New Technology Report

Trend of Location Information Distribution and Management Technology

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One of the important sources of information for mobile multimedia is the location information of mobile phones. This article discusses the technical trend of location information distribution and management technology to use this information in various systems and applications.

1. Introduction

Among the sources of information for mobile multimedia, one of the most important is the location information of mobile phones. This information is originally used within the mobile communications network to transmit electrical waves to a mobile phone in the area where the recieving mobile phone is. Recently, affected by regulations such as Enhanced 911 [1] of Federal Communications Commission (FCC), attention is being focused on applications which use the location information of mobile phones and various terminals connected to them.

This article explains the location information distribution and management technology required to use the location information of mobile phones and various terminals connected to them as a mobile multimedia application.

2. Status of Location Information Services

This section outlines the location information services using mobile phones supplied in Japan.

The first location information service using mobile phones is the one that uses Personal Handy-phone System (PHS) which started in the latter half of 1997, enabled the user to locate a third person using a personal computer or facsimile and obtain the information of the area where the user was with a laptop computer. Then a micro-browser was installed in mobile phones, enabling the user to reference information around the current location with a standalone mobile phone as well as the combination of a mobile phone and a laptop computer using communication methods other than PHS.

Since early 2000, new services have allowed the user to

search for information around the car via the mobile communications network by connecting a mobile phone to the car navigation system, and to transfer information about the current location between a pedestrian's mobile phone and the mobile phone connected to the car navigation system. In addition, location information services using the network-assisting Global Positioning System (GPS) capability have emerged.

Another service enables sending or receiving messages between people in a short distance using the direct communication capability of mobile phones. This is a kind of location information service implemented based on the relative location of the mobile phones.

From the viewpoint of the location information distribution and management technology, we should note the following three points. First, formats and protocols need to be unified and open. In the present situation, transferring location information with mobile phones over various systems or applications is very difficult because there are incompatibilities among providers, communication media, and systems. Second, services and applications based on the relative coordinates (distance) between mobile phones also have various possibilities. Past and current services mainly use absolute coordinates such as PHS and GPS. Although absolute coordinates will also be used in the future, communications using relative distance are considered to have great possibility in view of mobile communications in the real world. Third, currently available services employ only a limited variety of applications that use location information. Wider variety of applications are needed. In the present situation, users can confirm the location of a third person on the map and search for town information near the current location on the map or in the existing database. However, applications that use other various systems and information sources have yet to come.

Among these three points, this article discusses the trend of the location information distribution and management technology, focusing on the first one, open information distribution and management, and the third one, wider variety of applications.

3. Location Information Use Overview

This section organizes the use of location information to help understand the location information distribution and management technology.

The location information distribution and management system can be classified as shown in **Figure 1**. The use of location information is largely divided into search and notification/registration. The difference between the two modes is that whether or not the person who requests positional measurement is the same as the person who receives the result of the measurement. Generally, in the notification/registration mode, the server receives the result of measurement. They are further divided into the one that processes their own position and the one that processes other persons' positions depending on whether or not the owner of the terminal to be measured is the same as the person who uses the result of measurement. According to these classifications, the location information use method can be divided into the following four: self-location search, self-location notification, other person search, and other person location notification. Figure 1 shows examples of services provided in each method. Recently the use of mobile phones is restricted in some areas such as trains, hospitals, and concert halls. Therefore, in the future, incoming and outgoing calls may be automatically controlled depending on the area or select either voice call or mail according to the area. Such flexible location information distribution and management technology is required.

4. Structure of the Location Information Distribution and Management Technology

The location information distribution and management technology is structured as shown in **Table 1**. The positioning method is constructed on various mobile communication methods. Network-based methods include the conventional positioning method based on the cell location of the station which covers the mobile phone [2] and other positioning methods which use the time difference or radio wave angles sent from the station to mobile phones, such as Angle Of Arrival (AOA), Time Of Arrival (TOA), and Time Difference Of Arrival (TDOA) [3, 4]. Methods of transmitting cell-based location information within the mobile communications network also belong to this layer in a broad sense of meaning. Autonomous GPS-based methods include positioning with normal GPS and corrected positioning with differential GPS information. Some network-assisted GPS [5, 6] receive information for positioning via the mobile communications network or use the calculation capability on the server. Another method obtains location information at the terminal connected to the mobile phone by putting a tag or marker on the building for sending and receiving infrared rays or weak radio waves such as Bluetooth★ [7, 8].

★ Bluetooth: Data radio-transmission technology developed by Intel, Ericsson, Nokia, and Toshiba

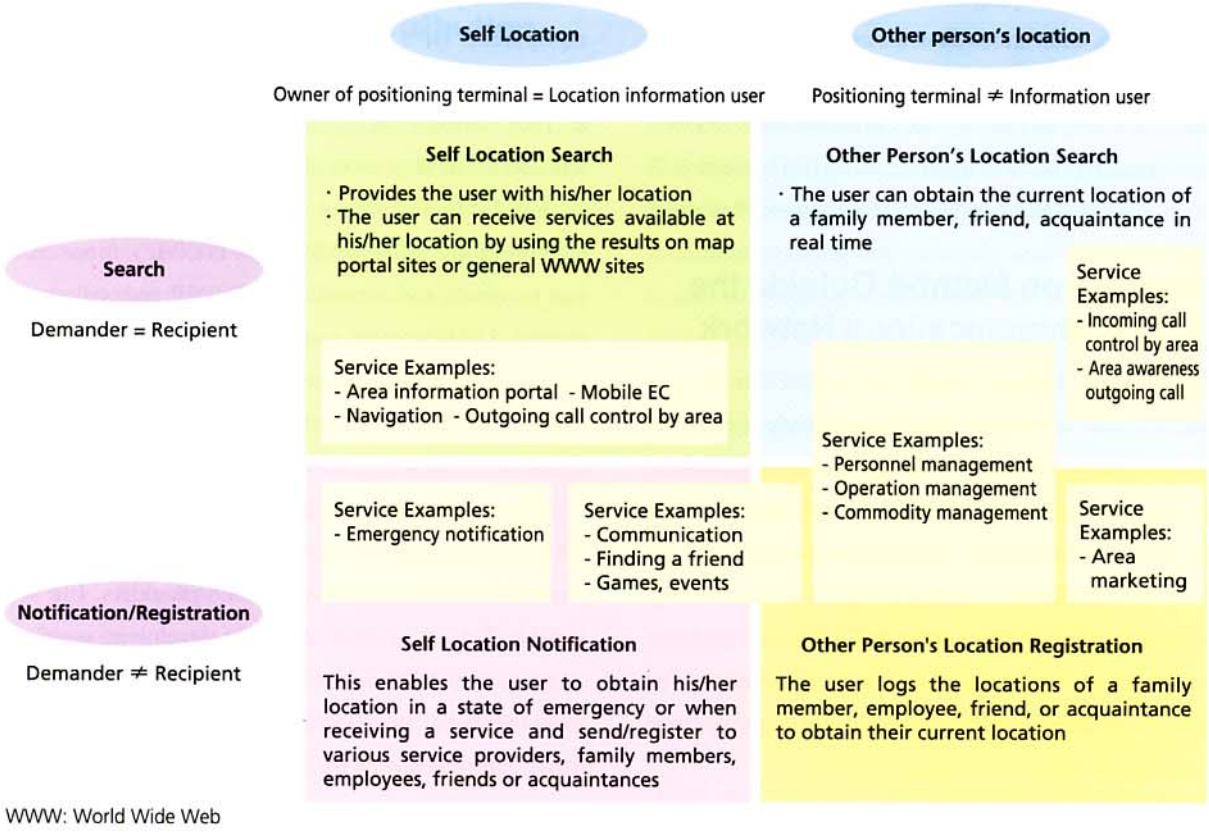


Figure 1 Location Information Use Overview

Table 1 Structure of the Location Information Distribution System

Information Sources		**WWW, maps, databases, and information services, etc.**
Location Information Distribution and Management Technology	**Location Information Distribution and Management Technology**	**Method for appropriately coordinating the obtained location information and information sources**
	Location Information Distribution Formats and Protocols	**Formats and protocols used for describing or transferring location information and location-related information**
	Transmission Method outside the Mobile Communications Network	**Method for transmitting location information seamlessly outside the mobile communications network**
Positioning Method		**Mobile network-based positioning, autonomous GPS-based, network assisted GPS-based, tags and markers**
Mobile Communication Methods such as PDC, PDC-P, PHS, and IMT-2000		

GPS: Global Positioning System
IMT-2000: International Mobile Telecommunications-2000
PDC: Personal Digital Cellular
PDC-P: PDC mobile Packet data communication system
PHS: Personal Handy-phone System
WWW: World Wide Web

The method also requires the transmission of the obtained location information to devices outside the mobile communications network, such as the application on the mobile phone, various terminals connected to the mobile phone, and the information server at the center. This method, particularly, requires a platform capable of transmitting location information seamlessly among various mobile communications networks, positioning methods, and terminals. We will discuss this method in Section 5, "Transmission Method Outside the Mobile Communications Network."

There are formats and protocols for distributing location information. They are used for transferring location information sent outside the mobile communications network among various systems over the Internet as well as location-related information such as map information related to that location information. We will elaborate on this in Section 6 Location Information Distribution Formats and Protocols.

A distribution and management platform is also required for

linking appropriately to the location information, World Wide Web (WWW), map, and various databases to promote the distribution of location information. This platform makes the most of information processing technology such as information retrieval and image processing. We will describe about this in Section 7, "Location Information Distribution and Management Platform."

5. Transmission Method Outside the Mobile Communications Network

The transmission method outside the mobile communications network is used to transmit the obtained location information to devices outside the mobile communications network, such as the application on the mobile phone, various terminals connected to the mobile phone, and the information server at the center. This method requires a platform capable of transmitting location information seamlessly among various mobile communications networks, positioning methods, and terminals. The following section introduces the two notable organizations studying such platforms.

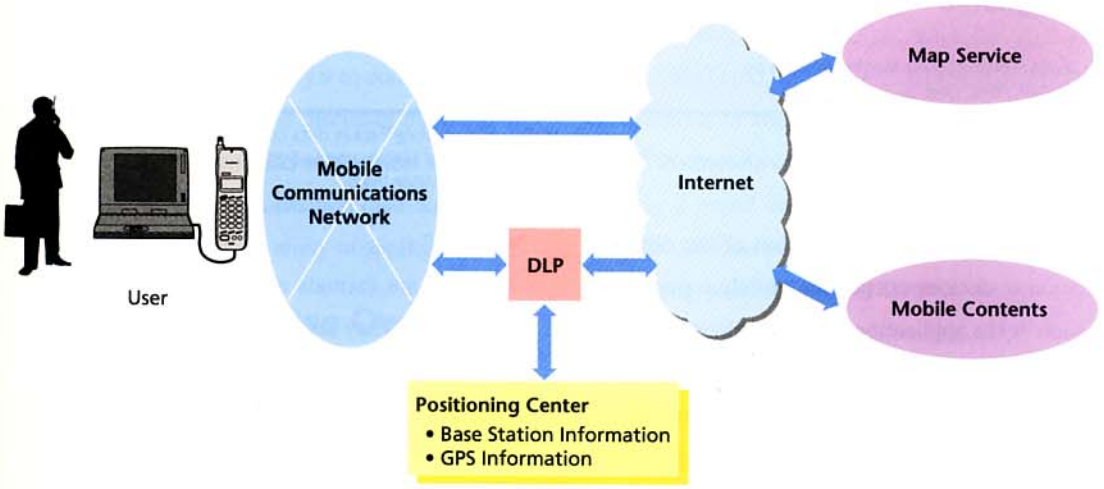
(1) DoCoMo Location Platform (DLP) Consortium [2, 9]

This consortium consists of about 180 companies (as of the end of 2000) including DoCoMo, domestic map makers, contents providers, GPS manufacturers, terminal manufacturers, studying a platform capable of providing location information seamlessly among different types of mobile communications networks, positioning methods, and terminals. Specifically, they have been studying protocol specifications called Location Information Service Application Protocol (LISAP) for processing positioning requests, various positioning sessions, and transmission of positioning results among terminals, DLP center equipment, GPS positioning centers, station information servers, and users' terminals and servers, as described in **Figure 2**. They started studying the protocol in July 1999, and created Version 1.0 in May 2000, and Version 2.0 in November 2000.

LISAP is a protocol defined mainly on Transmission Control Protocol/Internet Protocol (TCP/IP). Since recent various terminals and servers have TCP/IP protocol stack implemented, LISAP is very easy to implement. Also, authentication password for privacy protection is precisely set for each user and for each function, thereby achieving high-level security.

(2) Location Inter-operability Forum (LIF) [10]

This forum consists of about 80 companies (as of November 2000) including Motorola, Nokia, Ericsson, network operators, terminal manufacturers, and service providers. LIF was organized in September 2000 aiming at developing positioning and acquisition methods and technologies which are independent of radio interfaces, specific positioning methods and network operators, and procedures for validating these methods and technologies. LIF itself, does not present any standardization plan basically, but works on various standardization organizations to attain its goal. LIF says it will work on standardization organizations including European Telecommunications Standards Institute (ETSI), 3rd Generation Partnership Project (3GPP), Wireless Application Protocol (WAP) Forum, Internet Engineering Task Force (IETF), World Wide Web Consortium (W3C), Open Geographic Information System consortium (OpenGIS), and American National Standards Institute (ANSI).



DLP: DoCoMo Location Platform
GPS: Global Positioning System

* Source: NTT DoCoMo News Release (July 29, 1999)

Figure 2 DoCoMo Location Platform Overview

6. Location Information Distribution Formats and Protocols

Location information distribution formats and protocols are used for transferring location information sent outside the mobile communications network over the Internet as well as location-related information such as area information and map information related to that location information.

For server-client systems, obtained location information is sent to the location-related information search server and information related that location is returned to the client. For P2P (Peer to Peer) systems, a sender sends location information to a recipient. Taking into account such information flow, standardization plans are categorized as shown in **Figure 3**. They are classified into eXtensible Markup Language (XML) based, Uniform Resource Locator (URL) based, extended HyperText Markup Language (HTML), extended HyperText Transfer Protocol (HTTP), and others. **Table 2** shows the overview of typical formats. In the present stage, however, none of them is decisive standardization plan.

Under the present conditions, a simple method like i-navi link familiar to terminal software developers and contents developers seems to be better than extending an existing standardization plan in terms of popularization. **Figure 4** shows a sample description of location information and location-related information in the format of i-navi link. In the future, these formats will become more general-purpose and extensible formats like XML-based ones.

On the other hand, protocols for location information distribution mainly use HTTP. IETF geopriv Working Group (WG) [21] has studied the mechanism of assuring security and privacy when transferring location information and now considers the enhancement of existing protocols such as HTTP. WAP Forum is also investigating specifications for location information distribution [22]. We have to pay attention to its future movement as well as IETF geopriv WG.

Other organizations try to describe the server location information in Resource Record of Domain Name System (DNS) using latitude and longitude [23, 24] or using zip code or address [25]. A similar DNS-based method is that Fully Quality Domain Name (FQDN) is used to detect the location (latitude and longitude) of the terminal or, oppositely, to obtain the name of the terminals around the specific location, by letting the mobile terminal register its location in the DNS server [26].

7. Location Information Distribution and Management Platform

The location information distribution and Management platform appropriately links location information to WWW, maps, and various databases to facilitate the distribution of location information. This platform makes the most of information processing technology such as information retrieval and image pro-

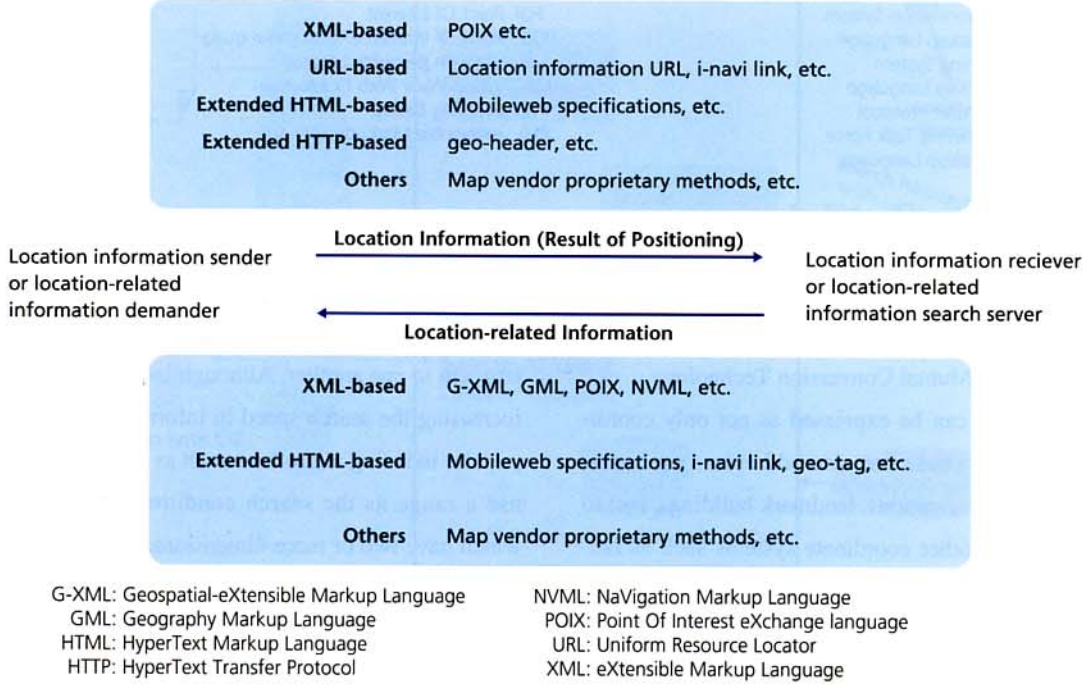


Figure 3 Classification of Location Information Distribution Formats

Table 2 Location Information Distribution Format Overview

	Coverage		Proposer	Features
	Location Information Expression	Location-related Information Expression		
POIX[11]	○ (XML)	○ (XML)	Proposed to W3C by Toyota and Others.	Since POIX was originally developed for use with car navigation, it can express moving direction, moving speed, moving means, and route information.
NVML[12]	—	○ (XML)	Proposed to W3C by Fujitsu.	Since NVML is used to describe navigational information from one point to another, it can express messages on the way as well as voice messages.
G-XML[13]	—	○ (XML)	Database Promotion Center, Japan	G-XML is designed to be an open GIS contents distribution and management platform by describing map information and POI information to be overlaid on it in the XML format. Version 1 was made public in May 2000. It liaises with GML to process the objects common to them. It is registered in JIS in August 2001 as "Geographical information – XML encoding method X7199 for geographical data conversion."
GML[14]	—	○ (XML)	OpenGIS Consortium	GML is designed to describe GIS information such as map information and POI information to be overlaid on it in the unified XML format. Version 1.0 was made public in May 2000.
i-navi link Specifications [15]	○ (URL)	○ (HTML)	NTT DoCoMo	The i-navi link specifications are designed to search for information on areas around the car in car navigation capable of i-mode communication and display its location on the car navigation map using the obtained POI information. GPS built-in PDA "Naviewn" [16] also employs the URL-based location information expression specifications as a Web linkage capability. The i-navi link specification is compatible with location information URL.
Location Information URL[17]	○ (URL)	—	Mobile Office Promotion Association	This format is not used for simply transmitting location information. It can also describe search conditions such as the type of information search and map information the user wants.
Mobileweb Specifications [18]	○ (Extended HTML)	○ (Extended HTML)	Mobileweb Promotion Association	This format is designed for use with Web browsers installed in car navigation systems. The user can transmit the current location as well as the destination as location information. A location in the location-related information can be set as the destination. This format has extended HTML tags in its own way and can therefore be used with particular browsers for car navigation.
geo-header[19] /geo-tag[20]	○ (HTTP)	○ (HTML)	Vancouver Webpages	This format is quite simple and clear. It stores location information in the HTTP header and information of the location the HTML document references in the HTML header. It has been submitted as an IETF Internet Draft but not being discussed in any particular WG.

G-XML: Geospatial-eXtensible Markup Language
GIS: Geographic Information System
GML: Geography Markup Language
GPS: Global Positioning System
HTML: HyperText Markup Language
HTTP: HyperText Transfer Protocol
IETF: Internet Engineering Task Force
NVML: NaVigation Markup Language
PDA: Personal Digital Assistant
POI: Point Of Interest
POIX: Point Of Interest eXchange language
URL: Uniform Resource Locator
W3C: World Wide Web Consortium
WG: Working Group
XML: eXtensible Markup Language

cessing, being composed of various technologies for dealing with various objects. The following section introduces some of such technologies.

(1) Location Information Mutual Conversion Technology

Location information can be expressed as not only coordinates by latitude and longitude but also addresses, zip codes, phone numbers, area codes, stations, landmark buildings, and so on. There are also some other coordinate systems such as latitude and longitude of various positioning systems and plane rectangular coordinates. The location information distribution and management platform requires a technology that enables mutual conversion of various location information expressions. Coordinates are used as the intermediate form for such conversion and expressed as polygons rather than points. Geometrical search is required to determine whether polygons overlap or are adjacent to one another. Although indexing is generally used for increasing the search speed in information retrieval techniques, popular indexing algorithms such as hash or Binary Tree cannot use a range as the search condition to search for polygons, which have two or more dimensional information. Therefore, in geometrical search, an indexing algorithm called r-tree index [27] is often used. This algorithm is the center of the location information mutual conversion technology.

(2) Location-oriented Information Integration Technology [28, 29]

When searching for location information with usual search engines on the Internet, the user has to enter a keyword that matches the expression of the location information. Furthermore, a geographical area cannot be easily specified in the search condition as address strings. The location-oriented information integration technology solves such problems as shown in **Figure 5**. This technology enables the location-oriented search engine to automatically extract the location information string in an HTML document on the Internet, convert it to latitude and longitude with the location information mutual conversion technology, automatically store them as pairs of the latitude/longitude and URL in the database, and search this database using any location information expression or polygon as the search key. For directory information with Common Gateway Interface (CGI), the location-oriented meta search engine works as a mediator to automatically create a search key string that matches the location information used by the directory, and then relays the search request. In addition, the location-oriented information filtering engine automatically extracts area-specific information from the collected information. This technology enables full and flexible search for location–related information on the Internet.

Example of Location Information Description

```
http://www.docomo.ne.jp/inavilink.cgi?pos=N35.39.51.20
E139.44.54.92&geo=tokyo
```

Example of Location-related Information Description

```
<HTML>
  <HEAD><TITLE>Recommended Restaurants</TITLE></HEAD>
    <BODY>
      DoCoMo Restaurant<BR>
        Display in navigation map:
          <!--pos:tokyo,N35.39.51.60,E139.44.54.70-->
            Toranomon x-x-x, Minato-ku, Tokyo
          <!--/pos--> <BR>
  </BODY>
    </HTML>
```

Figure 4 Sample Description based on i-navi link Specifications

(3) Route Map Information Summarizing Technology [30]

The most important location-related information is map information. However, when a map is displayed on a small screen such as a mobile phone or a terminal connected to a mobile phone, it is very difficult to understand it since there are too much information. This technology automatically selects the required information to display according to the situation and converts the map to the optimum media for the user to understand the map easily. **Figure 6** shows a sample system that uses this technology. Even if the resolution of the screen rises dra-

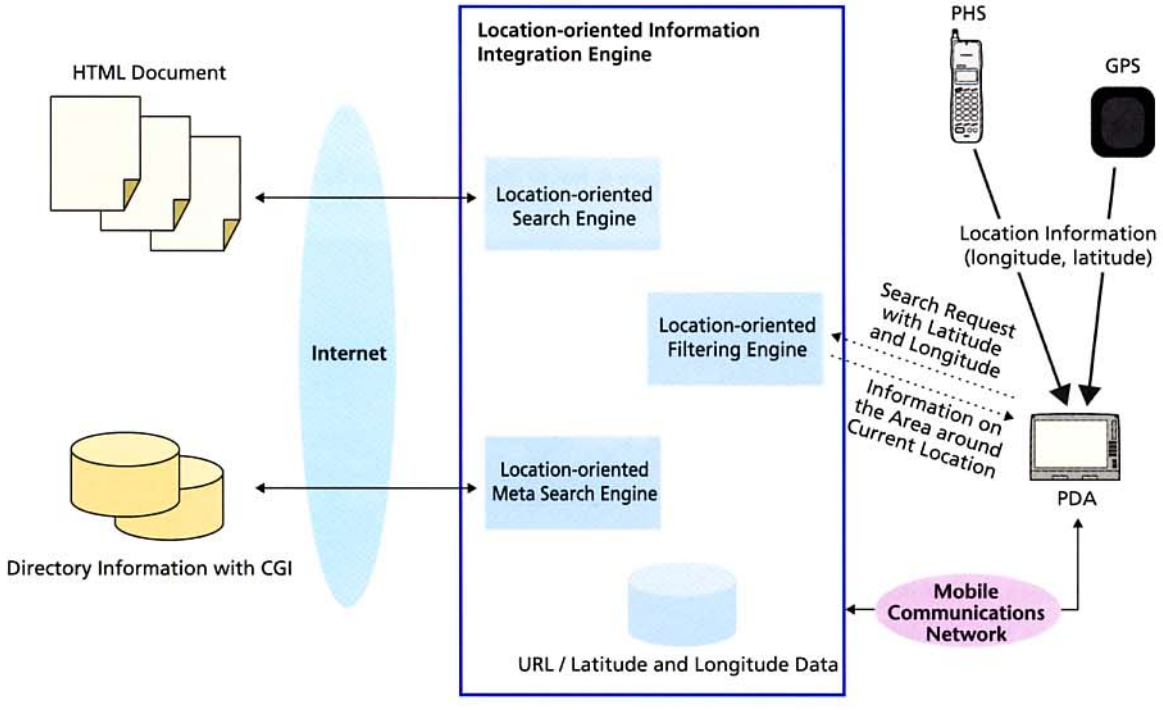


Figure 5 Overview of Location-oriented Information Integration Technology

matically or a lot of information can be displayed like holography, the technology that automatically selects the required information according to the user's situation and controls the media is essential in providing maps that are easy to see and understand anytime and anywhere.

(4) Augmented Reality (AR) Technology [31]

While Virtual Reality (VR) artificially creates three-dimensional images for the user to feel as if he or she were in the real world, Augmented Reality (AR) overlays virtual images on the real world images to create an environment in which the real world is expanded. This technology combines precise three-dimensional (in units of centimeters) location detection, orientation detection, image processing, and image recognition technologies to overlay appropriate image information in the real world. In the situations where mobile multimedia users interact with the real world rather than with a virtual space, there are many cases where the AR technology can be applied. The real view navigation technology [32] is typical. **Figure 7** shows an example of this technology. In this example, information is overlaid on objects in the image actually shot with a camera. By overlaying additional information according to the situation, more sophisticated interaction with the real world can be made in a mobile environment.

(5) Object Detection Technology

If you want to know precisely about an object in the real world, you have to get information actively. If the knowledge about the object is not enough, you may have to read guide books or use some devices as required. Technology that enables easy access to information on the object not only reduces time and labor but also makes your life richer through communication with various objects, brought about with innovative and high value added services. One of the means to make the dream come true is this object detection technology.

This technology can be implemented with a processing center and a terminal such as a mobile phone with a camera or a camera with a mobile phone. A photographic image is sent to the processing center along with the geographical position obtained by the terminal or the mobile communications network. The processing center narrows down candidate images by using images stored in the processing center as location-related

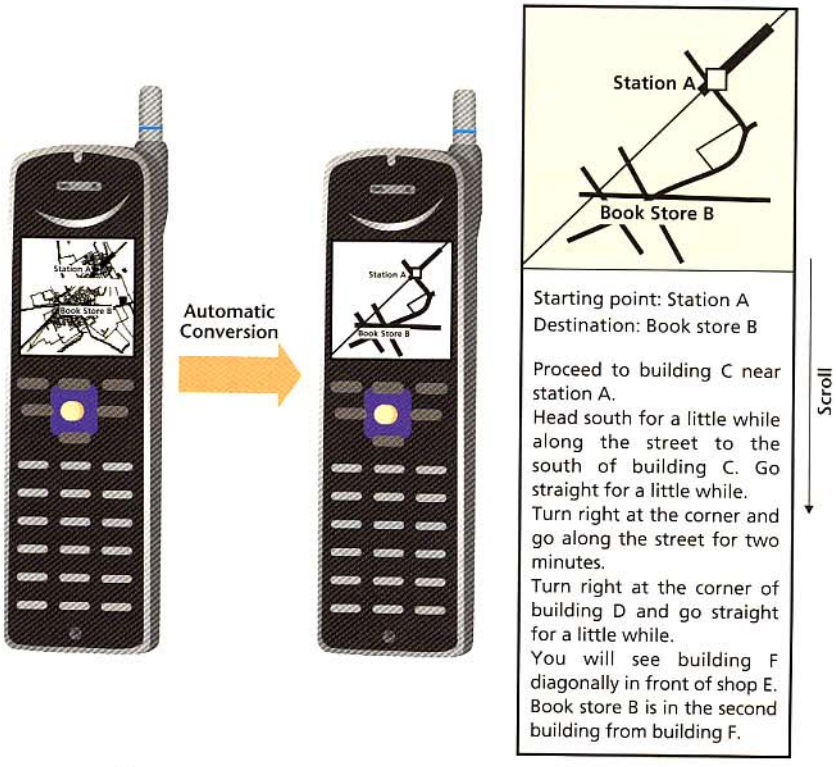


Figure 6 Route Map Information Summarizing Technology

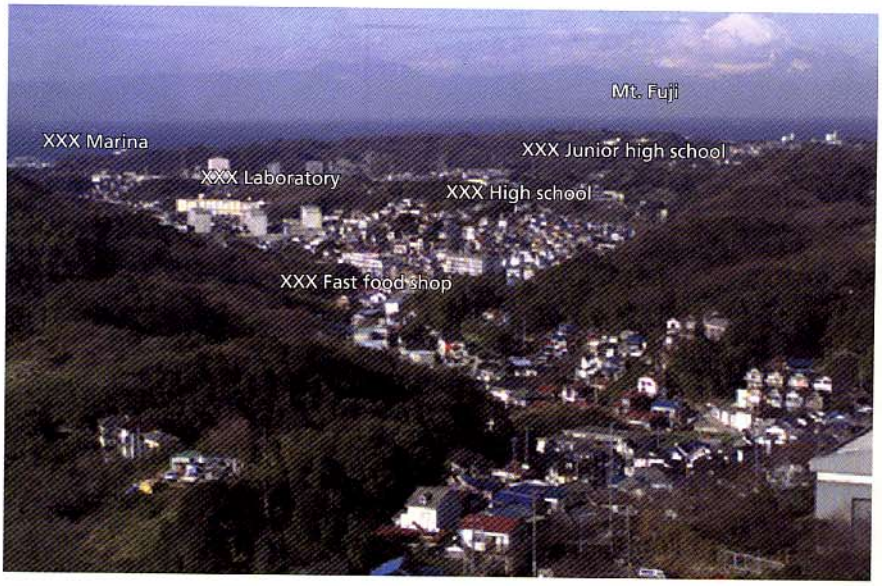


Figure 7 Example of Real View Navigation Technology

information and the geographical position sent from the mobile phone, and then matches the image information to determine the object.

We are studying to achieve robust image matching while taking into account the reasonable usage scenarios and services (such as information search by showing street signs to a mobile phone as shown in **Figure 8**) and focusing on image features that are stable to various environments and photographing conditions [33]. To achieve broader services, we are investigating effective image features based on color information and geometric information. In order for mobile users to use the services naturally, technologies that can achieve both precision and speed at a high level are required.

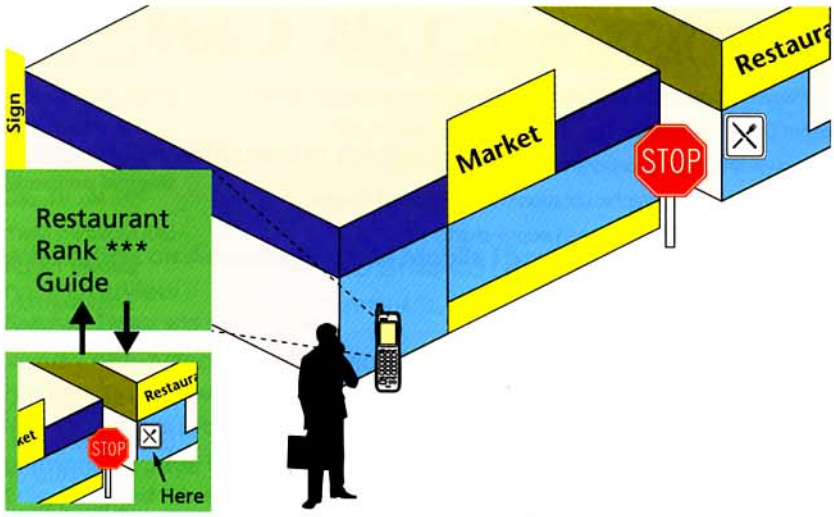


Figure 8 Operation Image of Object Detection Technology - Information Search on Street

8. Conclusion

We have discussed the location information distribution and management technology required when using location information of mobile phones, an important source of information in mobile multimedia, as a mobile multimedia application for mobile phones and various terminals connected to them. According to recent surveys [34, 35], services that users want to use or most attracted to next-generation (3G) mobile phones are location service and pedestrian navigation. To provide more sophisticated location information services, location information distribution and management technology described in this article is essential in addition to positioning technologies and their implementation technologies. We will continue the research and development for further advancement.

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GLOSSARY

3GPP: 3rd Generation Partnership Project
ANSI: American National Standards Institute
AOA: Angle Of Arrival
AR: Augmented Reality
CGI: Common Gateway Interface
DLP: DoCoMo Location Platform
DNS: Domain Name System
E911: Enhanced 911
ETSI: European Telecommunications Standards Institute
FCC: Federal Communications Commission
FQDN: Fully Qualified Domain Name
G-XML: Geospatial-eXtensible Markup Language
GIS: Geographic Information System
GML: Geography Markup Language
GPS: Global Positioning System
HTML: HyperText Markup Language
HTTP: HyperText Transfer Protocol
IETF: Internet Engineering Task Force
IMT-2000: International Mobile Telecommunications-2000
LIF: Location Inter-operability Forum
LISAP: Location Information Service Application Protocol
NVML: NaVigation Markup Language
Open GIS: Open Geographic Information System consortium
P2P: Peer to Peer
PDA: Personal Digital Assistant
PDC: Personal Digital Cellular
PDC-P: PDC mobile Packet data communication system
PHS: Personal Handy-phone System
POI: Point Of Interest
POIX: Point Of Interest eXchange language
TCP/IP: Transmission Control Protocol/Internet Protocol
TDOA: Time Difference Of Arrival
TOA: Time Of Arrival
URL: Uniform Resource Locator
VR: Virtual Reality
W3C: World Wide Web Consortium
WAP: Wireless Application Protocol
WG: Working Group
WWW: World Wide Web
XML: eXtensible Markup Language