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Home Network Electrical Appliance Control With The UPnP Expansion

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Abstract

The control of electrical appliances residing in the home network can be accomplished via Internet with the UPnP expansion without modifying an existing UPnP. In this paper, we propose the Internet Gateway that consists of an UPnP IGD(Internet Gateway Device) DCP(Device Control Protocol) and an UPnP Bridge as a system to control electrical appliances of home network. UPnP IGD DCP is to enable the configurable initiation and sharing of Internet connections as well as assuring advanced connection-management features and management of host configuration service. It also supports transparent Internet access by non-UPnP-certified devices. UPnP Bridge searches for local home network devices by sending control messages, while control point of UPnP Bridge looks up devices of interest on the Internet, subsequently furnishing the inter-networking controlling among devices which belong to different home network systems. With our approach, devices on one home network can control home electrical appliances on the other home network via Internet through IGD DCP with control commands of UPnP.

Key words : Home Network, UPnP, Internet Gateway

1. Introduction

Home network has started for the purpose of sharing of resources, remote education, remote treatment, home automation, and multimedia services at home. There are lots of multiple wired and/or wireless home network technologies available nowadays. The UPnP(Universal Plug and Play) is an effective middleware to control the home appliances regardless of home network technologies applied.

It is the UPnP that extends the plug and play concept to the networking based on the standard Internet Protocol[1]. The Internet will be supplied recently in assumption and individual PC, the game flag and T.V back will be connected in the Internet and it will reach and integrates the new service is attempted[2]. The UPnP is an architecture for pervasive peer-to-peer network connectivity of intelligent appliances, wireless devices, and PCs among all participating components. The UPnP presents home network middleware for local home electrical appliances control based on internet protocols. It is designed to bring easy-to-use, flexible, standard-based connectivity to ad-hoc or unmanaged networks in the home, a small business, public spaces, any of which can be attached to the Internet.

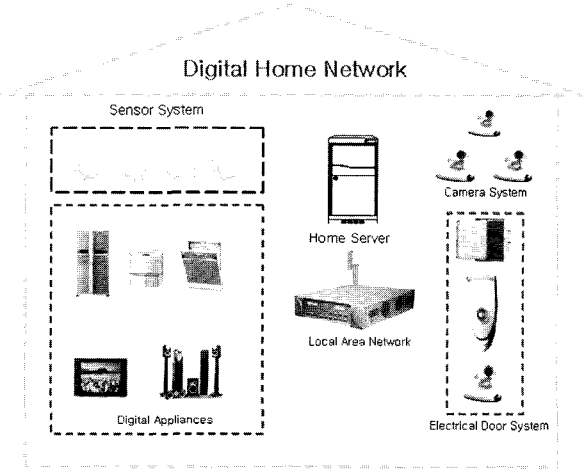

Figure 1. Architecture of general home network

The UPnP is distributed, open networking architecture that utilizes TCP/IP and the Web technologies to enable seamless proximity networking in addition to control and data transfer among networked devices in the home, office, and public spaces. However, it has the limitation of its availability in that it works just in local home network for accessing and controlling electrical appliances[3].

In this paper, we propose Internet Gateway that consists of UPnP IGD(Internet Gateway Device) DCP(Device Control Protocol) and UPnP Bridge for controlling electrical appliance of home network connected to Internet. UPnP IGD DCP is to enable configurable initiation and sharing of Internet connections, advanced connection-management, management of

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host configuration, supporting transparent Internet access by non-UPnP-certified devices. UPnP Bridge searches for local home network devices by sending control messages. Control Point of UPnP Bridge looks up devices of interest on the Internet, subsequently delivering the inter-networking controlling among devices which belong to different home network systems. With our approach, devices can control home electrical appliances on other separated home network via Internet through IGD DCP with control commands of UPnP.

In summary, Electrical appliances of home network can be controlled via the Internet with the UPnP expansion without modification of an existing UPnP in the same home network.

2. The UPnP Overview

The UPnP is encompassing the broad scope targeting home networks, proximity networks, and networks in small businesses and commercial buildings[4]. It enables data communication between any two devices under the command of any control device on the networks. The UPnP is independent of any particular operating system, programming language, or physical medium, supporting zero-configuration networking and automatic discovery, whereby a device can dynamically join a network, obtain an IP address, announce its name, convey its capabilities upon request, and learn about the presence and capabilities of other devices. Optional DHCP and Domain Naming System (DNS) Servers are likely to be used on the network if available. Furthermore, a device can depart from a network smoothly and automatically without leaving any unwanted state behind.

Learning from the Internet's success, the UPnP heavily leverages its components, including IP, Transmission Control Protocol(TCP), Universal Datagram Protocol (UDP), HyperText Transfer Protocol (HTTP), and Extensible Markup Language (XML). The UPnP involves a multi-vendor collaboration for establishing standard Device Control Protocol (DCPs). Similar to the Internet, these are contracts based on wire protocols that are declarative, expressed in XML and communicated via HTTP[5].

A cross-industry UPnP Forum, which has more than 500 industry members as of November 2002, has been working on the standardization of the UPnP. The primary task of the forum is to produce Device Control Protocols (DCPs) that describe standard methods for device interaction using XML. The UPnP specification is still in a preliminary stage; major issues such as security have not been addressed yet.

2.1 The UPnP Protocol Stack

The UPnP network device implementers use protocol standards, such as GENA (General Event Notification Architecture), SSDP (Simple Device Discovery Protocol), and SOAP (Simple Object Access Protocol), in order to accomplish automatic discovery and description. UDP, which is multicast, is employed for discovery and events. TCP handles description and control, while control point uses HTTPMU to inquire what devices are present[3].

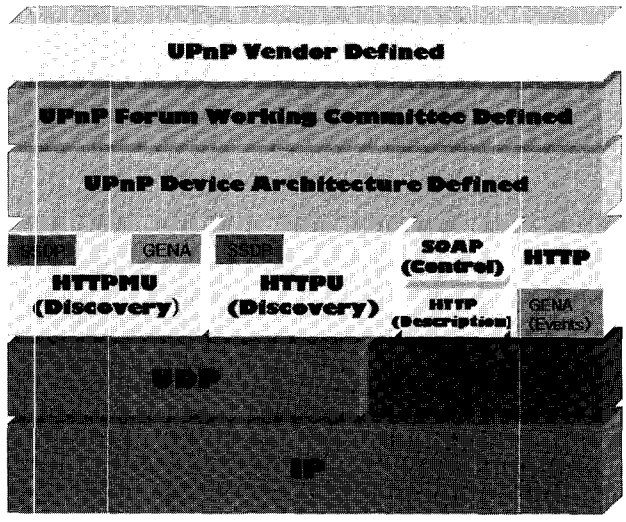


Figure 2. The UPnP Protocol Stack

2.2 Steps to UPnP Networking

The UPnP Device Architecture is a framework that defines the protocols for communication between controllers, or control points, and devices. The UPnP functionality involves five processes[4]:

▪ Discovery

When an UPnP device is added to the network, the discovery protocol allows the device to advertise its presence to control points by using the Simple Service Discovery Protocol (SSDP). Information exchanged between the device and the control point is limited to discovery messages that provide basic information about the devices and their services (e.g., their types, identifiers, and pointers to more detailed information).

▪ Description

Using the URL provided in the discovery process, a control point receives XML information about the device, for example, manufacturer information such as make, model, serial number, and URLs to vendor specific Web sites. In addition, the description process can also include a list of embedded devices, embedded services, and URLs used to access device features.

▪ Control

With given knowledge of a device and its services, control points use URLs provided during the description process to access additional XML information that describes actions to which the UPnP device services respond, along with parameters for each action. Formatted in XML, control messages use Simple Object Access Protocol (SOAP).

▪ Eventing

Once a control point subscribes to a service, the service publishes updates to the control point to announce changes in device status when one or more of the state variables that are evented undergo change. Event messages are formatted in XML and use General Event Notification Architecture

(GENA) protocol.

▪ Presentation

If an UPnP device has an URL for presentation, then the control point can retrieve a page from this URL, load the page into a browser and, depending on the capabilities of the page, allow a user to access interface control features, device, or service information, or any device-specific capability implemented by the manufacturer.

3. Design of UPnP for Internet Connectivity

To achieve actual home network service for which home communication electric appliances are connected, it is necessary to provide services even when users are outside as well as when they are home. Home network usually consists of private networks because of lack in IPv4 address and security problems. Therefore home network and Internet network are basically separated. Standardization of IPv6 is actively progressing. Control middlewares such as JINI and UPnP which are introduced to control unresolved technological problems works normally when devices are controlled inside home network. However, many problems emerge when devices are controlled by the Internet network outside.

The UPnP architecture lends itself well to the discovery, configuration, and management of an IGD(Internet Gateway Device). An IGD is an IP addressable device typically residing at the edge of a home or small-business network. An IGD interconnects at least one LAN with a WAN interface for Internet access. An IGD also provides local addressing and routing services between one or more LAN segments as well as to and from the Internet.

In this paper, we propose Internet Gateway that consists of UPnP IGD(Internet Gateway Device) DCP(Device Control Protocol) and UPnP Bridge for controlling electrical appliance of home network connected to Internet.

3.1 The UPnP IGD DCP

IGD DCP(Device Control Protocol) is designed to support internet network and home communication electric appliances to be connected at UPnP internet Gateway. It creates a device list web document and stores environment information of home communication electric appliances.[7] CGI modules and demon modules included in IGD DCP make it possible to expand functions of web server and specialize functions according to time of information storage. It transports control order to UPnP Bridge.

The IGD DCP has a four-pronged focus: Configurable initiation and sharing of Internet connections, advanced connection-management features, management of host configuration services (DHCP), and support for transparent Internet access by non-UPnP-certified devices.

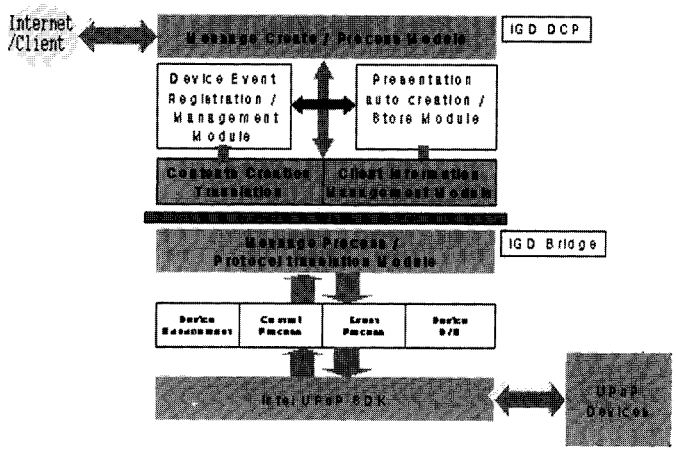


Figure 3. UPnP Internet Gateway System Architecture

3.2 The UPnP Gateway

The UPnP Bridge aims on providing and controlling information on devices of home communication electric appliances. It has device list information of home network, adding device information with a device discovery event and delivering a device search message in case of implementation. It controls device by receiving control order that delivers SOAP message to corresponding devices and resultant messages to DCP. It delivers event messages of devices to DCP through inside control point.

4. The UPnP Expansion Realization and the Results of Experiments

In this paper, the UPnP expansion internet gateway system was developed based on Linux. As a test system, an embedded system in which Linux was installed for function control was employed for the simulation of communication home electric appliances. In order to achieve wire and wireless environments simultaneously, this study provides one jointly-used IP to internet gateway system developed upon Linux and to the wireless notebook system in which Windows XP Professional is installed. Embedded Linux system devices consist of private IPs.

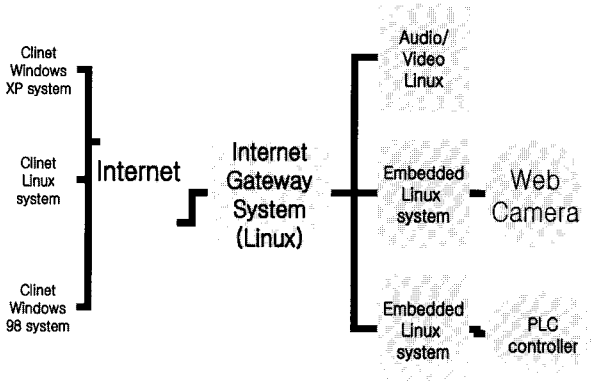


Figure 4. The UPnP Internet Gateway System Test Model

Figure 4 shows schematics of the system. Internet users can confirm and control devices such as cameras, lamps and audios by approaching the home network via Internet gateway. When users select one device in the home network, the presentation results on the corresponding devices are delivered through Internet gateway, whereby users can control and monitor devices. This device control mechanism is shown in Figure 5 and 6:

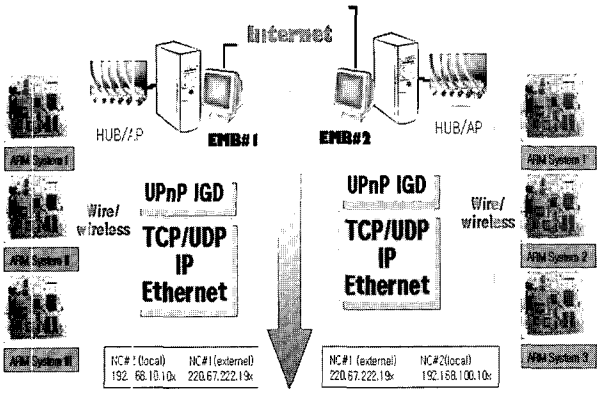
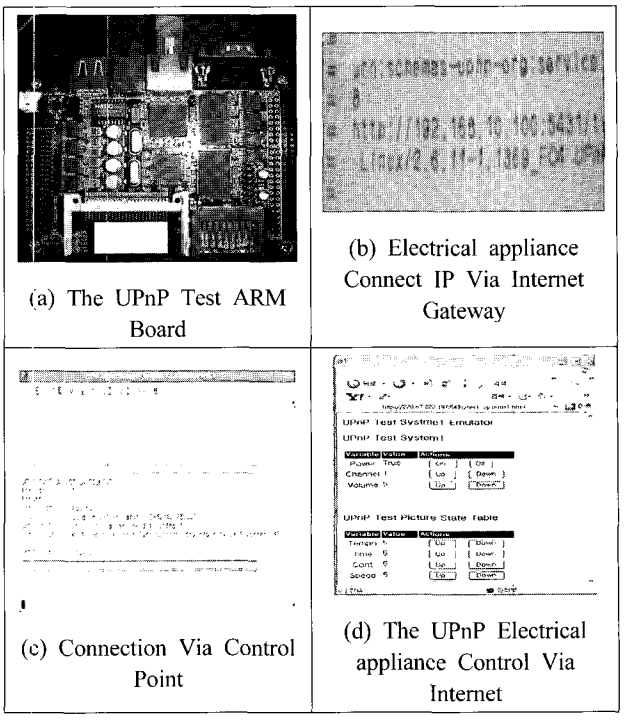


Figure 5. The UPnP Expansion Realization



(a) The UPnP Test ARM Board

(b) Electrical appliance Connect IP Via Internet Gateway

(c) Connection Via Control Point

(d) The UPnP Electrical appliance Control Via Internet

Figure 6. The Results of device control test experiments

When communication home electric equipments in private network are controlled via outside Internet networking through UPnP internet gateway, time delay is not observed, since the general home appliances does not require large amount of data transfer. However, multi-media communication service requiring large amount of data showed some delay in processing steps, which should be resolved in the further study.

5. Conclusion

At present, JINI or UPnP is the prevailing technology to control home network equipment, providing the method to control devices within home network. To utilize and control communication appliances within home network built on actual private network, their functions should be expanded.

In this study, the UPnP internet gateway system founded on expanded UPnP was proposed and its realization was investigated through the experiment. In the proposed UPnP gateway system which monitors and controls communication home appliances in private home network, Internet users use presentation provided by the corresponding devices. The advantage of the system introduced in this study is that users can have the same control environment in Internet network as home network. The present system has the limitation in that it can only monitor and control communication home devices. Further study is necessary on supporting multi-media contents and on security policy of users' authority for each device.

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