A Personal Agent that Supports Communication in the Ubiquitous Communication Environment

Hajime KUSU* Hiroshi ISHII** Hiroaki NISHIKAWA*** and Kazumasa TAKAMI*

*Graduate School of Engineering, Soka University, Hachioji-shi, Tokyo, Japan

**Professional Graduate School of Embedded Technology, Tokai University, Minato-ku, Tokyo, Japan

***Graduate School of Systems and Information Engineering, University of Tsukuba, Tsukuba, Ibaraki, Japan

***Abstract*- In the coming ubiquitous communication environment, a large variety of devices will be connected to the network, and web services will evolve further, allowing users to receive communication services more flexibly than today. In addition, most devices will be permanently connected to the Internet. In order to create an easy-to-use ubiquitous communication environment for human-to-human communication, we consider a personal network (PN) that consists of a home network and personal area networks (PAN). In the PN, input/output (I/O) devices available in the user's immediate surroundings are used. This paper focuses on the network configuration management functions for a PN. A protocol that controls communication in the higher layer using XML and HTTP is proposed. Finally, this paper discusses a personal agent (PA) that is always at hand to support the user. We have developed a prototype of the personal agent system and verified its basic operation.**

Keywords: Ubiquitous communication environment, Personal Agent, Personal Network, PAN, Touch & Select

I. INTRODUCTION

To ensure the management and interoperability of different devices connected to personal computers, a number of standards have been developed, such as UPnP and Jini. There have also been studies on how to use networks easily, such as the way to construct a private network rapidly by using devices available in a user's immediate surroundings [1], and DUET system [2] that deals with the use of a PA. However in the system described in [1], when the user wants to control a terminal, there isn't the selection method directly. This shows no use soon by intuitively specifying it even if there is a terminal in sight. Moreover in the DUET system [2], the composition method to do the communication between PA that draws close to the individual is examined, but the composition method of Personal Network (PN) that centers on PA is not described.

In this paper, we discuss the composition method of the PA to offer the user centered personal service in the ubiquitous environment. In addition, we propose the use of the Touch & Select method as a comprehensive method of selecting and managing the devices that the user needs when PN that centers on PA is constructed. Furthermore, to support communications in the ubiquitous environment, the architecture of a PA that can use I/O functions more flexibly is described. The PA is characterized by its use of a protocol in which the data structure is described by XML and by its use of HTTP for lower-layer session control. We describe the development of a prototype PA system and Touch & Select Function, and the verification of its basic operation. Another issue we are considering is implementation of this mechanism over versatile communication environment including ad hoc network for some emergency cases where current infrastructure does not work well [3] and underlying platform such as energy-efficient and highly-multiplexable data-driven processor [4].

The rest of this paper is organized as follows. Section II gives a description of the ubiquitous communication environment and the PA. Section III presents the design of the PA and how to communicate. Section IV explains the prototype system, device selection using the Touch & Select Method and the verification environment. The conclusions are given in Section V.

II. COMMUNICATION IN THE UBIQUITOUS COMMUNICATION ENVIRONMENT

A. *PN and PAN*

In the ubiquitous communication environment it is expected that users should be able to readily access a network specifically configured for them, anytime and anywhere, regardless of the particular surroundings in which they find themselves at the time of communication. Consequently, a concept known as a PN has emerged, which treats the networks available in the general area where an individual is normally located as a logical network [5] (Figure 1).

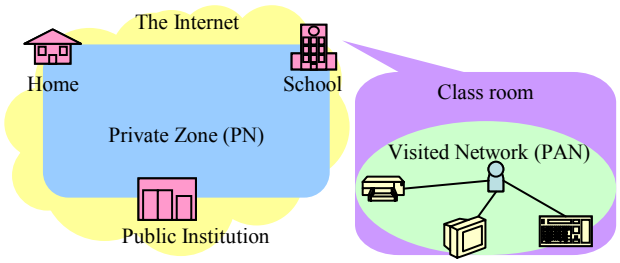

Figure 1. PN and PAN in the Ubiquitous Environment

A PN is composed of smaller networks called PANs. A PAN is a local network that is composed of devices that are available in the user's immediate surroundings at the time of communication. As a result, the user can communicate with a terminal which provides enough processing power to undertake operations that cannot be achieved with the PA unit alone.

In this paper, the PAN where the user is usually present is referred to as the Home PAN (HPAN), and a PAN where the user is currently located as the Visited PAN (VPAN).

B. Communication using the PA

Figure 2 illustrates an example of a situation where the PA may be used. The PA is always at hand for the user, and is installed on a portable terminal, such as a PDA. The user carries the portable terminal, and uses it to handle the devices and data available in his or her surroundings or in remote places. By enabling the PA to use devices connected to PANs as I/O devices, it is possible to construct a communication environment with high extendibility.

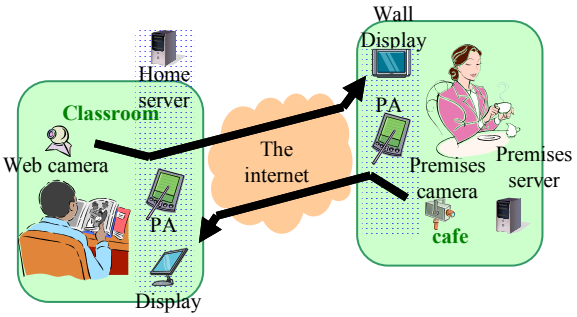

Figure 2. Example of use of PA

C. Requirements for the PA protocol

(1) Connectivity and safety in the Internet

In the ubiquitous environment where different networks are interconnected, it is necessary to ensure connectivity across the boundaries of logical networks, each of which has a built-in security mechanism to prevent unauthorized access. Moreover, it is necessary to consider safety, to protect the user's privacy, because there is the possibility of malicious activity, such as eavesdropping, in the Internet.

(2) Generic data structure

To be usable in the ubiquitous environment, the data structure should offer high readability and be well suited to processing by different programs.

(3) Intuitive Interface

Since the PA supports services for the user; it should not require detailed knowledge to operate it, and it must have an intuitive interface.

III. PA CONFIGURATION

The PA consists of three parts, as shown in Figure 3: the PN&PAN configuration control, needed for participation in the network and for the construction of a PN out of individual PANs; the device selection control, needed for the selection of appropriate devices in a PAN; and the communication control, needed for communication with other PAs. Of these, this paper focuses on the device selection control and the communication control.

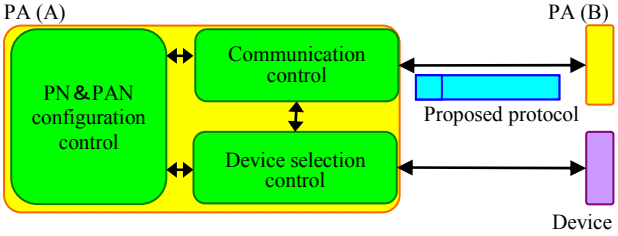

Figure 3. PA configuration

A. Communication using HTTP and XML

(1) Protocol defined using HTTP and XML

To satisfy the requirements described in Section II.C, we have defined a new protocol using XML and HTTP, which are used widely in web-based internet communications.

(2) Communication method

The communication protocol controls communication between PAs by exchanging XML-defined data using POST. The POST method of HTTP was originally designed to select an appropriate function from among a number of functions in the server. Therefore, the POST method is suitable for specifying the communication control function in a PA node.

B. Device selection control

The device selection control acquires information about devices connected to PANs and controls communication with those selected as I/O devices.

(1) Information required for the device selection control

In a ubiquitous environment, where a variety of devices are connected to the network, several devices of the same type may be connected to a PAN. Therefore, information that identifies individual devices is needed. In addition, information about the properties of individual devices is needed, such as the type of device, its capabilities and the precision level at which it can perform its operations. The information about whether the device is an input device or an output device and about what types of media (e.g. text, image, sound, etc) it can handle is particularly important for communication. There may be different definitions of media. For simplicity, we have narrowed down media types to four: text, still image, video, and sound. Table I summarizes these items of required information.

TABLE I
INFORMATION ABOUT A DEVICE USED FOR DEVICE SELECTION CONTROL

Information	Description
Address	Identity of device
I/O	Whether for input or output
Device type	Type of device
Media type	Type of communication media
Device precision	Achievable level of precision

The address is used to specify the device on the network. The media type is sent to the other party in the communication to indicate what medium will be used. If, for example, the communication originator specifies sound as the input medium, and the other party specifies text as the output medium, their media do not match, and they cannot communicate with each other. To prevent such inconsistency, it is necessary to examine the data to determine the media type to be used before the PAs concerned begin to communicate with each other. The precision information of a device may be the resolution in the case of a display, for example, VGA. This information is used by the user to determine whether he or she can use the specified device.

(2) Information management

Where should device information, such as that listed in Table I, which is needed for device selection control in a PAN, be stored? We have chosen to store this information in the device itself, and allow the information to be accessed by others as necessary. Because each device contains information about itself, each device can be easily treated as a simple object. This makes it easy for the device to participate in the network.

(3) Procedure for acquiring device information

When communicating using peripheral I/O devices, it is necessary to recognize and select the available devices. As the selection method for use in this situation, we propose the Touch & Select method.

With the Touch & Select method, XML that describes the ability of each device is written beforehand into an RFID tag which accompanies the device, and this provides a method of recognizing the device and selecting it, by reading the tag of the device that the user wants to use and specifying it. It is easy to for the user to feel that he or she is specifying the device by directly touching it in this method. Moreover, the load on the PA is reduced, and there is the additional advantage that it consumes hardly any network bandwidth because selection of the device does not require any communication packet to be transmitted. Figure 4 illustrates an example of use, and Figure 5 shows the sequence for the selection operation. Figure 5 shows the tag reader and PA as separate items, but integration of a PA and tag reader in a single terminal is under consideration.

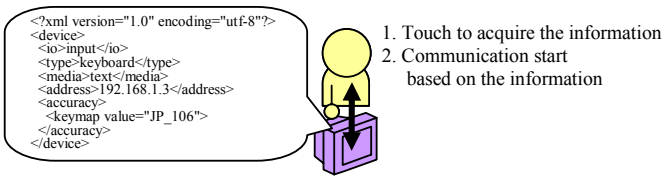

Figure 4. Example of use of Touch & Select Method

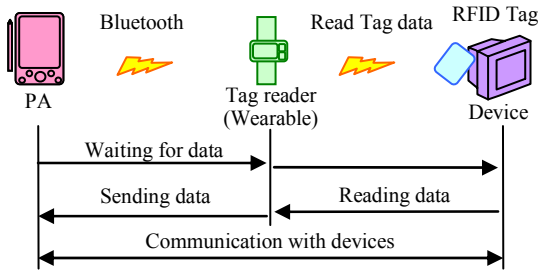

Figure 5. Device selection in when using Touch & Select

(4) Structure of device information data

Figure 6 shows the format of an XML message that is written into the RFID Tag accompanying the device. Device information is recognized as belonging to a device by the "<device>" (device tag) markup. In the device tag, the various necessary data items are described as a markup tags. Each parameter can be read by referring to the markup character string.

```
<?xml version="1.0" encoding="utf-8"?>
<device>
  <io>input or output</io>
  <type>Device type</type>
  <media>Media type</media>
  <address>Network Address</address>
  <accuracy>
    <ValueName value="Value">
  </accuracy>
</device>
```

Figure 6. Format of a message used by a device

C. PN&PAN configuration control

The PA is installed on a portable terminal, such as a PDA, and is expected to move frequently. Therefore, the PA is not connected continuously to a server (Home Agent : HA) that exists in the HPAN or to devices, but connects temporarily. In addition, secure communication is required, since personal information such as user's individual information, personal interests, and PA configuration are handled in the PN. For this reason, PN&PAN configuration control provides the function of offering secure communications between the PA, devices, and the HA. Specifically, it is assumed the composition based on P2P-VPN [6] that uses IPSec. The HA is centered of construction, deletion, and the continuing management of PN. Figure 7 illustrates an example of the composition of a PN.

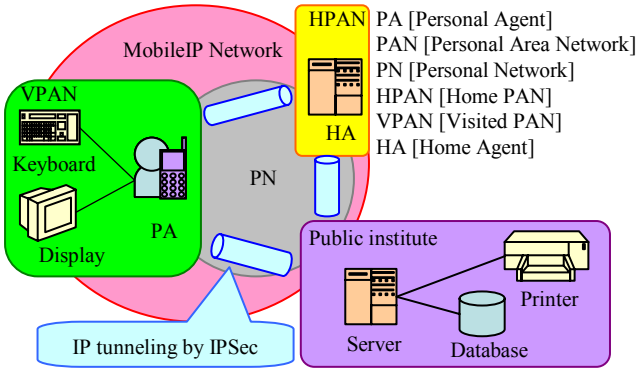

Figure 7. PN composition constructed by P2P-VPN

D. Communication control

The communication control part controls the communication using one of the devices whose connections are managed by the device selection control and the PN&PAN configuration control.

(1) Information necessary for communication control

The information necessary in a PA for controlling communication includes information about the identity of the other party, the position of the other party within the network, whether the other party is available for communication, the functional capability of each control message, and the device that will be used for I/O in the communication. These items of information are listed in Table II.

TABLE II
INFORMATION ITEMS NEEDED FOR
COMMUNICATION AND THEIR PURPOSE OR MEANING

Information	Purpose
Method	Method name
Nickname	Easy-to-remember nickname
Presence	Availability for communication
PA Address	Identifies the PA within the PN
ID Address	Identifies the terminal to be used for communication
I/O device	Data about the device used as I/O

The "method" information is the name of the message used for communication control and indicates the functionality of the message, such as "UseStartRequest" and "CommunicationStartRequest". The PA Address is the identity in the PN given by the PN&PAN configuration control. The ID Address identifies the device used. It is derived by applying a specific operation to the MAC address, which is uniquely allotted to each network interface. An individual is identified on the principle that each person has only one PA. The data about the I/O device includes the device management data described earlier.

(2) Procedure for establishing communication

Let PA1 be the originator of the communication and PA2 the other party in the communication. First of all, PA1 selects a device, and sends PA2 a message requesting the start of communication. PA2 selects a device that matches the request, and sends a reply to start the communication. The communication is then started, and data is exchanged. When one of the parties sends a message requesting the closing of the communication, the other party sends a reply to close the communication.

(3) Message format

Figure 8 shows the structure of a typical message written in XML. This is based on Table II. This message requests the establishment of a connection with the other party. This message consists of the HTTP header and the payload.

```
(HTTP header is excluded)
<?xml version="1.0" encoding="utf-8"?>
<method type="CommunicationStartRequest">
<nickname>Nickname</nickname>
<presence>online</presence>
<paaddress>PA Address</paaddress>
<idaddress>ID Address</idaddress>
<input>Input Device information</input>
<output>Output Device Information</output>
</method>
```

Figure 8. Format of a message used for communication control

E. Communication sequence

Figure 9 shows the communication sequence of this system.

When PA1 has determined whom to communicate with, it acquires I/O device information using the Touch & Select Method to recognize and select (AcquireDeviceData), selects one, and sends a use-device request to it (UseStartRequest). The connection completes (UseStart Reply). If the device is available for communication, PA1 sends a start-communication request to PA2 (CommunicationStartRequest). PA2 also searches for and selects an I/O device to use (from AquireDeviceData to UseStartReply). When PA2 has an I/O device ready, it sends a start-communication reply to PA1 (Communication StartReply), and the communication is started. When one of the parties sends a close-communication request to the other party (CommunicationCloseRequest), both parties send a stop-use request to their respective I/O device (from UseStopRequst to UseStopReply), and the communication is terminated (CommunicationCloseReply). Finally, PA1 disconnects the device (from UseStopRequest to UseStopReply).

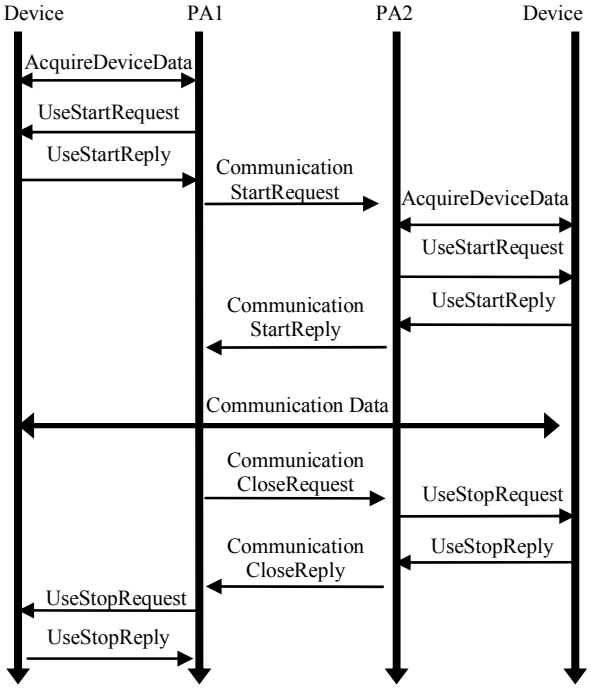

Figure 9. communication sequence

IV. PROTOTYPE SYSTEM AND VERIFICATION

A. Prototype system software

(1) PA

We have developed a prototype software system that implements the functions described in Section III excluding the PN&PAN configuration control part. Using this system, a user can establish communication using an I/O device (which is emulated by software) that exists within the same LAN. Initially, a waiting window is displayed. To start communication, the user selects the device on the device selection window. In the device selection window, the user selects the devices using the Touch & Select Function. Figure 10 shows the device selection window.

The user touches the tag by the hand with tag reader, and to read the device information, pushing the Touch & Select button in the lower part of the window. There are displayed the details of the read I/O device information in the upper part and central part of the screen. When the preparation for the communication is completed, and pushed the connect button, a communication window appears.

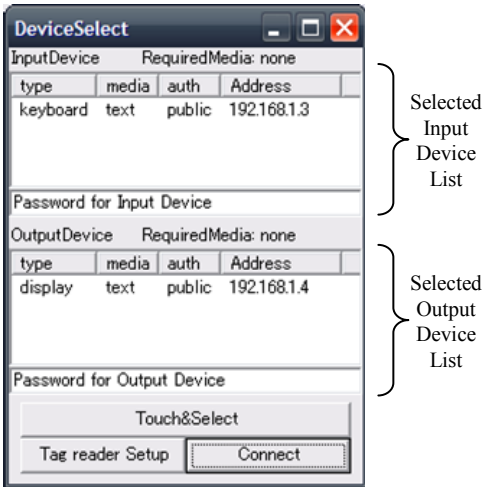

Figure 10. PA: Device selection window

(2) Device Emulator (DE)

This program emulates a device equipped with a network API. It waits for a request to arrive from the PA. When a request arrives, the DE returns an XML message that describes the characteristic data of the device. It can also function as an input-output device for the PA. There is one DE for each type of device. This paper shows examples for a keyboard DE and a display DE. Figure 11 shows the waiting window of the DE (keyboard).

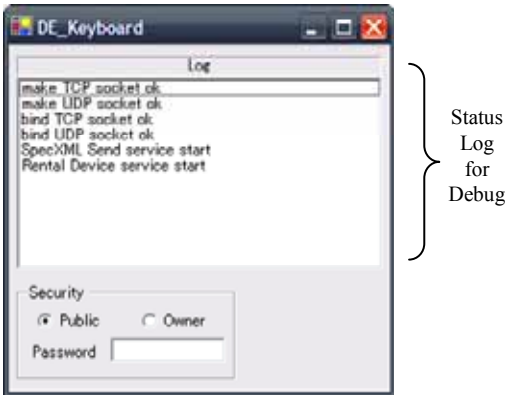

Figure 11. DE_Keyboard: Waiting window

(3) Communication Server (CS)

This software resides in the HPAN. It stores the communication log using the PN, which is configured when the PA is accessed. As in the case of the DE, the Communication Server waits for a request. When it receives a request from the PA, it receives the log data and stores it in the machine. Figure 12 shows the Waiting log message window.

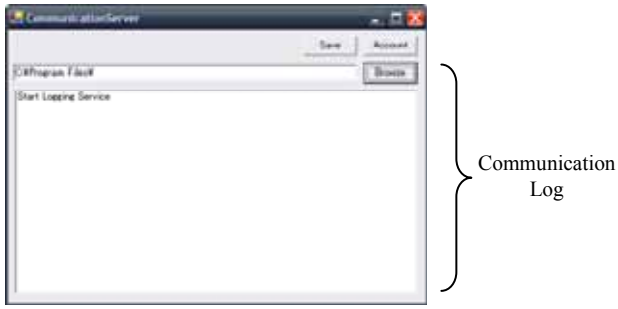

Figure 12 CS: Waiting log message window

B. System outline

Figure 13 illustrates the configuration of the prototype system. The PA, DE, and CS are all on machines running Microsoft Windows XP. A LAN is used to simulate the PAN. Since the configuration control of the PN&PAN is excluded from the prototype system, both the HPAN and VPAN are simulated as a single LAN. Also, the CS is placed in the same LAN.

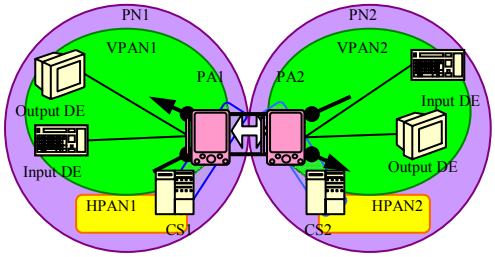

Figure 13. System composition

Because of abundant libraries exist for the stream form not caught in the type of data, and be able to easy development comparatively, we selected VB.NET as the development language, considering the ubiquitous environment.

C. Evaluation by performance verification

The PA system was evaluated by verifying the performance in the environment of Figure 13.The DEs of a keyboard and a display, a PA, and a CS were placed in each of the two PANs. It was confirmed that it was possible to use an I/O device with the Touch & Select Method in each PAN and to communicate according to the procedure shown in Figure 9. The IP address was used for the PA address, and the MAC address was used for the ID address. The values of the settings used in each PA are shown in Tables III and IV. In addition, Figures 14 and 15 show the device information that was used by PA1 as an example of the device data used.

The device data shown in Figure 14 and figure 15 that was used in this performance verification was about 190 bytes. An RFID tag has a maximum capacity of 256 bytes, as decided by ISO/IEC. This example shows that this sufficient for this application.

TABLE III
VALUES USED IN EACH PA FOR THE VERIFICATION OF OPERATION

Variable	PA1	PA2
Network Address	192.168.1.0/24	192.168.2.0/24
Nickname	User1	User2
PA Address	192.168.1.1	192.168.2.1
ID Address	00:13:CE:E0:28:FB	00:0F:1F:4E:82:02

TABLE IV
VALUES USED IN DES FOR THE VERIFICATION OF OPERATION

Variable	Keyboard	Display
Address (for PA1, PA2)	192.168.1.3, 192.168.2.3	192.168.1.4, 192.168.2.4
I/O	Input	Output
Device type	Keyboard	Display
Media type	Text	Text / Image
Device precision	Empty	200 x 200
Password	Empty	Empty

```
<?xml version="1.0" encoding="utf-8"?>
<device>
  <io>input</io>
  <type>keyboard</type>
  <media>text</media>
  <address>192.168.1.3</address>
  <accuracy>
    <keymap value="JP_106">
  </accuracy>
</device>
```

Figure 14. Example of message sent by a DE_keyboard

```
<?xml version="1.0" encoding="utf-8"?>
<device>
  <io>output</io>
  <type>display</type>
  <media>text, image</media>
  <address>192.168.1.4</address>
  <accuracy>
    <resolution value="200x200">
  </accuracy>
</device>
```

Figure 15. Example of message sent by a DE_display

V. CONCLUSIONS AND FUTURE WORK

This paper has proposed a PA function that supports communication in the ubiquitous communication environment, and a Touch & Select Function, and described how it can be implemented using HTTP and XML. The basic operation of the PA has been confirmed through development of a prototype system. In the future, we will study the PN&PAN configuration control, adaptation to a variety of communication media, and a device naming system suitable for device management within the PN.

ACKNOWLEDGMENT

This research was partially supported by TAF (The Telecommunications Advancement Foundation), 2006 fiscal year.

REFERENCES

[1] H.Hirai, N.Mimura, H.Morikawa and T.Aoyama: “Realization of a Service-oriented Network Using a Host Grouping Framework”, IEICE Gen. Conf.’06 (in Japanese)

[2] I.Iida, T.Nishigaya, and K.Murakami, “DUET: An Agent-based Personal Communications Network”, IEEE Communications Magazine, pp.44-49, Nov 1995

[3] C.O.Chow and H.Ishii, "A Simulation Study on Multipoint-to-point Video Streaming over Mobile Ad hoc Networks", PIMRC'06, Sep. 2006

[4] H. Nishikawa, "Design Philosophy of a Networking-Oriented Data-Driven Processor-CUE", IEICE Transactions on Electronics, VOL. E89-C No. 3, pp. 221-229, Mar. 2006

[5] Nico Baken, Edgar van Boven, Frank den Hartog, and Ramin Hekmat, “A Four-Tiered Hierarchy in a Converged Fixed-Mobile Architecture, Enabling Personal Networks, ” Journal of the Communications Network, volume 3, part3, pp.98-104, November 2004

[6] K.Yagi, O.Honda, H.Oosaki, K.Matsuda, and M.Imase, “A Ring-based P2P-VPN Realizing the Cyber-Society”, Technical report of IEICE (IN2005-12), pp. 61-66, May 2005.