An Approach to support the Interoperability of Intelligent Grouping and Resource Sharing (IGRS) and Universal Plug and Play(UPnP) in Home Network Environment

Shizhe Tan[1], Jing Zhang[2], Fajiang Sun[3]
Department of Electronic Engineering
Ocean University of China, Qingdao, China, 266100
e-mail: tanshizhe@ouc.edu.cn, jingzhang_love@163.com, fajiangsun@163.com

Shengxu Wang[4]
63981 Army
Wuhan, China, 430311

***Abstract*— To achieve interconnection and interoperability among different devices in home network environment, such as TV, PAD, and computer. Several digital home network protocol standards, such as UPnP, Java Intelligent Network Infrastructure (Jini), IGRS, etc, are proposed. But, devices based on these different protocols cannot discover or control each other, so it is very important to achieve interoperability among these devices. A method of interconnection between IGRS network and UPnP network based on Open Service Gateway Initiative (OSGI) platform is proposed in this paper. A service agent on the OSGI platform is designed. This paper described the system architecture and implement process of this method. The experiment result of this method is also described. It is shown that the Service search and protocol conversion between UPNP and IGRS devices are implemented effectively.**

***Keywords:* IGRS, UPnP, Interconnection, Interoperability, OSGI, Home Network.**

I. INTRODUCTION

Digital home network aims to solve the problem about interconnection and interoperability among home devices based on different protocols. In such home network environment, all devices can interconnect and interoperate with each other, so consumers can easily share their digital resources ,such as their pictures, audio and video, and so on. To achieve this goal, much effort had been made to develop several digital home network protocol standards, such as UPnP, Jini, IGRS, etc. Among the above described protocol standards, UPnP and IGRS are more important home networks standards.

UPnP is an open architecture protocol which based on established standards, such as Transmission Control Protocol (TCP), User Datagram Protocol (UDP), Hyper Text Transport Protocol (HTTP), Extensible Markup Language (XML), Simple Object Access Protocol (SOAP), and General Event Notification Architecture (GENA), etc. It supports devices to connect seamlessly and simplify the implementation of network in the home environments.

IGRS is another network architecture protocol based on many networking protocols, such as TCP, UDP, HTTP, SSDP, SOAP, and Web Services Description Language (WSDL), etc. It can implement intelligent grouping, resource sharing and service collaboration among devices in a local area network (wired and wireless), and improve the interoperability and usability among devices. Furthermore, IGRS creates new application models for consumers and maximizes the resource usage of each device. Now, there are lots of digital home appliances supporting these UPNP and IGRS standards, but they cannot interoperate with each other, which leads to difficult usage and inconvenience for consumers.

II. RELATED WORK

In order to achieve interconnection and interoperability among devices based on different protocols in home network environment, great efforts have been done to propose some methods.

To realize the interaction issue among devices which based on different protocols, we have put forward a method. The first goal is to achieve the interoperability among different devices. In [1], López de Vergara et al proposed the application of the ‘‘autonomic communications” paradigm to realize the interoperability among different devices. Through this paradigm, each device has the ability of realize self-configuration, self-optimization, self-healing and self-protection. Based on the architecture proposed in [1], we need to integrate a variety of different protocols into a platform. In [2], Chen et al integrated SLP, UPNP, SIP into OSGI platform to realize the automatic device discovery, registry and management. On the basis of the above, we need to implement the interoperability between devices of different protocols. In [3], Bottaro et al used various protocols bridges to act as technical mediator between different interaction protocols and service invocations and services event notification. In [4], Allard et al embodies the realization of interoperability. They used service-specific proxies to bridge Jini and UPnP s, by which we can realize the interoperability of Jini and UPnP. Some works proposed an adaptive middleware to provide an adaptive autonomic configuration for different home networks [5]-[9]. Moreover, they provided an autonomous fault management which including fault diagnosis and recovery from unexpected faults, such as device plug-outs, network link failures, service failures, and other incidents of the same kind. These works focuses on interconnection and interoperability among devices which based on most protocols, but they do not consider IGRS

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protocol. Hu et al [10] proposed engine architecture and transfer method for device/service description, according to the transformation engine developed a bridge, by which we can realize the interoperability between IGRS devices and UPnP devices.

This paper discusses the difference between IGRS protocol and UPnP protocol in the aspect of addressing, discovery, description, control, event notification. Furthermore, a new approach is proposed to support interoperability between UPnP devices and IGRS devices in home network environment.

III. PRELIMINARY

Many standard mechanisms are used in IGRS and UPnP protocol. We found that the UPnP protocol and IGRS protocol are compatible through the analysis of the two protocols. Then we can summarize form the following five aspects.

(1) Addressing

The addressing of UPnP protocol is based on IP, and IGRS protocol has no specific way of addressing. So the two protocols can use flexible addressing mode.

(2) Discovery

The discovery mechanism of IGRS and UPnP protocol both use SSDP protocol. So, IGRS and UPnP can realize the discovery each other of equipment service.

(3) Description

IGRS and UPnP both adopt XML template to define device description template, but IGRS adopts WSDL as service description template, which is different form UPnP, and UPnP adopts the custom describe template. IGRS has expansibility on description, so it can complete the mutual perception through injecting the corresponding UPnP describe extension on IGRS equipment service description.

(4) Control

UPnP service control invocation mechanism adopts SOAP protocol mechanism. IGRS defines invocation mechanism based on the session, and it supports equipment interaction as the extended interface based on the unsafe pipeline. So IGRS can complete the service control between the equipment as long as injecting UPnP service interface description in the service description under unsafe pipeline.

(5) Event

IGRS adopts event mechanism based on pipeline, while UPnP adopts GENA mechanism. But IGRS services provide event subscription interface to UPnP devices to complete equipment between event subscription and notification under unsafe pipeline.

Fig. 1shows equipment interaction diagrams of IGRS and UPnP equipment interconnection.

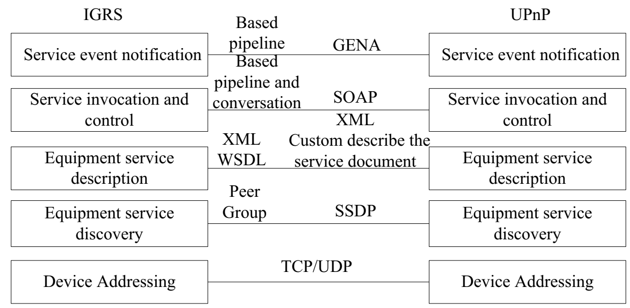


Figure1. Equipment interaction diagrams of IGRS and UPnP

IV. PROPOSED ARCHITECTURE

It realizes freedom fusion between IGRS and UPnP by designing the agent model. In fact, agent module consist of protocol Conversion Bridge, IGRS virtual device and UPnP virtual device. In view of IGRS control point, IGRS virtual device is an IGRS device, and it can access control remote UPnP service. Similarly, UPnP control points can access to the IGRS services by UPnP virtual device conveniently. Figure2 shows interconnection between IGRS device with UPnP device through the agent module.

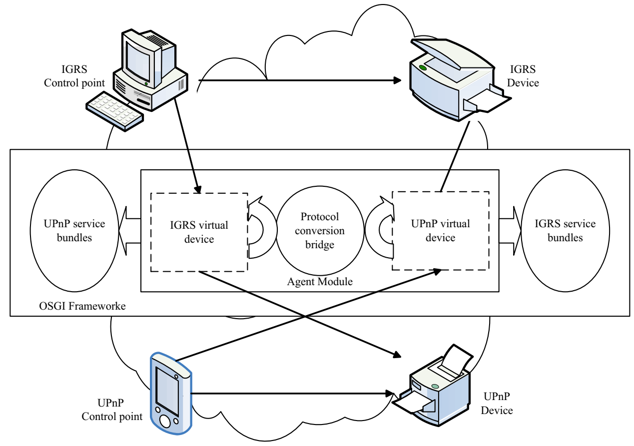


Figure2. Schematic diagram of interconnection between IGRS device with UPnP device through the agent module

Protocol Conversion Bridge is message format of identifying IGRS and UPNP. It can parse messages and process different formats transformation according to the need. UPnP virtual device and IGRS virtual device have the same working principle, so this paper expatiates the design process of the latter only. IGRS virtual equipment is divided into four modules, including IGRS virtual device coordination module, IGRS virtual device description update and publish module, IGRS virtual device service description update and publish module and UPnP service invocation module.

A. *IGRS virtual device coordination module*

This module is used to coordinate IGRS virtual device description update and publish module, IGRS virtual device service description update and publish module and UPnP service invocation module to achieve the interaction function of IGRS and UPnP devices. As shown below.

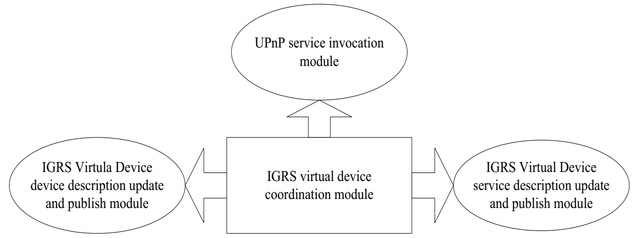


Figure3. The relationship between IGRS virtual device coordination module and others

B. IGRS virtual device description update and publish module

The module has two important data structure. They are online equipment list and equipment service mapping table. The former is mainly used for IGRS virtual device service description updates and publish module. The latter is used to update the device description file of UPnP virtual device and provides service agent for IGRS control point according to service lookup service where the equipment.

Its working process is that it detects the mapping table of equipment service to make sure if exist elated records after listening UPnP devices send announcement of online devices. If not, it needs to increase the records of description of the equipment and service. It must delete all records associated with the device in the mapping table of equipment service after listening UPnP devices send announcement of offline devices. To ensure the IGRS virtual device can complete the agency of services supported by all UPnP devices. The module also needs to send equipment search to search all UPnP devices in the network, and update equipment service mapping table according to the response of the equipment. Finally it will add all services of device services mapping table to the service list of device description, and spread to the IGRS network multicast through online declaration of device.

C. IGRS virtual device service description updates and publish module

This model has a data structure that is service description file has described list of device which used with the IGRS virtual device device description update and publish module online equipment list.

Its working process is that it can know the line of the specific device up and down, comparing with the on-line equipment list and service description file has described list of device. For just online equipment, IGRS virtual equipment service description file add the information of the equipment. For just offline equipment, IGRS virtual device service description file delete the information of the device. Finally, it make empty that the device list of service description file and copy the contents of online equipment list.

D. UPnP service invocaion module

This module is used to intercept the UPnP service invocation message, and then invoke the UPnP service through calling UPnP service SOAP message. In the end, it translated the result to IGRS messages and sent to IGRS control point of the service. The Figure4 shows that the Work process of this module.

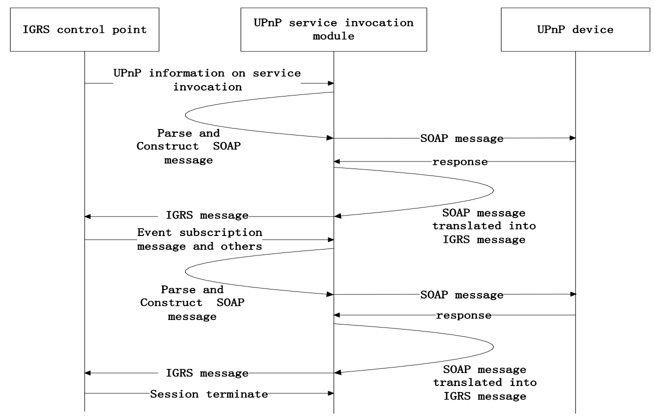


Figure4. workflow of UPnP service call module

V. APPLICATION AND ANALYSIS OF THE PROPOSED ARCHITECTURE

A. The process of devices interaction based on agent model

The proposed protocol architecture can well adapt to the home network environment, the process of devices interaction based on this architecture is shown in Figure5. IGRS & UPnP virtual device based on the protocol architecture translates different types of messages between IGRS devices and UPnP devices, so these two devices can find multimedia resources and share contents, meanwhile they can play and control Audio Video resources by out-of-band connection established between devices and the media server.

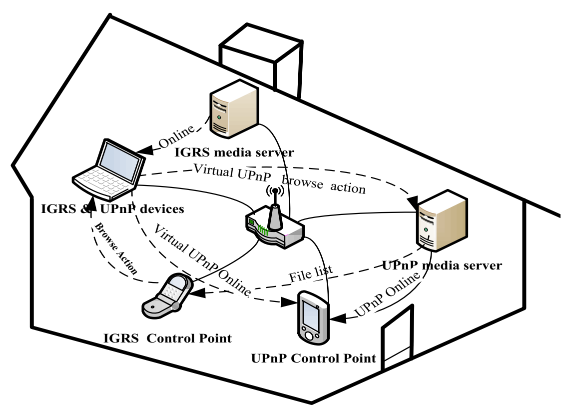


Figure5. Devices interaction basing on agent model framework

B. Agent model operation

The interconnection between UPnP devices and IGRS equipment realizes based on the eclipse3.7 platform. At runtime, agent module will take the initiative to search UPnP and IGRS equipment, using packet Sniffer tools to acquire search message. As shown in Figure6.

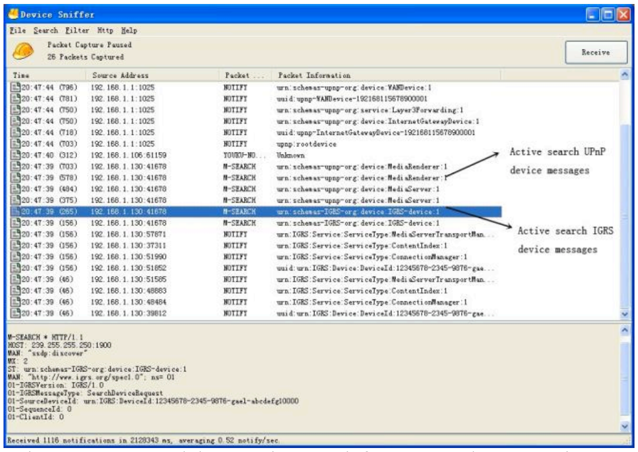


Figure6. Agent module proactive search for UPnP and IGRS equipment

C. *Efficiency analysis*

To test the performance of the proposed architecture, three experiments have been done. The following environment is used in these experiments: The testing computer features 2.8GHz frequency CPU and 4 GB RAM.

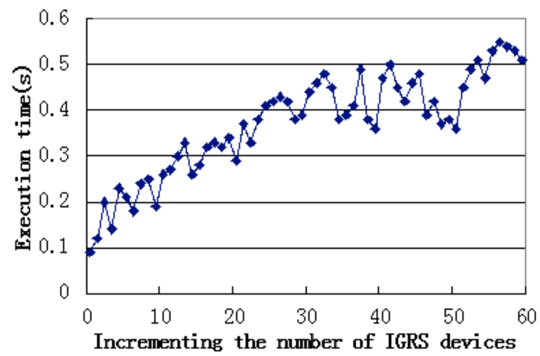
When the number of advertised devices increased from1 to 60, the execution time of the proposed protocol architecture is calculated. Each simulation repeated 30 times. Then average values are provided to act as the final execution time of each simulation, which improves greatly the accuracy. Three experiments are described detailedly in the below.

In the first experiment, 60 IGRS devices are running successively. Figure7(a) shows the result. It is observed that the mean execution time of the proposed architecture rises when the number of devices increases. The average execution time taken for the case with 60 IGRS devices is below 0.55 s. Because the processing time of the proposed architecture has a negligible rise when the number of services increases, this average execution time is acceptable.

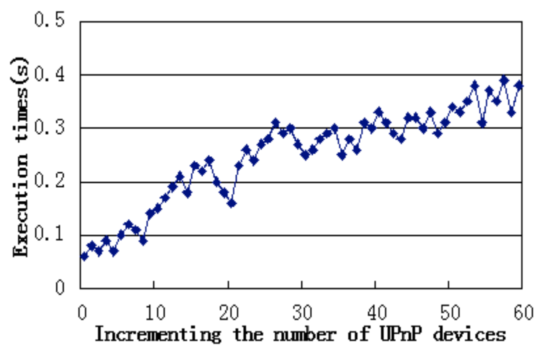
In the second experiment, 60 UPnP devices are running successively. Figure7(b) shows the result, the average execution time taken for the case with 60 UPnP devices is below 0.4 s. Comparing with the first experiment, it is faster because the complexity of IGRS is higher than UPnP.

In the third experiment, 30 UPnP devices and 30 IGRS devices are running successively. In order to reflect the variation of home network environment, they are selected randomly to run. Figure7(c) shows the result. The average execution time taken for the case with 60 devices is below 0.63 s. Because it needs to deal with IGRS devices and UPnP devices, and converts them to the corresponding virtual devices, this average execution time is reasonable.

As shown in Figure7, when the number of devices is in a certain area, the average execution time tends to be linear. Due to limitation of hardware configuration and increase of network load, the average execution time rises with the increasing number of devices, but is controlled in a small range. Therefore, the proposed architecture implements reliably interoperability between the IGRS devices and UPnP devices in home network environment.



(a)



(b)

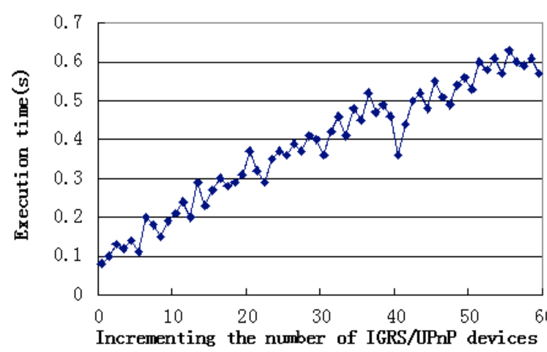


Figure7. (a)-(c) show the relation between the average execution time of the proposed architecture and the incrementing number of different devices. All results are normalized without big fluctuations.

VI. CONCLUSION

In this paper, aiming at the problem that a large number of IGRS devices and UPnP devices in home network cannot interoperate with each other, a new approach is proposed to implement seamless interconnection and interoperation between IGRS devices and UPnP devices. This approach not only implements the interoperability between IGRS devices and UPnP devices, but also can interoperate efficiently with IGRS devices or UPnP devices alone. Some experiments have been done to verify the feasibility of the proposed architecture. In the future, it is essential to expand the architecture to make it fit to the interoperability of more different protocols.

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