A-GPS SUPL International Roaming

Technology Reports

FOMA Location Information Functions Using SUPL International Roaming —Location Positioning Function—

NTT DOCOMO is already providing an A-GPS positioning function within Japan using a combination of GPS and FOMA network functions, but outside of Japan, while roaming internationally, the same level of location information function has not been available. To address this, we have developed an SUPL function, which enables A-GPS positioning outside of Japan as well. With this function, a positioning service which retrieves the current position can now also be provided while roaming internationally.

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1. Introduction

NTT DOCOMO has been providing a service which reports the current location of the phone for quite some time, making use of a positioning service that uses GPS and the FOMA network [1]. Also, due to high user demand for functions such as sending notification of one's location in times of emergency, or informing parents of the location of their children, NTT DOCOMO has been providing current-location notification and location providing services [2] since the spring of 2006. These functions are provided within Japan in services such as "imadoco search" and "Business mopera GPS Location," and demand for location-based services among users appears to be increasing. Users roaming out of Japan are also showing demand for these types of location-finding services using GPS.

There are two main approaches for using GPS to provide these types of services: independent positioning and Assisted-GPS (A-GPS). With independent positioning, the information needed to compute a position is obtained by decoding the GPS signal. This requires an environment with a strong GPS signal, but in many situations, it is difficult to acquire an adequate signal and perform GPS positioning successfully. On the other hand, with the A-GPS approach, the mobile terminal receives GPS satellite navigation and other data that it needs to make a GPS positioning (hereinafter referred to as "assist data") such as a reference location, through the FOMA network. This allows the GPS signal to be decoded more easily, reducing positioning time required and expanding the area where positioning is possible, so A-GPS has come into common use.

NTT DOCOMO's current service distributes this assist data using the Control Plane (C-Plane)[*1], but there are only a limited number of overseas operators able to provide positioning information using the C-Plane in the same way as NTT DOCOMO, so it has not been possible to offer the GPS positioning services while users are roaming internationally.

Secure User Plane Location (SUPL) [3]

*1 **C-Plane**: Transmission path for control signals such as establishing and disconnecting communications.

is an A-GPS mechanism specified by the Open Mobile Alliance (OMA), which uses the User Plane (U-Plane)[*2] as the bearer for transmitting assist data between mobile terminals and the network. By supporting SUPL, an A-GPS positioning function can be provided without depending on the overseas operator's network, as long as packet roaming is available.

In this article, we describe the SUPL-based GPS-positioning service infrastructure used to provide positioning services while roaming internationally. We also give an overview of the new SUPL current positioning function available on summer 2009 mobile terminal models.

2. SUPL Positioning Method and Network Control Mechanism

2.1 Functional Overview and Network Connection Mechanism

An overview and network architecture of the SUPL current positioning function is shown in **Figure 1**.

After starting SUPL (Fig. 1 (1)), the mobile terminal establishes a packet connection with the Charging and Protocol Conversion Gateway (CPCG)[*3] for SUPL communication. After establishing the connection it sends an SUPL connection request (Fig. 1 (2)). The CPCG determines the service from the connection-request destination port, separates out the packets for the SUPL Location Platform (SLP) (Fig. 1 (3)), and connects to the SLP. The SLP performs user authentication and establishes a Transport Layer Security (TLS)[*4] secure communications path with the mobile terminal (Fig. 1 (4)). Using GPS satellite navigation messages periodically pre-fetched from the Global Reference Network (GRN)[*5], the SLP generates the assist data required by the mobile terminal to measure its position. The SLP is able to receive GPS satellite navigation messages for anywhere in the world by connecting with the GRN. The SLP sends the assist data over the U-Plane to the mobile terminal (Fig. 1 (5)),

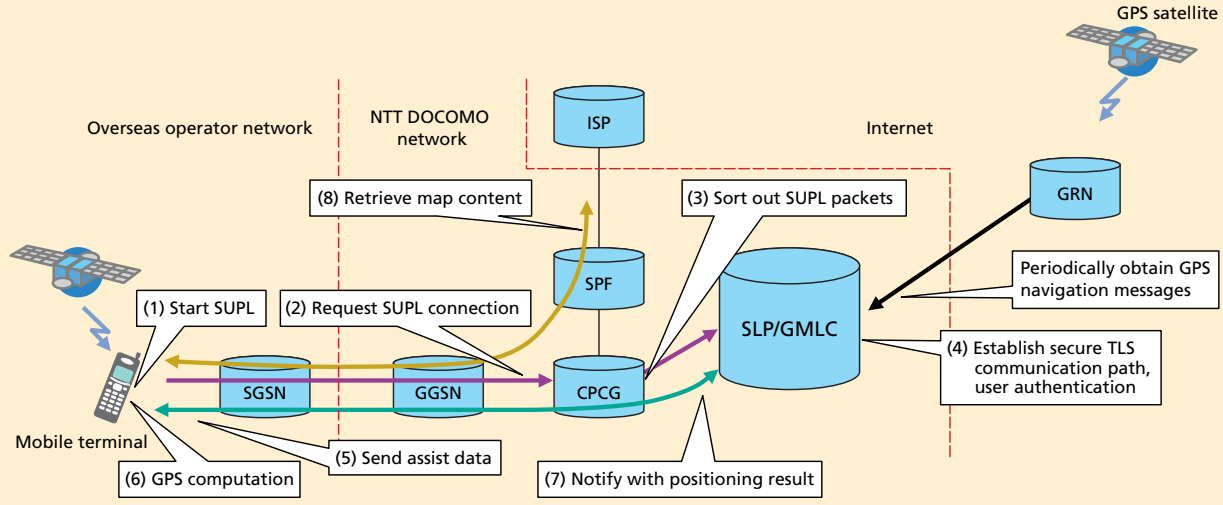

Figure 1 Overview and network architecture of the SUPL current positioning function

*2 **U-Plane**: Transmission path for transferring user data.

*3 **CPCG**: i-mode gateway equipment in the FOMA network.

*4 **TLS**: A protocol which standardizes and extends SSL as an Internet technology guaranteeing security. Compared to SSL, it includes expanded encryption algorithms and error messages.

*5 **GRN**: Provider of GPS satellite navigation data.

and the mobile terminal performs the GPS computation based on this assist data (Fig. 1 (6)). It then sends the data back to the SLP (Fig. 1 (7)). The mobile terminal can then retrieve mapping content from an Internet Services Provider (ISP) (Fig. 1 (8)) and use it to display the current location.

2.2 SUPL Communications Mechanism

The SUPL communications sequence is shown in **Figure 2**. The communications protocol used between the mobile terminal and the SLP conforms to the User-plane Location Protocol (ULP), specified by the OMA.

After performing user authentication between the mobile terminal and SLP, the SLP selects a highly reliable reference location[*6] based on the request for assist data from the mobile terminal. Assist data is derived from the selected reference location and sent to the mobile terminal. The mobile terminal performs the GPS positioning based on the assist data, and if positioning is successful, it notifies the SLP with the result.

3. Derivation of Assist Data

The success rate for GPS positioning by mobile terminals depends on the accuracy of the reference location used by the mobile terminal for GPS computation, but while roaming internationally, the location data available for SUPL positioning from overseas networks is not as accurate as that available in Japan, so it is difficult to obtain highly accurate reference locations. Because of this, we have equipped NTT DOCOMO network equipment with functionality to derive more-accurate reference locations, increasing the accuracy of assist data sent to mobile terminals, and increasing the success rate of GPS positioning. The SLP uses the following method to derive a reference location optimized to the user's conditions, which is sent to the mobile terminal as assist data.

1) Derive Position by Inquiry to the Other Operator's Network (Cell-based Positioning)

With the i-area service provided by NTT DOCOMO, location information can be retrieved from the base station in communication with the terminal (cell-based positioning). The i-area can also be used within the network areas of some overseas operators. Thus, in these areas a reference location can be obtained at the level of the base station where the terminal is currently located.

2) Derive Reference Location Using Successful GPS Positioning

When a GPS positioning using SUPL (latitude and longitude) is successful, the SLP stores it, together with the SUPL positioning request informa-

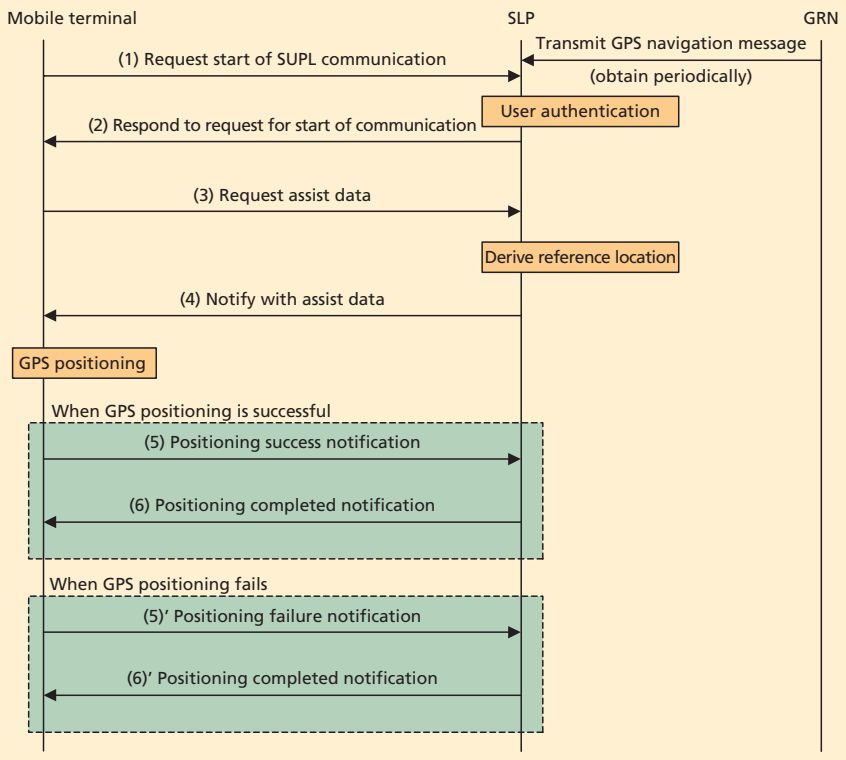

Figure 2 SUPL communications sequence

*6 **Reference Location**: One element of the GPS assist data specified by the 3GPP. It includes elements such as latitude and longitude coordinates and a radius of error that expresses likely distance from the true location. Generally, the more accurate this information is, the better GPS positioning performs.

tion. For later requests matching a stored request and result, the stored reference location can be used as assist data for the mobile terminal.

3) Derive Reference Location Using Data from the Terminal's Local SGSN

The reference location can be derived from location information from the Serving GPRS Support Node (SGSN)[*7] for the area at the user's current location.

If it is possible to estimate the location from the current SGSN, the estimated location may be a more accurate reference location than is possible using location information from the current local operator, as described below.

4) Derive Reference Location Using Information from the Current Local Operator

When requesting SUPL communications, information about the operator where the mobile terminal user is currently roaming is sent to the SLP. A corresponding reference location can be derived from the Mobile Country Code (MCC) and the Mobile Network Code (MNC), which are included in the information about the current local operator.

4. Functions Provided on Mobile Terminals and Their Features

This chapter describes the new SUPL functions and their features that will be provided on summer 2009 mobile terminal models.

4.1 Terminal Operation Regardless of Roaming Status

No particular configuration in required to use the SUPL function while roaming internationally. The location positioning function can be used in the same way as with GPS positioning in Japan.

Also, SUPL communication uses the same Access Point Name (APN)[*8] as is used for i-mode services, so all transitions, from GPS positioning to retrieving map data, can be made without breaking the packet connection, allowing SUPL and i-mode service functions to be used at the same time. While performing GPS positioning using SUPL, communication between the mobile terminal and the SLP is done through a highly secure TLS-encrypted connection, so location information is delivered in a secure manner.

4.2 Efforts to Improve Positioning Functionality in Mobile Terminals

As described in Chapter 3, we are making efforts on the NTT DOCOMO network to improve the accuracy of reference locations used for positioning, but we are also devising ways to improve positioning performance when a reference location of poor accuracy is received by the mobile terminal.

1) Handling Wide-area Reference Locations

We are equipping mobile terminals with schemes that actively estimate the reference location, even when an imprecise, wide-area reference location is received from the network. By improving the accuracy of the reference location used for GPS positioning, GPS positioning performance is improved.

2) Make Use of the Reference Location even when GPS Positioning Fails

When GPS positioning fails, the next operation can be done based on the error radius of the reference location received by the mobile terminal.

Specifically, when GPS positioning fails, if the mobile terminal determines that the reference location is accurate enough, the user can use it as though it was the result of successful positioning. Or, if the mobile terminal determines that the reference location is not accurate enough, it can ask the user to select the current location from a list of cities as described below in 3), and this can be used as a more accurate reference location to re-attempt GPS positioning. For moderately accurate reference locations that do not fit either of these situations, positioning will fail and the application will exit.

3) Selection by User from a List of Cities

If GPS positioning fails and the mobile terminal determines that the reference location is not accurate enough, the user can select the current location from a list of cities, and this can be used as the reference location to re-attempt GPS positioning (**Figure 3**). Specifically, the user selects a city from a list

*7 **SGSN**: A logical node having packet communications functions as specified by the 3GPP.

*8 **APN**: The name of a network connection point used by corporate users and others to connect to the network.

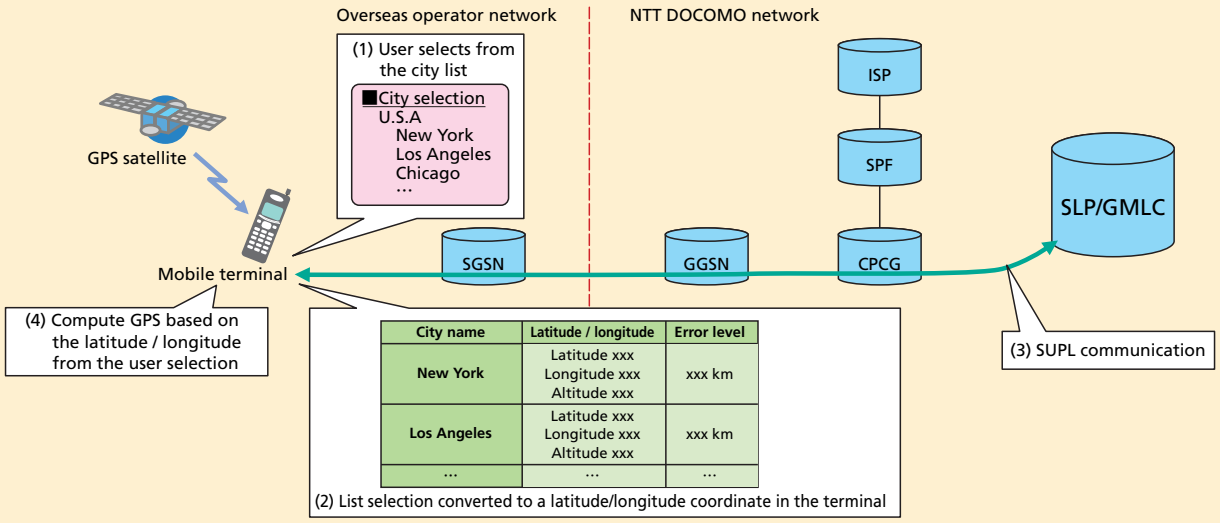

Figure 3 GPS repositioning due to selection on city list

of cities stored on the mobile terminal in advance, and the reference location is derived by converting the city to a set of coordinates. The derived reference location can be used to re-attempt GPS positioning, and can result in higher GPS positioning performance.

5. Conclusion

Through various schemes with both network and mobile terminal functions, we have improved the accuracy of reference locations used for GPS positioning by the SUPL infrastructure for GPS positioning services. This has enabled use of location services such as checking the current location while roaming internationally, providing a more agreeable, mobile user experience similar to that possible within Japan.

We plan to further expand the location data market, and fill-out the range of mobile terminals supporting SUPL and location-based services even while roaming internationally.

References

[1] N. Hagiya et. al: "Structure and Function of the FOMA i-area System," 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, Mar. 2006.

[3] Open Mobile Alliance: "Secure User Plane Location Architecture Approved Version 1.0," Jun. 2007.