Special Article on Mobile Multimedia and ITS
Pedestrian Location Information Service

Location information services, normally used to locate people, have the potential to locate any other moving object. DoCoMo currently offers two location information services for pedestrians, namely, Ima-DoCo and DoCo-Navi Services.

This article provides an overview of these services and the DLP (DoCoMo Location Platform) — the blueprint for location information service in the future.

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1. Introduction

Today, mobile communication services mainly consist of voice and short-mail exchange, e-mail exchange and file transfers via corporate LANs, and e-mail exchange and website browsing via Internet Service Providers (ISPs).

The location information in mobile communication terminals can be used to locate not only people, but potentially to be used to locate bicycles, parcels, pets, or any other object in motion. It can serve as the foundation for an entire range of new services.

Recently, DoCoMo launched two location information services for pedestrians: the Ima-DoCo Service, which relies on information from the Base Station (BS) of the Personal Handyphone System (PHS); and DoCo-Navi Service, which depends on the Global Positioning System (GPS). DoCoMo has also established a consortium named the DoCoMo Location Platform (DLP) Study Group, to examine the future of location information services within the industry.

These services and discussions should contribute enormously towards the progress of Intelligent Transport Systems (ITS), in the field of pedestrian support services.

This article describes the basics of the Ima-DoCo Service, DoCo-Navi Service and DLP.

2. Ima-DoCo Service

The PHS service area is composed of extremely small radio zones called microcells. Smaller cell radii help minimize the size of radio equipment and maximize the life of the terminal's battery, by raising the efficiency of frequency use and reducing the level of transmission power. PHS-BSs are therefore installed close to each other, at intervals of 100 to 500 meters. This means that if the BS nearest to the PHS terminal and its position (latitude and longitude) can be identified, the terminal can be located within an accuracy range of 100 to 500 meters. Applying this theory to the PHS location information service, DoCoMo (then named NTT Personal) launched the Ima-DoCo Service since May 1998.

2.1 Service Overview

Ima-DoCo Service is a PHS network service that provides information on the position of PHS terminals with Ima-DoCo Service support. It can roughly locate a terminal as long as it is in the PHS service area. However it can't identify the terminal's position via home-use or office-use antennas, when it is switched off, or out of range, or in use. Depending on the power and location of the BS used for identifying the terminal's position as well as the surrounding radio environment, the margin of error is a few hundred meters.

PHS terminals with Ima-DoCo Service support include P-doco?, which is a terminal dedicated to location information services, some models of Docchimo (SH821i and SH811), and some models of Paldio (631S, 621S, 622S, 611S, 331S-II, 332S, 341S and Dorae-phone) as well as mobile cards (P-in and P-in comp@ct).

Handling location information also require careful consideration to the protecting privacy.

DoCoMo ensures security with passwords. When a user applies for the Ima-DoCo Service, DoCoMo issues a search password consisting of 8 numbers to the user for the PHS terminal concerned. If the user inputs an invalid search password, DoCoMo will not provide any information regarding the position of the terminal. The search password can be changed by the user at any time, by following the instruc-

tions on a prerecorded message.

2.2 System Configuration

The system configuration of Ima-DoCo Service is illustrated in Figure 1.

The PHS terminals with Ima-DoCo Service support referred to in section 2.1 receive a proximate PHS-BS's CS-ID (Cell Station Identification, in which Cell Station is another name for the PHS base station) and send this unique CS-ID to the Ima-DoCo Service Center.

Along with the server, the Ima-DoCo Service Center is connected to two databases: the User Data Base (User DB), which manages the search passwords of PHS terminals to be searched and other user data; and the Cell Station Identification Data Base (CS-ID DB), which manages the CS-IDs and latitude-longitude data of cell stations.

There are two types of access points: the PC access point for business users and the fax access point for home users. The latter is connected with a fax server equipped with a map database.

2.3 Service Sequence

Ima-DoCo Service users can be divided into three types: business-users, home-users and location-content users. The service sequence for each user type is as follows:

(1) Business-User Type

In the business-user type, sales personnel, maintenance staff and other company employees carry a PHS terminal to raise their business efficiency by utilizing the information about their current position and activity history.

Figure 2 shows the service sequence for the business-user type. The service works as follows:

① The user accesses the Ima-DoCo Service Center from a client system installed in the company, and sends a position search request.

② The Request includes the PHS number (phone number) and the search password of the PHS terminal to be located as parameters. The server at the Ima-DoCo Service center checks whether the password is correct by referring to the database.

③ If the password is correct, the server will send a position search command to the PHS terminal to be located, and a position search response to the client system.

④ In response to the position search command, the PHS terminal to be located measures the strength of waves from cell stations and sends the CS-IDs of the two stations emitting the strongest waves as parameters in the position notification, to the server.

⑤ In response to the reception of the two CS-IDs, the server converts the CS-IDs into latitude-longitude data by referring to the database, calculates their midpoint between the two and determines it as the position of the

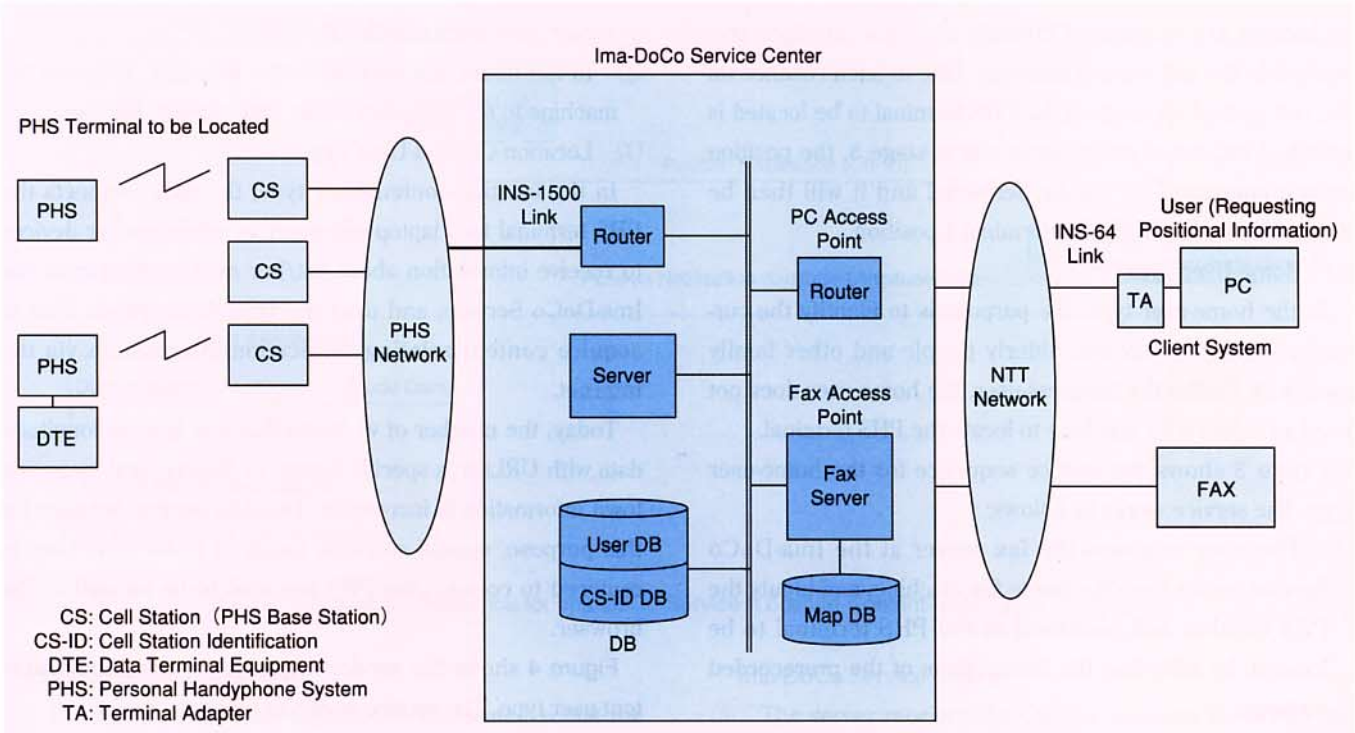


Figure 1 System Configuration of Ima-DoCo Service

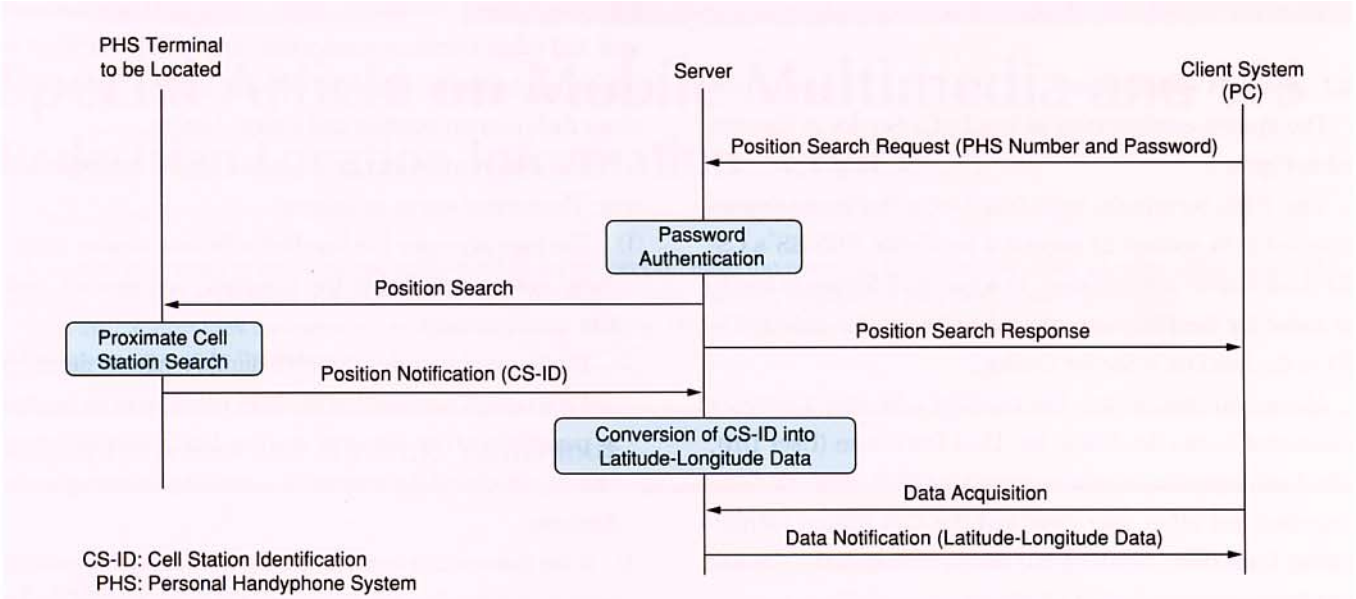


Figure 2 Sequence for Ima-DoCo Service (Business-User Type)

PHS terminal to be located.

⑥ When the server receives a data acquisition command from the client system, it sends the determined position (latitude-longitude data) as parameters in the data notification to the client system.

The messages between the client system and the server described above are exchanged through a unique HTTP interface.

The messages between the server and the PHS terminal to be located are exchanged through a unique interface prescribed in the call control message. Due to such reliance on the call control message, if the PHS terminal to be located is switched off, out of range, or in use at stage 3, the position search command do not be delivered and it will then be impossible to determine the terminal's position.

(2) Home-User Type

In the home-user type, the purpose is to identify the current position of children, elderly people and other family members. Unlike the business-user, the home user does not need a PC, but a fax machine to locate the PHS terminal.

Figure 3 shows the service sequence for the home-user type. The service works as follows:

① The user accesses the fax server at the Ima-DoCo Service center from the home fax machine, and inputs the PHS number and password of the PHS terminal to be located, by following the instructions of the prerecorded message.

② Upon receiving the PHS number and password, the fax server sends a position search request to the server in the same way as in the business-user type. Then, the same procedures apply as in the business-user type, up to acquiring the latitude-longitude data of the PHS terminal to be located in the data notification.

③ Once the fax server receives the latitude-longitude data, it draws a map of the area matching the acquired latitude-longitude data, by referring to its own map database. Next, it plays a prerecorded message to the fax machine to inform the user of its intention to send the map. The fax server then starts sending the map.

④ In the home, the user hears the message, switches the machine to fax reception mode, and receives the map.

(3) Location-Content-User Type

In the location-content-user type, the user connects the PHS terminal to a laptop computer or other similar devices to receive information about his/her own position from the Ima-DoCo Service, and uses the latitude-longitude data to acquire content relating to location information via the Internet.

Today, the number of websites that link latitude-longitude data with URLs in a specific format to display local maps and town information is increasing. To use a normal browser for this purpose, special software (such as Koko Navi Lite) is required to connect the PHS terminal to be located to the browser.

Figure 4 shows the service sequence for the location-content-user type. The service works as follows:

① From Data Terminal Equipment (DTE) with special software, a user sends a position notification request to the

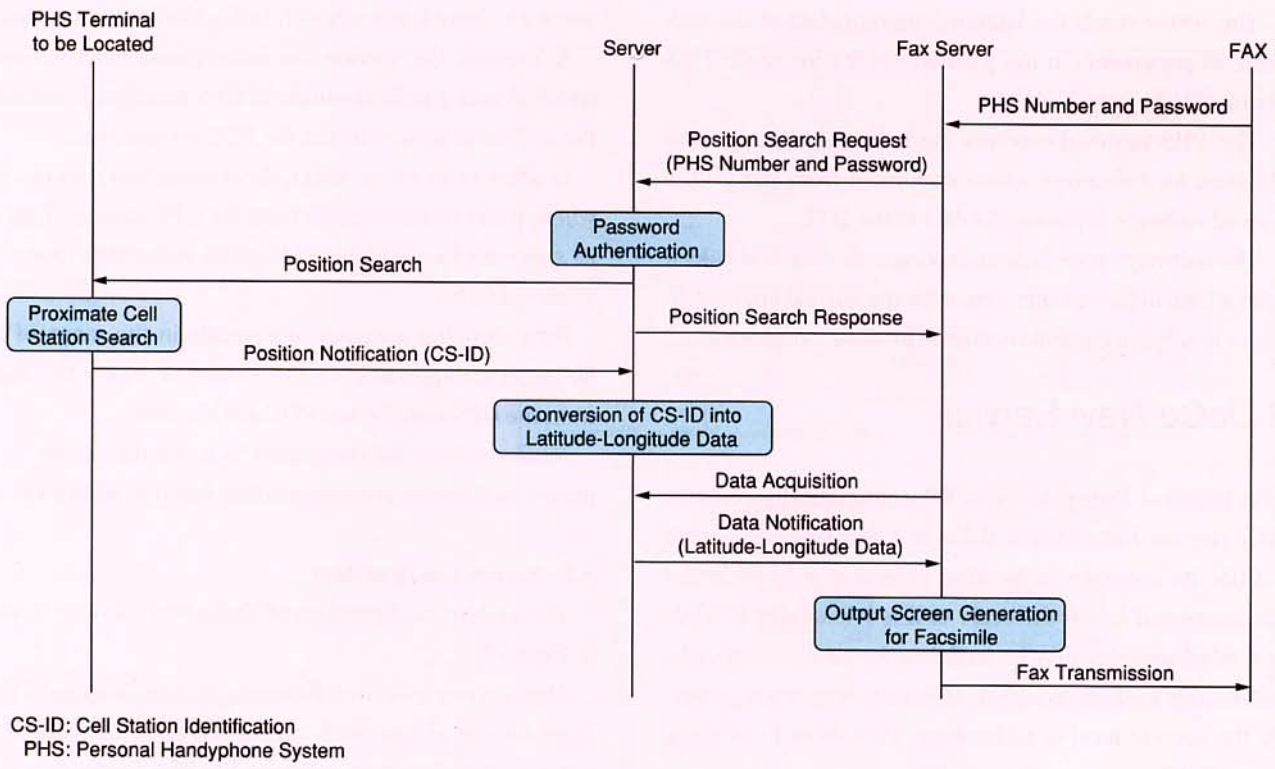


Figure 3 Sequence for Ima-DoCo Service (Home-User Type)

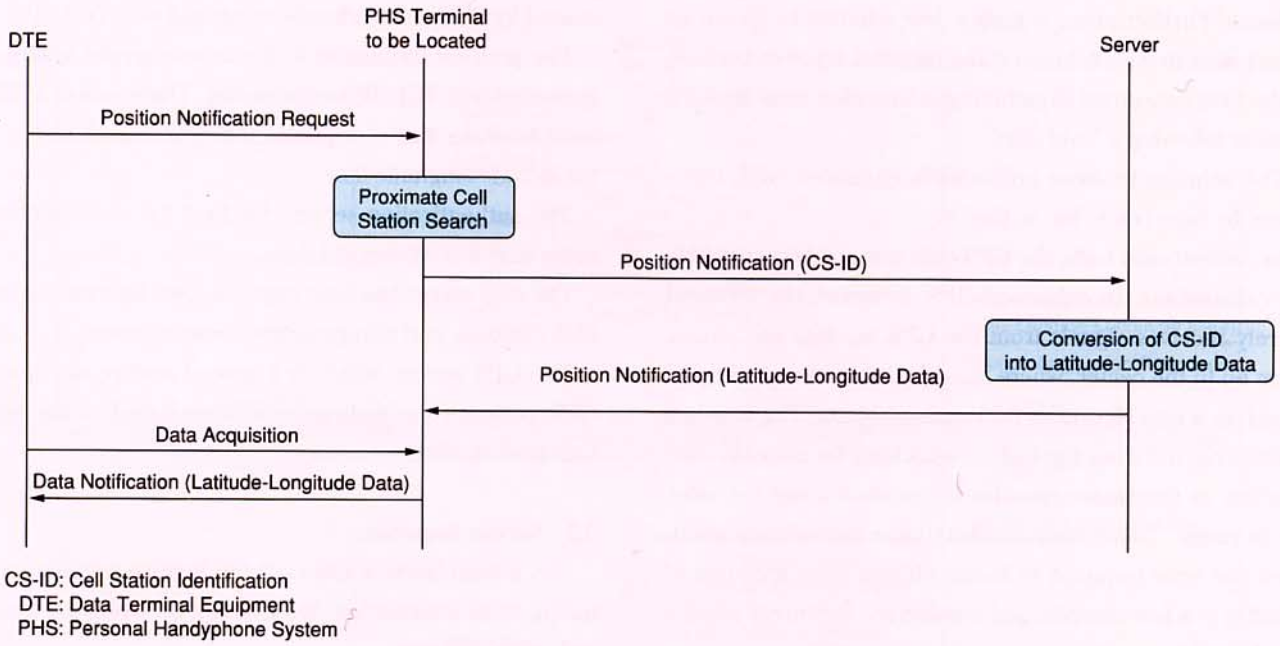


Figure 4 Sequence for Ima-DoCo Service (Location-Content-User Type)

PHS terminal to be located.

② In response, the PHS terminal to be located sends the CS-IDs of two cell stations emitting the strongest waves as parameters in the position notification to the server at the Ima-DoCo Service Center.

③ The server receives the CS-IDs, converts them into latitude-longitude data by referring to a database, and calculates the midpoint between the two (sets of latitude and

longitude data).

④ The server sends the latitude-longitude data of the mid-point as parameters in the position notification to the PHS terminal to be searched.

⑤ The PHS terminal receives the latitude-longitude data. As soon as it receives a data command from the DTE's special software, it passes the data to the DTE.

⑥ The software receives latitude-longitude data, and links it with a URL in the specific format for the normal browser, in order to acquire content relating to location information.

3. DoCo-Navi Service

The Personal Digital Cellular Telecommunication System (PDC) can use Base Station (BS)s in a way that's similar to the PHS, its accuracy in locating objects due to its larger radio zones will be on the scale of a few kilometers. While this level of accuracy may be sufficient for weather forecasts, an alternative method require to seek to improve its accuracy.

At the current level of technology, the Global Positioning System (GPS) is a potential candidate.

Traditionally, GPS suffered from problems in sensitivity and took too long to locate objects. It was too insensitive to locate objects amongst skyscrapers or anything at all indoors. Furthermore, it took a few minutes to locate an object after first switching on the terminal's power because of the time consumed in gathering information from the GPS satellite following a "cold start".

The solution to these problems is enhanced GPS, introduced by SnapTrack, Inc. in the US.

In conventional GPS, the GPS chip was solely responsible for calculations. In enhanced GPS, however, the terminal merely receives signals from the GPS satellite and passes them on to the center, where the calculations are performed based on a new algorithm for locating objects. The terminal is also relieved from the task of searching for a visible GPS satellite, as the center provides information about the satellite in range. These improvements have dramatically shortened the time required to locate objects from a couple of minutes to a few seconds, and boosted the sensitivity about a hundredfold.

Since January 2000, DoCoMo has provided a pedestrian navigation service based on enhanced GPS, under the name of DoCo-Navi Service.

3.1 Service Overview

DoCo-Navi Service is a PDC network service that provides map and town information concerning the current position of users who have terminals with DoCo-Navi Service support.

At present, the service can be accessed from Naviewn, a terminal with a built-in enhanced GPS function. It can access the service as long as it is in the PDC service area.

In order to locate an object, the terminal must be in a place where it can receive signals from the GPS satellite. However, its range for locating objects is much wider than that of conventional GPS.

Its positioning accuracy is normally in the range of 10 to 50 meters, depending on the extent to which the signals from the GPS satellite and PDC are blocked.

Naviewn must be connected to a cellular phone or city phone, as it has no communications function of its own.

3.2 System Configuration

The system configuration of DoCo-Navi Service is shown in Figure 5.

This service requires Naviewn to download a relatively large amount of data, such as map and town information. The radio section therefore relies on the PDC network's circuit switching (CS) rather than packet exchange. The efficiency of data transfer in the radio section is enhanced by a unique protocol for CS, which prevents communication delays caused by PPP and overheads associated with TCP/IP.

The protocol terminates at the access server, where it is converted into TCP/IP for the center. There is also a billing-area database that coordinates the charge area codes with the latitude-longitude data.

The authentication server checks a list of authenticated users stored in its user database.

The map server has both map and town information in the map database, and also generates route information.

The GPS server, which is a special feature of enhanced GPS, performs positioning calculations based on the signals sent from Naviewn.

3.3 Service Sequence

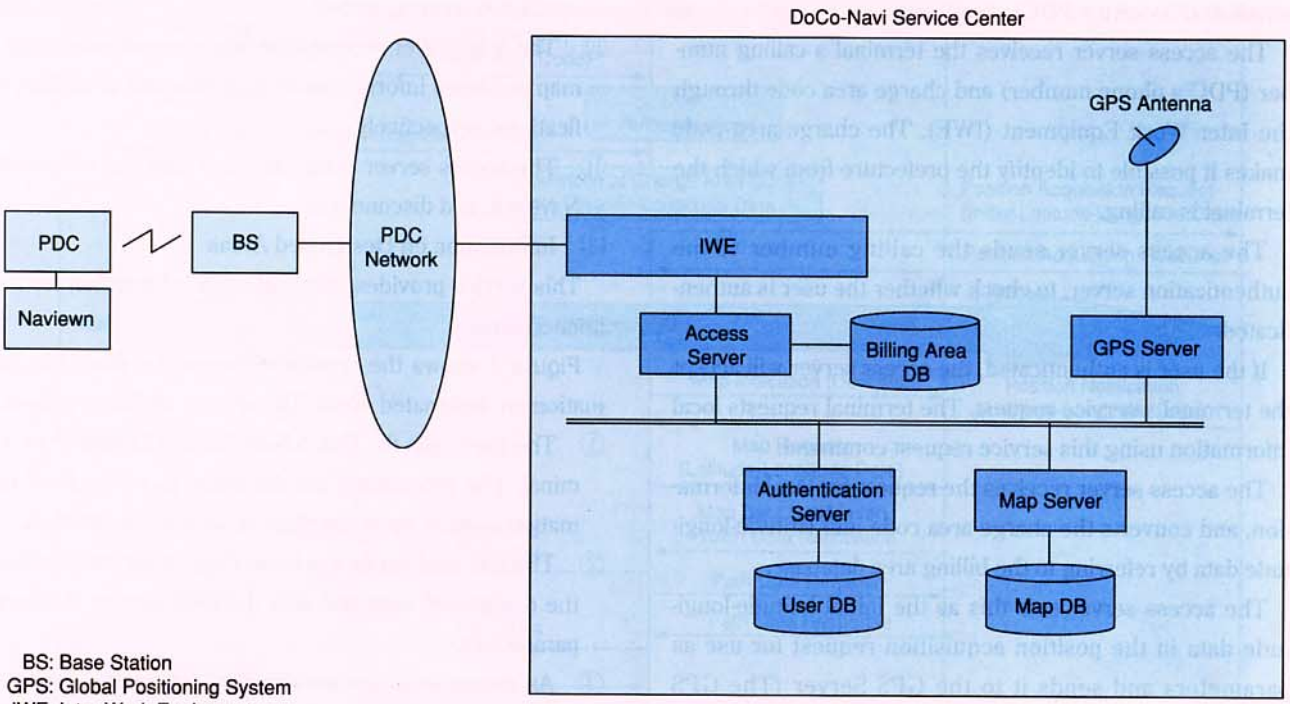
DoCo-Navi Service offers three service options on the menu: local information, information on designated areas, and route guidance.

The service sequence is as follows:

(1) Local Information

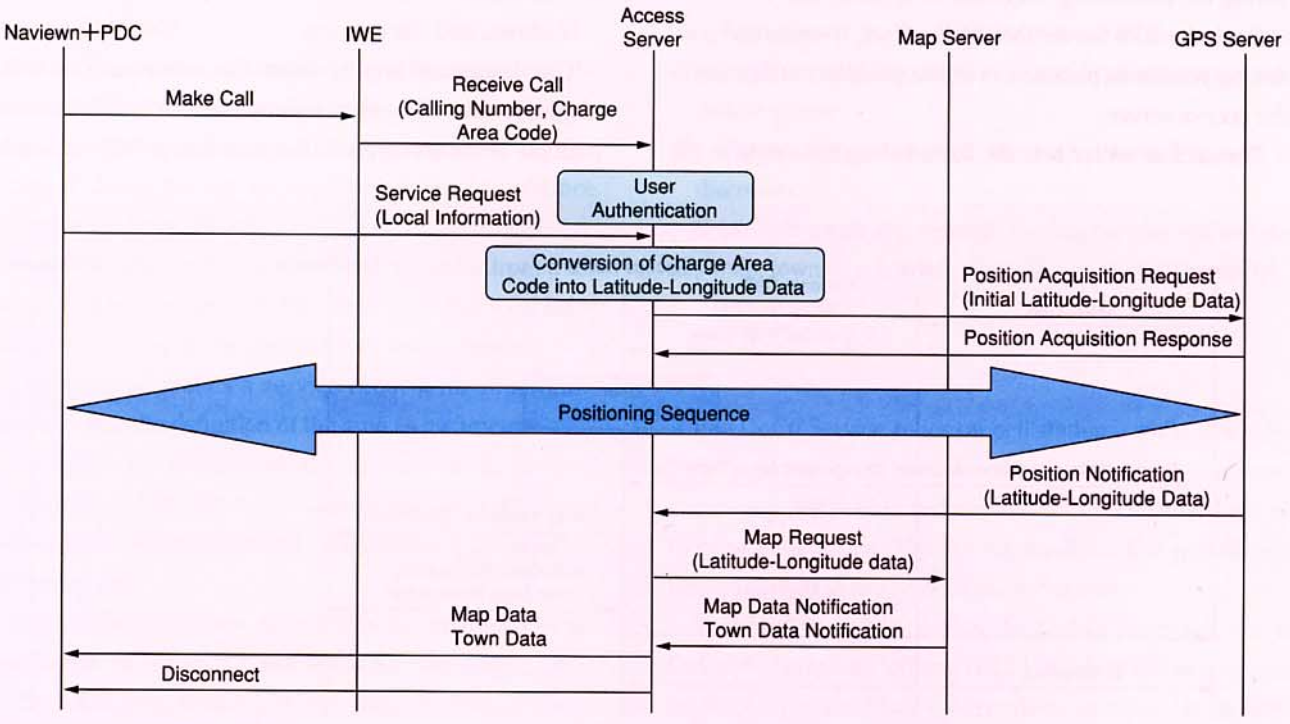
This service provides map and town information relating to the user's current position.

Figure 6 shows the sequence for the local information service. The service works as follows:



BS: Base Station
GPS: Global Positioning System
IWE: Inter Work Equipment
PDC: Personal Digital Cellular Telecommunication System

Figure 5 System Configuration of DoCo-Navi Service



GPS: Global Positioning System
IWE: Inter Work Equipment
PDC: Personal Digital Cellular Telecommunication System

Figure 6 Service Sequence for DoCo-Navi Service (Local Information)

① The user calls the DoCo-Navi Service center from the terminal (Naviewn + PDC).

② The access server receives the terminal's calling number (PDC's phone number) and charge area code through the Inter Work Equipment (IWE). The charge area code makes it possible to identify the prefecture from which the terminal is calling.

③ The access server sends the calling number to the authentication server, to check whether the user is authenticated.

④ If the user is authenticated, the access server will accept the terminal's service request. The terminal requests local information using this service request command.

⑤ The access server receives the request for local information, and converts the charge area code into latitude-longitude data by referring to the billing area database.

⑥ The access server sets this as the initial latitude-longitude data in the position acquisition request for use as parameters and sends it to the GPS Server (The GPS Server needs the initial latitude-longitude data to execute enhanced GPS.).

⑦ The GPS server receives the request, and sends a position acquisition response to the access server. Then, it identifies the position of Naviewn by enhanced GPS, following the positioning sequence with Naviewn.

⑧ Once the GPS Server locates Naviewn, it sends the positioning results as parameters in the position notification to the access server.

⑨ The access server sets the latitude-longitude data in the notification for use as parameters in the map request, and sends it to the map server.

⑩ The map server receives the map request, and sends the map and town information in map data and town data notifications, respectively.

⑪ The access server sends the map data and town data to Naviewn, and disconnects.

(2) Information on Designated Areas

This service provides map and town information for a designated area.

Figure 7 shows the service sequence for providing information on designated areas. The service works as follows:

① The user calls the DoCo-Navi Service Center from a terminal. The procedures are the same as in the local information service, up to the stage of user authentication.

② The terminal sends a service request for information on the designated area and sets the definition of the area as parameters.

③ As response to the service request for the designated area, the access server sets the definition of the area in the map indication command, and sends it to the map server.

④ The map server sends the map and town information that correspond to the definition to the access server in map data and town data notifications, respectively.

⑤ The access server sends the map data and town data to Naviewn, and disconnects.

The designated area is defined in terms such as latitude-longitude data, address, phone number, or name. However, if multiple areas are defined, the map server will not send any

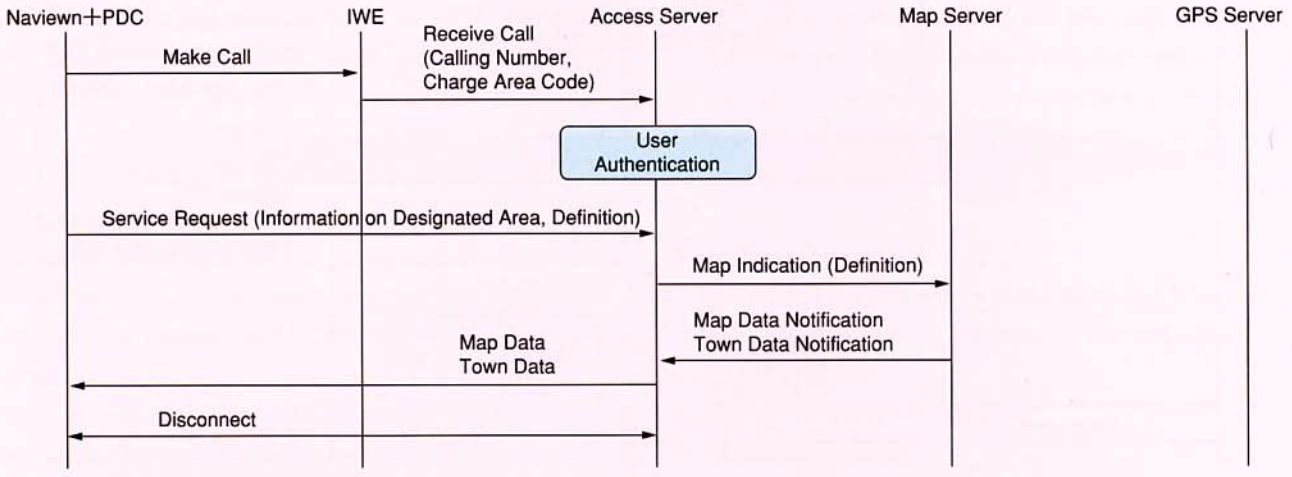


Figure 7 Service Sequence for DoCo-Navi Service (Information on Designated Areas)

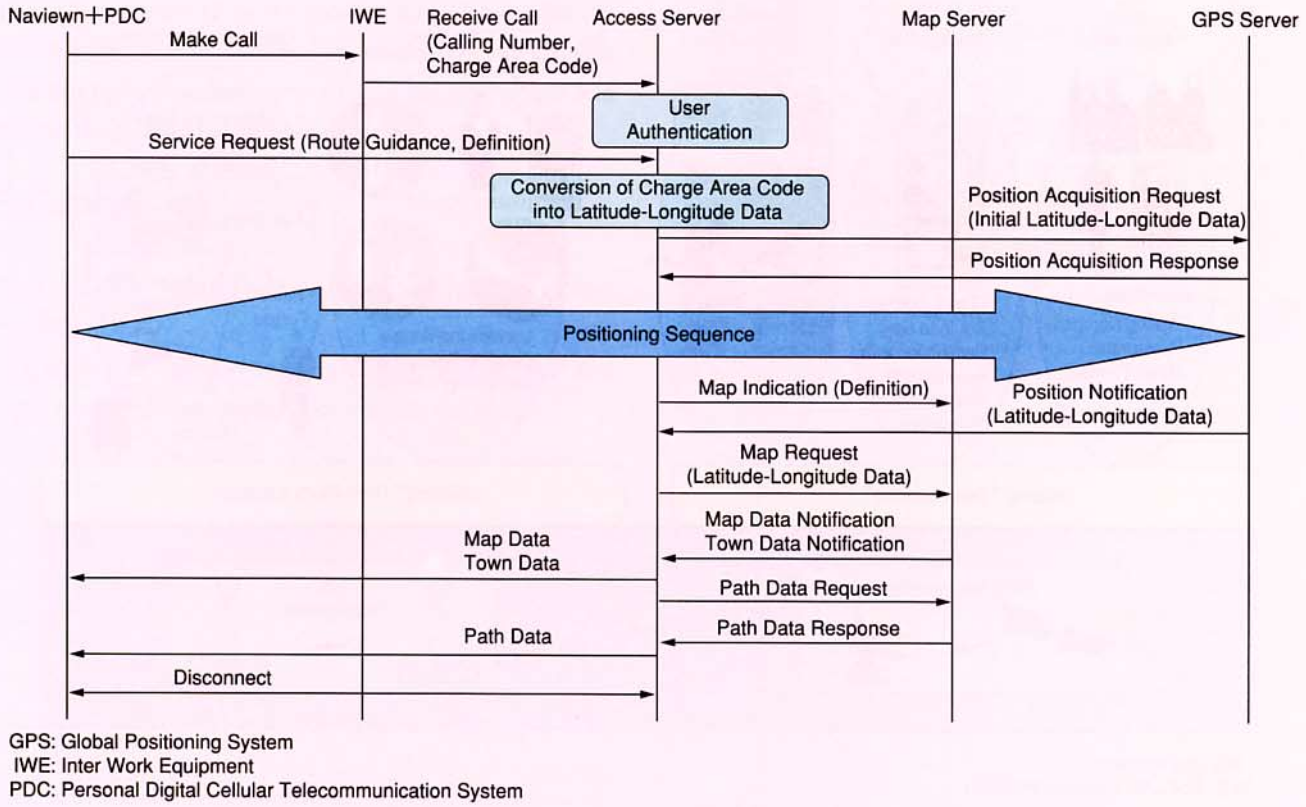


Figure 8 Service Sequence for DoCo-Navi Service (Route Guidance)

map or town information.

(3) Route Guidance

This service provides information about the route from the current position to a designated area, and map and town information relating to the user's current position.

Figure 8 shows the service sequence for route guidance. The service works as follows:

① The user calls the DoCo-Navi Service Center from a terminal. The procedures are the same as in the local information service, up to the stage of user authentication.

② The terminal makes a service request for route guidance and sets the definition of the area as parameters.

③ After this, the procedures are the same as in the local information service, up to the stage where the GPS server locates Naviewn by enhanced GPS following the positioning sequence.

④ Meanwhile, the access server sets the definition in the map indication command, and sends it to the map server.

⑤ The positioning results are sent from the GPS server to the access server. The subsequent procedures are the same as in the local information service, up to the stage where map and town information is sent to Naviewn.

⑥ Then, the access server transmits a path data request to the map server.

⑦ As response to the path data request, the map server sends the route information to the access server in path data response.

⑧ The access server sends the path data to Naviewn, and disconnects.

If multiple areas are defined, the map server will not send any map, town or route information.

4. DLP

Ima-DoCo Service relies on cell stations, while DoCo-Navi Service depends on the GPS. At present, there are several competing positioning techniques, with no standardized protocol or data format. The system configuration therefore differs according to the positioning technique.

To improve this situation, DoCoMo prorosed out the DoCoMo Location Platform (DLP) in July 1999, as a standard interface for location information services in order to improve amenities to users, and to expand and stimulate the market for such services (Figure 9). At the same time, DoCoMo launched a consortium called the DLP Study Group with mobile information terminal manufacturers, GPS

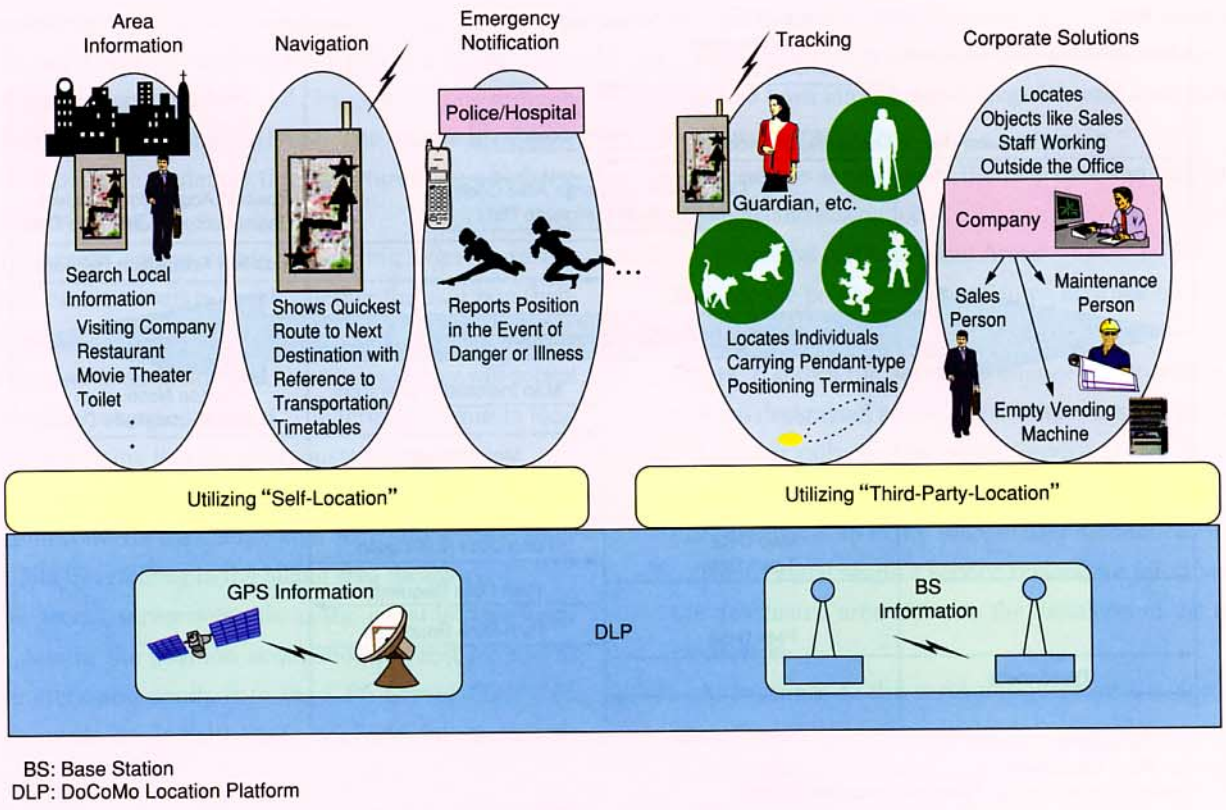


Figure 9 Image of DLP Services

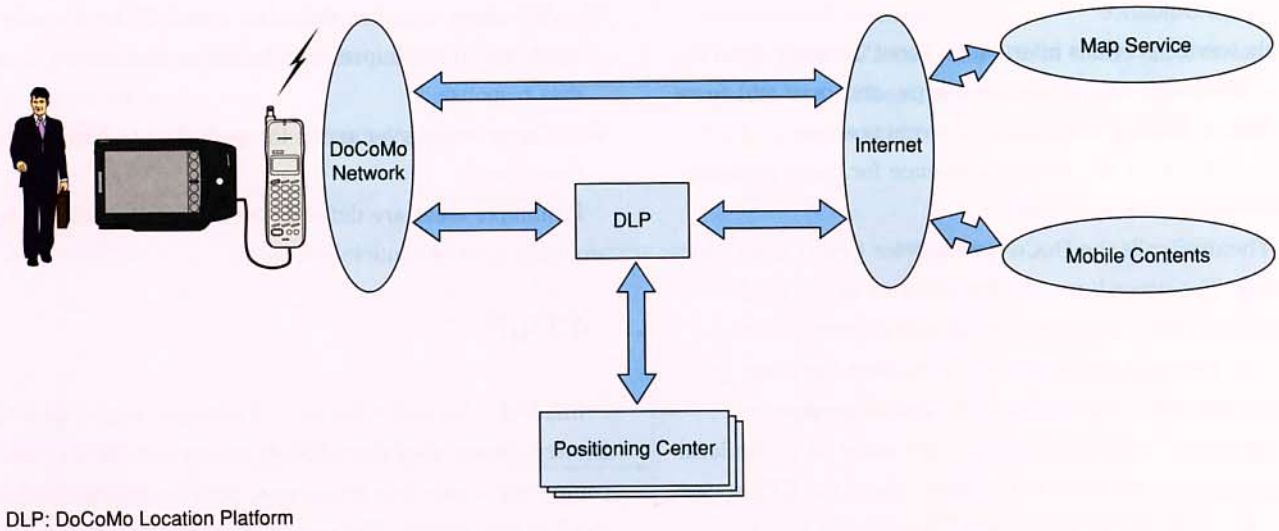


Figure 10 Configuration Image of DLP System

makers and map producers, in order to develop DLP in cooperation with a wide range of companies.

The public responded to DLP extremely well: the DLP Study Group, which was launched with the affiliation of 33 companies, had boosted its membership to more than 150 companies as of July 2000.

The configuration of the DLP system is shown in Figure 10. Each positioning technique is absorbed into the DLP, as a "positioning center". Compatible terminals and subscribers to various location information services can access DLP via a standardized interface and use DLP to locate objects and people. DLP also supports a high level of security for the pro-

tection of privacy.

The establishment of such a location information platform makes it easier to enter the location information market. Our aim is to create new businesses based on fresh ideas and stimulate the market for location information.

5. Conclusion

This article outlined the Ima-DoCo Service, DoCo-Navi Service and DLP.

We intend to accelerate the introduction of DLP and expand new services based on location information.