Expansion of FOMA Location Information Functions —Location Notification and Location Provision Function—

Yasuo Souman, Shigeto Uno, Akihiro Tsutsui, Masato Aso and Aki Kariya

DoCoMo has already been providing the location positioning function, which combines GPS and FOMA network functions. In order to meet increased user demands, the location notification and location provision functions have been implemented to provide the "imadoco search" service and "Business mopera GPS Location" service.

Technology Reports

1. Introduction

DoCoMo has been providing i-area and open i-area, which are location information functions that make use of networks [1]. In October 2005, the first FOMA terminals equipped with Global Positioning System (GPS)[*1] were released. At the same time, DoCoMo started to provide the location positioning function, which utilizes GPS and the FOMA network functions [2].

With the location positioning function, it has become possible to utilize local information related to the immediate surroundings of the current mobile terminal location, services assisting a user in navigating to his/her destination and so on by linking the function with various applications.

Against this background, DoCoMo launched two new FOMA location information functions from the spring of 2006, location notification and location provision, in order to address increased user demands such as being able to notify one's current location to a third party in case of an emergency and searching for the locations of third parties. Making use of the

*1 GPS: A system for measuring location in terms of latitude, longtitude, and altitude with high accuracy using information transmitted from orbiting satellites.

location provision function, DoCoMo launched the "imadoco search" service for the purpose of addressing usage scenarios such as parents wanting to know the locations of their children on maps. Moreover, the "Business mopera GPS Location" service, which takes advantage of both of the two new functions, was launched at the same time as well, allowing corporate users to provide value-added services such as urgent services where troubleshooting personnel is able to arrive at problem sites faster than ever before in case of emergencies, or attendance management systems where employees' working conditions can be monitored remotely using mobile terminals instead of time cards.

Note that the location notification function is used to notify location information of a mobile terminal to third parties, whereas the location provision function is used by third parties to search for information about the location of a mobile terminal. Both functions are available in FOMA terminals equipped with GPS, in the same way as for the location positioning function of the FOMA location information functions. Moreover, they can be used concurrently during voice/video phone calls and packet communication.

The "imadoco search" service allows parents who want to check upon their children's whereabouts to use i-mode terminals or PCs (My DoCoMo Service[*2]) to confirm the locations of the parties they are looking for on maps. In addition, all FOMA and i-mode terminals, i.e., not only FOMA terminals equipped with GPS, are included among the target mobile terminals, such that people carrying terminals other than these can be searched for. With this arrangement, it becomes possible to identify the rough location (the current cell) of even mobile terminals without GPS.

In order to provide these functions and services, we carried out the necessary development for the FOMA network and mobile terminals.

This article provides an overview of the location notification and location provision functions, the "imadoco search" service, as well as mobile terminals that are able to provide such functions and services.

2. Overview of Location Notification and Location Provision Functions

The location notification and location provision functions were implemented by exploiting control protocol between the FOMA network and the terminal developed for the location positioning function [2], which acquires information about the location of a mobile terminal, and by adding functions for connecting the FOMA network with LoCation Service Clients (LCS Clients)[*3]. The "Business mopera GPS Location" service provides these two functions to corporate users, i.e., LCS Client users.

Figure 1 shows an overview of the configuration of the FOMA network providing the new services and functions. The following explains how an LCS Client connects to the FOMA network, as well as the methods of network control utilized between mobile terminals, the FOMA network and LCS Clients in the location notification and location provision functions. The Mobile Originated-Location Request (MO-LR)[*4] procedure prescribed by the 3rd Generation Partnership Project (3GPP) is used as the control method for the location positioning and location notification functions, whereas the Mobile Terminated-Location Request (MT-LR)[*5] procedure is used for the location provision function [3].

2.1 Methods of Connecting the FOMA Network and LCS Clients

In the FOMA network, an External Business user Service Control Point (EBSCP)[*6] [4] provides functions for connecting with LCS Clients. Two modes are provided for connecting between an EBSCP and an LCS Client: leased line connection and connection via the Internet. This allows an LCS Client to select the optimum connection mode taking factors such as demand projections for applicable services, connection delay time and other service quality measures, initial implementation cost etc. into consideration. Moreover, the communication protocol of both connection modes conform to the Mobile Location Protocol (MLP)[*7] defined by the Open Mobile Alliance (OMA)[*8], as recommended by 3GPP.

---

*2 My DoCoMo Service: A Website that DoCoMo customers can access using PCs to handle payment of fees, changing subscriptions, etc.

*3 LCS Client: A generic name for the systems providing the location notification and location provision functions that are the FOMA location information functions. In this article, application service providers, corporate users.

*4 MO-LR: A function used by mobile terminal users to acquire the current location information, and to notify the current location information to LCS Clients via networks.

*5 MT-LR: A function used by LCS Clients to acquire the current location information of mobile terminal users via networks.

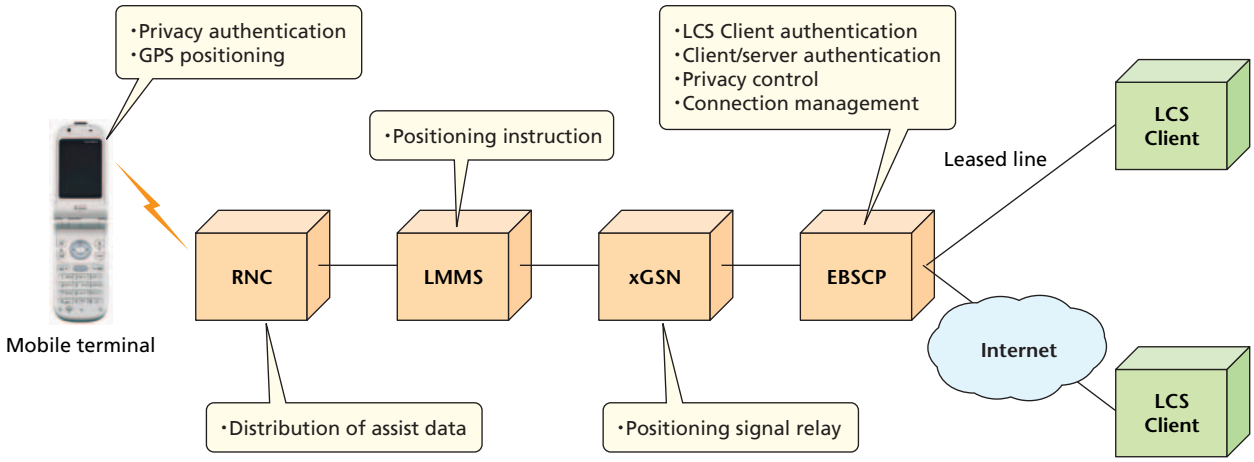

Figure 1 Overview of FOMA network configuration and functions

Since the location notification and location provision functions handle location information of mobile terminals which is very important personal information, the connection between the FOMA network and LCS Clients must remain highly secure at all times. For this reason, it was determined to adopt the following authentication schemes, and the corresponding connection requirements were defined.

1) LCS Client Authentication Function by Transmitting IP Addresses in the Location Provision Function

In the location provision function, an EBSCP maintains request source IP addresses together with associated LCS Client IDs for each LCS Client and will only accept positioning requests if the LCS Client ID matches the IP address from which a positioning request is issued.

2) Client/Server Authentication Function

In the location notification and location provision functions, Secure Socket Layer (SSL)[*9] communication is used when connecting to LCS Clients via the Internet to carry out authentication using client/server certificates for each positioning request. Moreover, a Certificate Revocation List (CRL)[*10] is updated regularly to eliminate connections from invalid LCS Clients.

2.2 Overview of Privacy Control Schemes

An authentication scheme using advanced features such as Codeword and Privacy List was implemented in EBSCPs in order to deal with the important issues of user privacy protection and LCS Client authentication when providing the location provision function.

A Codeword is a password that a user can set arbitrarily; it is required for a third party to acquire information of the location of the mobile terminal via the DoCoMo network. Positioning request signals from LCS Clients must include Codeword data notified from users; if the Codeword data does not match, positioning requests are not accepted.

A Privacy List refers to positioning permission conditions set by a user for each LCS Client; these permissions can be either one of the following three conditions: "location allowed with notification," "location with notification and privacy verification; location restricted if no response" and "location not allowed." The FOMA network always refers to the Privacy List data of the relevant user before handling positioning requests.

To make the system as convenient to use for users as possible, the Codeword and Privacy List settings can be made and changed via simple Web pages.

2.3 Network Control Systems

1) Network Control System for the Location Notification Function

Figure 2 shows an overview of the network control system used in the location notification function. A mobile terminal notifies the result of positioning by the GPS to an LCS Client and then transmits a positioning request signal with the specified notification destination LCS Client ID to a Local Mobile

*6 EBSCP: A device that maintains profile data of each provider such as the name and IP address and handles authentication with each provider, connection management in the FOMA network.
*7 MLP: A location information transmission/reception protocol between networks and LCS Clients in 3GPP.
*8 OMA: An industry standardization organization established for the purpose of standardization of service and application implementation technologies for mobile communication as well as securing mutual connectivity.
*9 SSL: A protocol that allows encoding communication and detecting data tampering between applications on networks, in particular between WWW browsers and servers.

Multimedia switching System (LMMS)[*11] (Fig. 2 (1)). The LMMS authenticates the user requesting the positioning and then transmits a positioning instruction to a Radio Network Controller (RNC)[*12]. The RNC instructs the mobile terminal to start the positioning processing and distributes assist data[*13] at the same time (Fig. 2 (2)). The mobile terminal, upon receiving the assistance data, finds its location via the GPS (Fig. 2 (3)) and notifies the result to the LMMS via the RNC (Fig. 2 (4)). Upon receiving the positioning result, the LMMS notifies the location information to an EBSCP via a serving/gateway General packet radio service Support Node (xGSN)[*14] together with the LCS Client ID of the notification destination specified in the positioning request (Fig. 2 (5)). The EBSCP notifies the location information to the LCS Client of the notification destination (Fig. 2 (6)). The LCS Client responds to the EBSCP that it received the location information (Fig. 2 (7)), the response is relayed to the mobile terminal (Fig. 2 (8)), and the positioning procedure is completed.

2) Network Control System of the Location Provision Function

Figure 3 shows an overview of the network control system used in the location provision function. An LCS Client wishing to search for location information of a certain mobile terminal sends a positioning request in which the telephone number and Codeword of the mobile terminal are specified to an EBSCP (Fig. 3 (1)). The EBSCP authenticates the mobile terminal to be searched for using the Codeword and judges whether it is all

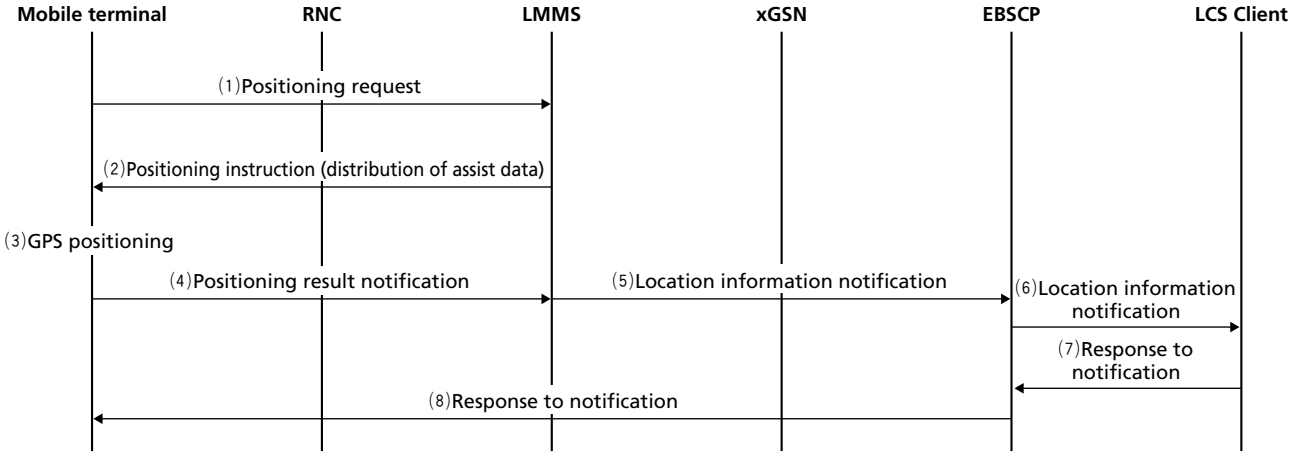

Figure 2 Overview of network control protocol for the location notification function

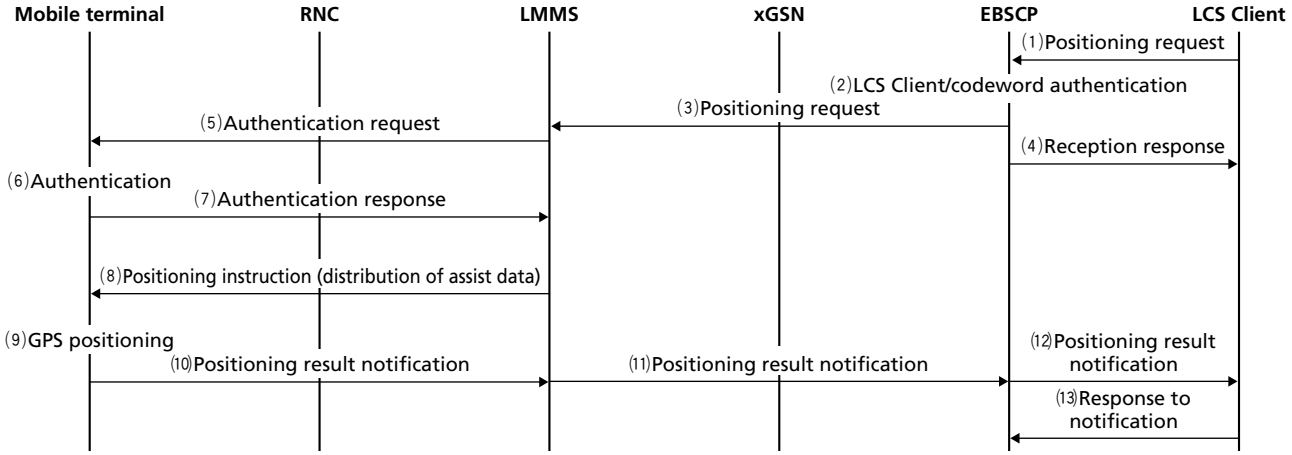

Figure 3 Overview of network control protocol for the location provision function

*10 CRL: A list of digital certificates invalidated within the valid period. It is possible to check whether or not a certificate is still valid by cross-checking the certificate and CRL.

*11 LMMS: A switching system at the subscriber level for circuit-switching communication in the FOMA network.

*12 RNC: A device defined by the 3GPP for performing radio circuit control and mobility control in the FOMA network.

*13 Assist data: Collection of parameters widely used for positioning by GPSs. A mobile terminal receives assist data distributed from a network and signals from a GPS satellite to perform GPS positioning calculation at higher accuracy.

right to accept the positioning request from the LCS Client (Fig. 3 (2)). If it judges that it is all right to accept the positioning request, it refers to the relevant positioning permission condition set in the Privacy List and transmits the positioning request of the applicable mobile terminal to an LMMS via an xGSN (Fig. 3 (3)). At the same time, the EBSCP returns a reception response to the LCS Client (Fig. 3 (4)) and cuts the connection to the LCS Client once. Here, a positioning result response can be connected to the request by adding the requestor ID of the positioning request to the reception response; we adopted a method that allows making use of the circuit resources effectively without maintaining unnecessary connections. The LMMS transmits an authentication request signal to the mobile terminal based on the positioning permission condition included in the positioning request (Fig. 3 (5)). The mobile terminal performs authentication processing based on the notified signal (Fig. 3 (6)) and replies to the LMMS with the authentication response (Fig. 3 (7)). Afterward, the GPS positioning procedure is carried out in the same way as for the location notification function (Fig. 3 (8) to (10)). Upon receiving the positioning result, the LMMS, replies to the EBSCP with the positioning result via the xGSN (Fig. 3 (11)). The EBSCP returns the positioning result with the set requestor ID to the positioning result notification destination LCS Client (Fig. 3 (12)). The LCS Client responds to the EBSCP that it received the location information (Fig. 3 (13)), and the positioning procedure is completed.

3. Overview of the "imadoco search" Service

"imadoco search" is a service under the "anshin (security) mission," through which DoCoMo is focusing its efforts to achieve its social mission of eliminating worries and creating peace in the society. In connection with the "imadoco search" service, DoCoMo has developed new functions for treasure Casket of i-mode service, high Reliability platform for CUStomer (CiRCUS)[*15], and the FOMA network to achieve improved security and search quality.

The main functions offered by CiRCUS and Kids Phones (SA800i) are as follows:

- The "imasugu search" function allows checking the current location at any time.
- The "schedule search" function performs positioning automatically at specific weekdays and hours set in advance.
- The "area monitoring" function notifies use-in-range information of areas set in advance (add-on to the schedule search function).
- The "buzzer search" function performs up to ten repeated searches when the security buzzer is activated and afterward at 15-minute intervals (this function is unique to Kids Phones).
- The "power-off search (timer search)" function performs searches when the power supply is turned off and afterward at user-specified time intervals (this function is unique to Kids Phones).

3.1 Improvement of User Security

In case of normal LCS Clients, the users' Privacy List data is managed by an EBSCP. In the "imadoco search" service, however, the privacy information for conducting positioning control is managed centrally in CiRCUS.

In addition, under normal circumstances, permission for positioning must be obtained from the search target side, but the ease of obtaining positioning information has been improved in case of emergencies and similar occasions. CiRCUS maintains identical ID information (information ensuring that the names of the searcher and the person searched for match, as specified at subscription) and allows GPS positioning as far as the names match even while in "privacy unset" status, i.e., immediately after subscribing. In order to protect users from being searched for against their will, Messages R[*16] are sent to the users for confirmation, not only when conducting searches but also immediately after subscribing, thus notifying to them that they have been specified as search targets. Finally, the "imadoco search" service can be turned off entirely by the user as well, as a way to deny search attempts.

3.2 Improvement of Search Quality

The following functions are implemented in the "imadoco

*14 xGSN: A packet communication processing device in the FOMA network, equipped with both the Serving General packet radio service Support Node (SGSN) function and the Gateway General packet radio service Support Node (GGSN) function defined by the 3GPP.

*15 CiRCUS: i-mode gateway system.

*16 Message R: One of the information transmission services provided by DoCoMo. A service that allows users to specify information they want to receive in sites providing message services, which will then distribute the information automatically to their mobile terminals.

search" service to improve the search quality.

1) GPS Positioning Request Congestion Control

The schedule search function of the "imadoco search" service automatically performs positioning processing at preset times. If many users happen to specify the same time slot, a large amount of GPS positioning requests may be sent to the FOMA network in question. In order to prevent the FOMA network from becoming congested and unable to provide the positioning service with a satisfactory performance, CiRCUS is equipped with a call control function. As a result, the positioning success rate can be kept high, although some delay may occur between the scheduled time and actual acquisition time. In addition, interruptions by other search services are permitted when processing scheduled searches in order to avoid situations where it is impossible to perform other searches due to accumulation of unprocessed scheduled searches.

2) Timing Control of Cell-based Positioning

FOMA terminals not equipped with GPS are able to perform cell-based positioning. It was decided to re-use the cell-based positioning function, which is already utilized in FOMA's i-area service, so that the function can be applied to already existing FOMA terminals and the development cost can be minimized. Since this function requires that the mobile terminal is connected to a packet network to work, it was decided that a "search confirmation Message R" should be sent to search targets.

This allows search targets to confirm whether search results can be disclosed or not at the same time and achieving almost the same level of privacy protection for existing FOMA terminals as for FOMA terminals equipped with GPS. In addition, since the timing at which the cell-based positioning processing is performed is affected by the conditions of the search targets and networks, CiRCUS has been expanded with a function to check the packet network connection status in advance.

3) Holding/Resuming Buzzer Searches

This function repeatedly performs a buzzer search with a high emergency level immediately after the completion of the previous positioning if the search target was already being positioned when the buzzer sounded, by holding and resuming the buzzer search by CiRCUS.

In addition, in order to address cases where buzzer search requests from Kids Phones cannot be accepted due to temporary congestion of CiRCUS, a response code prompting resending is returned to Kids Phones to improve the reliability of the system in case of emergencies.

3.3 CiRCUS Network Control Systems

1) Overview of Privacy Control System

CiRCUS uses LCS Client IDs differently depending on the condition set in the Privacy List by a user, and makes requests to an EBSCP accordingly. The EBSCP sets the initial value of Privacy List for each LCS Client ID of CiRCUS, judges the Privacy List of the user with the LCS Client ID at positioning requests only, and makes a positioning request.

2) Network Control System

Figure 4 provides an overview of the network control system used for providing the "imadoco search" service for FOMA terminals not equipped with GPS. Note that the network control system for FOMA terminals equipped with GPS is the same as shown in Fig. 3.

When executing GPS positioning, CiRCUS transmits GPS positioning requests to all EBSCPs uniformly (Fig. 4 (1)). After authenticating the "imadoco search" service (Fig. 4 (2)), an EBSCP transmits a response to the positioning request to CiRCUS (Fig. 4 (3)) and a GPS positioning request to the mobile terminal (Fig. 4 (4)). A FOMA terminal not equipped with GPS returns an error to the GPS positioning request (Fig. 4 (5)) and the EBSCP notifies CiRCUS that the target user is a FOMA terminal not equipped with GPS in case an error is returned (Fig. 4 (6)). If the positioning target user is a FOMA terminal not equipped with GPS, CiRCUS sends a Message R informing the user that cell-based positioning is performed (Fig. 4 (7)) and executes the positioning (Fig. 4 (8)). Note that the search target is able to decide whether or not the cell-based positioning result is disclosed to the searcher by selecting the appropriate option in the confirmation Message R sent to the search target (Fig. 4 (9)). In addition, regardless of whether the target mobile terminal is equipped with GPS or not, the location acquisition result is only notified to the searcher as differences

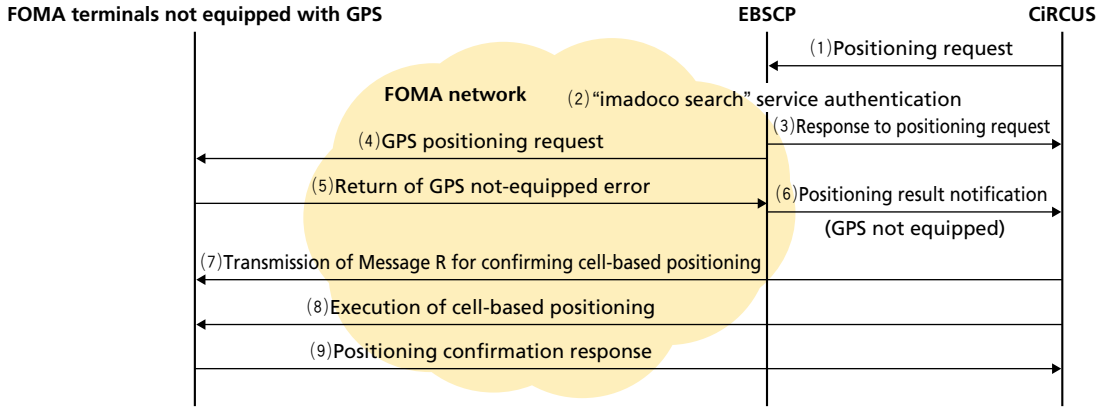

Figure 4 Overview of the "imadoco search" service network control protocol in case of FOMA terminal not equipped with GPS

in positioning levels.

Thus, by making it impossible to distinguish between cell-based positioning by FOMA terminals equipped with GPS located in GPS blind spots and cell-based positioning by FOMA terminals not equipped with GPS, searchers are prevented from recognizing the type of the search target's terminal.

4. Mobile Terminal Control Functions

4.1 Function Overview

This section explains the functions implemented in SA700iS and SA800i (Kids Phones), which are FOMA terminals equipped with GPS.

The location notification function is activated through simple operations: it is activated with one-touch operation, i.e., holding down a certain key, or linked to voice call initiation etc. For the location provision function, it is furthermore possible to specify whether or not to provide location information using mobile terminals. If it is allowed to provide location information, a confirmation screen is displayed to notify users when they receive search requests from networks; further, pictograms[*17], Light Emitting Diodes (LED) and sounds are used to alert the users, thereby conforming to the personal information protection guidelines [5].

4.2 Functions Unique to Kids Phones (Safety and Security Functions)

Kids Phones are equipped with the following functions for safety and security (**Photo 1**).

1) The location information notification function is linked with a security buzzer (linking with voice call initiation is also possible).
2) The location information notification function remains activated when the power supply is off.
3) The location information notification function is activated by a timer after the power supply is turned off.
4) The terminals are equipped with a high-gain GPS antenna.

Functions 1) to 3) send request signals to CiRCUS, which triggers the location provision function. Each of the request signals is classified and each request can be identified within CiRCUS. In addition, when functions 1) to 3) are activated, third parties are prohibited from interrupting the processing; i.e., it becomes necessary to enter a password to interrupt the positioning. Similarly, password entry is also required when turning

(a) Front (b) Rear (security buzzer)

Photo 1 External view of SA800i (Kids Phone)

*17 Pictogram: Icons and other forms of picture display, rather than letters. Pictograms such as i-mode and antenna symbols are used in DoCoMo's mobile terminals.

the power supply off and the battery pack structure does not allow easy removal of the battery in order to prevent the power supply from being turned off easily.

Function 4) achieves antenna gain improvements of approximately 2 to 3 dB compared to chip antennas[*18] for general mobile terminals. This has been made possible by making effective use of the space in the location where the backside LCD is mounted, as well as the thickness of the mobile terminal itself to implement large patch antennas[*19] to support average usage forms of users. With these arrangements, a dramatic improvement of the GPS performance (improved GPS accuracy and successful rate of GPS fix, shorter positioning time to GPS fix and wider areas where positioning can be performed) has been achieved.

5. Conclusion

This article described the LCS Client connection methods, network control protocols, service methods and mobile terminal control protocols implemented to support the FOMA location information functions, i.e., the location notification and location provision functions, as well as the "imadoco search" service.

The location notification function and location provision function form the foundation of DoCoMo's location information services and play important roles when providing new services in the future. The "imadoco search" service is also very important in terms of DoCoMo's contributions to the society. We aggressively aim for an expansion of the location information market in the future as well and work toward further improvement of the convenience for DoCoMo users, continually expanding and upgrading the FOMA terminals equipped with GPS as well as location information functions and other services.

References

[1] N. Hagiya et al.: "FOMA i-area System Configuration and Functions," NTT DoCoMo Technical Journal, Vol. 11, No. 2, pp. 60–69, Jul. 2003 (In Japanese).

[2] M. Aso et al.: "Location Information Functions for FOMA Terminals—Location Positioning Function—," NTT DoCoMo Technical Journal, Vol. 7, No. 4, pp. 13–19, 2005.

[3] 3rd Generation Partnership Project: "TS23.271, Technical Specification Group Services and System Aspects; Functional stage 2 description of Location Services (LCS)"

[4] T. Hasegawa et al.: "IP Service Control Point and Signaling Gateway for IP Common Channel Signal Network," NTT DoCoMo Technical Journal, Vol. 7, No. 4, pp. 27–33, 2006.

[5] Guideline on Protection of Subscribers' Personal Information in Broadcasting (Announcement No. 695, Aug. 31, 2004, by Ministry of Internal Affairs and Communications)

*18 Chip antenna: A type of antenna with a flat rectangular shape. Widely used with a mobile terminal due to its miniaturization and light weight.

*19 Patch antenna: A type of antenna with a flat shape. Although they require more area than linear antennas, they are advantageous in making mobile terminals thinner in that they allow creating thin antenna devices.