３．２．８　自律移動支援に関する研究

Conduct of free mobility assistance project

Ken Sakamura[1], Yuichi Toya[2], Kunihiko Oka[3]*
1. Professor, Interfaculty Initiative in Information Studies, Graduate School of the University of Tokyo / Director of the YRP Ubiquitous Networking Laboratory, Japan
2. Director for Policy Planning, Director General for Policy Coordination, Ministry of Land, Infrastructure and Transport, Japan
3. Director, Advanced Road Design and Safety Division, National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure and Transport, Japan
1 Asahi, Tsukuba, Ibaraki, Tel: +81-29- 864-4539, E-mail; oka-k87da@nilim.go.jp

ABSTRACT

Japan now faces a decline in its population of young people as a result of the aging of the population and a falling birth rate plus a shortage of care givers for elderly people, creating a demand for measures to establish a Universal Society in which everyone uses their own capabilities to assist each other.

In response, the Ministry of Land, Infrastructure and Transport has, with the support of companies in various industries, combined their knowledge and set its sights on society ten years in the future to undertake the Free Mobility Assistance Project: a project to construct an environment permitting free mobility necessary to participate in society.

This report presents an outline of the free mobility assistance system and the state of progress of the project.

KEYWORDS
Elderly and physically impaired people, RFID tag, location based service, ubiquitous computing

CONCEPTS OF THE SYSTEM STRUCTURE

The following are the three principal concepts of the system being developed by the Free Mobility Assistance Project. The system will be developed and introduced by combining the knowledge of industry, academia, administrative bodies and citizens to achieve the goal of firmly establishing the system in ten years.

[1] Open system
As the technologies are refined by a series of corroborative experiments, the system specifications will be released to the public to construct it as an open system.

[2] A general purpose expandable system
It will be a highly general purpose and expandable system so that it will not only assist the free mobility of elderly and physically impaired people, but contribute to the creation of services for non-handicapped people, foreigners, and so on.

[3] A system intended to establish an international standard
The goal will be for the entire system and its constituent technologies to become international standards.

INFORMATION PROVISION FOR FREE MOBILITY

The purpose of the free mobility assistance system is not only to be able to assist elderly and physically handicapped people, but all pedestrians including non-handicapped people, foreigners, and so on. It is, therefore, necessary to understand what kind of information should be provided and in what form to people who actually move in pedestrian spaces. When these questions have been answered, it will be possible to construct a system and develop its components that will satisfy users' needs. The first step was, therefore, to clarify the information provision items and forms of information provision required to assist free mobility.

Information required for free mobility

The following tables show the results of classifying situations were users require information as before and after departure, then extracting examples of items required by visually handicapped, wheelchair users, and by foreigners. But there is one precaution that must be followed when performing such a classification. There are individual differences between people in each of these classes, and the type and degree of detail of the information that each person requires vary. It is, therefore, necessary for the system to perform profiling to set the information level according to the state of each person. To take wheelchair users that is one item on the table as an example, the information that should be provided will vary between users of electric wheelchairs, physically strong wheelchair users, and those who cannot travel without assistance from another person.

Table 1 - Information Required by Pedestrians

Before departure

	Physically handicapped people	Wheelchair users	Foreigners
Information characteristics	Require audible and tactile guidance	Obtain information identical to that obtained by non-handicapped people (they can see and hear)	Require information in foreign languages
Information	Route and time required to reach destination Usable transport systems, time required, and fees State of operation of public transportation systems Information about the destination and locations along the route	Same as on the left	Same as on the left

During travel

	Physically handicapped people	Wheelchair users	Foreigners
Information characteristics	Require audible and tactile guidance	Obtain information identical to that obtained by non-handicapped people (they can see and hear)	Require information in foreign languages
Information	• Relief information • Explanations of conditions and substitute mobility methods during emergencies and disasters • Present location and direction (guidance) • Boundaries of sidewalks, obstacles on the road • Location of crosswalks, signals • Entrances to stairways, elevators, and vehicles • Entrance to destination (location, shape, etc.) • Information about the interiors of facilities • Roadside guidance (facilities, shops) • Edges of platforms etc,, proximity of trains	• Relief information • Explanations of conditions and substitute mobility methods during emergencies and disasters • Information about the interiors of facilities • Passable routes • Locations and descriptions of barrier free facilities • Roadside guidance (facilities, shops) • Bus operation information (Non-stop, lift-equipped busses, etc.)	• Explanations of conditions and substitute mobility methods during emergencies and disasters • Present location information • Destination • Information about public transportation systems • Communicating desire to taxi drivers

State of information provision by free mobility assistance

The forms of information provision for free mobility were considered by clarifying how people usually provide and obtain information

As an example, consider a case where information is provided to people as they are preparing to leave their home to shop or dine. One way they obtain information before departing is to listen to the TV or radio. In this case, a person just operates a switch to obtain information that has been transmitted in one direction by broadcast media. In almost all cases, the receiver only receives information (there are methods of participating in a broadcast by submitting requests by telephone, but these are special cases.). This is because just like a loudspeaker announcement inside a store or at an event venue, it is transmitted regardless of the desires of the receivers.

Information transmitted in this way in one direction from a transmitting side such as a broadcaster is called "push type information." This type of information is convenient because it can be received automatically, but on the other hand, if the information is of no use to people, it is just noise. So a filtering function that enables each person to receive only information relevant to that person is necessary.

In contrast, the desires of users of information play an active part when they willingly purchase a magazine or book and selectively read parts of if they are interested in. This type that users obtain or refer to intentionally in this way is called “pull type information.” This information lacks the convenience of being obtainable automatically, but its benefits are that each user is not disturbed by noise and obtains only information that each one wants.
A process that combines features of these can be called a conversation. There are cases where the provider of information starts a conversation with the other person (push type) and cases where a recipient of information obtains it by asking the other person a question. Figure 1 shows a figurative image of these types.

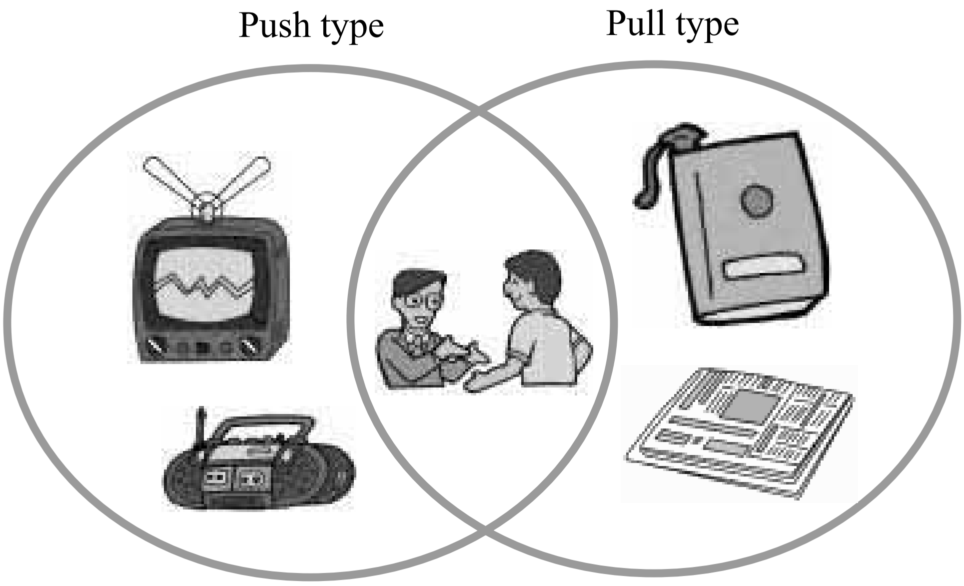

Figure 1 - Classification of Information Exchange Methods

It has recently become impossible to overlook the existence of the internet. This can be called “pull type information”, because receivers search web sites to obtain information that they want. The internet contains every kind of information about people’s destinations; not only store, restaurant, and tourist information, but schedule and route guidance, weather information and much more. The spread of cell phones now permits people to receive these services as they travel and at their destinations.

Considered this way, it is clear that we now live surrounded by information. But, this vast quantity of information includes not only that which we truly need, but incorrect information, stale information (information about past events), etc., so that if people cannot use it skillfully, they are drowned in a flood of information and their lives may even be endangered. This may actually obstruct free mobility. It is, therefore, vital to create a ubiquitous network environment where anyone can obtain only the information they need from this flood of information, where they need it, and in a form suitable to each person.

BASIC ARCHITECTURE

To consider the basic architecture of the system, openness is an extremely vital element. Procurement specifications will be written in the public domain. At the stage where the system is actually constructed, this may be done by a unique method that takes advantage of each developer's expertise, but the content that is discussed at the external specification level will be open. It will not be done dependent on specific hardware or a specific maker. Establishing an information system to serve society dependent on a specific organization would endanger the security of the system. The future sustainability of the system and its potential to evolve will be emphasized.

The following are concrete examples of what elements are suitable as basic architecture.

[1] T-Engine architecture
This architecture will be compatible with each type of CPU in the built-in system and have a high level of software portability. This means if a different CPU is installed, all that is necessary is to recompile the software. And its OS (T-Kernel) is completely open so that anybody can obtain it and use it for development.

[2] Ubiquitous Communicator (UC)
It is the terminal created by the Free Mobile Assistance Project to be carried by pedestrians. It is a general purpose communication terminal based on the T-Engine architecture, and future cell phones will include the UC functions, simplifying portability of software.

[3] Place identification technologies (markers)
If ucode is transmitted, the type does not matter. Markers include infrared markers, weak radio wave markers, Zigbee, and RFID tags.

SYSTEM CONFIGURATION

The free mobility assistance system will consist of the following basic components.

[1] Tags and markers (ucode transmitters)
-- RFID, infrared markers, weak radio wave markers, Bluetooth, Zigbee, etc.

[2] Portable terminals (receivers)
Ubiquitous Communicator, UC-Phone etc.

[3] Servers
-- Information servers (for providing place information)
-- Ucode resolution servers

Item [3] servers are essential for a ubiquitous networking environment, but they can be omitted at locations where the information is in tags and in cases where it is possible to cache data in portable terminals in advance. Because regarding the latter, it is necessary to download data, it is necessary to connect with servers at hot spots.
It is possible for there to be differences in configuration depending on the environment where is actually operated, but the following is the basic configuration. First the user obtains ucode from a transmitter. When a user has entered a zone with infrared and radio wave markers, the user automatically receives the ucode and where there are attached tags, the user obtains ucode by holding the portable terminal near a tag.

Next, the portable terminal obtains the address (corresponds to a URL on the internet) of an information server that stores information corresponding to the ucode that the portable terminal obtained by accessing the ucode resolution server at the UID center. Then it accesses the address that it has obtained to obtain place information. Because in a ubiquitous computing environment, there are a vast number of ucode tags and information servers scattered around the world, giant distributed directory databases called ucode resolution databases will maintain a relationship with ucode and information service servers. And according to the information that is accessed, there are cases where information will be provided only to users with access rights.

As methods of accessing a network, it is necessary to use a wireless LAN or a PHS telephone network, but these face access time problems. It is necessary to classify places as those that are successively linked to the network and places where data is cached in the terminal in advance and transmitted immediately. It is necessary to be extremely careful because it there are any problems with the timing of the provision of information about an approaching intersection to visually impaired people in particular, they may be seriously endangered. Experimental connections to servers are the subject of research, because it is a problem related not only to free mobility, but a common problem for all ubiquitous networking technologies.

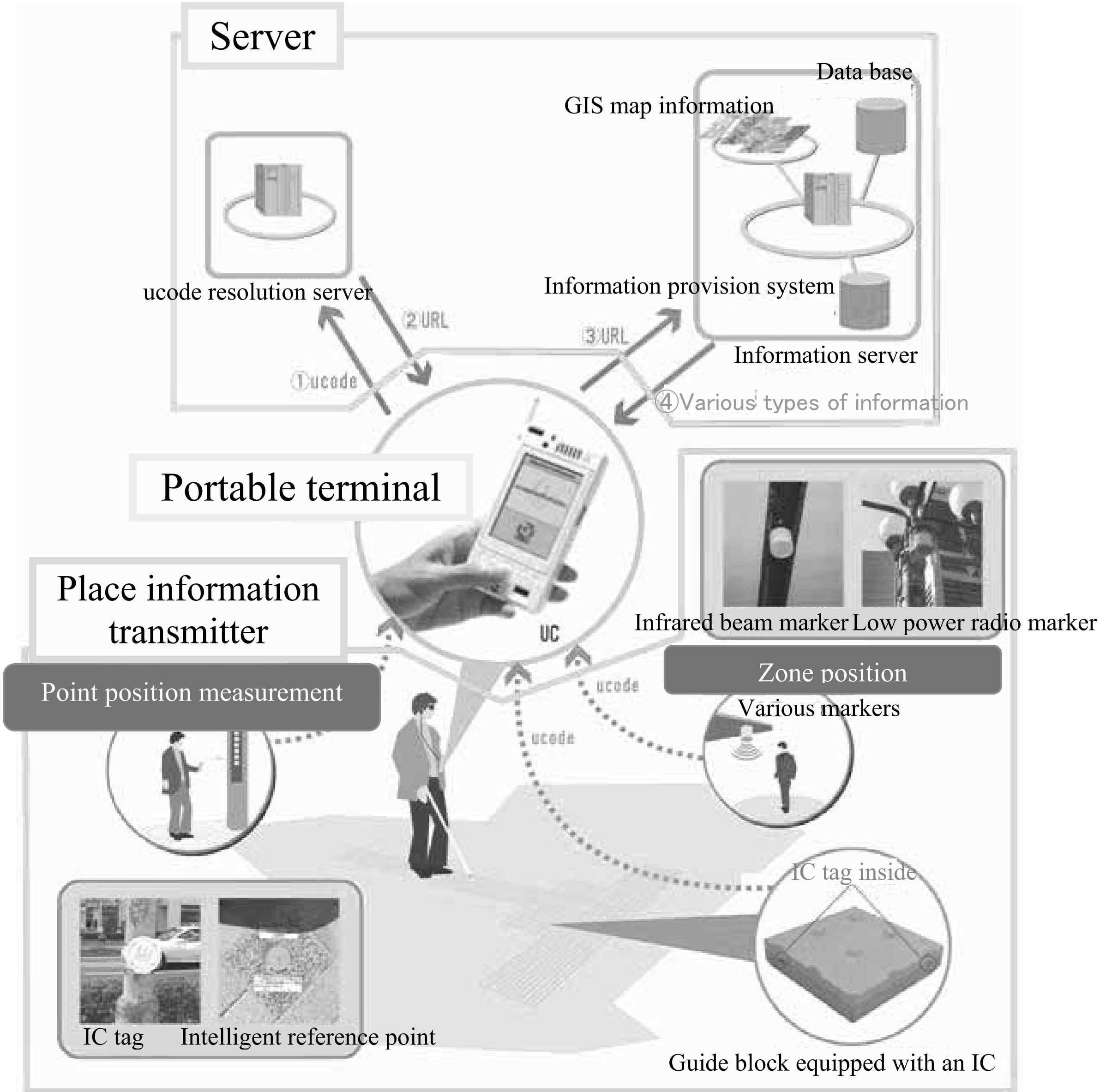

Figure 2 - System Image

PROJECT PROGRAM

This project began in earnest with the organization of the Free Mobility Assistance Project Implementation Committee in March 2004. The committee members who are conducting the study include not only academic experts, social welfare specialists, and infrastructure managers, but also physically handicapped people. The development has been conducted with the help of more than 60 supporting private companies from the data communication, electric, communication, map making, and many other industries and many regional governments.
In 2004, the services and component technologies were studied at the same time as experiments were conducted at two locations, one above and one below ground level, to clarify the performance of the place information transmission technologies—mainly the hardware—in actual usage environments.

In 2005, the experimental range has been widened as shown in Figure 2 to include full-scale corroborative experiments in Kobe. Many experimental subjects including handicapped people evaluated the system and the services. During 2005, system technical specifications will be enacted based on the results of corroborative experiments and the system will be introduced and firmly established in various regions based on nationwide common technological specifications.

SIGNIFICANCE OF THE CORROBORATIVE EXPERIMENTS

In order to complete the free mobility assistance system, we must conduct a series of social experiments, and study problems while carrying out concrete improvements to overcome them in order to introduce the system nationwide. The experiments are counted on to achieve the following goals.

[1] Permit the construction of a reliable system based on technological refinements in actual spaces.
[2] Permit the creation of a system with the participation of residents of regions where it will be established and with members of the private sector.
[3] Permit the construction of an easy-to-use system by hearing the opinions of local citizens.
[4] Permit the dissemination of information about the details of the system both inside and outside Japan.

OUTLINE OF THE PRELIMINARY CORROBORATIVE EXPERIMENTS

• Experiment period
September 30, 2004 to March 4, 2005

• Location of the experiments
The model location selected as the site of the experiments is Kobe where reconstruction undertaken since the Hanshin Awaji Earthquake (January 17, 1995) has concentrated land, sea, and air transportation systems. Because it is a tourist city, the experiments were counted on to be part of the activities of the Visit Japan Campaign.

• Experimental range
The preliminary corroborative experiments were carried out in Sanchika that is an underground shopping mall and in Kyomachi-suji that is an above ground shopping area (Fig. 2.2.2), both in the center of Kobe.

In Sanchika, the experimental range was a passageway extending about 70 meters from north to south—from Yume-hiroba on the north side to the intersection just before block 5 and block 6—and including the 40 meter long east-west passageway that intersects the longer passageway. RFID tags were installed on the ceilings of the passageways along with guide blocks for visually impaired people (enclosing RFID tags), infrared markers, and wireless LAN.

At Kyomachi-suji, RFID tags, guide blocks for visually impaired people (enclosing RFID tags), and weak radio wave markers were installed for about 150 meters from north to south and 100 meters from east to west centered on the Nichigin-mae Intersection.

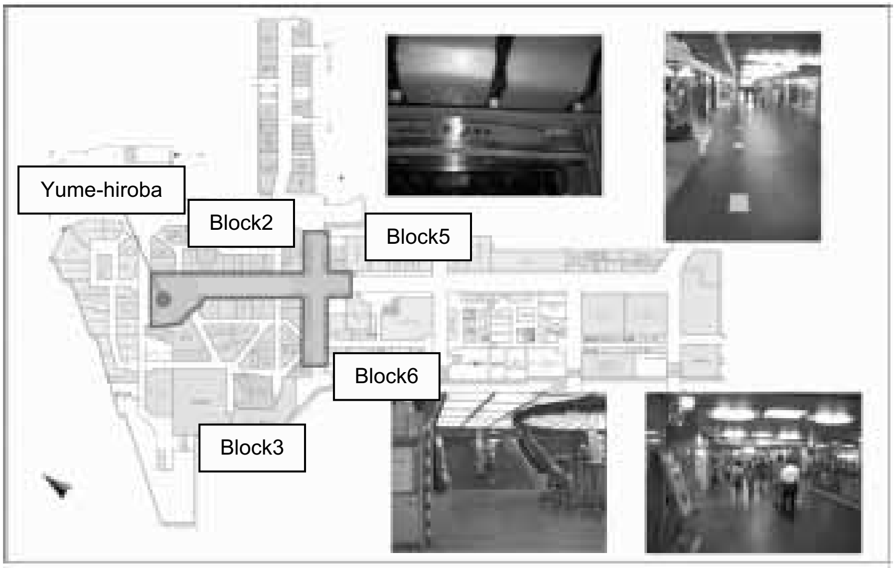

Figure 3 - Sanchika Experimental Area

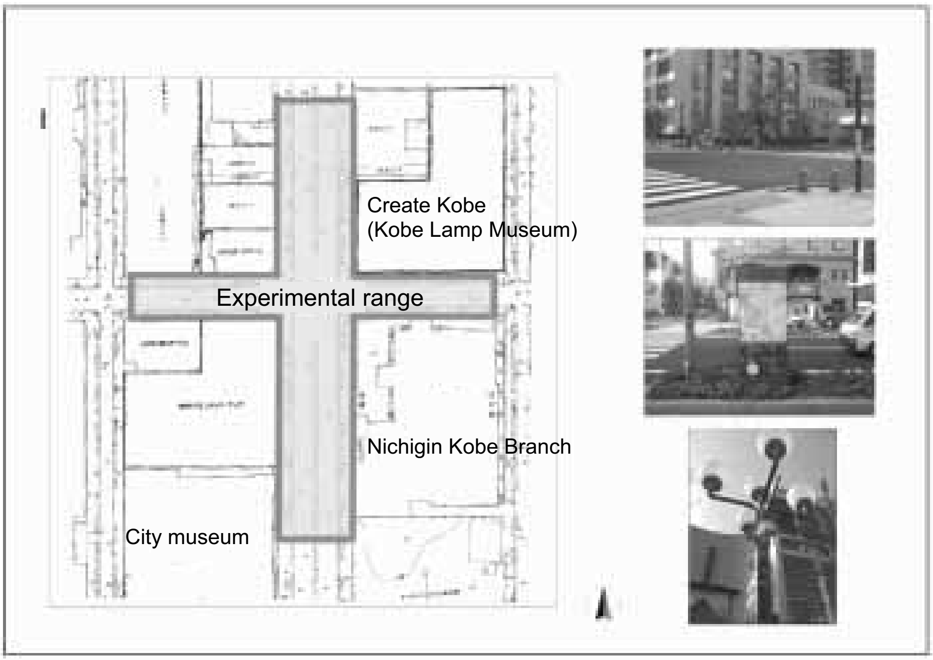

Figure 4 - Kyomachi-suji Experimental Area

OUTLINE OF THE FULL-SCALE CORROBORATIVE EXPERIMENTS

The experimental range was expanded to perform full-scale corroborative experiments beginning in June 19, 2005. An outline of the full-scale corroborative experiments will be presented orally.

ACKNOWLEDGEMENT

This research was done under the free mobility assistance project. The authors wish to express their appreciation to all the members in connection with a project.

REFERENCES

[1]Toshiyuki Yokota, Susumu Takamiya, Yuji Ikeda (2000), Research on ITS for pedestrians, In Proceedings 7*th World Congress on ITS*, Torino.
[2]Nozomu Mori, Yuji Ikeda (2001), For Barrier-Free Society by using IT in the future, *Civil Engineering Journal*, vol.43, No.1, pp.38-43.
[3]Nozomu Mori, Yuji Ikeda (2001), Research on needs and system configuration of pedestrian ITS, In Proceedings 8*th World Congress on ITS*, Sydney.
[4]Nozomu Mori, Yuji Ikeda (2002), Current situation of research and development of ITS for Pedestrians, *Civil Engineering Journal*, vol.44, No.9, pp.54-59.
[5]Nozomu Mori, Yuji Ikeda (2002), Positioning technologies for pedestrian navigation, in proceedings 9*th World Congress on ITS*, Chicago.

Technical features of the free mobility assistance system

Jun Yamada[1], Toshiyuki Adachi[2], Shinsuke Setoshita[3]*
1. Chief Secretary of Director's Office, YRP Ubiquitous Networking Laboratory, Japan
2. Director of Planning Department, Kinki Regional Development Bureau, Ministry of Land, Infrastructure and Transport, Japan
3. Senior Researcher, Advanced Road Design and Safety Division, National Institute for Land and Infrastructure Management, Ministry of Land Infrastructure and Transport, Japan
1 Asahi, Tsukuba, Ibaraki, Tel: +81 29 864 4539, setoshita-s8910@nilim.go.jp

ABSTRACT

In Japan, information communication technologies that have advanced remarkably in recent years have been used to attempt to assist people whose mobility is restricted, mainly visually impaired people. But because systems that only assist people with restricted mobility are too expensive and that there are no established standards, advanced trials have only been carried out locally.

On the other hand, the falling youth population and rising number of elderly caused by the low birth rate in Japan has resulted in a shortage of care-givers, creating a demand for measures to establish a Universal Society in which everyone uses their own capabilities to assist each other.

So under the leadership of the Ministry of Land, Infrastructure and Transport, efforts have begun to create the free mobility assistance system: a nationally uniform mobility assistance system that can be used not only by visually impaired people and others whose mobility is restricted, but by all pedestrians including the elderly and non-impaired people including visitors from other countries.
This report presents an outline of technology that is the center of a free mobility assistance system.

KEYWORDS
Assistance for the elderly and physically impaired, RFID tag, location based service, ubiquitous computing

TECHNICAL FEATURES OF THE FREE MOBILITY ASSISTSTANCE SYSTEM

The principal feature of the free mobility assistance system is that the foundation of the service is not "position" information, but "place" information.

The already widely used car navigation systems use satellite positioning systems (GPS etc.) to establish the user's "position", or in other words, the users "latitude, longitude, and elevation" as the foundation of its service. The position obtained using a satellite positioning system includes error, but because automobiles travel only on roads, map matching technology can accurately clarify their positions.

But because pedestrians do not walk only on road networks that are recorded in data bases, a system for pedestrians cannot always use map matching technology. A satellite positioning system cannot measure positions inside buildings.

Another important consideration is that for pedestrians, information about their position, or in other words latitude, longitude, and elevation information has almost no significance. In other words, for pedestrians, information about the place: “sidewalk on the south side of street A,” “platform to the north on subway line B,” or “No. 2 Internal Medicine Dept. Waiting Room at Hospital C” are most significant.
A free mobility assistance system consists of RF-ID tags and various kinds of markers that transmit “place” information, and portable terminals that users carry to obtain this information. An outline of this is explained in this and the following chapters.

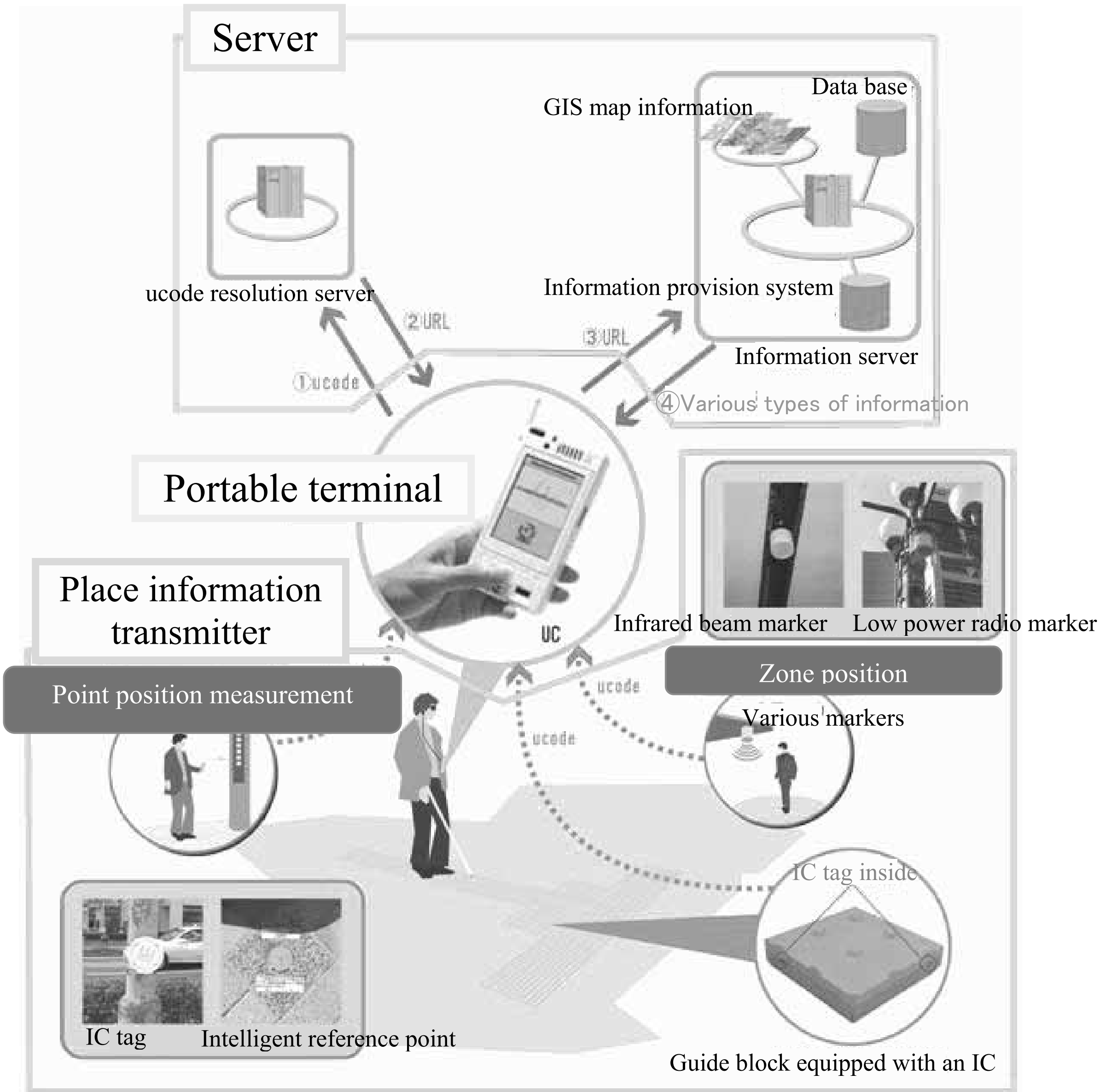

Figure 1 – Image of the basic system

Figure 1 shows an image of a basic system.
The free mobility assistance system is basically constructed of the following elements.

- Place information transmitter
  - -- RF-ID Tag, various markers
- Portable information terminals (receiver)
- Server
  - -- Place information code resolution server
  - -- Information server

Its structure may vary according to the environment where it is actually used, but the following is the basic operation of the system.

First the user obtains the place information code from the place information transmitter. A user obtains place codes by accessing a point type transmitter such as an RF-ID tag where these are installed, or automatically obtains places codes from zone transmitters such as various kinds of markers upon entering a zone where they are effective.

Next the portable terminal accesses a place information code resolution service to obtain the address of an information server that houses information corresponding to the place information code. This system is similar to that of a DNS service on the internet.

The portable information terminal accesses the address obtained from the place code resolution server to obtain place information. A system that can add the attributes of the users (type and degree of disability, or facility manager etc.) and the attributes of the terminal (screen size, multi-media functions and other terminal performance) to the request, enabling the portable information terminal to obtain information suited to each user's needs is also being studied.

The method of accessing the network is studied according to the place it is used and type of the terminal—wireless LAN or cell phone network—and although not particularly specified, it is assumed that in all cases, there will be a time delay until the place code is resolved and the necessary information is obtained. Therefore, assuming cases such as those where danger information is provided to visually impaired people so that a delay in provision of the information would be critical, a method of storing a certain range of data in portable information terminals in advance will also be used.

RF-ID TAG EQUIPPED GUIDE BLOCKS

Guide blocks (flat plates with tactile protrusions) have been used for a long time to guide visually impaired people in Japan. These are paving use blocks or rubber sheets with protruding spots or lines on their surfaces. Visually impaired people are guided by touching these protrusions with their white canes or the sole. RF-ID tags will be installed either inside or on the back surface of these guide blocks to transmit place codes to the portable terminal held by visually impaired people through antennae on the tips of their white canes. Broadly categorizing RF-ID tags by communication frequencies reveals they are 125KHz band, 13.56MHz band, and the 2.45 GHz band (the UHF band (860 – 960MHz band) is omitted, but

RF-ID tags for use in guide blocks use the 125KHz band. Table 1 shows a comparative outline of the frequency bands.

One essential function of guide blocks equipped with RF-ID tags is ensuring as wide a range of communication by the tags as possible, so that visually impaired people can access the information in the RF-ID tags by searching for the protrusions on the blocks with the white canes as they have done in the past. It is, therefore, necessary for each antenna to be extended over the entire guide block surface, so loop coil shaped antennae with angles of about 25cm are used. The antenna of an RF-ID tag is sealed in a resin case that is embedded inside or under concrete blocks. To install them on a rubber sheet type guide block, they are sealed inside resin sheets that are applied to the back of the rubber sheets.

Table 1 - Communication Frequencies and Characteristics of RF-ID Tags

Communication frequency	125KHz band	13.56 MHz band	2.45GHz band
Operating principle	Electromagnetic conduction method	Several 10s of centimeters	Radio wave communication method
Communication distance (passive case)	Several 10s of centimeters * Varies according to installation environment, leader properties, etc.	Several 10s of centimeters * Varies according to installation environment, leader properties, etc.	~ 2m * Varies according to installation environment, leader properties, etc.
Environmental resistance (moisture tolerance, oil tolerance)	○	○	△
Metal tolerance	△	△	△
Noise tolerance	△	△	○

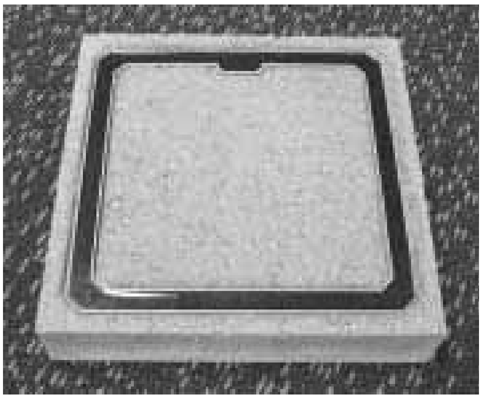

Figure 2 - RF-ID Tag Installed on the Back of a Concrete Block

Figure 3 - RF-ID Tag Installed on the Back of a Rubber Sheet

RF-ID TAGS (STREET INSTALLATION TYPE)

These are sticker type or plastic plate type tags, each enclosing an RF-ID tag that is a small approximately 1 to 4 square mm IC chip equipped with an antenna several centimeters long. A user other than a visually impaired person can obtain place code information by holding the leader installed in a portable information terminal close to it. A visible symbol is printed on the sticker or plate, and according to conditions at the installation location, either a sticker type or a plastic plate type—waterproofed—is used.

Unlike the barcode or two-dimensional barcode type that have been used for the same purpose in the past and that can be optically read, its surface is resistant to dirt and it cannot be easily copied. The price of the RF-ID tag itself is less than US. $1.-: an extremely low price that allows many tags to be installed. Its communication frequency is 2.45GHz band. Table 2 is a comparative outline of the frequencies.

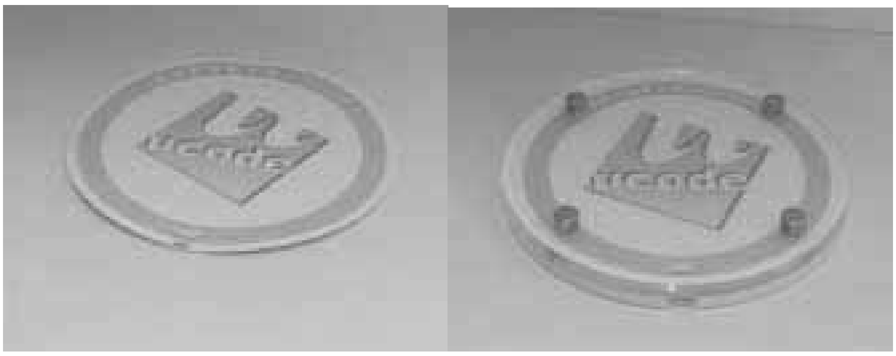

Figure 4 - Sticker Type (Left) and Plastic Plate Type (Right) Tags

TYPES OF MARKERS

Markers include those installed on the ceilings of buildings, on street lights, etc. and those that transmit the place codes to the portable information terminals by infrared beams or by radio waves. Unlike RF-ID tags equipped guide blocks, the markers provide information automatically as soon as a portable information terminal enters the effective range, even if the user does not actively try to contact the tags.

Either infrared or radio wave type can be selected according to installation conditions. Each type of marker can be installed inside solar batteries to be used without electric wires.

PORTABLE INFORMATION TERMINALS

The portable information terminal now being used for corroborative experiments is the Ubiquitous Communicator. The Ubiquitous Communicator is a portable information terminal equipped with an RF-ID tag leader and multiple communication methods and it is used as tool for communication between a ubiquitous computing environment and users. The free mobility assistance system operates by obtaining place codes from RF-ID tags and various kinds of markers and providing a variety of information to users.

Figure 5 - Ubiquitous Communicator

PLACE INFORMATION CODES

Place codes transmitted by RF-ID tags and markers are unique (not duplicated) ID codes with maximum length of 128 bits but basically without any special significance.

A portable information terminal transmits an inquiry to a place information code resolution server in order to resolve locations of information corresponding to the place information code it has received. Its operation is similar to that of a DNS server used on the internet. This permits users to obtain information suited to each user's attributes with the same ID code. And in a case where the information for a place has changed, where the owner of a shop has changed for example, only information on the server needs to be changed, but information in RF-ID tags and markers does not have to be revised. Consequently, this system is extremely easy to maintain.

PLACE INFORMATION CODE RESOLUTION SERVER

The place code resolution server is a widely distributed type directory data base that stores the addresses of information servers holding information related to a place according to the place information code. In a manner of speaking, the place information code resolution server is a system that links the "real world" represented by the place information code with an electronic “virtual world” inside the information system, and it is the important core system of the free mobility assistance system.

The information associated with a place by an RF-ID tag or marker (place information code) is read by the portable information terminal that transmits it to a place code resolution server through a wireless network, the internet, or other network. The place code resolution server searches for information about the place, then based on the results of its search, returns the address of an information server that stores information to be actually provided to the portable information terminal.

INFORMATION SERVER

The portable information terminal can then access the addresses of the information servers it has received from the place code resolution server to obtain a variety of information about the place and services at that place that are stored in the information server. Examples include map information, navigation information, tourism information etc. and other kinds can also be used. It can also vary the content of the information provided according to the user.
The services that should be provided by the free mobility assistance system, information necessary to achieve each of these services, and the format used to represent the attributes of users and terminals are all being studied at this time.

SUMMARY

Corroborative experiments of the basic communication technologies of the free mobility assistance system were carried out in Kobe from late 2004 to March 2005 (preliminary corroborative experiments). These have been followed by the final corroborative experiments intended to broaden the range of the experiments at Expo 2005 Aichi Japan beginning in May 2005 and in Kobe beginning in June 2005. The final results of the final corroborative experiments will be announced later.

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REFERENCES

[1]Toshiyuki Yokota, Susumu Takamiya, Yuji Ikeda (2000), Research on ITS for pedestrians, In Proceedings 7*th World Congress on ITS*, Torino.
[2]Nozomu Mori, Yuji Ikeda (2001), For Barrier-Free Society by using IT in the future, *Civil Engineering Journal*, vol.43, No.1, pp.38-43.
[3]Nozomu Mori, Yuji Ikeda (2001), Research on needs and system configuration of pedestrian ITS, In Proceedings 8*th World Congress on ITS*, Sydney.
[4]Nozomu Mori, Yuji Ikeda (2002), Current situation of research and development of ITS for Pedestrians, *Civil Engineering Journal*, vol.44, No.9, pp.54-59.
[5]Nozomu Mori, Yuji Ikeda (2002), Positioning technologies for pedestrian navigation, in proceedings 9*th World Congress on ITS*, Chicago.