory Service (CDS) is most important for multimedia devices, as it exposes the physical media of a server to the network in a container structure which can be browsed and searched.

The Media Server, Media Renderer and Control Point can reside in one physical appliance or they can be distributed across the network. It is essential to understand that playback on UPnP devices without DLNA compliance can fail if both do not support the same media formats, although the device capabilities are exchanged prior to the transfer.



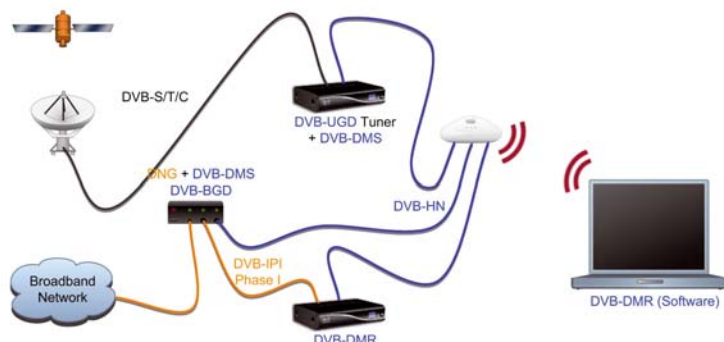
**Figure 4**  
3-Box model in the UPnP-AV architecture, version 0.83  
(Source: University of the Saarland)

If a UPnP-enabled device follows the DLNA guidelines, it is called a “Digital Media Player” (DMP) or “Digital Media Server” (DMS) depending on the supported functionalities (see Fig. 4).

Chip vendors such as SMC (http://www.smc.com), Broadcom (http://www.broadcom.com) and Freescale (http://www.freescale.com) have already developed system-on-a-chip solutions which contain a DLNA stack for integration in CE devices.

## Home networking in DVB

DLNA, mainly dominated by American and Asian corporations, has initially focused only on the exchange of pictures, music and videos. In contrast, the Digital Video Broadcasting (DVB) Consortium has been mainly working on broadcast delivery systems [8]. To achieve a sustainable develop-



**Figure 5**  
**Home Network Reference Model** (Source: University of the Saarland)

segment and the Delivery Network (DN). Both domains are connected via a Delivery Network Gateway (DNG). Each end point in the HN is called a Home Network End Device (HNED).

The DVB-HN Reference Model (see Figs 5) is based on UPnP-AV and defines how typical Radio and TV services, including teletext, subtitles, EPG and recording, can be shared across a Home Network [9]. Some media format- and transport-related requirements were not initially supported by the DLNA Guidelines but have now been successfully introduced into DLNA. In particular, the following DVB requirements have been taken up by DLNA:

- IP multicast RTP/UDP for the transport of DVB-IPTV;
- H.264 video coding in SDTV and 720p/50 for HDTV;
- mapping of DVB-SI, SD&S or BCG and TV-Anytime to UPnP-CDS (Content Directory).

Some requirements are optional in DLNA but are mandatory for DVB, and vice versa. For that reason, a Digital Media Player in DVB (DVB-DMP) has to implement some features differently to a player that fits in with the DLNA requirements (DLNA-DMP). A so-called commercial video player (CVP) profile is an attempt to harmonize both player specifications.

When the Digital Media Server (DMS) concept (Fig. 6) was introduced, there was the possibility of realizing a broadcast receiver by means of the “tuner representation” given in Appendix B of the DLNA Guidelines. Depending on the type of broadcast network, DVB-HN defines two new device classes:

- Unidirectional Gateway Device (DVB-UGD) with a DVB-S/C/T tuner;
- DVB-DMS or a Bidirectional Gateway Device (BGD) which connects to a broadcaster through broadband access.

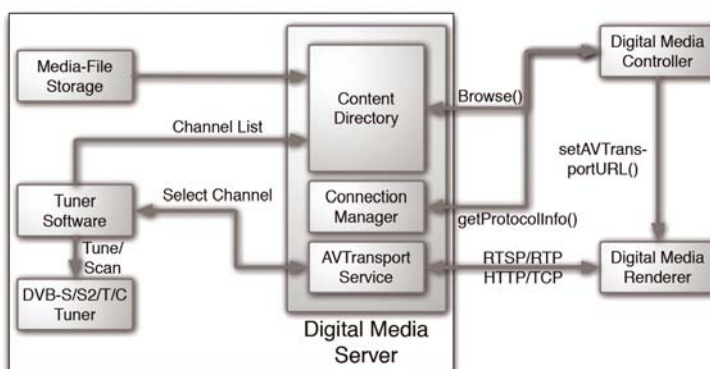
The representation of dynamic contents and their metadata is done through the UPnP-AV Content Directory (CDS) with a mapping of DVB-SI to the CDS container. After a channel search, each Radio and TV service is represented as a CDS item with programme-associated data from SI tables such as BAT, and with SDT or EIT being added as attributes.

Multiple languages or multiple audio tracks can be included as MPEG-2 Programme-Specific Information (PSI) or separately as multiple instances of one video stream. Depending on the number of

ment of networked devices for European markets, the DVB Consortium has liaised with DLNA through the DVB Home Networking Task Force of the IP Infrastructure group under its Technical Module (DVB-TM-IPI/HN).

It is now understood by DLNA that DVB-DLNA system integration may be the key feature for the mass-market success of media-networked devices in the long run.

The DVB specifications distinguish between a Home Network (HN)



**Figure 6**  
**Digital Media Server Architecture** (Source: University of the Saarland)



payment. To this end, device manufacturers should implement the relevant DVB specifications such as CI (v2) and CPCM that are aimed at setting up systems to balance the interests of free-to-air (FTA) and pay-TV providers. In the meantime, the CI-plus Consortium specifies another system separately from DVB.

Technology is in principle available for the secure transfer of multimedia content from the provider to the end-user, independent of the local WPA- or WEP-based network security. For this purpose, Conditional Access (CA) systems such as Nagravision, Betacrypt or NDS Videoguard, which restrict general access, can be combined with Digital Rights Management (DRM) systems such as OMA, FairPlay or Windows Media DRM (WM-DRM). DRM systems can assign dedicated Usage State Information (USI) such as “Copy Once” or “Copy Never” to special content items. Encryption of the media transport link between two devices within the home can be performed by HDCP via HDMI or DTCP via IP. Both systems can also carry some basic USI flags. If the content owners cannot agree on a single system, an intermediate CA/DRM bridge can carry out an authorized translation of USI flags from a Nagravision-encrypted DVB-S transport stream to a secure WM-DRM container on the fly, to be playable on a PC.

Despite a potential re-distribution over the internet, these scenarios are not relevant for some public service broadcasters. For example, the German public service broadcasters ARD and ZDF declared the prohibition of any type of encryption on their content – whether for delivery, storage or connectivity. This demand is reflected in a free-to-air Content Management Descriptor which signals a “Do not scramble” bit to the receiver. However the users might not understand why they can stream the time-shifted broadcasts of ARD and ZDF from the living room to the bedroom while the same procedure does not work with content from German Pay-TV services.

Therefore it seems that a key to the adoption of IP interfaces in set-top boxes or integrated television sets (iDTVs, IRDs) for the mass market is to be found in the settlement of expectations around intellectual property rights (IPR), especially for movies and TV productions.

## Products on the market

UPnP- and DLNA-enabled home-networked devices are becoming increasingly available commercially. Many routers and residential gateways can already be controlled by simple UPnP commands. Most operating systems like Windows and Linux are enabled to support the UPnP protocol. The exception is Apple which stays with its own protocol, *Bonjour*. This restricts Apple networking to devices which support the iTunes platform and Apple web services. Although some third-party suppliers offer iTunes-compatible media sharing with their devices, the client will always have to be an Apple product (e.g. an iPod, iPhone or Airport Express). Nevertheless, Apple seems to “tolerate” Elgato (<http://www.elgato.com>), a third-party UPnP software supplier whose applications are used on the iPhone.

In contrast to the Apple Media Centre Front Row and the “iPod for TV” (aka Apple-TV), some Microsoft editions of Windows come with native broadcast support. Even though Microsoft requires Windows Media Centre (XP/Vista Media Centre, MCE/VMC) as the host operating system to be remotely connected to their Extender (MCX), the next version of Windows (i.e. Windows 7) was announced to be DLNA-certified [13]. An additional Windows logo programme should make some more optional DLNA features mandatory. The latest public preview of Windows 7 beta [14] already comes with a UPnP Control Point in Windows Media Player and a partially implemented DMP in Windows Media Centre.

It can be expected that support for UPnP-AV in Windows Media Player and Windows Media Centre (in Windows 7) will enable the streaming of free-to-air recordings to various CE devices such as the PS3 or Loewe Connect. Microsoft will have to implement an on-the-fly transcoding from their new proprietary container (.wtv) to a DLNA-compatible MPEG-2 single-programme transport stream (SPTS) or a programme stream (PS).

The dLAN TV SAT system from Devolo (<http://www.devolo.com>), for example, bridges DVB-S signals for in-house distribution over PLC/IP. Another approach is offered by Reel Multimedia with their live streaming-enabled NetCeiver (<http://www.reel-multimedia.com/en/dokumente/netceiver/NetCeiver.pdf>), which resides in an enhanced set-top box, and an additional NetClient which is functionally quite similar to Microsoft's Media Centre / Extender technology.

Both the popular DreamBox and the open-source video recorder software LinVDR for Linux are able to stream a single programme to a PC. Experienced users can upgrade the missing UPnP support to these open-source operating systems. UPnP streaming clients with an integrated Renderer and Control Point came along with Loewe Connect HD, Playstation 3, Xbox 360, some Blu-Ray disc players, a few set-top boxes and several streaming clients (digital media adapters), such as Popcorn Hour which is based on the Sigma 8635 chip. In some multi-radio appliances such as the Pure Evoke Flow, with WLAN/DAB and FM capabilities, UPnP support is added to the radio chipset by means of a so-called media player mode.

UPnP-AV servers are integrated in many Network Attached Storage (NAS) devices such as those from Buffalo and QNAP, in routers such as Fritz!Box or from Netgear, and in Windows Media Player, Windows Home Server and even Eye Connect on the Mac. Third-party Media Centre applications such as Myth-TV for Linux or MediaPortal, Sage-TV and TV-Central for Windows provide basic networking support in combination with Radio / TV recording.

The system architecture in the next release of MediaPortal, v2, is said to use UPnP-AV as a networking middleware [15]. The free Media Centre client, Xbox Media Centre (XBMC) also supports UPnP-AV and is now available for Windows, Linux and Mac.

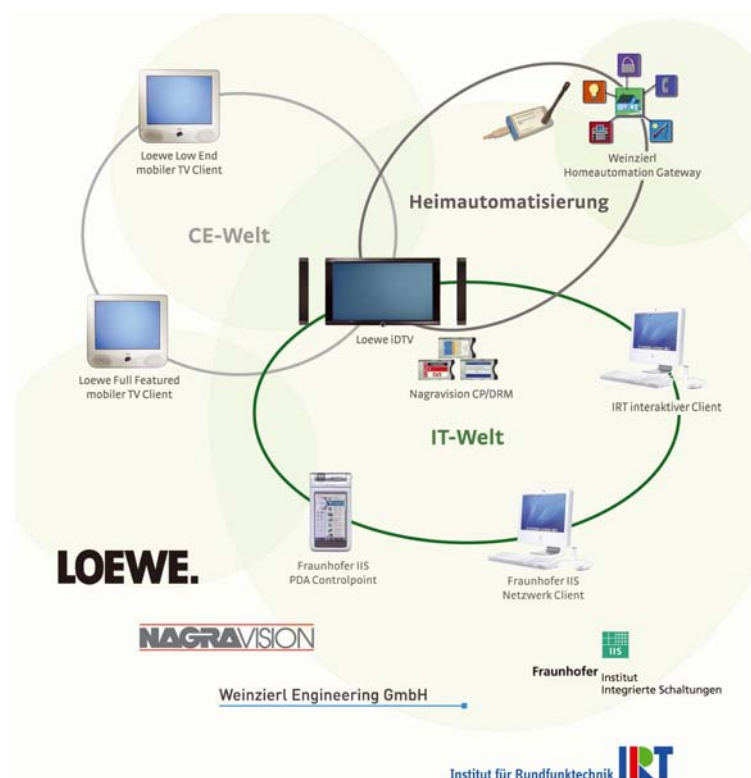
## Abbreviations

<b>BAT</b>	(DVB) Bouquet Association Table	<b>HDCP</b>	High-bandwidth Digital Content Protection
<b>BCG</b>	(DVB) Broadband Content Guide	<b>HDMI</b>	High-Definition Multimedia Interface
<b>CA</b>	Conditional Access	<b>HTTP</b>	HyperText Transfer Protocol
<b>CDS</b>	Content Directory Service	<b>iDTV</b>	Integrated Digital (or Decoder) TeleVision
<b>CE</b>	Consumer Electronics	<b>IP</b>	Internet Protocol
<b>CI</b>	Common Interface	<b>IPR</b>	Intellectual Property Rights
<b>CPCM</b>	(DVB) Content Protection and Copy Management	<b>IRD</b>	Integrated Receiver/Decoder
<b>CRT</b>	Cathode Ray Tube	<b>IT</b>	Information Technology
<b>CVP</b>	(DVB) Commercial Video Player profile	<b>LAN</b>	Local Area Network
<b>DAB</b>	Digital Audio Broadcasting (Eureka-147) <a href="http://www.worlddab.org/">http://www.worlddab.org/</a>	<b>MHP</b>	(DVB) Multimedia Home Platform
<b>DCP</b>	Device Control Protocol	<b>MoCA</b>	Multimedia over CoAx
<b>DLNA</b>	Digital Living Network Alliance <a href="http://www.dlna.org/home">http://www.dlna.org/home</a>	<b>NAS</b>	Network-Attached Storage
<b>DMP</b>	Digital Media Player	<b>OMA</b>	Open Mobile Alliance <a href="http://www.openmobilealliance.org/">http://www.openmobilealliance.org/</a>
<b>DMS</b>	Digital Media Server	<b>PLC</b>	Power-Line Communication, also written PLT, BPL ...
<b>DRM</b>	Digital Rights Management	<b>RTP</b>	Real-time Transport Protocol
<b>DTCP</b>	Digital Transmission Copy Protection	<b>SD&amp;S</b>	(DVB) Service Discovery & Selection
<b>DVB</b>	Digital Video Broadcasting <a href="http://www.dvb.org/">http://www.dvb.org/</a>	<b>SDT</b>	(DVB) Service Description Table
<b>DVB-S</b>	DVB - Satellite	<b>SOAP</b>	Simple Object Access Protocol
<b>EIT</b>	(DVB) Event Information Table	<b>SPTS</b>	Single Programme Transport Stream
<b>IEEE</b>	Institute of Electrical and Electronics Engineers (USA) <a href="http://www.ieee.org">http://www.ieee.org</a>	<b>SSDP</b>	Simple Service Discovery Protocol
<b>EPG</b>	Electronic Programme Guide	<b>UPnP</b>	Universal Plug 'n' Play <a href="http://www.upnp.org/default.asp">http://www.upnp.org/default.asp</a>
		<b>USI</b>	Usage State Information
		<b>WLAN</b>	Wireless Local Area Network
		<b>WPA</b>	Wi-Fi Protected Access

## Research on home networking

WiMAC@home [10] was finalised in March 2009. The project was partially funded by the German Federal Ministry of Economics and Technology within the initiative “Next Generation Media”. The consortium – consisting of Loewe, Fraunhofer-IIS, the IRT, Nagravision and Weinzierl Engineering – went a decisive step beyond the current state-of-the-art. In this project, a new iDTV was developed that can be used for archiving broadcasts, videos and photos, and for sharing them over a local wireless network.

Additionally, live TV services and premium Pay-TV content can be accessed securely across the network. DVB signals are exchanged with UPnP-AV-compliant devices following the guidelines of the DLNA. TH-Show can even follow the user automatically, using a UPnP-based context-awareness server, in combination with WLAN localization of devices.



**Figure 8**  
Interoperability in the CE and IT domains including home automation (Source: WiMAC@home)

Home Automation for building services, such as the control of shutters, lighting and heating, are other key aspects of the project. Every device shall be usable within the network, regardless if connected via WLAN, Powerline, Ethernet, Konnex<sup>1</sup> or DigitalSTROM<sup>2</sup>. Even interactive services can be shared through the network, when applications and programme-associated data within a DVB Transport Stream are exchanged from the Loewe iDTV Server to the portable IRT client using UPnP [16].

Other CE projects from the German NGM initiative, such as Homeplane and SerCHo, expand the functionalities developed in WiMAC@home, in terms of QoS optimization and deployment of home-centric services. WiMAC@home ended by staging a large Symposium for the public, including a demonstration of the system, at the IRT on 31 March 2009 [17].

## Conclusions – what should broadcasters do?

This article shows that home networks have become an important means for delivering audiovisual content to multimedia, computer and broadcast terminal devices in the home. Their impact on the delivery of radio and television broadcasts to the general public will undoubtedly grow in the future. While several proprietary products are currently available in the consumer market, many manufacturers have already started to commercialize open-standard, interoperable and user-friendly UPnP and DLNA consumer electronic appliances. These are all very cheap and affordable, so that the market will be able to evolve quickly. DVB-HN-compatible CE devices will follow shortly. Only new IP-enabled iDTVs or set-top boxes can make home networking a success in the mass market place.

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**Martin Schmalohr** graduated in 1996 from the University of Applied Sciences in Munich with a degree in Electrical Engineering. He joined the Audio Systems group at the IRT in 1998, focussing on the subjective evaluation of audio and video coding systems. He is/was involved in the work of the European IST/ICT research projects P2P-Next, kuMobile, Savant, GMF4iTV and Sambits.

Since 2005, Mr Schmalohr has been leading the IRT activities within the national collaborative research project WiMAC@home (Wireless Media and Control at Home). He is also involved in the work of EBU, DVB and DLNA technical groups. In 2008, he became chairman of the EBU group D/CH (Connected Home) and, in 2009, he joined the IRT department "Platforms for Broadcast Systems".

**Franz Kozamernik** graduated from the Faculty of Electrotechnical Engineering, University of Ljubljana, Slovenia, in 1972.

He started his professional career as an R&D engineer at Radio-Television Slovenia. Since 1985, he has been with the EBU Technical Department and has been involved in a variety of engineering activities covering satellite broadcasting, frequency spectrum planning, digital audio broadcasting, audio source coding and the RF aspects of various audio and video broadcasting system developments, such as Digital Video Broadcasting (DVB) and Digital Audio Broadcasting (DAB).

During his years at the EBU, Mr Kozamernik has coordinated the Internet-related technical studies carried out by B/BMW (Broadcast of Multimedia on the Web) and contributed technical studies to the I/OLS (On-Line Services) Group. Currently, he is the coordinator of several EBU R&D project groups including B/AIM (Audio in Multimedia), B/VIM (Video in Multimedia) and B/SYN (Synergies of Broadcast and Telecom Systems and Services). He also coordinates EBU Focus Groups on Broadband Television (B/BTV) and MultiChannel Audio Transmission (B/MCAT). Franz Kozamernik has represented the EBU in several collaborative projects and international bodies, and has contributed a large number of articles to the technical press and presented several papers at international conferences.



With the growing availability of broadband connections and bundled residential gateways or routers, many users already own a private home network (even though they might not even be aware of it).

There are several issues that need to be resolved in order to roll out home networks successfully. Stable firmware embedded in the home devices and easy-to-use handling of these complex devices may still be an issue. Content security issues are still not resolved and may adversely affect the users' acceptance of networked devices.

Like HDMI and HDCP today, DLNA and network interfaces might be the next criteria for consumer electronic purchases of tomorrow – especially when it comes to the replacement of old CRTs with new multifunctional flat displays. In the homes of tomorrow, services will be accessed through a residential IP network, regardless of their physical connection – whether it is by means of telephony, webcasting, mail, web or television.

Broadcasters should continue working actively in the various standardization bodies including DVB, DLNA and UPnP in order to assure that the broadcast requirements are duly met. The EBU Project Group D/CH (Connected Home), chaired by Martin Schmalohr (IRT), has already contributed significantly to these processes. The Group is in the process of developing a test bed in order to test QoS, latency, synchronizations and other technical parameters that are critical for the high-quality performance of home networks. The group has also contributed to the latest D/HDREC (HD Receiver) specification in terms of home networking.

Broadcasters should try to impact the market development. We should encourage the CE and IT industries to integrate open-standard, interoperable, horizontal market solutions, as opposed to the multiple proprietary solutions that are currently available in the market. Any home-networking technical solutions, in order to be future proof and acceptable to all actors in the value chain, must guarantee technical quality and content security.

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