Personal Server Model for Real-Space Networking

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Abstract. As the Internet population grows, not only computers but household electric appliances, such as VCRs and a refrigerators, will become connected to a network. The demand of connecting appliances to a network is increasing, however, other cheap objects are difficult because of the cost or technical problems.
In this research, we focus on connecting people to the Internet. We propose the *Personal Server Model* that sets up a personal agent on the Internet. An agent, we called *Personal Server*, obtains person's information by using sensors. Personal Server also provides information via Internet. With this Personal Server, any person can become an Internet node virtually. By treating person as an Internet node, applications that use the personal information can be developed easily like conventional Internet applications.

Keywords: Ubiquitous, Context Based Computing, Sensor Network, Real-Space Networking.

1 Introduction

Ubiquitous computing environment is said to be embedding a computer at various things, and offers convenience to a user. In ubiquitous computing environment, not only electric appliances but also even homes and vehicles have connected to Internet[1]. Moreover these things, it is thought that there are many advantages of connecting other cheap and common object like a coffee-cup to the Internet in Real-Space[4]. However, there cheap object can not be embeded because of the cost or technical problems.

The Real-Space Networking aims to connecting these objects also to the Internet by using *sensors*. And any network application can obtain information about these object via Internet.

The target object in this research has the following features.

- No Internet connectivity because of various reasons like cost, a size.
- Mobile. Active or Passive is not concerned.
- Elemental substance. In other words, multistage composition is not target.

Among the objects with such features, we especially focus on the "person". By connecting person to Internet, various kinds of information can be obtained.

There are numerous kinds of information that are personal information. For instance, schedules, contact addresses and context information such as walking, sitting, attending a meeting, driving a car and so on. The files in the person's home directory may be included. All personal information is important. It can become more convenient by using this information. Though, we will concentrate on the personal location information in this research.

Next, the two scenarios of the application using person's location information will be described. and after scenarios, we introduce related works in section 2. In section 3, we propose *Personal*

[4] In this paper, "Real-Space" is human sensible space. Opposite word is "Virtual-Space".

Server Model that manages personal sensor information. In section 4, we describe detail of Personal Server Model . In section 5 and 6, we introduces our experimentation and evaluation. Section 6 concludes the paper with discussions and future work.

Health-care A patient does not appear in the hospital at a scheduled time for a medicine, and cannot contact. In this case, an ambulance can be dispatched to the place where the patient's is by grasping it's position. However, in the case with people, moving to places where cannot be grasped by GPS, such as underground and inside buildings, must also be considered. In addition, person can be use heterogeneous sensor to obtain various kinds of information.

Alarm clock Even in a case where an alarm clock goes off, and the person is still in bed, the alarm clock can detect from the location information that the person is still sleeping. An alarm clock would then continue to ring until necessary.

2 Related works

The Active Bat system [3] is the Location-aware Computing system. Active Bat uses an ultrasound in order to detect location. In Active Bat, users and objects have cheap and small tags which receive ultrasound in order to detect location.

Cricket Location Support System[4] uses ultrasound and cheap receivers in object in order to detect the location of object. Cricket use radio frequency signals additionally in order to time measurements. In Cricket, location is decided by triangulation relative to the beacons.

Recently, studies based on IEEE 802.11b has became major like robot location [5]. Since IEEE802.11b becomes an wireless network method that has wide usage, becomes cheap and small device. However, if target object has no electronic power like cheap object, system can not detect its location.

Geographical Location Information (GLI)[6] is able to map a mobile entity on the Internet to a geographical location. The GLI system consists of home and area servers. These servers are managed based in a hierarchical server structure toward highly scalable system However, GLI system assumed absolute coordinate like GPS.

3 Personal Server Model

This paper focuses especially on person. In this section, we describe our personal server model that manages personal information from the sensor at each own personal server.

3.1 Assumptions

Sensors are required in order to obtain information from Real-Space. However, there are various kinds of device type of sensor like data set. In addition, the movement of person who are targeted in this paper becomes problem. And, in order to discriminate person uniquely, it is necessary to have Globally Unique ID. Next, we will describe about detail of these assumptions.

Heterogeneous Sensors Infrastructure To realize Real-Space Networking environment, sensors are needed to obtain personal location information. However, contrary to related works, we use not only the sensor which the user holds, but also the sensor infrastructure which is installed in the environment. Because, one sensor can not cover all location. For example, GPS can cover above ground, however, GPS can not detect under ground or in building.

Since that, we need various kinds of sensors to detect person's location. In figure 1 illustrates these sensor environment. There are various kinds of sensor infrastructures. Sensor infrastructure A in figure 1 has many sensors and these sensors connects each other like most Sensor-Network. Sensor infrastructure B and C has many sensors and send information to sink-node(Data-Base) like Active-Bat. Sensor infrastructure D has only one sensor device and that sensor can cover like GPS. User moves these sensor infrastructure and sensors nearby user obtain user's current information.

In addition, each sensor infrastructure has Administrator. The administrator manages and maintain these sensors. Consequently, administrator can get user's information. Therefore, security and privacy become problem.

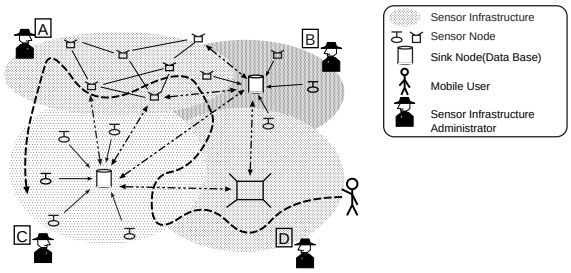

Fig. 1. Supposed Environment

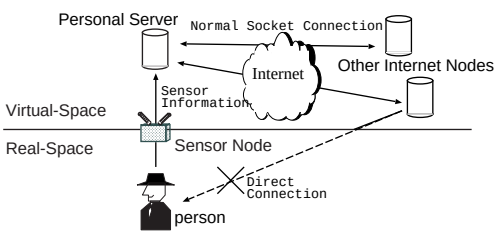

Fig. 2. Personal Server Model

All person has Globally Unique ID(GUID) In order to identify the user from sensors, we assume every persons have GUID and sensors can get these GUID using Auto-ID[7] or other method. GUID is used SDP described later.

We assume only uniqueness about GUID. However, structure of ID space and ID development is out of Target.

3.2 Personal Server Model

In heterogeneous sensor infrastructure as mentioned above, there are two problems. One is where manages sensor information and the other is privacy.

We propose the Personal Server Model in order to resolve these problems. In this model, each person have the *Personal Server* that stores personal information like Location Information. Figure 2 shows this model.

Sensors sense personal information, and send it to his/her Personal Server. Personal Server accumulates the personal information. The other Internet nodes can access to the Personal Server in order to get that personal information in stead of direct access to person who is not connected to the Internet. In other words, Personal Server will serve as proxy or agent in the person's virtual-space.

In Personal Server Model, we can say the Personal Server is mapped object on Internet from person. According to that, when other Internet node obtains personal information, connect with other ordinary Internet manner like socket connection. Eventually, Internet Application that use personal information can be developed easily.

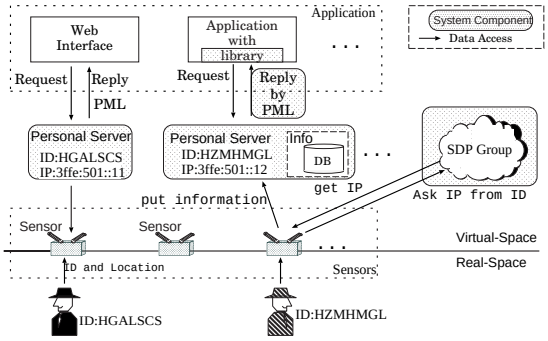

Fig. 3. System Component

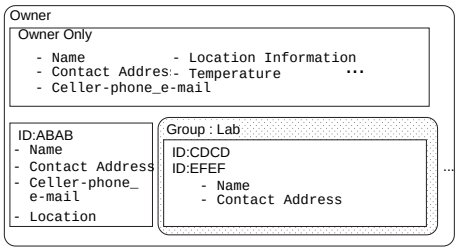

Fig. 4. Access Control in the Personal Server

4 System Architecture

In this section, we will describe the system architecture based on Personal Server Model. Figure 3 shows the system components which is half-tone dot meshing. We then describe about these system components.

4.1 Sensors

As mentioned, we assume using Heterogeneous Sensors in order to obtain user's personal information. We classify sensors into the following two kinds.

- Self-directed type sensor
- Sensor Infrastructure

Self-directed type sensor is a sensor where the sensor and sensing target is same. For example, GPS sensor receives the electric wave from a satellite and obtains its position. Therefore, sensing target is GPS sensor itself. Although this type has high accuracy, in many cases, these devices tend to be quite expensive.

Sensor Infrastructure are installed sensor as infrastructure. Many kinds of these sensor infrastructure sense the target when the target enter within the coverage of sensing. For instance, there are many studies to detect cheap target devices by using RF(Radio Frequency) or other method and obtain target owner's location. Though sensor infrastructure itself is expensive, target devices are cheap. Consequently, this kind of sensor is useful to operate as infrastructure. In addition, it must be noted that, when we use this kind of sensor as a location sensor, obtained information becomes relative location. For example, GPS uses latitude and longitude and altitude. However, RF sensor cannot get this absolute coordinate, but only labels such as room name.

As mentioned above, this research assumed on the Heterogeneous Sensor Infrastructure. Hence, it is necessary to accommodate to two kinds of sensors. However, Users do not always have sensor devices in Heterogeneous Sensor Infrastructure.

4.2 Personal Server

Personal Server is the Internet node that holds the user's information in Real-Space. The other Internet node can obtain personal information such as location information of the owner of that Personal Server by accessing to the Personal Server.

Internet nodes that wants to obtain user's information sends a request message to the Personal Server which has the GUID of the target person. Request message must contain the GUID of the person whom is using that Internet node. Personal Server returns user's information described by PML to the request node. Basically, Personal Server has this function.

It may be setup the Personal Server anywhere on the Internet. Moreover, the Personal Server always needs to be connected to the Internet. However, as long as it is a short time, the Personal Server may move. It becomes impossible to obtain the person's information in the meantime.

Privacy Protection Personal Server may be set up anywhere on Internet and many Internet nodes may connect to the Personal Server. Since Personal Server has the personal information like location information, privacy protection is required. Moreover, only one Personal Server has managed his personal information. Since the personal information managed unitary on one Personal Server, when performing privacy protection, it is necessary to protect only one Personal Server.

We prepare an access control mechanism in order to realize privacy protection. When requesting personal information, Internet node must include GUID in a request message. The access control mechanism inside the Personal Server changes sending personal information to according to GUID contained in a request message. Personal Server may return nothing if request is invalid. Thereby, information cannot be passed to a request from an unexpected partner or the partner who does not want to give. Figure 4 shows access control list in Personal Server. Access control mechanism is

moved according to this access control list. In this figure, personal server may send name, contact address and location information to the user which has ID:ABAB. However, personal server may send only name and contact address to the user(ID:CDCD) and user(ID:EFEF) because they are belong to Group:Lab. The group is maintained only one personal server. For that reason, though the user which is belongs to Group A in someone's access control list, the same user do not necessarily belongs to Group A in another user's access control list.

4.3 User's information in Real-Space

We propose *Person Markup Language(PML)* in order to describe the user's information in Real-Space. When Personal Server exchange personal information with other Internet node, PML is used.

PML PML is XML[8] based language for describing personal information. PML must contain a core part. A core part contains GUID, Location Information, and Timestamp that obtained the last Location Information. Because every object have these information.

Figure 5 shows an example of a simple description of one person.

```
<d2:D2
  xmlns:d2=''http://www.sfc.wide.ad.jp/~shirou/Work/d2/d2/''
  xmlns:person=''http://www.sfc.wide.ad.jp/~shirou/Work/d2/person/''>
    <d2:core>
    <d2:id>HZMHMGL</d2:id>
    <d2:location>Meeting Room 1</d2:location>
    <d2:timestamp>2002-09-10 18:24:49</d2:timestamp>
    </d2:core>

    <person:person>
    <person:name>WAKAYAMA Shirou</person:name>
    <person:nickname>Shirou</person:nickname>
    <person:e-mail_addr>shirou@sfc.wide.ad.jp</person:e-mail_addr>
    <person:organization>KEIO SFC</person:organization>
    </person:person>
</d2:D2>
```

Fig. 5. an example of user's Information described by PML

The core section of PML example in Figure 5 shows also that this person has ID:HZMHMGL and that his actual location is in the room called *Meeting Room 1*, and the Timestamp from which the Location was last obtained.

Moreover, PML can describe various kinds of information in addition to the core section. Figure 5 shows also person name and e-mail address. Thus, PML is extensible so that various kinds of information may be expressed. User's information described by PML is updated on the fly by the sensors or user himself.

4.4 Server Discovery Protocol(SDP)

Other Internet nodes and sensor nodes need to know the Personal Server IP address in order to access to the certain person's Personal Server. In this paper, as mentioned above, it is assumed on all persons holding GUID.

Server Discovery Protocol (SDP) changes person's GUID into that person's Personal Server IP address. We can say that SDP changes GUID that is independent of location into IP address depending on a location.

Group of nodes using SDP handles Server Discovery Protocol. These SDP groups are overlay network on Internet. There connect each other, and they exchange the conversion table to Personal

Server IP address from GUID. Node that has participated in SDP Group can convert the GUID to that Personal Server IP address. SDP mechanism is designed based on pure P2P network like Gnutella[9].

However, it is not desirable on privacy protection that other unnecessary nodes hold the conversion table to IP address from GUID. Therefore, Conversion table has no GUID itself but one-way hashed ID such as MD5. Only node that knows right GUID can map certain IP address. Thereby, even if Personal Server IP address understands the middle node of SDP group, it can not know whose GUID it is. In addition, even if it connect the Personal Server IP address, it will be denied in the access control mechanism of Personal Server.

5 Experimentation with some hundreds of people

The experimentation based on Personal Server Model was conducted during the WIDE-camp in September 2002. WIDE-camp is research conference held at a Hotel where member of WIDE Project[10] gather and open BoFs to have discussions. 274 people participated in this experiment during 3 nights and 4 days.

In this experimentation, in order to create many Personal Servers, IPv6 was used. Next, we then describe about each part of system component detail.

Figure 6 shows the Map. Each room are labeled with a name like "BOF1". Location information of Participants is expressed using this labels. In this experiment, labeling was performed manually. The white circle in figure 6 shows the place in which RF-Reader where setup as mentioned below. Note that figure 6 will be used at section 6.

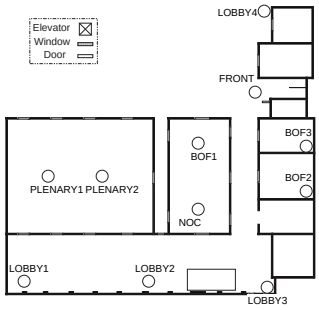

Fig. 6. Hotel Map

For the Location detection by LIN6 mentioned later, segments is divided for each and every room to show a prefix for each room. Furthermore, in this experiment, since the host for many Personal Servers was not able to be prepared, one host was attached two or more IPv6 addresses as Alias. Then, Personal Servers for all the members was prepared virtually.

5.1 Sensors

We used two kinds of devices as Location Sensor. One is RF-Reader and the other is LIN6-MA. RF-Reader is human location sensor in Real-Space, and LIN6-MA can provide location information from network prefix.

RF-Reader We use the RF-Code[12], which is a system for detecting a human location.

The cost of sensor construction is one of reasons for having chosen RF-Code. Although other systems, such as Active Bat, have very high accuracy, however, huge cost is required. In this experimentation, it is enough if personal location is known per room. Therefore, cost becomes important rather than accuracy.

Therefore, the Self-directed type sensor that needs a high cost device for an individual user is unsuitable. We selected RF-Code as an Environmental installation type sensor, and all users

always carry a cheap and small tag. The tag is shown in Figure 7. The right tobacco is used to compare the size.

This RF-ID tag is a tag carrying its own battery, each with a Globally Unique ID, and sending the ID by using 300MHz radio frequency. We used this RF-ID GUID as GUID of Personal Server Model. Tag sends this GUID once every 3 seconds, and when RF-BaseStation catches this GUID, it detects that a user is in detection within a sensing area of that RF-BaseStation. Figure 8 shows RF-BaseStation.

Furthermore, we prepared three kinds of the antenna attached to RF-BaseStation. Since this sensitivity different, the antenna was properly used according to the size of the each room. Thereby, one RF-BaseStation area can cover mostly equivalent to one room. Moreover, two or more leaders are installed in the large room.

Fig. 7. RF-Code Tag

Fig. 8. RF-BaseStation

When two RF-BaseStation and the person enter between them, it becomes a most important problem when choosing its location.

Moreover, Hotel used at WIDE-camp had thin walls, and radio waves passed through them easily. Therefore, a RF-reader BaseStation will receive an ID ranging over the room. Consequently, person may seem to have moved even though they didn't.

However, many BoFs and presentation are made at WIDE camp. In this circumstances, we can assume that once people goes into the room, they will not leave that place for a certain period of time.

Therefore, the position diagnosis algorithm in consideration of hysteresis was adopted. This algorithm can reduce miss detection of movement.

We used the Mobile Gear[11] for connecting network and RF-BaseStation. The Mobile Gear connects to network by using Wireless LAN; added to this, RF-BaseStation and Mobile Gear have a battery. RF-Reader set is completely movable by wire free.

Mobile Gear connect to RF-BaseStation by using RS-232C, and sends GUID sensed by RF-BaseStation via network to Personal Server of owner known by GUID. Mobile Gear sends the label of RF-Reader set additionally. According to this label, location information is determined.

Moreover, the Mobile Gear is operated by NetBSD/hpcmips. Reliability is increasing by using not WindowsCE but NetBSD. In addition, it is manageable from remote host.

LIN6-MA In LIN6[13], unique ID of a meaning called LIN6ID is assigned to each host. After a host can assign network prefix, LIN6ID and network prefix will be compounded and an IPv6 address will be generated automatically. By registering this IPv6 address into Mapping Agent (MA), a host notifies a communication partner of in which network it exists, and realizes Location Independency.

If a user connects Note PC with the network, LIN6ID and network prefix will be compounded and an IPv6 address will be generated automatically . This IPv6 address is sent to MA with

LIN6ID. MA, which received the IPv6 address, transmits an IPv6 address and LIN6ID to the process called NLX (Network Location eXchanger). NLX can know owner of the note PC by LIN6ID, and the network by network prefix. As shown below in subsection**??**, the network that has different prefix for every room in this experiment, it is possible to get to know the location of Note PC by network prefix.

In this experimentation, we used LIN6 as another location sensor. Every 16 LIN6ID was assigned every participant in order to support when a participant has two or more PCs,

5.2 User Interface

Two kinds of interfaces were prepared as an interface to Personal Server. One is interface for human, the other is used to develop.

Web Interface We prepared the web interface to connecting Personal Server and obtaining location information. Users can get the following things through this web interface.

- Search location information
  By specifying a location, it is possible to get the list of users who are near that location. From this list, the situation of that location and how many participants are gathering can also be known via network.
- Search information from location
  By specifying a location, you can get list of users who exist near that location. From this list, the situation of that location and how many users are gathering can be known also via network.
- Tracking Note-PC
  We are able to find out the location where Note PC is put based on LIN6ID which described below.
- Acquisition of Personal Server IP address
  It is possible to perform SDP(Server Discovery Protocol) through a web interface. Thereby this interface, it is also possible to get Personal Server IP address and to obtain information from Personal Server directly.

Library Moreover, we prepared library of the C language for accessing Personal Server so that it might be easy to develop the application which uses location information. This library contains the functions, which can get the IPv6 address of Personal Server using SDP, and connect to Personal Server and acquires PML. In addition, SDP command line program was also created.

6 Evaluation

In this section, we will describe about Evaluation of this system. First, we will start about accuracy of sensor. The three kinds of evaluation will be shown that are Human Location Tracking, Human behavior and General Movement. Next, we will discuss about Personal Server Model.

6.1 Human Location Tracking

At first, we compared tracked one person movement and actual movement. Figure 6.1 shows sensed location and actual location while 24 hours (actually, 18 hours).

6.2 Human Behavior Observation

We collected every user's location from each personal server in order to obtain statistics human behavior data. From this results, we select at two rooms it show the characteristic motion of people and these graphs is shown in Figure 10 and11. These figures, which mean how many people, are in the room for every time. As for Figure 10, BOF2, people are beginning to be detected from

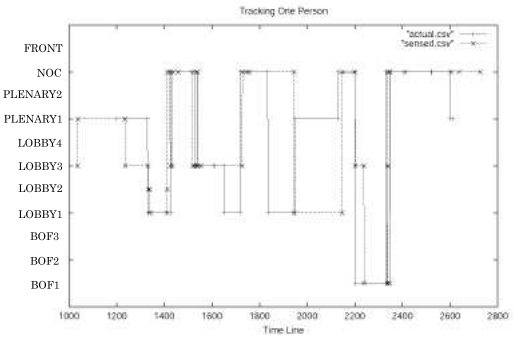

Fig. 9. Sesnsed Movement and Actural Movement

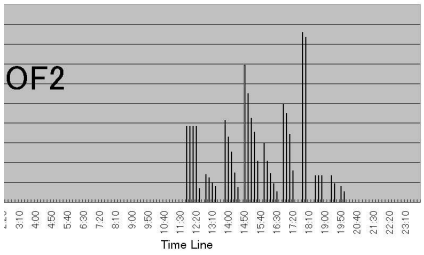

Fig. 10. Number of People of room "BOF2"

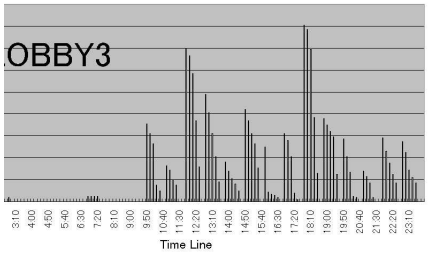

Fig. 11. Number of People of room "LOBBY3"

the 11:30 time by which BOF was started. Moreover, it is not detected at all midnight. However, in Lobby3 which is a passage, it is always detected except for early morning. In addition, all graphs has decline pattern. It is possible that people move all together at the beginning and end of Meeting. A behavior of people can be grasped from these figures.

General Movement Matrix of table 1 shows movement of people about "from where" and "to where" in one day. This table shows whether Location-Modeling could be performed by combining the map of figure 6. The still more efficient location detection technique can be used now like this experiment not by the short period of time but by applying in the long term.

Table 1. Movement Table

From \ To	BOF1	BOF2	BOF3	PLENARY1	PLENARY2	LOBBY1	LOBBY2	LOBBY3	LOBBY4	NOC	FRONT	Total
BOF1	-	24	0	14	20	11	28	54	0	18	6	175
BOF2	18	-	12	24	28	24	37	51	0	13	6	213
BOF3	1	13	-	1	1	1	5	9	0	0	7	38
PLENARY1	36	32	6	-	188	83	134	173	4	43	21	720
PLENARY2	20	29	2	160	-	47	115	157	2	43	23	598
LOBBY1	11	28	1	46	61	-	129	61	0	26	10	373
LOBBY2	23	39	4	76	117	133	-	102	2	34	14	544
LOBBY3	55	65	11	78	153	59	108	-	5	113	47	694
LOBBY4	1	0	0	0	5	3	1	3	-	0	1	14
NOC	18	19	0	22	41	24	33	104	0	-	5	266
FRONT	9	5	2	10	25	9	13	46	0	5	-	126
Total	192	254	38	431	639	394	603	760	13	295	141	3760

7 Conclusion

This research aims being connecting the person whom it did not connecting network to Internet.

We proposed Personal Server Model that uses an agent on the Internet as a communication node, named "Personal Server". Sensors sense personal information like location, and send to his

Personal Server. Then Personal Server holds this personal information. If other Internet node wants to obtain personal information, connect to the Personal Server, and can get personal information.

According to this Personal Server Model, durability, low cost and privacy protection were performed. In addition, Internet applications, which use the personal information on Real-Space, can be developed by the same technique as usual Internet application.

7.1 Experimentation

In order to establish Personal Server Model, the actual proof experiment was conducted. In this experiment, RF-ID was used for Location-Sensing, 274 participants' movement was detected, and it held to each Personal Server.

Moreover, web Interface for using this location information and library for using from the C language were prepared. Thereby, application that uses personal location information can be developed easily.

7.2 Future Work

Present Personal Server has only a function, which is Access Control and holding information described by PML. However, Personal Server holds various kinds of personal information. Therefore, more convenient environment will be able to be offered if it becomes possible to extend the function of Personal Server easily if needed.

In addition, we use two kinds of sensor devices in this implementation. We cannot say heterogeneous sensor environment by using only two kinds of devices. Since that, we will develop more sensor devices and more applications.

Although especially Personal Server Model has focused to person, it is applicable also to the simple device that does not have Internet connection nature by the reasons of cost and so on. Therefore, it is necessary to extend the target range of this research as a Real-Space network will spread from now on. It will be necessary to specifically perform further extension of PML.

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