Resource Management Technologies for Home Network Services

Hirofumi Yamazaki†, *Zhi Zhang, and Ikuo Yoda*

Abstract

Recently the number of resources, such as home appliances, connected to home networks has been increasing. If they can cooperate, they will be able to provide a lot of services, and home life will be much more convenient and comfortable. However, there are several resource standards and situations; this obstructs resource cooperation. This article describes our resource management techniques for facilitating cooperation among different resource standards and our techniques for detecting the location of resources. Our resource manager converts the different types of resource information into a uniform style and manages it to reduce the processing load. Network management technologies are utilized for location detection to reduce maintenance work.

1. Introduction

Broadband access networks provided using optical network and ADSL (asymmetric digital subscriber line) technologies now enable continuous connections between home equipment and the Internet. More and more home appliances, besides computers, are being connected to networks. Access networks work with home information appliances to promote the setting up of home networks. There are now home network services that can connect and control home appliances, such as air conditioners and electric lights, from outside the home. The number of appliances that will be connected to home networks will increase dramatically in the near future. We define resources as service users and components, such as home appliances and computer applications. A lot of home services can be provided if the resources cooperate with each other. This means that home life will be more convenient and more comfortable. Information about the function and the location of the resources is required for the resources to cooperate. And information about resource allocation to services is also needed because some services may require specific resources at the same time. We have proposed Home Service Harmony [1], [2] for home network services created by resource cooperation. It runs on only one service gateway in a home. The resource manager in Home Service Harmony collects resource information and uses it to provide home services in a home. This article describes our resource management technologies in Home Service Harmony.

† NTT Cyber Solutions Laboratories
Yokosuka-shi, 239-0847 Japan
E-mail: yamazaki.hirofumi@lab.ntt.co.jp

2. Resource cooperation for home network services

We explain a video forwarding service in **Fig. 1** as an example of a home network service to clarify the concept of resource cooperation. Kazuo and Hanako live a long distance away from each other. When Kazuo wants to watch a video with Hanako, they send information to each other to set up their video clients and his home server, which stores the video. However, it is difficult for them to watch the video together if she does not know how to set up her client. In cases like this, they can easily enjoy the service if there is an automatic system for setting up the equipment. When the system receives Kazuo's request, it finds the video client closest to Hanako from information about her location. It then forwards the video from Kazuo's home server to their clients and they can then watch the video on their own screens. Furthermore, the viewing environment can be improved if the light-

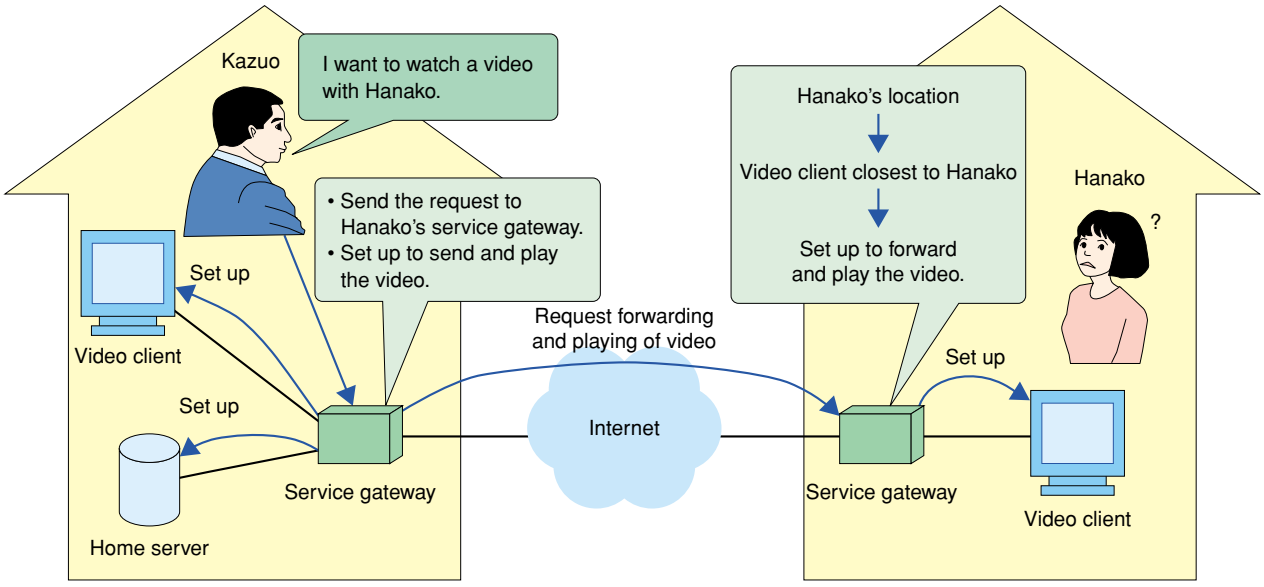

Fig. 1. Resource cooperation for video forwarding service.

ing in each room is adjusted and the background music is muted. This video forwarding service can be achieved through cooperation between the resources, such as Kazuo, Hanako, their video clients, and Kazuo's home server. When brightness adjustment and sound muting are required, the electric lights and audio equipment also cooperate with the other service resources. The automatic system in this example can be achieved by Home Service Harmony, which runs in the service gateway of each home. The resource manager in Home Service Harmony collects the resource information in a home and manages it. Home Service Harmonies in the respective homes use the information and communicate with each other to create the video forwarding service. In this way, when a service is requested, the resources are automatically selected and combined to create the required service. This resource cooperation can offer more services and makes home life more convenient and comfortable, as shown in the example.

3. Techniques for handling various resource standards

Each home uses various resource standards, such as UPnP (universal plug and play) [3] and ECHONET (energy conservation and homecare network) [4] and progress is being made in their standardization. However, each of the conventional home network services is created in accordance with only one of the resource standards. This restricts the combinations of resources, leading to the number of such services being small. We are developing a resource manager that handles various resource standards to provide a lot of services. If the resource manager is flooded with the various kinds of resource information that conforms to the standards, the system could become overloaded, because it must interpret all the different kinds of information before it can provide the home services. Our resource manager converts the different types of resource information to a uniform style when it collects resource information, and it then manages one type of information. Therefore, the resource manager does not have to interpret the various kinds of information when the home services are created. This reduces the load on the system.

Figure 2 shows the structure of our resource management software. There are management software modules that correspond to the respective standards between the resources and the resource management software module. They communicate with the corresponding resources through protocols set by the respective standards. They also communicate with the resource management software module using only one protocol. This means that the resource management software module gets the information from the resources via the respective management software modules. Therefore, it can communicate with all the resources using only one protocol. This reduces the load. Each software module is implemented on a plat-

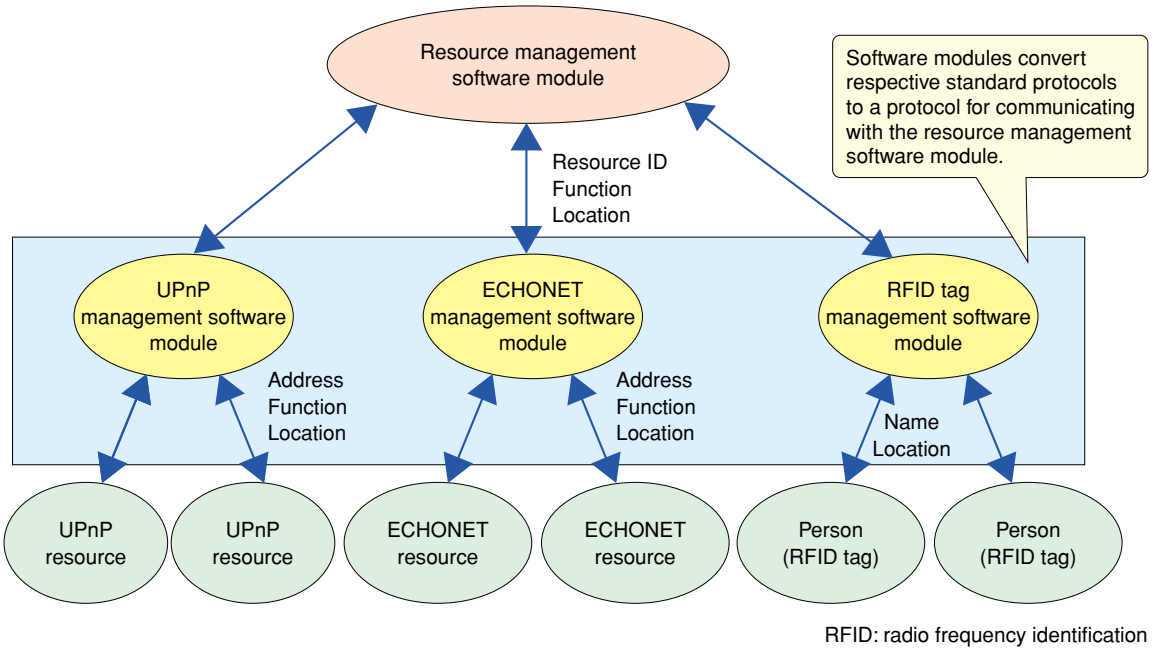

Fig. 2. Structure of resource management software.

form conforming to OSGi Alliance* specifications, which allows software modules to be added to the system without stopping or interrupting it. Therefore, when a new standard is required in a home, the corresponding management software module is installed. The system does not have to be stopped, and resource management continues during installation. Then, the new standard's resources are available in the home without restarting the system.

Figure 3 shows an example of the information managed by the resource manager. Resource information is divided into common items and individual items. The common items include information shared by all of the resources, regardless of the standards, and the individual items are standard-specific information. The resource manager assigns an identification number to each resource and handles its information using this number. Common items are used to search for resources required by a service and to allocate resources for the service. This resource information management enables us to create services without interpreting the various standards, which facilitates resource cooperation. The common items are the function, location, services using the resource, and allocation rate for services about the respective resources. The reason the allocation rate information for services is needed is that some services can share resources. For instance, when two same-sized images are shown on a display, the display, which is a kind of resource, is allocated to the two services showing the images at an allocation rate of 50% each. A service must have resource allocation rates so that the resource manager can determine whether the service can share resources with another, or how much of a resource can be shared by the service. Individual items include standard specific addresses, and so on. These items can be accessed using the identification numbers of the respective resources.

4. Resource location detection

Information regarding resource locations is required when the resource manager chooses resources to create services. In our system, the unit for location management is a room. We determine the anchor points in a home network in real space. These

* The OSGi Alliance is an open forum, whose mission is to specify, create, advance, and promote 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 letters OSGi originally meant open services gateway initiative, but today, they represent an abstract attribute label (modifier) for objects associated with the organization. In repositioning its public image to better align with its true mission, the advancement of an open, portable, standardized service platform for cross-industry use, the OSGi Alliance wanted to retain the recognition achieved by the organization since its formation in 1999, while clarifying that its specifications and other work products were applicable for uses, venues, and devices far beyond the domains usually associated with typical "gateways". NTT is a member of the OSGi Alliance. http://www.osgi.org/

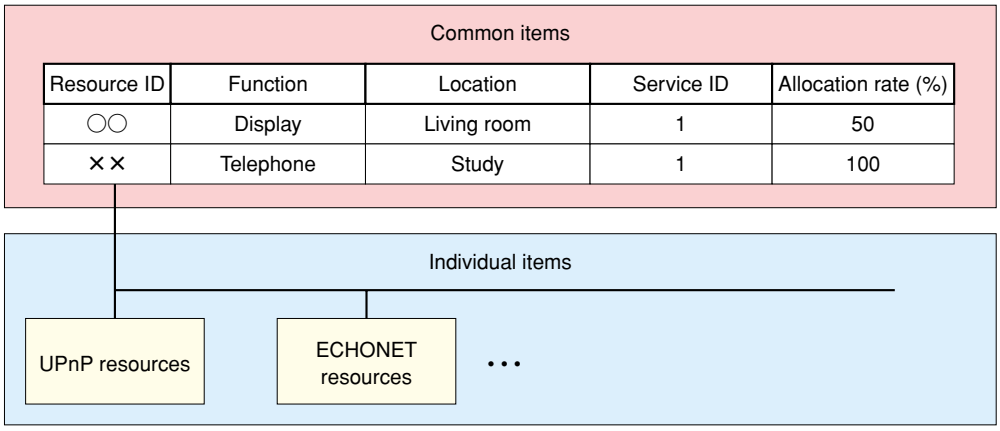

Fig. 3. Information managed by the resource management system.

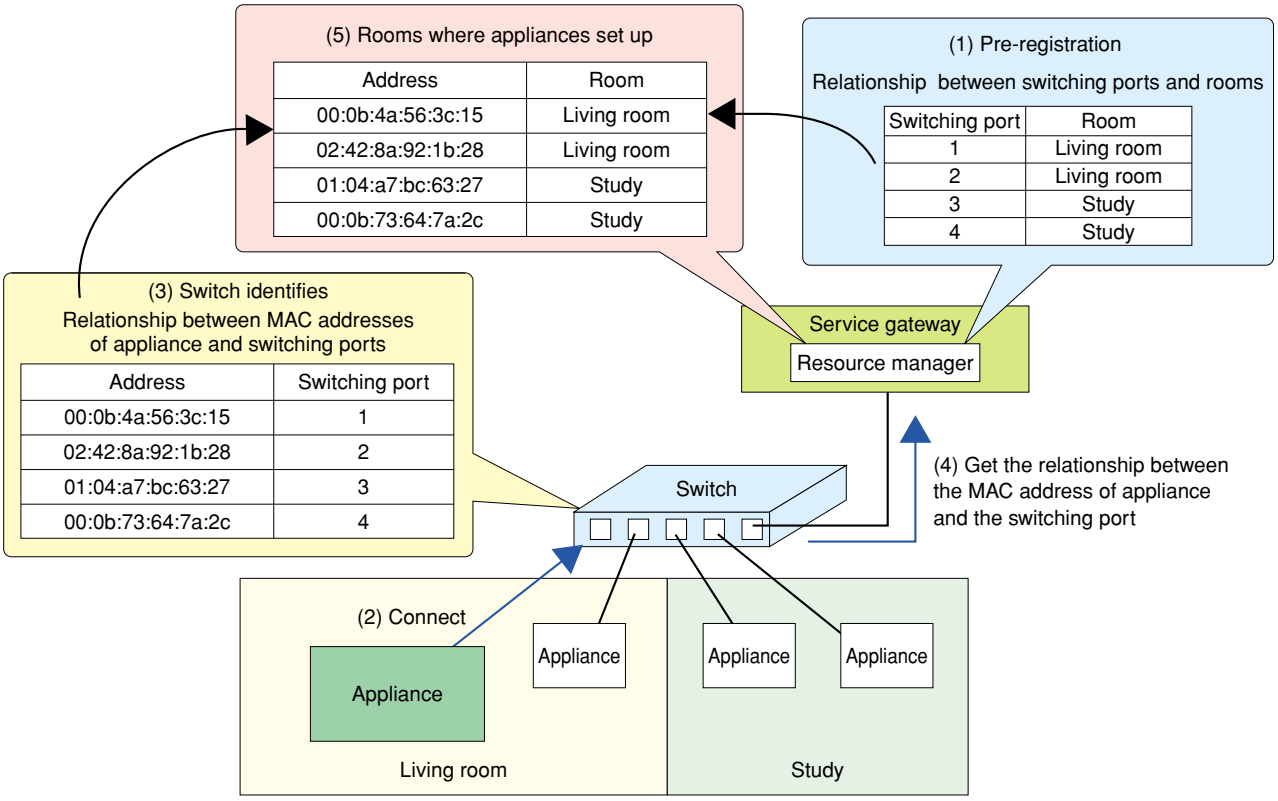

Fig. 4. Detecting resource locations on Ethernet.

are fixed parts of the network in a home. When a resource is connected to an anchor point, our resource manager detects the resource and identifies its location from the anchor point. This arrangement is shown in **Fig. 4**, where Ethernet is used as an example. We will now describe the techniques used for detecting the resources and identifying their locations.

There is a switching port associated with each room in the house. The relationship between the switching ports and rooms is registered in advance with the resource manager in the service gateway (Fig. 4(1)). Home appliances in a room are connected only to the associated switching ports. Therefore, the switching ports are the anchor points. In the network, IP (Internet protocol) addresses are assigned to the appliances using DHCP (dynamic host configuration protocol) [5]. When an appliance is connected to the network (Fig. 4(2)), it requests an IP address from the DHCP

server, which then assigns an IP address to the appliance. The DHCP server runs on the service gateway as the resource manager. Therefore, the resource manager can monitor the address assignment communication and can identify the appliance's IP and MAC (media access control) addresses. The switch identifies the relationship between the MAC address and the port connected to the appliance (Fig. 4(3)). The resource manager gets the information from the switch by using SNMP (simple network management protocol) [6] (Fig. 4(4)). It also identifies the location of the appliance from the pre-registered information about the rooms associated with the switching ports and the port connected to the appliance (Fig. 4(5)).

The resource manager can also identify the locations of people using the radio frequency identification (RFID) system. Antennas are set up in the respective rooms, and the people wear RFID tags in the home. The relationships between the rooms and the antenna identifiers and between the people and the tag identifiers are registered in advance with the resource manager. The tags frequently send out tag identifiers. When one of the antennas detects a tag identifier, the RFID system sends the antenna identifier and tag identifier to the resource manager. In this way, the system can track the locations of the people from both the identifiers and the pre-registered information.

Conventional location management systems, such as RFID systems, use active tags, which have batteries to enable sufficient signal intensity for resource detection in a room, but it is troublesome to have to change batteries when they expire. Therefore, we use the RFID system only to identify the locations of people and utilize network management technologies to detect the locations of appliances. This approach limits the number of tags and reduces the labor required for maintaining the location management system.

5. Conclusions

The number of resources connected to home networks is increasing every day. If resources can cooperate, they will be able to provide many services and home life will be much more convenient and comfortable. However, there are several resource standards and situations. This obstructs resource cooperation and it will be some time before they are unified. Therefore, a resource manager is required to handle the various resource standards to enable cooperation among the many available resources. We are developing Home Service Harmony for home network services created through cooperation among resources conforming to various standards. Home Service Harmony has a resource manager for collecting resource information and using it to provide services in a home. This article described our resource management techniques for facilitating the cooperation between the different resource standards and our techniques for detecting the resource locations.

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Hirofumi Yamazaki

Senior Research Engineer, Network Appliance and Services Project, NTT Cyber Solutions Laboratories.

He received the B.E., M.E., and Ph.D. degrees in electrical engineering from Osaka University, Suita, Osaka in 1986, 1988, and 1997, respectively. He joined NTT in 1988 and has been engaged in R&D of photonic switching systems and multicast networks. His research interests include resource management technologies for home network services. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan and IEEE.

Zhi Zhang

Research Engineer, Network Appliance and Services Project, NTT Cyber Solutions Laboratories.

He received the B.E. degree in electronic engineering from Shanghai University of Engineering Science in 1995 and the M.E. degree in information systems from Nara Institute of Science and Technology, Nara in 1999. In 1999, he joined NTT Network Innovation Laboratories. He has been engaged in the implementation of an OSS (Operation Support System) using J2EE technology and a home network resource manager. His research interests include management technologies for homes network and carrier networks. He is a member of IEICE.

Ikuo Yoda

Senior Manager, Network Appliance and Services Project, NTT Cyber Solutions Laboratories.

He received the B.E. and M.E. degrees in electrical engineering from Waseda University, Tokyo in 1986 and 1988, respectively. In 1988, he joined NTT where he was engaged in R&D of TMN-based network management systems. In 1999, he joined NTT Comware Corp. where he was engaged in the development of motion picture delivery systems. In 2002, he moved to NTT Network Innovation Laboratories. His research interests are home networks and service management. He is a member of IEICE and the Information Processing Society of Japan.