UPnP AV Architectural Multimedia System with a Home Gateway Powered by the OSGi Platform

Dong-Oh Kang, Kyuchang Kang, Sunggi Choi, and Jeunwoo Lee, *Member*, IEEE

Abstract —*The key issue of multimedia systems in home network environment is interoperability among different kinds of multimedia devices. And, as for multimedia content providers outside a home, another issue of multimedia systems in home network environment is how to provide the multimedia service from the outside of a home. We developed a UPnP AV architectural multimedia system with a home gateway powered by the OSGi platform, which gives interoperability among multimedia home devices in home network environment, and a powerful tool for multimedia content providers to provide smarter multimedia service for users in a home*[1].

Index Terms — UPnP AV architecture, home gateway, OSGi, multimedia system, home network

I. INTRODUCTION

As home network technology has been developed rapidly, there are increasing chances to access and enjoy multimedia contents distributed in a home via home network. For example, we can enjoy a music clip of a CD title stored in another PC via home network. And, the recent trend of digital convergence makes PCs and consumer electronic devices working together. That means many consumer electronic devices will be equipped with networking capability of accessing multimedia contents distributed within a home. Therefore, the key issue of multimedia systems in home network environment is interoperability among different kinds of multimedia devices. And, as for multimedia content providers outside a home, it is necessary to access the multimedia system in home network, and provide the multimedia contents. That means that another issue of multimedia systems in home network environment is how to provide the multimedia service from the outside of a home [1]-[4].

Multimedia service for information appliances can be classified into two categories: one is the intra multimedia service, and the other is the extra multimedia service [5]. The intra multimedia service aims at the networked AV system within home network that have relatively high speed such as ethernet, IEEE 1394, power line, etc. And, the extra multimedia service aims at streaming multimedia contents via internet that relatively low speed from a remote server outside a home. The multimedia system should provide both extra multimedia service and intra multimedia service in home environment. In this paper, we propose an UPnP AV architectural multimedia system with a home gateway powered by the OSGi platform for the multimedia system in a home.

For interoperability of home network devices in a home, many home network middlewares have been developed such as UPnP (Universal Plug and Play), Jini, HAVI (Home Audio Video Interoperability), etc. As for the multimedia system, UPnP and HAVI defined some architecture. The UPnP (Universal Plug and Play) forum developed UPnP AV architecture as the standard of multimedia system in home network environment to render interoperability among multimedia appliances [7], [8], [10]. UPnP AV architecture is based on UPnP technology, and defines some functions of multimedia services. Nowadays, DLNA (Digital Living Network Alliance) adopted UPnP AV architecture for their design guideline of home network devices, which means UPnP AV architecture will be promising [11]. The OSGi (Open Service Gateway Initiative) alliance is an open forum for Open Service Gateway Initiative. OSGi platform is the platform by which the remote service providers dynamically download their service bundle via internet, and gives the connection between home network and internet [6], [9].

In this paper, we adopt the UPnP AV architecture as the solution for the intra multimedia service. Furthermore, every entity of the proposed UPnP AV architectural multimedia system is made as an OSGi service bundle operating on an OSGi platform. That makes use of merits of both standards: UPnP and OSGi. By using OSGi platform in a home gateway, we can make the software bridge OSGi bundles among home network muddlewares in the home gateway, which functions as the bridge connecting various devices with various home network middlewares. That means that we can acquire inter-middleware interoperability and the interoperability can be extended to the non-UPnP devices which use non-UPnP middlewares. By the home gateway powered by the OSGi platform, UPnP AV architectural multimedia devices can communicate with service providers outside a home. Therefore, based on collected information about UPnP AV architectural multimedia devices, service providers can provide the optimized service for the home. And, the user in a home can enjoy the extra multimedia service in the same way as the intra multimedia service. As for the multimedia service providers, they need not prepare another protocol to connect the UPnP AV architecture with their own media transfer protocols like

[1] Dong-Oh Kang is with the Electronics and Telecommunications Research Institute, Daejeon, Korea (e-mail: dongoh@etri.re.kr).

Kyuchang Kang is with the Electronics and Telecommunications Research Institute, Daejeon, Korea (e-mail: k2kang@etri.re.kr).

Sunggi Choi is with the Electronics and Telecommunications Research Institute, Daejeon, Korea (e-mail: csk63421@etri.re.kr).

Jeunwoo Lee is with the Electronics and Telecommunications Research Institute, Daejeon, Korea (e-mail: ljwoo@etri.re.kr).

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WMS, RTSP, etc.

The outline of this paper is as follows. In Section II, some preliminary subjects are reviewed. In Section III, the UPnP AV architectural multimedia system with a home gateway powered by an OSGi platform is proposed as the multimedia system in home environment. In Section IV, we deal with the implementation of the proposed system .In Section V, some other issues are discussed related with the multimedia system for further development. And, finally, some concluding remarks are given in the last section.

II. PRELIMINARIES

This section covers some preliminary subjects for the proposed multimedia system in home network environment: classification of multimedia service in home environment, UPnP AV architecture, OSGi platform.

A. Extra service and Intra service

Multimedia service for internet appliances can be classified into two categories: the intra multimedia service and the extra multimedia service [5].

The intra multimedia service aims at making the networked AV system within home network environment which is at the relative high speed, and gets a little network traffic loads.

The extra multimedia service aims at streaming multimedia contents via internet from remote server outside a home to information appliance in a home. Then, because the internet is at relatively low speed, and gets relatively heavier traffic loads, it is important to select the transfer file format and the transfer protocol, get some configuration of the client and network configuration. That means the remote multimedia service provider should know information about AV devices in a home. Furthermore, some delivery manager may be needed on either the server or the client.

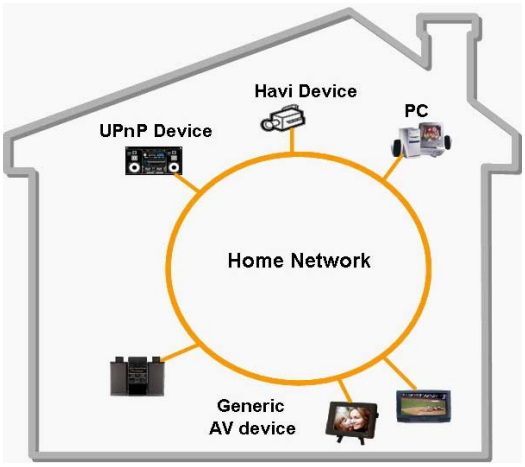

Fig. 1. Intra multimedia service.

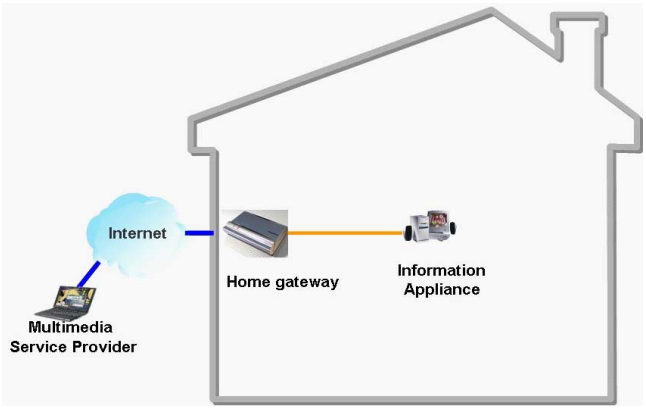

Fig. 2. Extra multimedia service.

B. UPnP AV architecture

UPnP (Universal Plug and Play) forum developed UPnP AV architecture as the standard of multimedia system in home network environment to render interoperability among multimedia appliances. UPnP AV architecture is based on UPnP technology, and defines some functions of multimedia appliances. The system is composed of MediaServers, MediaRenderers, Control Points as depicted in Fig. 3.

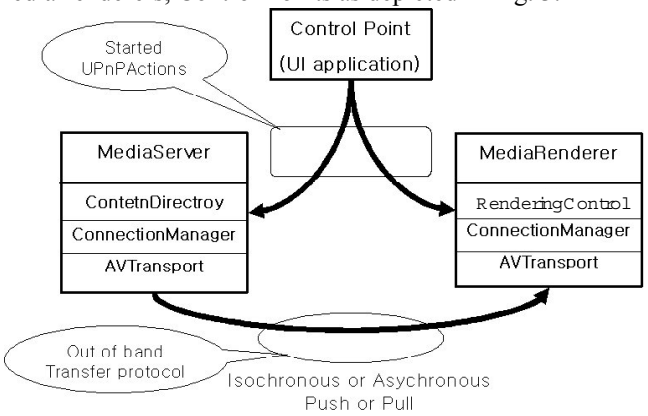

Fig. 3. UPnP AV architecture.

A MediaServer is an UPnP device that has the ContentDirectory, ConnectionManager, AVTransport UPnP services. A MediaRenderer is an UPnP device that has the RenderingControl, ConnectionManager, AVTransport services. A Control Point is the UPnP control point which controls operations of the MediaServer and the MediaRenderer by using UPnP action protocol: SOAP. The Control Point shows multimedia contents of the MediaServer by invoking UPnP actions of ContentDirectory UPnP service. If a user selects a multimedia content, the Control Point makes connection between the MediaServer and the MediaRenderer by using ConnectionManager UPnP services. And, the multimedia content selected by the user is transferred by invoking UPnP actions of AVTransport UPnP service. Actual transfer of the multimedia content is out of UPnP protocol; UPnP Control Point just controls operations of multimedia transfer, and adjusts the problem of transfer protocol and file format. Possible transfer options are isochronous or asynchronous, push or pull mode.

C. OSGi Platform

The OSGi alliance is an open forum for Open Service Gateway Initiative. The forum specifies, creates, advances, and promotes an open Service Platform for the delivery and management of multiple applications and services to all types of networked devices in home, vehicle, mobile and other environments. The OSGi platform enables service providers to download OSGi service bundles from a bundle repository to a gateway. The dynamic installation and uninstallation of bundles make it possible to upgrade software of a device by a remote service provider while the device is operating.

The OSGi forum made the UPnP service specification in OSGi Release 3 in March, 2003, which enables service providers to make OSGi service bundles as UPnP devices in home network environment. That means OSGi UPnP Device service bundle is exported as the software UPnP device to UPnP network. The devices which have OSGi UPnP service bundle behaves like an UPnP device, and interacts with other real UPnP devices in home network. Therefore, a home gateway with OSGi UPnP service bundle can get information on UPnP devices in home network via UPnP protocol: SSDP. The remote multimedia service provider can get information on UPnP multimedia devices in home network via OSGi UPnP service bundle on a home gateway, which gives more intelligent extra multimedia service.

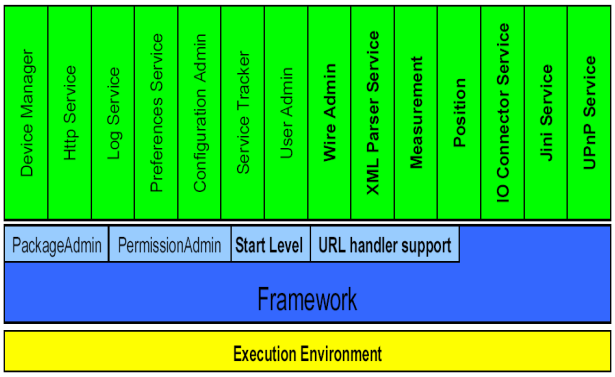

Fig. 4. OSGi Platform Release 3.

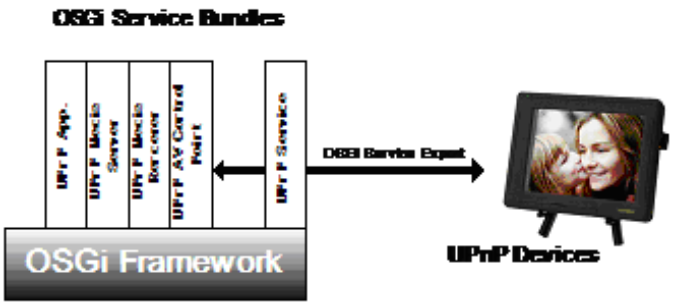

Fig. 5. OSGi UPnP Service export to UPnP network.

III. UPnP AV Architectural Multimedia System with a Home Gateway Powered by OSGi Platform

In this paper, we propose the UPnP AV architectural multimedia system with a home gateway powered by OSGi platform for the multimedia system in home network environment, which should render both the intra multimedia service and the extra multimedia service.

A. Intra multimedia service system

The UPnP AV architecture is adopted for the intra multimedia service, then, there are UPnP AV architectural entities: UPnP AV control point, UPnP MediaServer, UPnP MediaRenderer. As depicted in Fig. 6, each UPnP AV architectural entity has two parts: an UPnP AV architectural middleware module and a multimedia function module. The UPnP AV architectural middleware module is composed of UPnP AV architectural OSGi service bundles, and an OSGi platform, which use a Java virtual machine. In case of the multimedia function module, some binary codes are used for a MediaServer and a MediaRenderer.

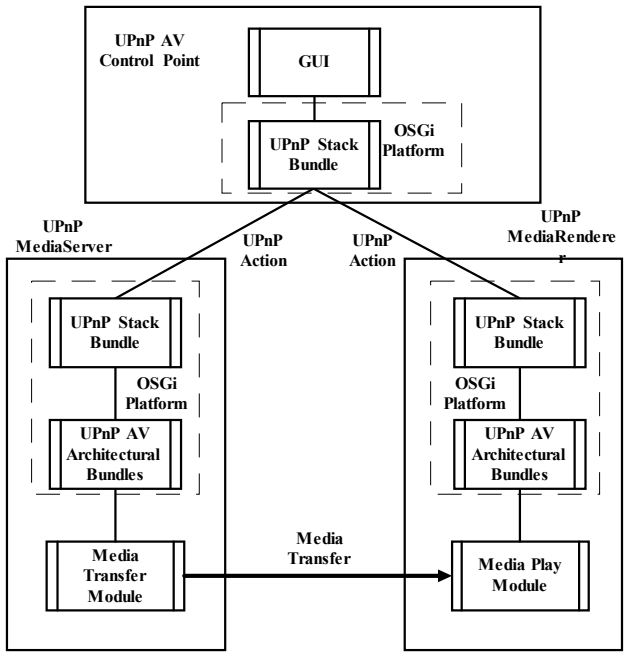

Fig. 6. Modular structure of UPnP AV architectural multimedia system.

Every multimedia device cannot have UPnP capability because UPnP technology requires some computing capability and networking capability. By downloading an OSGi bundle dealing with a generic multimedia device onto a home gateway or other AV devices, a kind of software bridges can be composed with UPnP AV architectural OSGi bundles. Also, it is applicable to the multimedia appliances using other home network middlewares such as HAVI. In Fig. 7, an UPnP/HAVI software bridge is depicted. In the figure, HAVI devices in home network are sensed by HAVI service bundle, and HAVI service bundle registers the HAVI devices to UPnP/HAVI bridge bundle. The UPnP/HAVI bridge bundle converts the HAVI capability into the appropriate UPnP service, and creates the corresponding UPnP device with OSGi UPnP service bundle which is exported to UPnP network. Therefore, UPnP devices in home network detect the home gateway as an

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UPnP device which gets the corresponding capability with the original HAVI device. Overall procedure for function usage of the different middleware is depicted in Fig. 8.

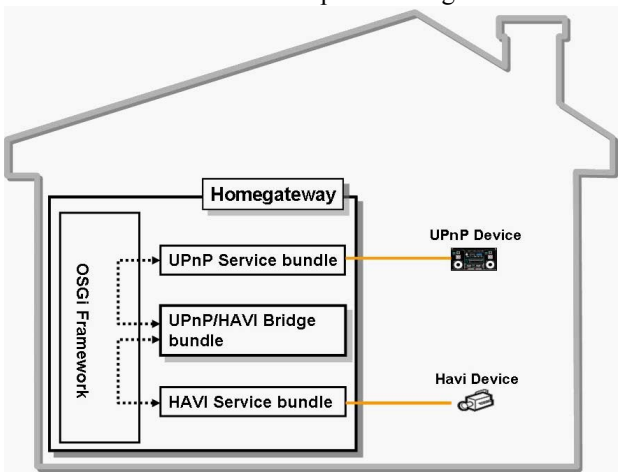

Fig. 7. Software bridge on OSGi platform with a home gateway.

B. *Extra multimedia service system*

For the extra multimedia service, we used a home gateway powered by OSGi platform, which gets an OSGi extra multimedia service bundle. The home gateway acts like a proxy for the multimedia contents outside home, then the user need not distinguish the multimedia contents outside a home from those inside a home. And, the multimedia service providers can use their present media service system without any change for the UPnP AV architecture.

The OSGi service bundle interacts with an UPnP AV control point, and gets information on UPnP devices in home network. By using UPnP Rendering control service, the UPnP AV control point can get some information on UPnP MediaRenderer in home network. Then, the OSGi extra multimedia service bundle gives the information to the remote multimedia service provider via internet. The service provider selects the appropriate file format, and transfer protocol, notifies those of the OSGi extra multimedia service bundle. Then, the OSGi extra multimedia service bundle invokes the virtual UPnP MediaServer which interacts with the real UPnP MediaRenderer in home network. Then, the UPnP MediaRenderer considers the virtual UPnP MediaServer on the home gateway as the real UPnP MediaServer. Therefore, the multimedia contents from extra multimedia service are shown in the UPnP control point in home network just like in the same way as the multimedia contents in the real UPnP MediaServers in a home, i.e., the user need not prepare another control point for extra multimedia service. When he or she just selects the contents from outside home and orders the virtual UPnP MediaServer using his UPnP control point via invoking UPnP actions, the UPnP MediaServer requests the multimedia service provider to transfer the multimedia contents to the home gateway. The virtual UPnP MediaServer conveys the data from the multimedia service provider to the UPnP MediaRenderer to which the user requested to transfer the contents. The overall process of the proposed extra multimedia service is depicted in Fig. 9.

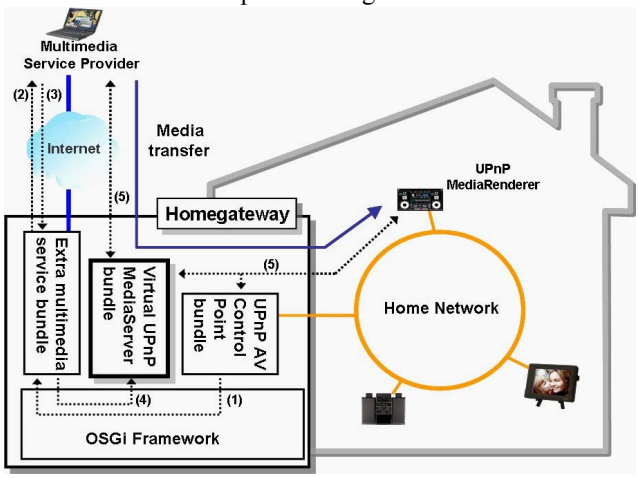

Fig. 9. Extra Multimedia service via OSGi platform with a home gateway.

As for the multimedia service providers, they need not prepare another mechanism to connect the UPnP AV architecture with their own media transfer protocols like WMS, RTSP, HTTP, etc. Therefore, the multimedia service providers can use the present system for multimedia service without any change for the UPnP AV architecture. That means that the home gateway acts like a kind of proxy between the UPnP

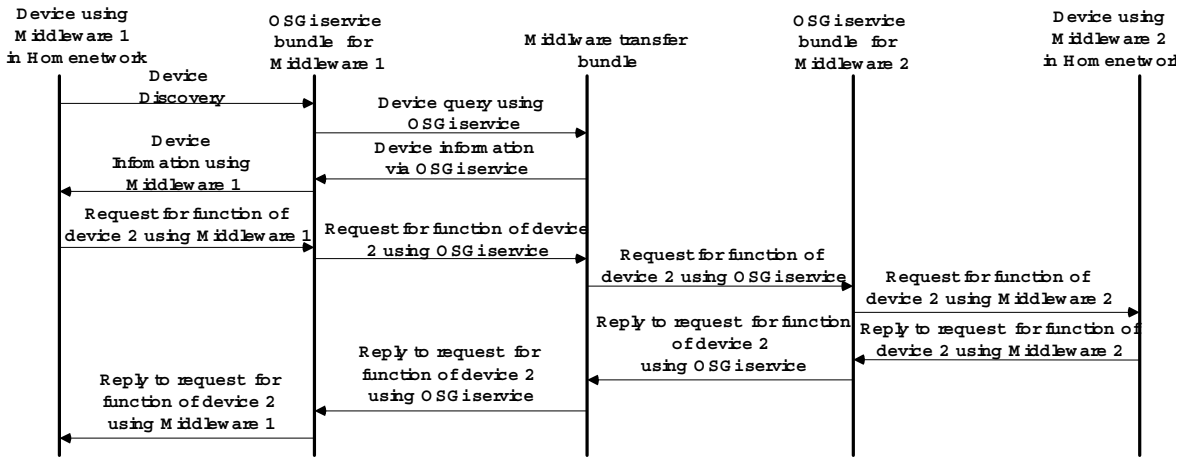

Fig. 8. Procedure for function usage of the different middleware.

MediaRenderer inside home and the multimedia service providers outside home.

Using the information about home network environment from extra multimedia service bundle, the multimedia service provider can set the virtual UPnP MediaServer configuration appropriate for the home network environment like file format, transfer protocol. For the file format to be transferred, the multimedia service provider may have various versions of the same contents with different file formats or have the transcoding capability. By this process, the remote multimedia service provider can provide more intelligent extra multimedia service to a home.

IV. Implementation

We implemented the proposed system in the various Linux based operating system. We adopted the proposed system to home servers, web-pads, etc. Total size of the OSGi bundles for the system is about 1.24 Mbytes. Therefore, the proposed system can be applied to the embedded system that has small resources. Fig. 10 shows the real implementation of the proposed multimedia system applied to the home server system.

In terms of the user interface, the graphic user interface is used as in the Fig. 11. When the user turns on the multimedia system, the user can select the genre of the contents that he or she wants among music, video, image, etc. After selecting the genre, the user selects one media content that he or she wants to enjoy. The media contents that are shown to the user are composed of the media contents distributed around the home and connected by home network. For the user, the contents are seen alike although they are located in different devices. After selecting the media contents, the user can select the UPnP MediaRender that he or she want to play the contents. When the user selects the player, he or she sees the control panel screen which is similar to a remote controller that we use in the ordinary daily life. By using the control panel screen, he or she can control the media transfer flow, i.e., play, stop, pause, etc. The overall procedure for users to select and play the contents is shown in Fig. 11.

Fig. 10. Implementation of the proposed system in a home server system.

V. Another Issues for Future Development

In this section, some other issues are discussed for the future development of the multimedia system except for what are

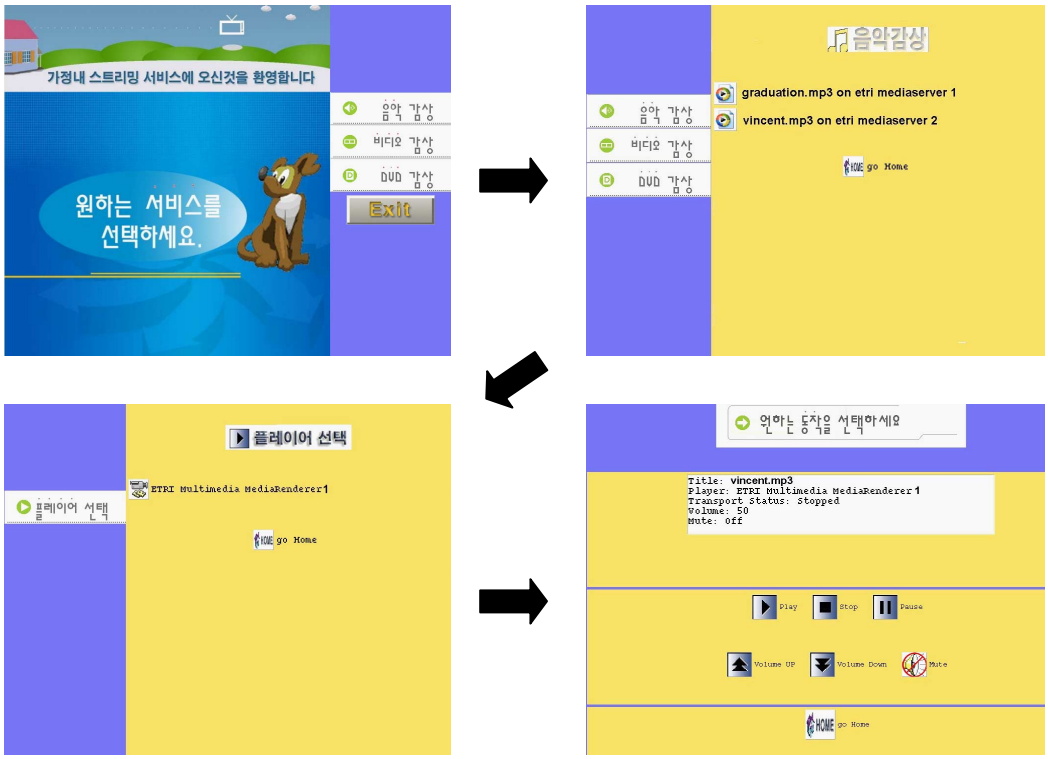

Fig. 11. Procedure for user interface for the proposed system.

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scrutinized in the previous section. The following issues are required to solve for the future development of the multimedia system.

First, the multimedia system should deal with the DRM (Digital Rights Management) or content protection problem. Especially, in case of the extra multimedia service, the content protection capability is more important.

Second, the multimedia system should have control the QoS (Quality of Service). Because the usage of internet of home is increasing, the traffic is heavier within a home. This situation requires some method of controlling QoS of the multimedia service.

Third, the multimedia system can deal with the collision problem with other standards or design guidelines such as Home networked device interoperability guidelines of DLNA, etc.

With an OSGi platform, the above three problem can be dealt with by the remote multimedia service provider by providing the new OSGi service bundle dynamically. For example, DRM bundle, OoS manager bundle can be downloaded by the remote multimedia service provider. And, multimedia service bundle abiding by another standard may work and the bridge between the proposed system and the bundle can solve the third problem. These are other merits by using an OSGi platform.

The UPnP QoS architecture is implemented into the proposed multimedia system [12]. The UPnP QoS manager is implemented in the home gateway because the home gateway is connected with all home network devices. Every UPnP devices gets the UPnP QoS device service, which is controlled by Control Point, and UPnP QoS manager. For better QoS of multimedia service, the combination of the UPnP QoS architecture with the UPnP AV architecture requires the future research effort.

IX. CONCLUSION

We proposed an UPnP AV architectural multimedia system with a home gateway powered by OSGi platform to give both intra multimedia service and the extra multimedia service to the users in home. By using the UPnP AV architecture and the software bridge implemented in the home gateway, the interoperability can be achieved among multimedia devices in home network environment. Furthermore, the proposed system, service providers can provide smarter multimedia service for users in a home. And, the user in a home can enjoy the extra multimedia service in the same way as the intra multimedia service without the additional devices. As for the multimedia service providers, they need not prepare another protocol and can use their present system to connect the UPnP AV architecture with their own media transfer protocols like WMS, RTSP, etc. And, there are some implementations of the proposed system with various Linux based systems. Because using Java technology in OSGi platform, the proposed system can be applied to the various hardware platform. And, the small sizes of the OSGi bundles for the proposed system make it to be applied to the embedded systems. In this paper, some issues were discussed for further development of the proposed system.

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Dong-Oh Kang (M'04) received his B.S. degree in electronic engineering from Yonsei University, Korea, in 1994. And, he received his M.S. and Ph.D. degrees in electronic engineering from Korea Advanced Institute of Science and Technology, Korea, in 1996 and 2001 respectively. Since 2001, he has been working at Electronics and Telecommunications Research Institute, and now, he is a senior member of engineering staff of the Post-PC Platform Research Team where he is developing a Post-PC platform. He became a Member (M) of IEEE in 2004. His research interests include home network middleware, distributed control, networked multimedia service, and Post-PC platform.

Kyuchang Kang received his B.S. and M.S. degrees in electronic engineering from Kyungpook National University, Korea, in 1994 and 1997 respectively. From 1997 to 2000, he worked on test and evaluation center at Agency for Defense Development as a researcher of engineering staff, where he developed Doppler signal analyzer and measurement system. Since 2001, he is working on the digital home research division at Electronics and Telecommunications Research Institute, where he is developing open service platform for the home server. He is also interested in mobile applications, distributed computing and network security

Sunggi Choi received his B.S. and M.S degrees in industrial engineering from Korea Advanced Institute of Science and Technology, Korea, in 1996 and 2002 respectively. From 1997 to 2000, he was a researcher at SsangYong Information and Communications, where he worked on IP networking and Ethernet switching. Since 2002, he has been a member of engineering staff of the Post-PC Platform Research Team at Electronics and Telecommunications Research Institute, where he is developing UPnP QoS architecture in the home server. His research interests include multimedia streaming over wireless LAN, 802.11e QoS and home network QoS management.

Jeunwoo Lee received his B.S., M.S., and Ph.D. degrees in electronic engineering from Kyungpook National University, Korea, in 1983, 1985, and 1998 respectively. Since 1985, he has been working at Electronics and Telecommunications Research Institute, and now, he is a principal research staff and the head of the Post-PC Platform Research Team where he is developing a Post-PC platform. His research interests include information appliances, home server architecture, home digital services, and Post-PC platform.

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