Development Reports

# Location Information Functions for FOMA Terminals —Location Positioning Function—

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*DoCoMo has developed location information functions that combine GPS and FOMA network control functions. The location positioning function enables current and accurate location information to be obtained from a FOMA terminal.*

## 1. Introduction

DoCoMo presently provides "i-area" and "open i-area" [1] location information services using network functions. Recent years, however, interest and demand are increasing both in Japan and overseas, for location information functions that combine the Global Positioning System (GPS) and network functions. To meet these growing needs in a timely manner, DoCoMo is working to expand its current services to high-performance positioning functions and location information services making full use of FOMA features.

Against this background, we developed functions in the FOMA network with the aim of commencing the provision of a GPS-based location positioning function in parallel with the launch of GPS-equipped FOMA terminals in the fall of 2005. This location positioning function, which is the most basic of the FOMA location information functions, combines the FOMA network and GPS to determine the user's current location. Mobile terminals that can use this function are FOMA terminals with GPS capability. In this article, we provide an overview of the location positioning function describing the positioning system and network control system that combine the FOMA network and terminal, the assistance data delivery system in the FOMA network, and the terminal control system .

## 2. Positioning System and Network Control System for the Location Positioning Function

We adopted Assisted-GPS (A-GPS) that uses control signals between the network and mobile terminal [2][3]. We first explain A-GPS and then describe the location positioning function that is performed between the mobile terminal and FOMA network.

### 2.1 Adoption of A-GPS and System Procedure

An autonomous positioning system in which a FOMA terminal receives signals only from GPS satellites would receive all information necessary for positioning from those satellites. The positioning process in such a system, however, can be time consuming on a mobile terminal and can also consume a considerable amount of power. These problems can be dealt with by adopting A-GPS. The A-GPS technique delivers the navigation messages from GPS satellites required by the FOMA location information function for positioning to the mobile terminal, which then performs positioning calculations. These messages are provided as “assistance data” from the FOMA network enabling high-speed and low-power positioning to be performed. On the other hand, an autonomous positioning system is capable of positioning even if radio signals cannot be delivered from the FOMA network, and for this reason, it is provided as a supplementary function in mobile terminal to provide for times that A-GPS cannot be deployed. The above mentioned assistance data provided from the FOMA network is a set of parameters used extensively for positioning by GPS.

**Figure 1** shows the A-GPS process overview. In this system, navigation messages that are transmitted by GPS satellites (Fig. 1 (1)) are collected and processed by the multimedia Service Agent for GPS assistance data providing (SAG), which generates and stores assistance data based on those messages (2). These data are delivered to the Radio Network Controller (RNC) (3). On receiving a positioning request from a mobile terminal (4), RNC delivers the assistance data to the mobile terminal (5), which can now use that data in combination with signals received from GPS satellites to perform positioning calculations (6).

### 2.2 Network Control System for the Location Positioning Function

The location positioning function determines the user’s current location as a result of terminal operations performed by the user. To satisfy the requirements of this function, the control system here adopts the Mobile Originated-Location Request (MO-LR) procedure prescribed by the 3rd Generation Partnership Project (3GPP) [4].

In a system that performs GPS-based positioning on a mobile terminal, it is important that the time needed to perform positioning be made as short as possible. In this development, we have significantly reduced the time needed for positioning by dividing assistance data into two types. These are assistance data that must be updated by any mobile terminal when initiating a positioning process, and assistance data that do not need to be updated for a while once they have been downloaded though they can be delivered when needed.

In particular, assistance data to be delivered at the time of a positioning request will include ephemeris information, which provides precise orbital data on a GPS satellite, the mobile terminal’s current cell location, and so on. Almanac information that provides brief orbital data on all GPS satellites will not be provided at this time. This is because almanac information can

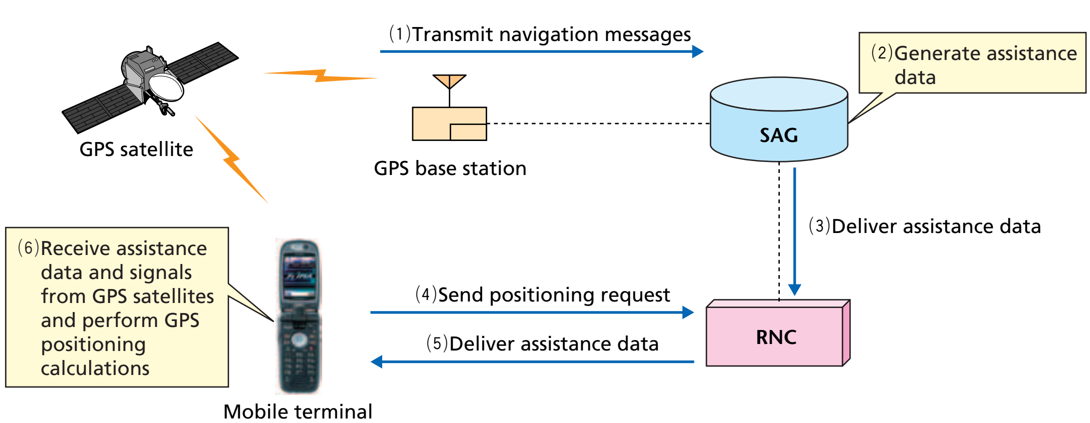


**Figure 1 A-GPS process overview**

be used for a relatively long period of time for positioning compared to other types of information, which means that there is a high possibility that almanac data that has already been delivered can be used again. Also of importance here is that the sending of all GPS satellite information at one time would involve a considerable amount of data. The above system can therefore shorten the time required to deliver assistance data, thereby shortening the time required for positioning and reducing the amount of wireless resources used.

**Figure 2** shows the specific control system used for our location positioning function. To begin with, the mobile terminal to perform positioning by GPS sends a positioning-request signal to the Location Mobile Multimedia switching System (LMMS) (Fig. 2 (1)). The LMMS authenticates the user making the positioning request (2), and sends positioning instructions to the RNC (3). Next, the RNC, on the basis of those instructions, sends assistance data to the mobile terminal and instructs it to begin positioning (4). If, at this time, the mobile terminal should no longer possess valid almanac information, it can obtain the data that it is lacking from the RNC (5). Once the mobile terminal has received all of the assistance data that it needs for GPS positioning, it proceeds to do so (6). On completing positioning, the mobile terminal reports positioning results to LMMS via RNC (7). Finally, on learning that positioning has been completed, LMMS sends a positioning-complete notification to the mobile terminal (8).

A user that obtains his or her current location by this function can now make use of various location information services such as sending to another user one's current location information by e-mail or accessing location information content.

# 3. Assistance Data Delivery System

## 3.1 Requirements for the Assistance Data Delivery System

As shown in Fig. 2, SAG delivers collected assistance data to RNC via LMMS. For requesting and delivering assistance data, messages may be passed through LMMS by capsuling the 3GPP-designated message format (TS25.453Rel.5) [5] between SAG and RNC within the original formats used between RNC and LMMS and between LMMS and SAG. On determining an assistance data delivery system to be used between SAG and RNC, the following requirements must be kept in mind.

- Assistance data used for GPS positioning must be kept valid.
- Processing load must be distributed and traffic must be reduced.

The following describes a system that can satisfy these requirements.

## 3.2 Extension to On-Demand System

There are three types of assistance data delivery systems defined in 3GPP standards as shown in **Figure 3**. These are On-Demand, Periodic, and On-Modification. Of these, the Periodic and On-Modification delivery systems require that SAG manage the delivery of assistance data to each destination RNC. In this development, we adopt the On-Demand delivery system that makes status management for each RNC unnecessary thereby simplifying the process and reducing network processing load. We also make functional extensions to the 3GPP On-Demand delivery system to distribute the load on SAG.

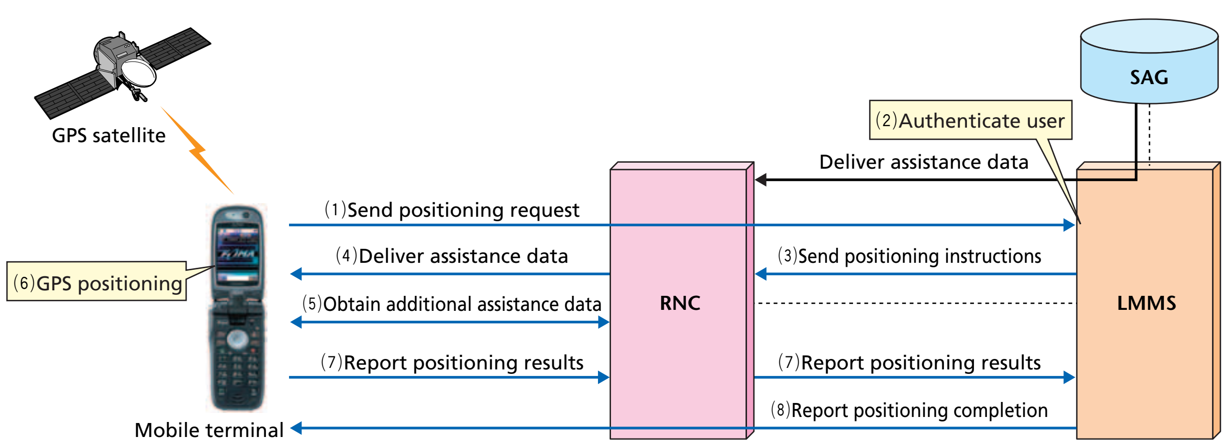


**Figure 2 Control system for location positioning function**

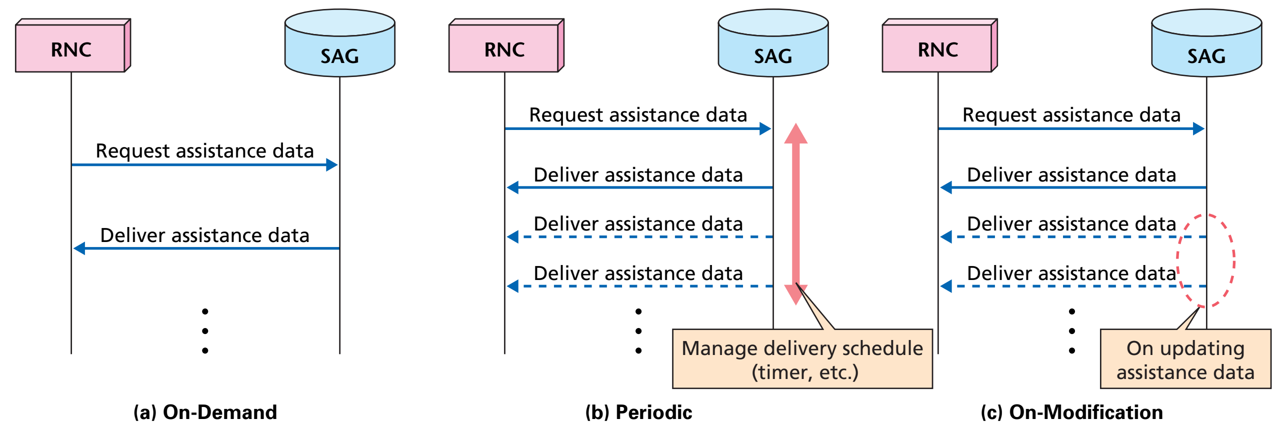


**Figure 3 Assistance data delivery system defined by 3GPP**

In the 3GPP On-Demand system, a request for assistance data is made to SAG via RNC every time positioning is to be performed by a mobile terminal. In this scheme, traffic expands as the number of terminal positioning requests increases and the number of assistance data requests made to SAG increases proportionally. Under these circumstances, processing load on SAG can be expected to rise.

To help ease this processing load, we add two new functions to the On-Demand system: an assistance data cache function and assistance data-request scheduling function. These functional enhancements make the processing load on SAG constant and, making use of valid periods of data use, raise efficiency by delivering to RNC only assistance data that need to be updated [6]. In this system, the assistance data delivery sequence between RNC and SAG is performed asynchronously with the positioning sequence between the mobile terminal and RNC. Using a procedure that does not make a request for assistance data to SAG every time a positioning request is made from the mobile terminal can keep load from concentrating at SAG. The features of this assistance data delivery system are described below.

1) Assistance Data Cache Function

Subjecting assistance data delivered from SAG to cache management at RNC means that the procedure for obtaining assistance data from SAG every time a positioning request is made from the mobile terminal can be omitted.

This function can not only shorten the assistance data delivery time to the mobile terminal, it can also eliminate the effects of a burst-like increase in mobile terminal positioning requests on traffic between RNC and SAG thereby simplifying facility design.

2) Assistance Data-request Scheduling Function

Implementing an assistance data-request scheduling function in conjunction with the above assistance data cache function ensures that assistance data is kept within their valid periods of use. The length of time that assistance data may be used before updating is required differs for each information element. With this in mind, we classify information elements into three categories—short cycle, medium cycle, and long cycle—and set a valid period of time for each of those categories. **Figure 4** shows RNC and SAG processing. Here, RNC evaluates at fixed intervals the valid period of use of assistance data stored internally in the cache, and makes requests to SAG for any assistance data that need updating.

This system can reduce the amount of data delivered to RNC from SAG and can ease negative effects on transmission channel bandwidth.

### 3.3 Distribution of Assistance Data Request Processing

As described in the previous section, making functions extensions to the 3GPP On-Demand system results in the sending of assistance data delivery requests from a single RNC at fixed time intervals. However, if multiple RNCs were to issue assistance data requests to a single SAG using the same timing, SAG processing would be concentrated in a short time interval. This problem can be dealt with at SAG itself by adopting traffic-volume restrictions to discard requests above a certain number and prevent a high load situation, as shown in **Figure 5** (a).

However, as the time cycle used to issue assistance data delivery requests is the same for all RNCs, the occurrence of overlapping timing and the resulting discarding of requests would not be a one-time thing. It would simply repeat every cycle preventing the updating of assistance data for at least some RNCs. To deal with this problem, a particular RNC that

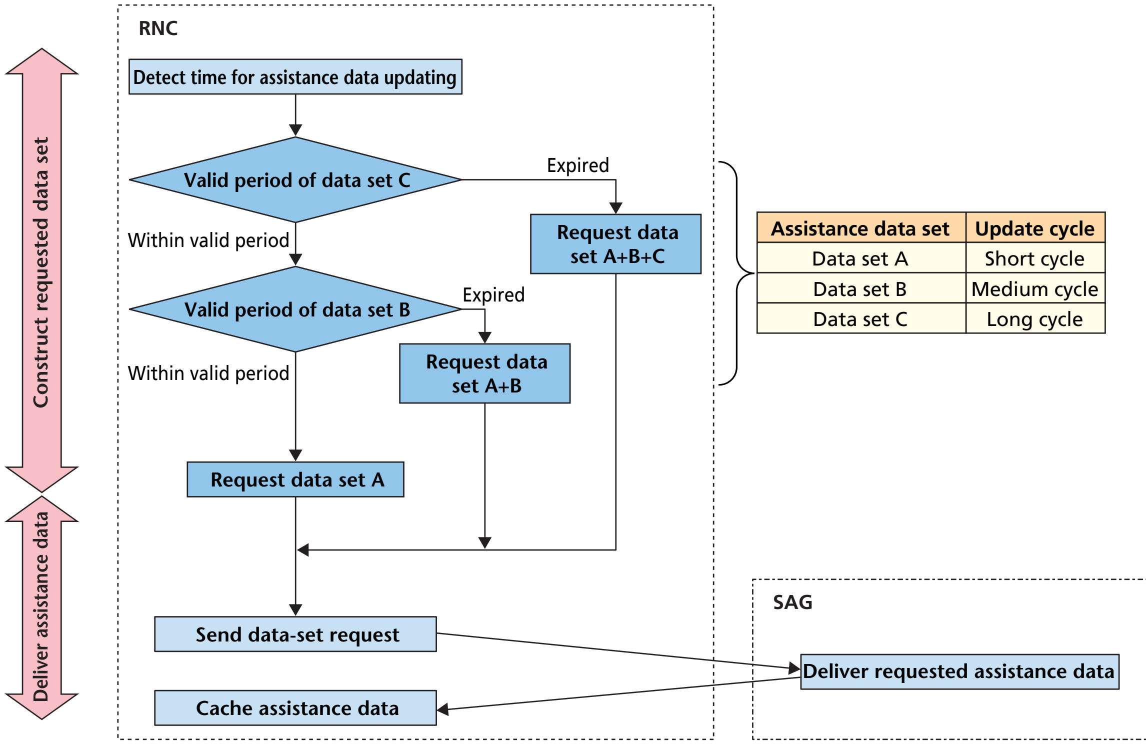


**Figure 4 RNC and SAG processing**

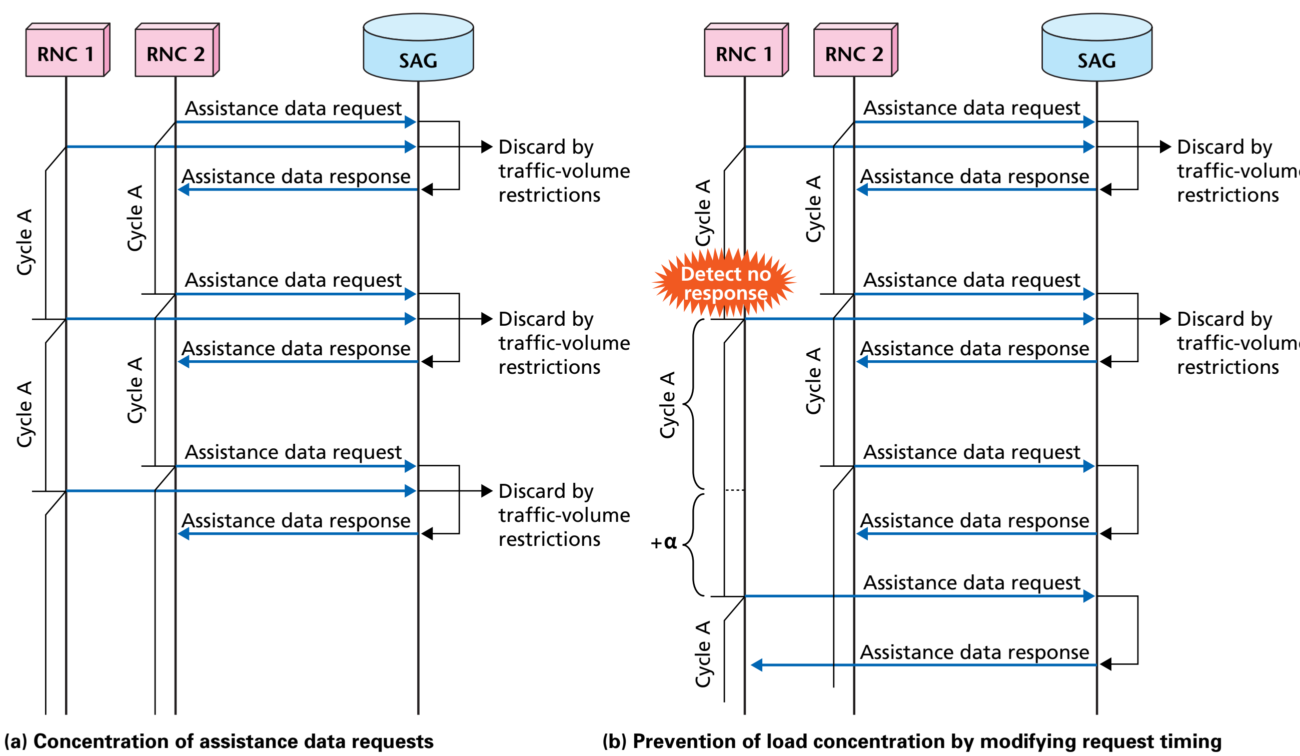


**Figure 5 Distribution of assistance data request processing**

obtains no response after issuing a prescribed number of assistance data delivery requests due to traffic-volume restrictions at SAG can elect on its own to shift its assistance data-request timing. The size of this time shift can be varied among the various RNCs enabling concentrated processing at SAG to be prevented in an autonomous manner.

## 4. Mobile Terminal Control Function

A GPS-equipped terminal comprises a positioning section for obtaining location information and an application section for using that location information. The following outlines the location positioning function incorporated in the mobile terminal and the application section that uses the location information so obtained. This function has been implemented in the SA700iS FOMA terminal.

### 4.1 Mobile Terminal Positioning Section

The positioning section of the mobile terminal consists of a GPS receiver and a positioning calculation section. The A-GPS mode and autonomous mode described in Section 2.1 are implemented here as GPS positioning methods.

On activation of a positioning session by the application section, the mobile terminal issues a request for assistance data to the FOMA network and performs positioning using the obtained data. Also, for locations where GPS signals are weak and positioning by GPS is difficult such as when indoors, the mobile terminal's cell location information as obtained from the FOMA network can be used as positioning results.

Furthermore, for situations in which GPS assistance data cannot be received from the FOMA network (such as when the mobile terminal is out of range) and positioning by A-GPS is not possible, the mobile terminal will switch from A-GPS to the autonomous positioning system. This implementation enables positioning to be performed even if radio signals cannot be received from the FOMA network.

Tracking mode, i.e., continuous positioning, is also supported for use in navigation functions.

The location information obtained by the positioning process is mainly presented in the form of latitude and longitude and positioning level. Here, positioning level means the level of positioning accuracy as estimated internally by the mobile terminal. **Figure 6** shows screenshots of positioning in progress and positioning completed, both of which display the positioning level, that is, the current accuracy of the location information in question. A positioning session may be halted at any time by a terminal operation and the results obtained up to that point may be used. The user can therefore check the current positioning level on the screen without waiting for the positioning process to complete and proceed to use location information once the positioning level has reached a value deemed sufficient for the purpose at hand. Positioning level may also be used for modifying scale when displaying maps on the mobile terminal.


(a) Positioning in progress (b) Positioning completed

**Figure 6 Screenshots of location positioning function**

### 4.2 Applications Using the Location Positioning Function

The location positioning function can be linked with other terminal functions such as i-mode, i-appli, camera, e-mail, phone book, and scheduler to enable location information to be used in diverse usage scenarios.

With i-mode, for example, location information can be used to obtain a map of one's current location or neighborhood information such as nearby restaurants and shops. A function is also provided for attaching a location-information Uniform Resource Locator (URL) to e-mail to obtain location information content.

An i-appli that uses location information can be created and executed on the SA700iS terminal. If the i-appli uses an Application Program Interface (API) designed for location-information use, it can obtain location information.

Location information obtained by the location positioning function can be affixed to a photograph taken with the terminal camera or added to the phone book or scheduler. Data that includes location information in this way may also be exchanged between GPS-equipped terminals by infrared connections, external memory, etc.

One particular feature of the SA700iS terminal is the built-in navigation function. With this function, the current location of the mobile terminal can be checked, terminal tracking can be performed, nearby restaurants can be searched for, and a route to one's destination can be displayed, for example.

## 5. Conclusion

This article described a positioning system that combines GPS and the FOMA network to provide a function for checking one's current location as part of FOMA location information functions, and an assistance data delivery system in the FOMA network and a network/terminal control system.

The location positioning function plays an important role as the most basic of FOMA location information functions. In the future, we plan to enhance and expand location information functions and services and extend the lineup of GPS-equipped terminals with the aim of developing the location information market even further.

## REFERENCES

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## ABBREVIATIONS

3GPP: 3rd Generation Partnership Project
API: Application Program Interface
A-GPS: Assisted-GPS
GPS: Global Positioning System
LMMS: Location Mobile Multimedia switching System
MO-LR: Mobile Originated-Location Request
RNC: Radio Network Controller
SAG: multimedia Service Agent for GPS assistance data providing
URL: Uniform Resource Locator