Location Information | GLONASS | UE-A

Technology Reports

Advanced Positioning Method for Smartphones — Support of A-GNSS (GPS + GLONASS) and UE-A Positioning —

As the use of smartphone terminals continues to spread, an increasing number of applications are using location information making the acquisition of this type of information increasingly important. However, under conditions in which GPS positioning is generally difficult as in indoor environments or building-intensive districts (urban canyons), a relatively long time is needed to perform positioning measurements, and it is not unusual for positioning to fail and no positioning results at all to be obtained. NTT DOCOMO has implemented A-GNSS positioning and UE-A positioning to improve the success rate of positioning and to enable positioning results to be obtained even if satellite-based positioning should fail.

Core Network Development Department — ***Takashi Suzuki***, ***Tomoharu Aoki***
Communication Device Development Department — ***Makoto Takahashi***
Online Marketplace Department — ***Susumu Ogata***

1. Introduction

Today, Application Programming Interfaces (API)*1 using location information are generally provided on smartphone OSs. The number of applications using location information is consequently on the increase and services that use location information are spreading rapidly. In addition, many smartphone terminals are equipped with a Global Positioning System (GPS) function as standard, and this function enables users to enjoy services that use detailed location information.

At the same time, GPS positioning generally involves calculations using signals from four or more GPS satellites, and it may not be possible to obtain detailed location information in environments that make the receiving of those signals difficult such as indoors or urban canyons. Consequently, a user of location information may eventually be left with no positioning results at all despite the fact that those GPS calculations may have required a relatively long time to be performed. This is hardly a convenient situation for the user, who desires that positioning results be obtained in a more accurate, faster and reliable way.

To resolve the above issues, NTT DOCOMO has developed an advanced positioning method for smartphones. Specifically, we have introduced Assisted-Global Navigation Satellite System (A-GNSS) positioning that enables positioning using GPS satellites and Russian GLONASS satellites as a mechanism for performing detailed positioning in environments where signals from GPS satellites cannot be sufficiently obtained. We have also introduced UE-Assisted (UE-A) positioning as a mechanism for ensuring the acquisition of positioning results even in environments where de-

*1 **API**: Libraries and other functions that can be used from an application, provided in a programming language.

tailed satellite-based positioning results cannot be obtained. Furthermore, as a part of UE-A positioning, we have introduced In-building Mobile Communication System (IMCS)*2 cell positioning as a mechanism for immediately obtaining positioning results in an IMCS environment having indoor base station equipment. This scheme enables positioning even in an environment in which the number of visible satellites needed for positioning is insufficient thereby enhancing the convenience of smartphone positioning.

This article describes an overview of the key functions in this advanced positioning method (A-GNSS positioning and UE-A positioning) for smartphones with the aim of making positioning services more convenient for users.

2. A-GNSS (GPS+GLONASS) Positioning Method

2.1 Overview of A-GNSS Positioning

NTT DOCOMO has so far been providing Assisted-GPS (A-GPS)*3 positioning in its smartphone terminals. The A-GPS method delivers data (hereinafter referred to as "assist data") that the smartphone terminal needs for GPS positioning such as an approximate position (hereinafter referred to as "rough position") of the user obtained from the network and orbital information on GPS satellites. Assist data helps to shorten the time required for GPS positioning and expand the area in which positioning can be performed [1]. This A-GPS method performs positioning using the satellite positioning system operated by the United States, which is made up of approximately 32 satellites (GPS satellites).

In general, a certain number of satellites must be visible to obtain results in A-GPS positioning, but there are environments in which this number cannot be satisfied such as urban canyons having a high concentration of buildings and structures and areas with mountain shadows (**Figure 1**).

There are, however, satellite positioning systems other than the one provided by the United States, such as Japan's Michibiki (quasi-zenith satellite*4), Russia's GLONASS, the European Union (EU) Galileo, and China's Beidou. All of these in combination with GPS provided by the United States can be referred to as a Global Navigation Satellite System (GNSS) in which constituent systems can operate in a mutually complementary manner. In other words, given a situation in which the number of visible satellites needed for positioning in GPS cannot be satisfied, positioning will still be possible if a signal or signals from another satellite system can be obtained for use in positioning calculations. There is also a type of GNSS positioning called A-GNSS positioning that makes use of assist data (GNSS satellite information, rough position, etc.) provided by the network. As in the case of A-GPS positioning, A-GNSS positioning shortens the time required for GNSS positioning and expands the area in which positioning can be performed through the use of assist data passed from the network.

NTT DOCOMO has taken the lead in supporting not just A-GPS positioning but also A-GLONASS positioning (one of the GNSS positioning methods) beginning with its 2013 winter handset models. This means that both GPS and GLONASS satellites can now be used for positioning purposes. The GLONASS system provides approximately 24 satellites, which, when

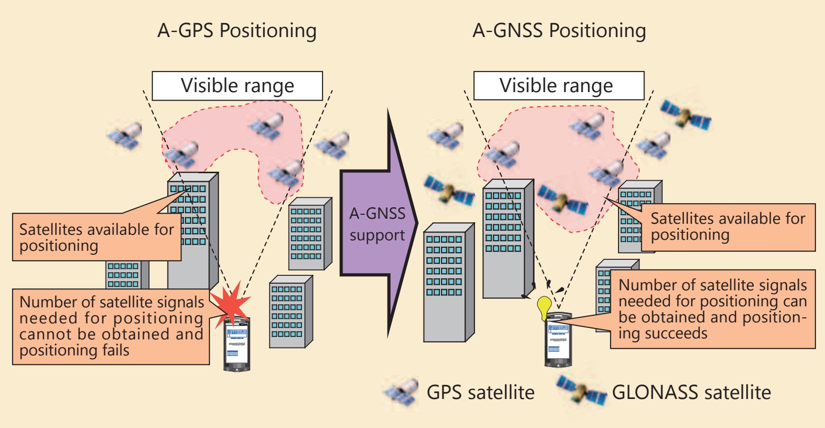

Figure 1 Limits of A-GPS positioning and improvement by A-GNSS positioning

*2 **IMCS**: NTT DOCOMO's system that provides communication environments in places such as high-rise buildings, underground areas and other locations where it is difficult or impossible for mobile terminals to make connections.

*3 **A-GPS**: A positioning system in which GPS satellite global positioning data is distributed as assist data from a network to mobile terminals.

*4 **Quasi-zenith satellite**: A satellite that remains over a specific area for a prolonged period of time by virtue of a satellite orbit that takes on a zenith (overhead) trajectory. This enables satellite signals from an overhead point not affected by buildings or other obstacles to be used thereby improving the positioning success rate in urban canyons.

combined with GPS satellites, means that a total of approximately 56 satellites (approximately 1.7 times the number of GPS satellites alone) can be used for A-GNSS positioning. Thus, if a user is in an urban canyon having a high concentration of buildings or an area with mountain shadows and the number of visible satellites needed for positioning cannot be initially satisfied, using GPS satellites in combination with GLONASS satellites makes it easy to satisfy the minimum number of visible satellites needed for positioning. This approach makes it possible to improve the positioning success rate even for environments in which a sufficient number of visible satellites has traditionally been hard to obtain.

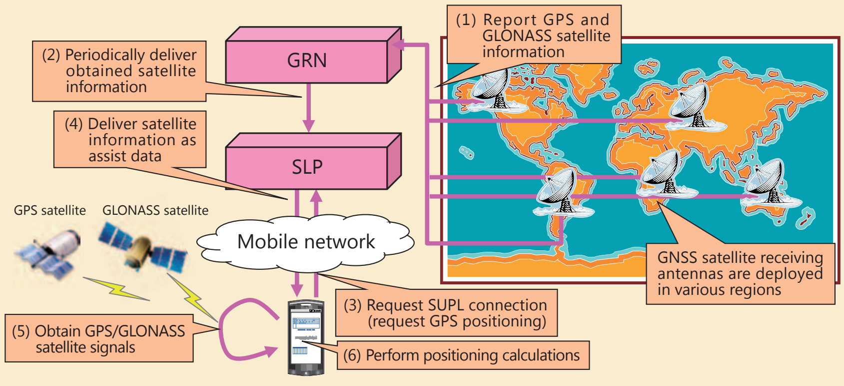

Figure 2 Overview of A-GNSS positioning and network configuration

2.2 Network Connection Method in A-GNSS Positioning

An overview of A-GNSS positioning and the network configuration are shown in **Figure 2**. The assist data needed for positioning can be delivered by either the Control Plane (C-Plane)*5 positioning method or the Secure User Plane (U-Plane)*6 Location (SUPL) method [2]. In the following discussion, we take up A-GNSS positioning by SUPL as an example to explain the network connection method.

To begin with, antennas for receiving signals from GPS and GLONASS satellites are deployed at points throughout the world, and the satellite information obtained by measurements at those points is transmitted to the Global Reference Network (GRN)*7 (Fig. 2 (1)). The GRN is therefore able to collect satellite information from throughout the world. The GRN, in turn, periodically delivers the collected GPS and GLONASS satellite information to the SUPL Location Platform (SLP)*8 (Fig. 2 (2)). In this way, the SLP is also able to obtain satellite information from throughout the world, and on receiving a SUPL positioning request from a smartphone terminal (Fig. 2 (3)), it delivers such satellite information to the terminal (Fig. 2 (4)). Here, the number of items of satellite information that can be forwarded at one time is limited, so the information to be delivered to the terminal is narrowed down to that most applicable to positioning at the terminal's current location. The smartphone terminal now uses the satellite information obtained from SLP to receive signals from the GPS and GLONASS satellites (Fig. 2 (5)) and perform positioning calculations (Fig. 2 (6)). In particular, the terminal performs adaptive processing according to the state of signals received from the available satellites: it can perform composite positioning using both GPS and GLONASS satellites or independent positioning by either GPS or GLONASS. This approach to performing positioning calculations can effectively improve the accuracy of positioning. Furthermore, while positioning calculations are carried out on the smartphone terminal in this case, they can also be performed on the SLP side. Positioning results obtained as described above can now be passed to a mobile terminal application so that the user can enjoy a location information service.

3. UE-A Positioning Method

3.1 Overview of UE-A Positioning Method

As described in section 2.1, A-GNSS positioning is a method that uses assist data for GPS and GLONASS satellites. This method can be further classified into

*5 **C-Plane**: Transmission path for control signals such as establishing and disconnecting communications.
*6 **U-Plane**: A path for the transmission of user data to the C-Plane, which is a control signal transmission.
*7 **GRN**: Provider of GPS satellite navigation data.
*8 **SLP**: The server which performs SUPL communication tasks such as distributing assist data to SET.

UE-Based (UE-B) positioning that performs positioning calculations on the smartphone terminal side and UE-A positioning that performs positioning calculations on the server side. An overview of UE-B positioning and UE-A positioning is given in **Figure 3**.

1) UE-B positioning

In UE-B positioning, assist data obtained at some point in time can generally be reused for a certain amount of time to perform positioning. This is advantageous from a power-saving point of view when performing positioning continuously over a short period of time as in tracking. However, if the number of visible satellites required for positioning cannot be satisfied, a positioning failure will occur in smartphone terminals such as Android™*9 handsets preventing any positioning results from being obtained. Some services, though, demand some kind of location information even if detailed positioning results using GNSS satellites cannot be obtained.

2) UE-A positioning

The UE-A positioning method performs positioning calculations on the server side. This means that the results of rough positioning stored on the server side can be returned to the smartphone terminal even if the number of visible satellites required for positioning cannot be satisfied. A rough position generally has an accuracy of several 10 m to several km since it consists of positioning information in units of base-station areas in which the user can camp. Supporting UE-A positioning in this way makes it possible to return optimal positioning results to the smartphone terminal according to the environment in which user positioning is performed.

This UE-A positioning method is advantageous in that some sort of positioning results can always be obtained but disadvantageous in that the server must be accessed to obtain those results. Using UE-A positioning can greatly increase power consumption if used for an application that involves continuous positioning as in tracking. It is therefore important that either UE-A positioning or UE-B positioning be used depending on the type

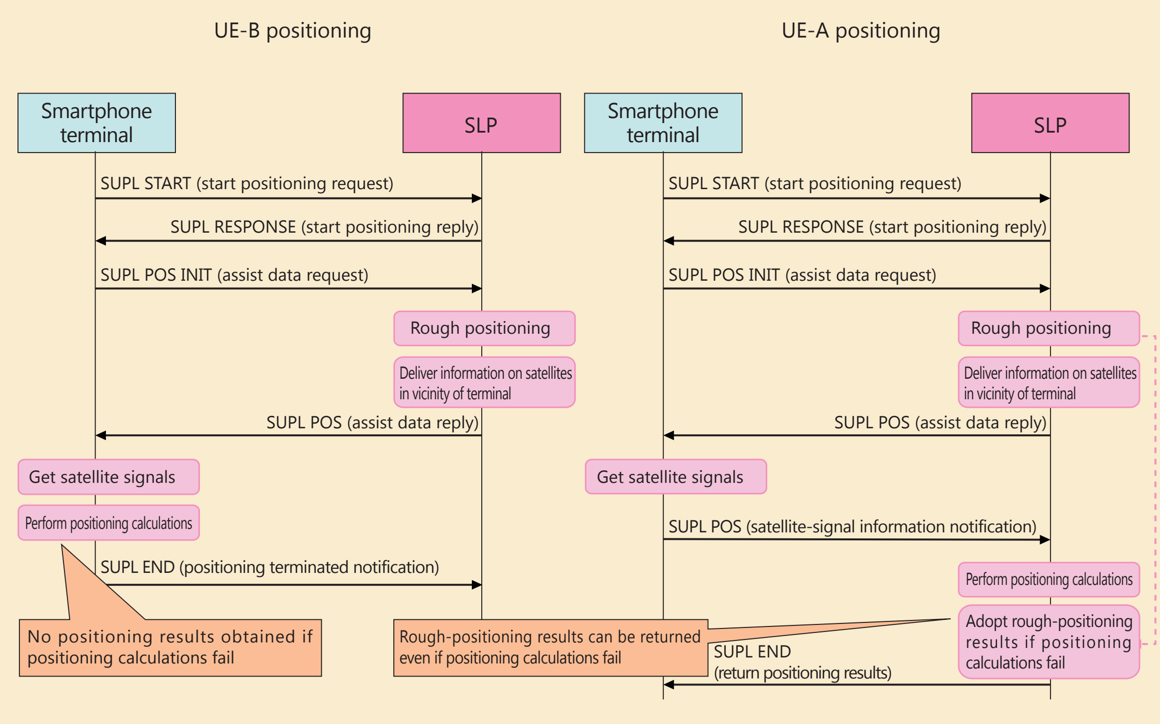

Figure 3 Overview of UE-B positioning and UE-A positioning

*9 **Android ™**: An open source platform targeted mainly at mobile terminals and promoted by Google Inc., in the United States. Android ™ is a trademark or registered trademark of Google Inc. in the United States.

of service being provided.

3.2 Overview of IMCS Cell Positioning Method

Given an environment in which GNSS satellite signals cannot be received as in a building or underground shopping arcade, a smartphone terminal will nevertheless attempt to receive those signals over a certain amount of time since it cannot determine beforehand whether it is currently located in an indoor environment. In such an environment, however, it is almost always the case that the number of visible satellites necessary for positioning cannot be satisfied and that no positioning results can be obtained. In response to this problem, we have introduced IMCS cell positioning as a mechanism for immediately receiving positioning results even for a smartphone terminal in such an indoor environment. An overview of IMCS cell positioning is shown in **Figure 4**.

In UE-A positioning, the server side can search for the smartphone terminal's rough position before the latter gets GNSS satellite signals. This searching process can be performed in a very short period of time. The IMCS cell positioning method can therefore determine whether the smartphone terminal is camped under IMCS from the results of rough-position searching, and if that happens to be the case, the server will return the rough position as positioning results and the smartphone terminal will not attempt to get GNSS satellite signals. This method therefore enables the smartphone terminal to obtain positioning results immediately (in approximately 1 sec) thereby significantly shortening the time needed for positioning.

3.3 Terminal Application Control Method

As described above, NTT DOCOMO provides UE-B positioning and UE-A positioning as two types of positioning methods with different features. As a result, an upper-level application that needs to obtain location information must select the most optimal positioning method according to the application's objective. This, in turn, means that a smartphone terminal must be able to designate which of those two methods to use. For this reason, NTT DOCOMO has implemented positioning-method selection control beginning with its 2013 winter handset models to enable either UE-B positioning or UE-A positioning to be designated depending on the type of positioning API.

The Android OS that has found widespread use in smartphone terminals generally provides two types of positioning APIs: a "single-shot" API for one-time positioning and a "tracking" API for continuous positioning. The single-shot API is mainly used when any kind of positioning results is immediately needed and the tracking API is mainly used to continuously obtain positioning results at short intervals.

Positioning-method selection control is implemented as follows. The smartphone terminal side initiates UE-A positioning when the upper-level application makes a single-shot positioning request. Activating UE-A positioning generates communications with the server side but guarantees that some sort of positioning results will

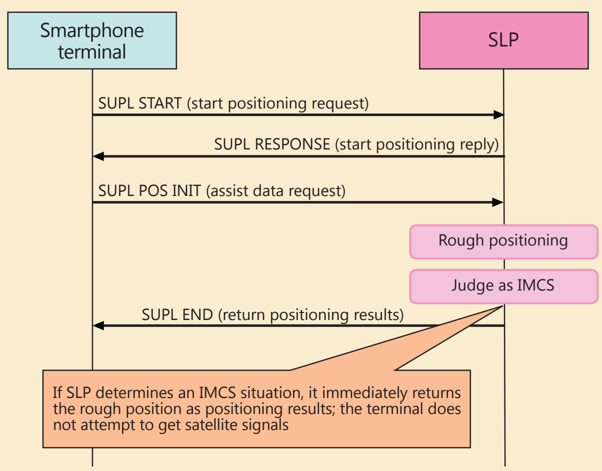

Figure 4 Overview of IMCS cell positioning

be obtained. On the other hand, the smartphone terminal will initiate UE-B positioning when the upper-level application makes a tracking type of positioning request. With UE-B positioning, there will be times when no positioning results can be obtained, but communications with the server will be kept to a minimum.

In the above way, positioning-method selection control enables an upper-level application to select the most optimal positioning method in terms of power consumption or positioning success rate depending on the application's objective.

4. Future Outlook

NTT DOCOMO has achieved an advanced positioning method using Russia's GLONASS satellite system with the aim of supporting A-GNSS positioning. In addition to GLONASS, a variety of new satellite systems are expected to become available for positioning over the next few years such as Japan's Michibiki (quasi-zenith satellite), the EU Galileo, and China's Beidou. Supporting these satellite systems in smartphone terminals as they become available should further improve the positioning success rate.

Additionally, since performing positioning calculations on the server side has already been achieved in UE-A positioning, it should be easy to implement new positioning technologies such as Wi-Fi®*10 positioning on the server side.

Looking forward, we expect the further evolution of A-GNSS and UE-A positioning to make the use of location information even more convenient for users.

5. Conclusion

In this article, we described an overview of the key functions in an advanced positioning method (A-GNSS positioning and UE-A positioning) for smartphones introduced by NTT DOCOMO with the aim of improving the convenience of positioning functions.

This support for A-GNSS positioning and UE-A positioning enables positioning results to be obtained in a more accurate, faster, and reliable manner thereby making location information services more convenient for users.

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[2] Open Mobile Alliance: "Secure User Plane Location Architecture Approved Version 1.0-15," Jun. 2007.

***10 Wi-Fi®**: A registered trademark of the Wi-Fi Alliance.