Technology Reports

Technology for Linking Mobile Terminals and Home Networks, and Prototype of Home Gateway Equipment

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A new service has been implemented linking mobile terminals with home networks comprised of PCs and information appliances that comply with DLNA guidelines. By using prototype of home gateway, the service enables secure access from outside the home, as well as the remote viewing and listening of content.

1. Introduction

The demand for sharing digital content (images, music and video) for enjoyment and relaxation within the home, independent of location and device, is gradually increasing, as is the number of compatible products increases in the market. Many such products and equipment comply with guidelines formulated by the Digital Living Network Alliance (DLNA). New technologies are now being investigated to facilitate the development of new services in which mobile terminals play a part of a home network, taking advantage of the progress being made in the development of information appliances.

The investigation of technology for linking mobile terminals and home networks is being focused on the technology that links the inside and outside of the home according to DLNA guidelines. These guidelines are expected to facilitate development and expansion in this area of technology in the future.

In terms of links within the home, the major home-use scenarios for DLNA-compatible mobile terminals were investigated to verify the applicability and utility of such mobile termi-

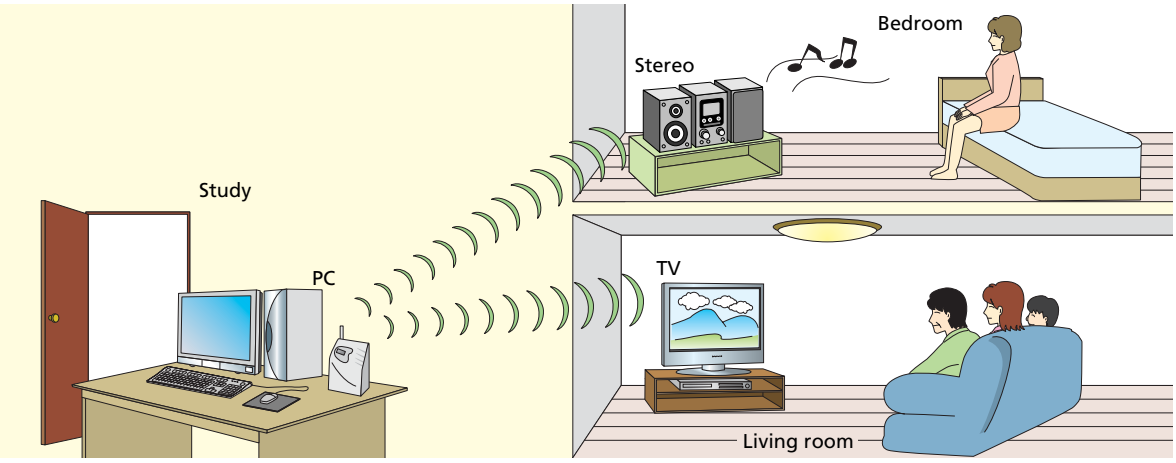

Figure 1 Example of scenario for playing content within DLNA guidelines

nals. For links outside the home, a prototype home gateway (hereinafter referred to as a 'mobile GateWay (GW)') was manufactured for mobile terminals to enable the remote viewing and listening of content in the home. Moreover, the issues associated with the technology required, as well as the methodology for its implementation, were investigated.

This article provides an overview of the DLNA, followed by a description of work underway on technology for linking both inside and outside the home.

2. Overview of DLNA

The DLNA is an industry organization consisting of the major manufacturers of information appliances, PCs and mobile terminals. It was initially established as the Digital Home Working Group (DHWG) in October 2003, and subsequently renamed DLNA in October 2004. As of September 2006, the organization includes more than 300 member companies, one being DoCoMo as a member of NTT Group. The DLNA is focused on the seamless sharing of digital content (images, music and video) between PCs, information appliances, and mobile devices, and currently engaged in investigating the scenarios of use, formulating guidelines, and the certification of logos.

Figure 1 shows an example of a possible scenario in compliance with DLNA guidelines. The PC in the study, TV in the living room, and stereo system in the second-floor bedroom are all DLNA-compatible devices connected to a home network. The PC stores videos and music files, of which videos are played back on the TV in the living room, and music is played on the stereo in the bedroom through this network.

2.1 DLNA Guidelines

DLNA guidelines have been formulated to ensure the interconnection of compatible products. These guidelines adopt widely used existing standards and general-purpose protocols to ensure ready compatibility with products. v1.0 [1] of the DLNA guidelines was formulated in October 2004. The scope of these guidelines was widened to cover mobile devices in the expanded edition [2] (hereinafter referred to as the 'expanded guidelines') formulated in March 2006.

Guidelines are formulated after investigation in accordance with the framework shown in **Table 1**, with mandatory requirements, recommendations, and options being specified.

2.2 Device Categories and Classes

DLNA-compatible devices are currently classified into two device categories and ten device classes (**Table 2**). The Home Network Device (HND)[*1] and Mobile Handheld Device (MHD)[*2] differ in terms of whether the mandatory requirements for mobile devices specified under Networking and

*1 HND: A device category covering fixed DLNA-compatible devices.
*2 MHD: A device category covering mobile DLNA-compatible devices.

Table 1 Framework for formulation of DLNA guidelines

Media Format	• Define the content format to establish ease of interconnection. • JPEG, LPCM, and MPEG-2, and JPEG with HND, MP3, and MPEG4-AVC with MND are specified as essential requirements for images, music, and video.
Media Transport	• Define the method for controlling the transmission and playing of content. • HTTP and RTP specified for the control of transmission and playing of content.
Media Management	• Define the method for the searching, selection, and management of content. • CDS is specified for acquisition of the content list and metadata.
Device Discovery and Control	• Define the method of detection and controlling of devices on a network. • SSDP is specified for device detection, GENA for sending and receiving device data, and SOAP for exchanging data between devices.
Networking and Connectivity	• Define the means of physical connection between devices, and the basic protocols. • Ethernet, 802.11a/b/g, etc. are specified as the means of cable and wireless connection, and IPv4, TCP, and UDP as the network protocols.

UDP (User Datagram Protocol): A transport layer protocol.
JPEG (Joint Photographic Experts Group): A method of encoding static image data.
LPCM (Linear Pulse Code Modulation): A method of converting analog signals (such as voice) to digital signals.
MP3 (MPEG Audio Layer-3): An audio compression technology specified in MPEG-1.
MPEG (Moving Picture Experts Group): A method of encoding video image data.
MPEG4-AVC (H.264/MPEG-4 AVC, MPEG-4 Part 10 Advanced Video Coding): A standard recommended by ISO as part of the MPEG-4 dynamic image compression standard.
RTP (Real-time Transport Protocol): A communications protocol used for the real-time distribution of audio and video streaming data.

Connectivity and Media Format elements shown in Table 1 are supported. The sharing of content is therefore possible when mandatory requirements, recommendations, and options for the physical layer and content format are the same for the various devices belonging to the HND and MHD categories.

Table 2 Device categories and classes

	Device category		Functions
	HND	MHD	
Device class	DMP	M-DMP	A device selecting and displaying content stored on a server.
	DMS	M-DMS	A device storing content.
	DMR	–	A device displaying content stored on a server.
	DMC	M-DMC	A device controlling selection and playing of content between a server and renderer.
	DMPr	–	A device printing content stored on a server.
	–	M-DMU	A device uploading content to a server.
	–	M-DMD	A device downloading content from a server.

DMC/M-DMC: (Mobile-) Digital Media Controller
DMPr: Digital Media Printer
DMR: Digital Media Renderer
DMS/M-DMS: (Mobile-) Digital Media Server
M-DMD: Mobile Digital Media Downloader
M-DMU: Mobile Digital Media Uploader

2.3 Sequence for Playing Content

Figure 2 shows the sequence up to playing a video stored on the PC (server) on the TV (player) in the scenario shown in Fig. 1. This assumes that the PC power has been switched ON, and that IP addresses are allocated automatically for the PC and TV by using Dynamic Host Configuration Protocol (DHCP)[*3].

After the TV power is switched ON, the Simple Service Discovery Protocol (SSDP)[*4] M-SEARCH signal is sent (Fig. 2 (1)) and a response received from the PC (Fig. 2 (2)). The TV then acquires device information from the PC (Fig. 2 (3) and (4)),sends a request for a report on changes in server power ON/OFF status with the General Event Notification Architecture (GENA)[*5] SUBSCRIBE signal (Fig. 2 (5) and (6)), and receives a notification of status with the NOTIFY signal (Fig. 2 (7) and (8)). Subsequently, the user searches for desired content and selects the necessary folders, then the search result and content list are displayed in accordance with Simple Object Access Protocol (SOAP)[*6] and Content Directory Service (CDS)[*7] (Fig. 2 (9) and (10)). After the video is selected, data is

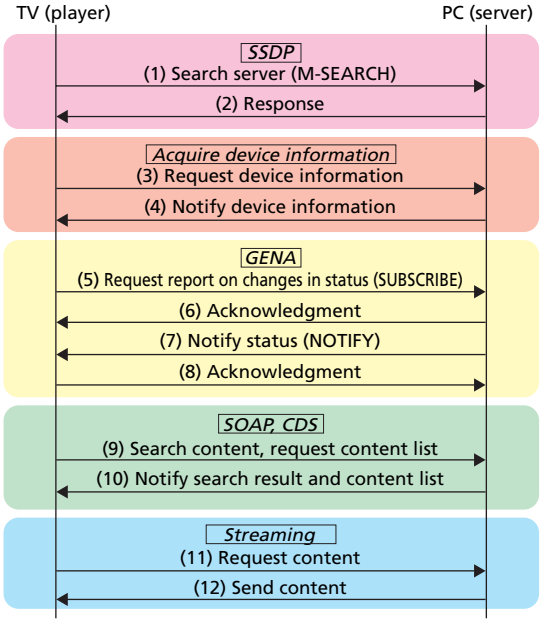

Figure 2 Sequence of playing content within DLNA guidelines

*3 DHCP: A protocol used for automatically allocating information (e.g., IP addresses) to computers connected to networks.
*4 SSDP: A protocol used for discovering devices on networks.
*5 GENA: A protocol used for the notification of events (e.g., changes in device status).
*6 SOAP: A protocol used for data exchange between devices.

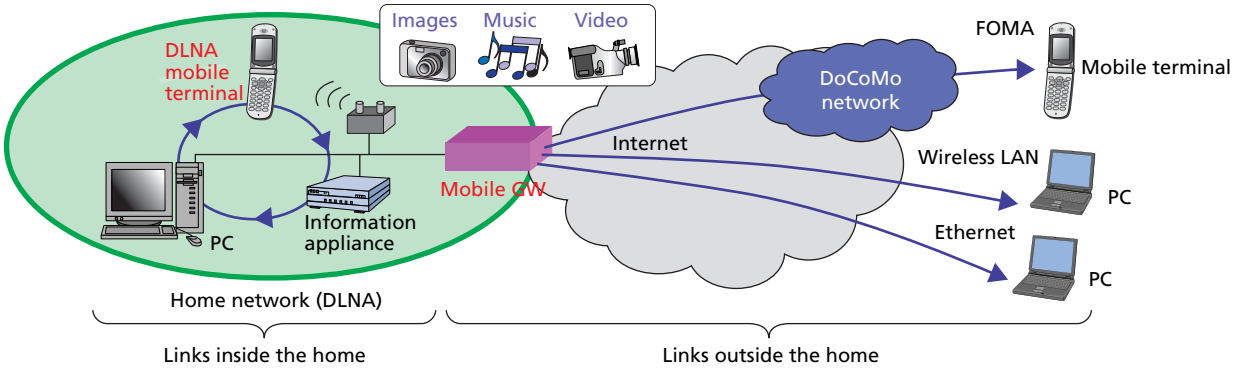

Figure 3 Two investigating areas for links inside and outside the home

streamed between the TV and PC for the playing of content (Fig. 2 (11) and (12)).

3. Investigation of DLNA Mobile Use

DLNA guidelines permit the sharing of content on home networks, and many PCs and information appliances compatible with V1.0 of the guidelines are already commercially available, though mobile devices compatible with the expanded guidelines have yet to be released. Possible scenarios for the use of mobile devices in remote access from outside the home have been proposed as subjects of future investigation, but related guidelines have yet to be formulated.

Given the situation above, the linking of mobile terminals with DLNA-compatible devices in a home network is to be investigated in terms of links inside and outside the home (**Figure 3**). Both types of links are described below.

3.1 Links Inside the Home

In order to verify the possibility and utility of mobile use under the expanded guidelines on links inside the home, representative scenarios in which DLNA mobile terminals that support functions under the expanded guidelines are connected to DLNA-compatible devices were investigated, and are described below.

1) Scenarios

Figure 4 shows the DLNA mobile terminal scenarios. When used as a player, the DLNA mobile terminal searches the server and selects content via a wireless LAN, and then plays

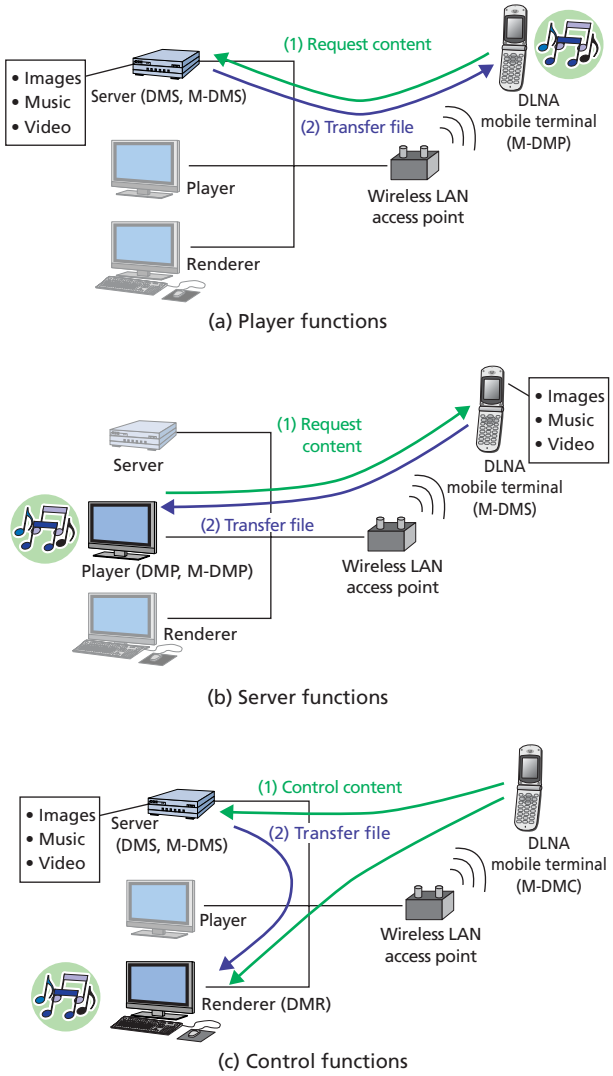

Figure 4 Use scenarios

*7 CDS: Rules related to the searching of content and displaying of lists.

Table 3 DLNA mobile terminal specifications

Dimensions (H × W × D)		102 × 49 × 18.3 mm
LCD		2.4 inch (approx.) TFT LCD
Mass		115 g (approx.)
Wireless LAN	Standard	IEEE802.11b/g
	Security	64-bit/128-bit WEP
DLNA player functions	Video codec	MPEG-4
	Audio codec	G.726
	Video file format	ASF
	Number of pixels	320 × 240 pixels
DLNA server functions	File format	JPEG
	Maximum number of pixels	1600 × 1200 pixels

ASF: Advanced Streaming Format
WEP: Wired Equivalent Privacy

back music and video stored on the server (Fig. 4 (a)). When used as a server, photos and videos taken and stored by the DLNA mobile terminal are played back on the TV (Fig. 4 (b)). When used as a controller, the DLNA mobile terminal is operated to display content stored on the server on a renderer[*8] (Fig. 4 (c)).

2) Evaluation Results

A DLNA mobile terminal satisfying the specifications shown in **Table 3**, a commercially available player device, and a PC supporting the server and rendering functions were used to investigate operation in the scenarios above. As a DLNA mobile terminal, the P902i equipped with a wireless LAN module and supporting DLNA middleware compatible with the expanded guidelines and application functions was used. This was of equivalent size and weight to the P902i [3]. **Photo 1** shows the menu screen of the DLNA mobile terminal.

The results of investigating the 3 scenarios with the device configuration shown in Fig. 4 are described below.

1) Player Function

Video files stored on the server, sent by HTTP, and encoded at a maximum rate of 100 kbit/s to 1 Mbit/s were displayed smoothly on the DLNA mobile terminal without any image deterioration or breakup.

2) Server Function

Photos taken on the DLNA mobile terminal and stored at a resolution of 640 × 480 to 1600 × 1200 pixels were displayed on the player within approximately the same time (a few seconds) as when the PC was used as a server.

*This function is provided only in Japanese at present.

Photo 1 Menu screen of DLNA mobile terminal

3) Controller Functions

In addition to the playback of music and video on the server with the renderer, the response to repeated pause and playback without delay was verified.

The investigation above verified that sufficient performance in these scenarios is provided by the DLNA mobile terminal based on the P902i, and that a mobile terminal can be handled as a device on a home network.

3.2 Links Outside the Home

In relation to links outside the home, an evaluation was conducted in terms of a technical investigation and prototype of a mobile GW for the remote playback of content stored on DLNA-compatible devices on a home network from mobile devices not specified under the DLNA guidelines. The required conditions, technical issues, and methods used for resolution associated with the prototype of the mobile GW are described below.

1) Required Conditions and Technical Issues

Conditions a), b), and c) below must be satisfied, and technical questions d) and e) resolved in order to implement links between DLNA-compatible devices inside the home and existing mobile terminals outside the home.

a) Establishment of Communications Security

Security is necessary to prevent the interception of commu-

*8 Renderer: A device that displays content. Differs from a player in that it does not support a user interface for the selection or playback of content.

nications, impersonation, or alterations to communications by a third party on the connection path.

b) Access Control Function

Since there are cases in which desired or permitted content differs for each individual when displaying multiple types of content stored on one or more servers on the home network, the display of content in the content list must be controlled.

c) Filtering Function

A number of options are necessary for selecting mobile devices (such as mobile terminals and PCs). However, each device supports a different use environment, including media format, file size, screen display size, and means of communication, and such changes to the home network as adding or deleting content stored on a DLNA-compatible device are possible. Therefore, efficient display in response to these different conditions is necessary.

d) Protocol Conversion Function

Information regarding the detection of devices on the network, as well as the selection and management of content for DLNA-compatible devices is sent and received in accordance with the DLNA framework. At the same time, since only Internet access with Hyper Text Transfer Protocol (HTTP) is possible with existing mobile terminals, connection with DLNA-compatible devices from outside the home requires protocol conversion.

e) Status Notification Function

DLNA-compatible devices on a home network support a function for the notification of changes in status, such as power ON/OFF status and the addition/deletion of content. The ability to understand device status is necessary regardless of whether a mobile device outside the home is communicating with the home network or not.

Introduction of the mobile GW was investigated as a means of satisfying these requirements.

2) Mobile GW System Configuration

Photo 2 shows the mobile GW; **Figure 5** shows the system configuration. Methods of resolving items a) to e) above as applied to the mobile GW and related processing are described below.

a) Communications Security

Secure Sockets Layer (SSL)[*9] client authentication with FirstPass and encrypted communications have been adopted for communications security for the mobile GW upon connection from a mobile device. When a connection request is transmitted to the HTTP server from the browser on a mobile device outside the home, the SSL client authentication module is called, the mobile device is authenticated by FirstPass (SSL client authentication), and communications are encrypted (Fig. 5 (1) and (2)), thus providing a high level of security with individual authentication.

Photo 2 Mobile GW

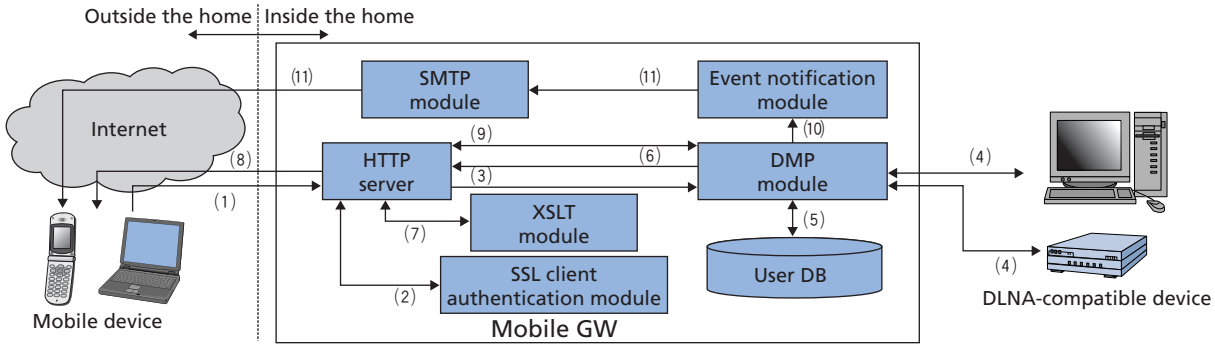

Figure 5 Mobile GW system configuration

*9 SSL: A communication security protocol used for encryption of communications and detection of data tampering in communications between clients and servers (mainly on the Internet).

b) Access Control Function

In the mobile GW, the user accessing the system can be identified in the SSL client authentication process with FirstPass. Therefore, by setting accessible 'DLNA-compatible devices,' 'folders' and 'extensions' for each user, the access control function is implemented, so as to the optimum content list is displayed for each user.

In the mobile GW, Digital Media Player (DMP) module issues, upon receiving requests from the HTTP server, acquisition request for the content and content list which is comprised of content, folder names and their URL that are stored in the DLNA-compatible device, and obtains response (Fig. 5 (3) and (4)). DMP module then refers to the access control list in the User DB (Fig. 5 (5)) returns an optimized eXtensible Markup Language (XML)[*10] data to the HTTP server (Fig. 5 (6)).

c) Filtering Function

Any mobile device such as mobile terminals, PCs, etc., can be connected to the mobile GW as long as it supports SSL client authentication with FirstPass. The mobile GW acquires identification of the type of mobile device and provides a dynamic display of the optimum content list, providing the user with content that is selected according to the type of his/her mobile device as well as to the content stored on the DLNA-compatible device without the user being aware of such adjustment.

The filtering function in the mobile GW involves HTTP server sending the obtained XML data and the User-Agent in the HTTP request from the mobile device to the XSL Transformations (XSLT)[*11] module, with the processing result for the appropriate device type returned to the mobile device (Fig. 5 (7) and (8)). Filtering rules, such as those regarding the media format supported by the mobile device and maximum available file size, are preset in the XSLT module, and the XSLT stylesheet necessary for processing XML data is used to dynamically create HTML data.

d) Protocol Conversion Function

In the mobile GW, protocols used between the HTTP server and the DMP and XSLT modules are converted to ensure that the mobile devices can communicate under the DLNA framework used between DLNA-compatible devices via Internet access using its browser (Fig. 5 (7) and (9)).

(a) Mobile terminal screen (b) PC monitor

*This function is provided only in Japanese at present.

Photo 3 Results of verifying the filtering function

e) Status Notification Function

The DMP module reports DLNA-compatible device information to the event notification module based on GENA protocol (Fig. 5 (10)), and sends an email to the preset address of the mobile device through the Simple Mail Transfer Protocol (SMTP) module (Fig. 5 (11)). Email is sent in the following cases:

- When power of the DLNA-compatible device is switched ON or OFF
- When content is added or deleted in the DLNA-compatible device

3) Verification Results

Photo 3 shows the results of verifying the filtering function used between a DLNA-compatible PC on a home network using the mobile GW, and mobile devices outside the home (mobile terminal and PC). Since both mobile terminal and PC communications are encrypted, the SSL icon appears on the mobile terminal and the key symbol on the PC to verify that the connection is secure. Moreover, it was also verified that the mobile device identification and filtering functions ensure that links to files exceeding the maximum available file size are not displayed on the mobile terminal, and that display is changed to suit the capacity of the mobile device being used.

4. Conclusion

This article has described the linking of mobile terminals with information appliances and home networks, and in particular, the technology used for linking inside and outside of the

*10 XML: A new markup language released in February 1998 for use in describing data handled on the Internet.
*11 XSLT: Conversion of documents written in XML to HTML, XML, or plain text.

home by using DLNA.

The links between external devices and media using local communications and external interfaces are expected to become increasingly important. Further investigation in this field and work on the technology development to expand the range of new services are being planned.

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