DLNA | Home Network | Internet

Technology Reports

Technology for Controlling Access to Content between Different Home Networks

As a new mobile communication service, we have developed an access control technique called MH2H. This uses mobile terminals as key devices for remotely accessing digital content such as photos, music and video with DLNA-compatible devices between different home networks.

Research Laboratories
Motoharu Miyake
Takashi Yoshikawa
Atsushi Takeshita

1. Introduction

The Digital Living Network Alliance (DLNA)[*1] has issued guidelines for the seamless sharing of digital content such as photos, music and video between consumer electronic devices such as PCs, information appliances and mobile terminals. A growing number of PCs and other types of information appliances support version 1.0 of the DLNA guidelines [1], and mobile terminals that support version 1.5 [2] (established in October 2006) are also starting to appear on the market. By using a mobile terminal as one device to perform content sharing, users can access digital content anywhere in their homes, and can use a DNLA-compatible TV to display photos and video recorded at home or outside.

There are also many users who want to be able to access content stored in a Server Device (SD) connected to their Home Network (HN) while they are away from home. To meet this demand, NTT DOCOMO began offering the Pocket U service in June 2008. This service allows users to remotely access their content at any time by using a FOMA network to access a PC on the HN instead of having all their content in the mobile terminal. This not only eliminates storage capacity limitations but also makes it unnecessary to copy content to the mobile terminal before it can be played back elsewhere. All users need to do to access content in their HN is bring their mobile terminal with them.

However, when visiting friends and family, it would be better if digital content could be displayed on a larger screen by accessing their household's Visited Home Network (VHN). A new framework is needed for this sort of use because the Pocket U service is provided within a different scope of usage. Meanwhile in the DLNA framework, the sharing of content in an HN is the current scope of application, which means it is not possible to remotely view content from a VHN in an HN even when using a DLNA-compatible TV.

We have developed Mobile Home to Home (MH2H) as an access control technique for remotely accessing original content stored on an SD such as a PC or Hard Disk Recorder (HDR) in an HN from a DLNA device in a VHN, such as a Player Device (PD) or Renderer[*2] Device (RD). MH2H allows content to be accessed without having to install special devices in the VHN or software in the PC, and allows content

*1 **DLNA**: An organization of manufacturers in the fields of information appliances, mobile terminals and PCs that promotes activities for standardization to ensure interconnection in the digital age and establish technical specifications called DLNA guidelines.

*2 **Renderer**: A device that displays content. Unlike a player, it has no user interface for the selection and playback of content.

to be accessed remotely with existing DLNA devices simply by bringing along a mobile terminal which is used for access management. The mobile terminal establishes a link to the HN to provide SD content information to the RD and PD in the VHN and to manage connections in content transmission, thereby allowing access control to be performed in more detail. Since the mobile terminal does not transmit the content itself, it can avoid the overheads associated with packet processing. This results in a service similar to Pocket U whereby users can use their mobile terminals to access original content stored on their own SDs in its original quality while out visiting friends or family with a DLNA-compatible TV.

This article describes the situations in which MH2H systems are used, and presents an overview of the system design and the results of evaluating a prototype system.

2. Overview of MH2H

2.1 Service Outline

Figure 1 shows an example of how MH2H could be used in practice. Pocket U is used for the playback of all content outside the home, while MH2H covers the use of content within VHN. In the MH2H service, a functionally enhanced mobile terminal and a Remote Access Gateway (RAG) in the HN are linked to the RD and PD in the VHN, whereby the photos, music and video files stored in the SD can be accessed over the Internet by the PD and RD. Here, the PD and RD in the VHN and SD are products conforming to DLNA guidelines.

In MH2H, the mobile terminal can implement four functions according to the following usage scenarios together with performing access control as a key device for controlling the HN:

1) Mobile Server Function

The mobile terminal behaves as a virtual server that only provides notification of changes in the equipment information and status in the VHN to enable content stored on the SD in the HN to be displayed and played back on the PD (**Figure 2**(a)).

2) Renderer Control Function

The mobile terminal behaves as a controller which controls the RD in the VHN to display and play back the contents stored on the SD in the HN (Fig. 2(b)).

3) Seamless Playback Function

The mobile terminal behaves as a controller that operates the RD and PD in the VHN, whereby the display and playback of contents stored on the SD in the HN can be migrated seamlessly between the mobile terminal and the RD in the VHN. In other words, users can watch some of the content on the mobile terminal, and then watch the rest on the RD. In this function, content converted for display on the mobile terminal is played back on the mobile terminal in the same way as in the Pocket U service, while the original content is played back on the RD (Fig. 2(c)).

4) Service Extension Function

When the mobile terminal is away from the VHN, the content stored on the SD in the HN can continue to be displayed and played back for a fixed period indicate by the mobile server function and seamless playback function.

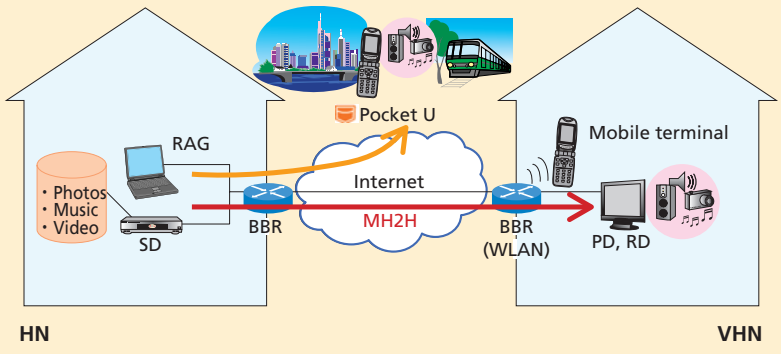


Figure 1 An illustration of content viewing using MH2H

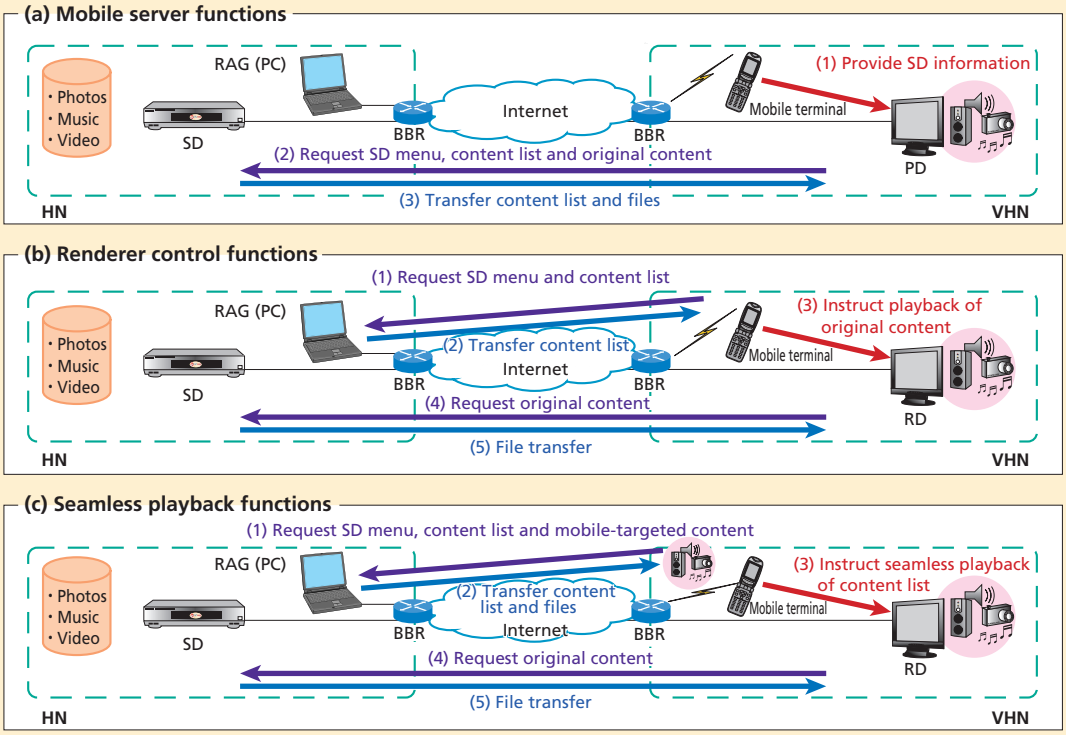


Figure 2 Usage scenarios

2.2 System Overview

The design principles behind the implementation of these usage scenarios include using the mobile terminal to control permission to access content from the VHN to the HN and to maintain security in order to prevent content from being accessed by unspecified large numbers of users, and implementing efficient assignment of functions and operating sequences to avoid additional processing loads (power consumption) associated with the transfer of packets in the mobile terminal.

The specifications derived from these two design principles are as follows.

- To prevent access from an unspecified large number of DLNA devices, the RAG allows temporary access to the registered mobile terminal and to DLNA devices in the VHN that have permission to connect to the mobile terminal. When the mobile terminal is removed, access is immediately denied. Access is always denied to unauthorized VHNs (external IP addresses).
- The RAG manages the number of registered mobile terminals and the number of simultaneous connections to the RAG.
- The RAG performs unified management of content lists stored on all the SDs, converts and saves content for the mobile terminal (preliminary transcoding/translation), transfers content in the RAG in response to content playback requests from the mobile terminal, and transfers original content in the SD in response to content playback requests from the PD and RD.
- The mobile terminal implements four functions: management of RAG connections in the HN (authorization requests, keep-alive responses), transfer of SD information (equipment information, event information), playback of content on mobile terminals, and RD con-

trol. The PD and RD transfer original content stored on the SD directly through the RAG (bypassing the mobile terminal), thereby avoiding increased processing load (power consumption) in the mobile terminal.

- Commercial equipment conforming to version 1.5 of the DLNA guidelines is used for the SD in the HN and the PD and RD in the VHN which are related with Digital Media Server (DMS), Digital Media Player (DMP), and Digital Media Renderer (DMR).

3. Details of Implemented Functions

An MH2H system is implemented by adding the following functions to the RAG and mobile terminal.

3.1 RAG Functions

1) Port Forwarding

A BroadBand Router (BBR) conforming to Universal Plug and Play (UPnP)[*3] is set up to transfer packets addressed to external IP addresses and designated port numbers to the RAG, and the BBR settings are cleared when the application is canceled.

2) Keep-alive

The communication between the RAG and mobile terminal is periodically checked to ensure that the mobile terminal belongs to the VHN. If the mobile terminal transmits a disconnection request packet or does not respond to a ping packet, it is denied access to the RAG even if accessed from a DLNA device in the VHN. Access is always denied from outside the VHN to which the mobile terminal belongs.

3) DLNA Aggregate

The RAG obtains content list information from all the SDs in the HN, and transmits the stored list in response to content list acquisition requests from the mobile terminal, PD and RD.

4) Media Format Management

The RAG converts the media format and bit rate of the content (video or music) stored on the SD in the HN according to a content conversion list (**Table 1**). When content is requested from the mobile terminal, it transmits the converted content, and when content is requested from the PD or RD, it transfers the content stored on the SD. For Joint Photographic Experts Group (JPEG) image files of up to 4,096×4,096 dots, a function for transferring them as 640×480 dot images is required in the SD, so this is not implemented in the RAG.

3.2 Mobile Terminal Implemented Functions

1) External IP Address Acquisition/Notification

UPnP is used to acquire an external IP address from the BBR of the VHN to which the mobile terminal belongs, and this IP address is notified to the RAG with a connection notified packet.

2) DLNA Device Capability Notification

When a content list is requested, in order to receive a response packet containing only those files that are capable of being played back, the media formats supported by the mobile terminal and RD are first notified to the RAG.

3) Player Function

Content converted by the RAG for the mobile terminal is accessed and played remotely from the VHN.

4) Controller Function

This function controls actions such as the discovery of RDs in the VHN and playing back and stopping remotely accessed content stored on the SD in the HN by the RD according to the procedure specified in version 1.5 of the DLNA guidelines.

5) Mobile Server Function

Provides the PD with event information and VHN equipment information as DMS/M-DMS as specified by version 1.5 of the DLNA guidelines. However, the content list and content are transferred directly from the RAG and SD by notifying the external IP

Table 1 Content conversion list

		Before conversion	After conversion
Video	Media format	MPEG-2	WMV
	Bit rate	10 Mbit/s or less	128 kbit/s or less
Music	Media format	AAC	AAC
	Bit rate	320 kbit/s or less	128 kbit/s or less

*3 **UPnP**: A technical specification for the mutual provision of functions between information appliances and mobile terminals and other communication devices at home connected via a network. Based on standard Internet technology and designed for use by simply connecting to the network without any complex operation or setup.

address and designated port number of the HN.

3.3 Content Viewing Sequence

Figure 3 shows the sequence whereby video files stored on the PC (SD) in the HN are viewed on a TV (PD) in the VHN in the mobile server usage scenario. In this scenario, the PC is already switched on, the acquisition of equipment information and content list information is performed by the RAG, and the mobile terminal is connected by WLAN to the VHN.

When the application starts up in the VHN, the mobile terminal transmits a connection request for the establishment of a connection to the RAG (Fig. 3(1)), and receives the response to this request and the SD information in the HN (Fig. 3(2)). The TV transmits a Simple Service Discovery Protocol (SSDP)[*4] M-SEARCH signal when it is switched on (Fig. 3(3)), and receives the response from the mobile terminal (Fig. 3(4)). After that, the TV receives the equipment information such as the external IP address and port number of the HN acquired by the mobile terminal at step (2) (Fig. 3(5)(6)). Also, a Generic Event Notification Architecture (GENA)[*5] SUBSCRIBE signal is used to send the mobile terminal a report request relating to changes of state such as switching the SD on or off, or adding/deleting content (Fig. 3(7)(8)), and receiving state notifications from NOTIFY signals (Fig. 3(9)(10)). After that, when adding/deleting content stored on the SD or starting up/shutting down the SD, the change in state is sent as an event report from the RAG to the mobile terminal and PD. When the user searches for content or a search is performed as part of a folder-moving operation, the resulting content list is displayed on the TV according to Simple Object Access Protocol (SOAP)[*6] and Content Directory Service (CDS)[*7] (Fig. 3(11)(12)). After a video has been selected, the content is played back by streaming data between the PC and TV (Fig. 3(13)(14)).

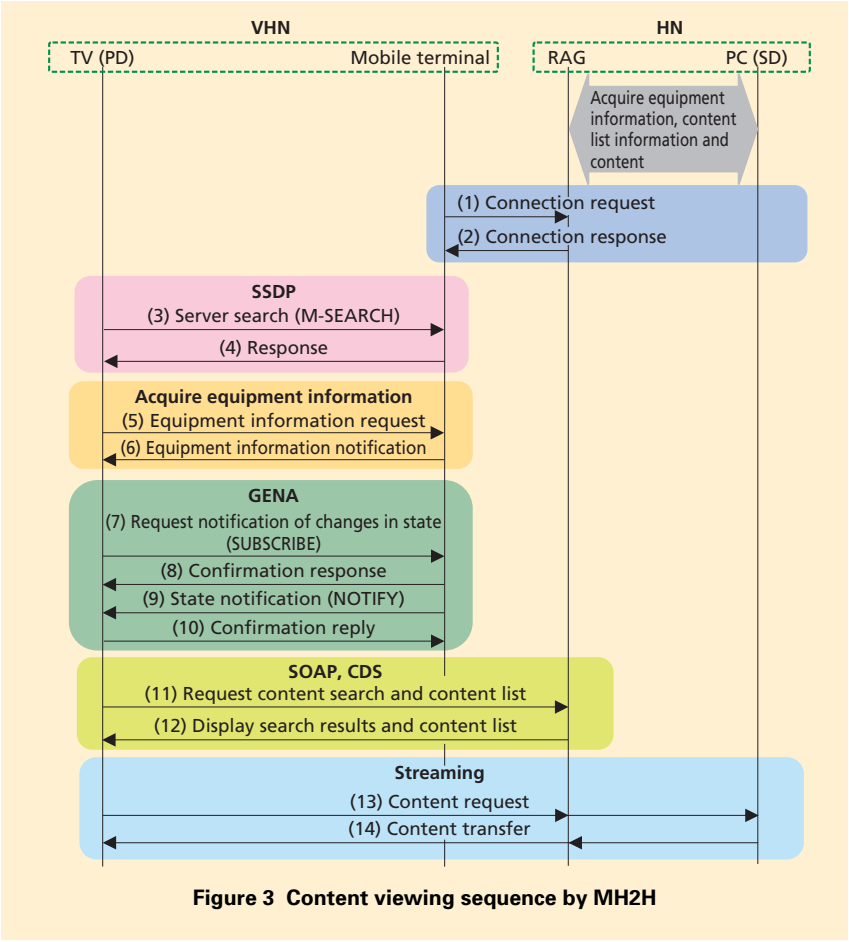


Figure 3 Content viewing sequence by MH2H

4. Implementation of MH2H System

To confirm the feasibility and usefulness of the MH2H system, we implemented the abovementioned usage scenario where the prototype RAG is connected to a mobile terminal and a commercial DLNA device, and we included capabilities for issuing event notifications to the VHN's PD by adding and deleting content on the SD and for terminating services to the PD and RD by disconnecting the mobile terminal from the VHN.

*4 **SSDP**: A protocol for detecting devices on a network.
*5 **GENA**: A protocol for notifying events such as changes in the state of equipment.
*6 **SOAP**: A protocol for calling up data and services on other computers via a network.
*7 **CDS**: A service used for purposes such as managing metadata relating to stored content.

For this implementation we used a commercial desktop PC and an hTc Z®*8 terminal. The HN and VHN were connected over the Internet, and the hTc Z terminal was connected to the VHN over a WLAN (IEEE 802.11g). The menu screen of the prototype application is shown in **Photo 1**. By inputting the HN's external IP address and port number, it is possible to connect to the RAG and select each function. In the following, we will describe the evaluation results obtained when implementing the mobile server, renderer control and seamless playback functions.

1) Mobile Server Function

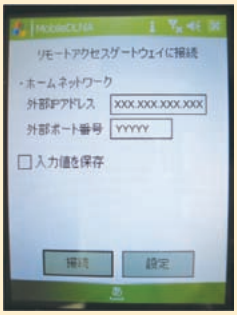
When the mobile server functions are started up in a mobile terminal, the SD in the HN is temporarily added to and displayed in the PD's list of SDs. When a folder is selected, its contents are listed in just the same way as the contents of an SD in the local network (**Photo 2**). Depending on the content selection, it was possible to perform smooth display/playback with no deterioration or breaks in video or music when transmitting from the HN photo files ranging in resolution from 640×480 to 4,096×4,096 dots (JPEG), video files with bit rates ranging from 6 to 10 Mbit/s (Moving Picture Experts Group phase 2 (MPEG-2)*9), or music files with bit rates ranging from 64 to 320 kbit/s (Advanced Audio Coding (AAC)*10).

2) Renderer Control Function

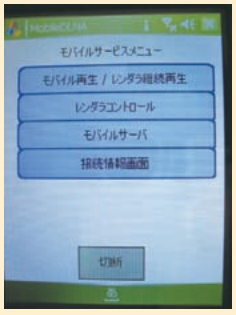
We used the RD to display and play back images, music and video stored on the SD in the HN according to instructions from the mobile terminal, and we confirmed that the system was able to respond without delay to commands such as pause, play, fast forward and rewind, which were acted upon within one second even when performed repeatedly.

3) Seamless Playback Functions

To confirm that the display device switching and media format switching are performed suitably when using an RD to view the continuation of content that was being viewed on a mobile terminal, we used an RD to perform seamless playback of photos, music and video that were being displayed/played back on a mobile terminal. In the case where RD retrieval and content acquisition/playback instructions are performed in the VHN, the content played back in the mobile terminal consisted of image files (JPEG) with a resolution of 640×480 dots, video files (Windows Media® Video (WMV)*11) with a bit rate of approximately 400 kbit/s and music files (AAC) with a bit rate of 128 kbit/s, but even if switching the acquisition and playback to an RD that displays image files (JPEG) with a resolution of 4,096×4,096 dots, video files (MPEG-2) with a bit rate of 10 Mbit/s and music files (AAC) with a bit rate of 320 kbit/s, it was possible to continue playback smoothly with no large breaks or disruption (**Photo 3**).



(a) Before RAG connection



(b) After RAG connection

Photo 1 Menu screen of prototype application

Photo 2 Content list displayed on PD (a DLNA-compatible TV)

*8 **hTc Z®**: A registered trademark of High Tech Computer Corp.

*9 **MPEG-2**: A video coding scheme defined by the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC).

*10 **AAC**: An audio coding scheme defined by the ISO/IEC.

*11 **WMV**: A video coding scheme developed by Microsoft.
Windows Media® is a registered trademark of Microsoft Corp. in the United States and other countries.

(a) Mobile terminal during playback (mobile terminal screen)

(b) Renderer during playback (mobile terminal screen)

(c) Renderer during playback (renderer screen)

Photo 3 Seamless playback displays

5. Conclusion

We have described MH2H access control technology which is expected to be developed in the future to allow content to be accessed between the VHN and HN using a mobile terminal and DLNA device.

Based on the results of verification in a prototype system, we have verified that in the envisaged usage scenarios where the RAG and mobile terminal are situated in the HN and VHN respectively, it is possible to use the mobile terminal to control the remote access of content via the Internet and to manage these activities. This sort of operation has not been possible within existing DLNA guidelines. In the WLAN communication between the mobile terminal and the DLNA device of a VHN, it was clear that care needs to be taken with regard to modes of control not covered by the DLNA guidelines.

In the future, it seems that the importance of linkage between mobile terminals and DLNA devices through local communication means such as WLANs will continue to increase. We plan to continue in our efforts to develop technologies for expanding the range of new services while making further progress in the study of such fields and the accumulation of know-how.

References

[1] Home Networked Device Interoperability Guidelines v1.0, DLNA, 2004.
[2] DLNA Networked Device Interoperability Guidelines-Expanded: Mar. 2006, DLNA, 2006.