GPS | Location Based Service | Reduced Positioning Time

Technology Reports

Time Reduction Function for GPS Positioning

In an environment where GPS positioning is not possible, it takes time until GPS positioning halts, which consequently increases user wait time. Processing is now available to predict the possibility of GPS positioning by monitoring acquisition status of GPS satellites during GPS positioning, and thus reduce positioning time and improve usability.

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1. Introduction

NTT DoCoMo introduced a location positioning function in October 2005 using a Global Positioning System (GPS)-enabled FOMA terminal and the FOMA network [1], followed by location notification and location provision functions [2] in March 2006, and the location information notification function [3] for emergency early warning in April 2007. GPS was first introduced as standard in the FOMA 903i series, and the rate of FOMA terminals supporting GPS has steadily increased since then, resulting in increased opportunities for users to use GPS functions through the provision of infrastructure and services for such location information.

GPS used in these services is a positioning system of artificial satellites developed in the early 1970s by the U.S. Department of Defense. Approximately 30 GPS satellites are currently operated, orbiting the earth at an altitude of 20,000 km, with each orbit taking about 12 hours. Terrestrial GPS receivers receive signals from the GPS satellites, measure elapsed time between transmission and reception to compute the distance, and compute the position of the receiver based on the distance and the coordinates of GPS satellites.

With the FOMA location based service, the highly accurate GPS is used for the normal measurement of position. However, when signals from GPS satellites cannot be received (e.g., inside the buildings or in subways), cell location information (network positioning results) for the FOMA terminal acquired from the FOMA network is used as the positioning result [1]. Thus, the usability deteriorates in locations where GPS positioning is not possible, requiring additional time to use the network positioning result, and a fixed positioning time.

GPS Measurement Continuation Decision Logic (MCDL) reduces positioning time in locations where GPS positioning is not possible in order to improve usabilty.

2. Overview of MCDL Function

MCDL predicts whether GPS positioning is possible within a fixed positioning time (positioning timeout time). If positioning is deemed impossible, GPS positioning halts immediately. **Figure 1** shows the area where MCDL is effective in reducing positioning time. The vertical axis represents positioning time; the horizontal axis represents positioning location. GPS positioning becomes more difficult as the positioning location moves to the right. As the positioning location moves from open sky (e.g., a location not blocked by buildings) to get close to an indoor window, the positioning time gradually increases, though GPS positioning is

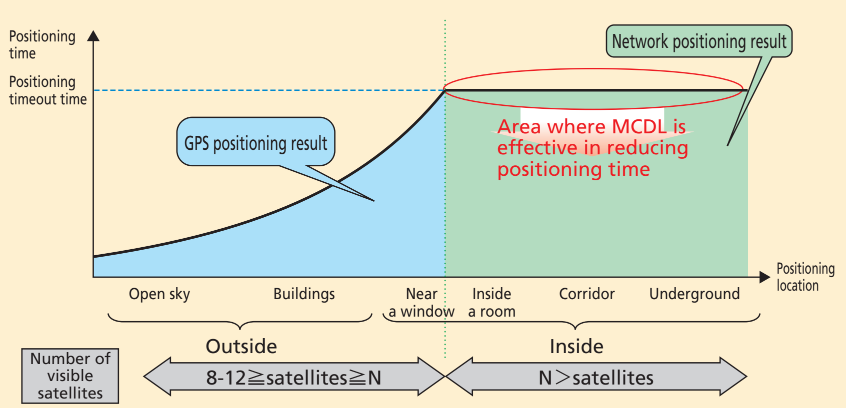

Figure 1 Relation between positioning location and positioning time without MCDL

still possible. As the positioning location moves underground from inside a room, GPS positioning becomes impossible within the positioning timeout time. MCDL reduces positioning time when GPS positioning is not possible. The measurement result is obtained with GPS positioning in locations where GPS positioning is possible, and from the network positioning result in locations where GPS positioning is not possible.

The possibility of GPS positioning is determined based on the number of GPS satellites acquired (e.g., number of visible satellites). As described in Chapter 1, GPS positioning requires the reception and measurement of signals from GPS satellites orbiting the earth, with at least N GPS satellites being used. GPS positioning is not possible unless N or more satellites can be acquired, since the minimum number of satellites necessary for GPS positioning (hereinafter referred to as "N" for the purposes of this article) varies with the positioning environment and status. MCDL predicts whether the number of visible satellites will reach N. GPS positioning halts when the number is predicted to be less than N. The boundary area (between possible and impossible positioning) for N varies depending on a building's structure, the time of the day (alignment of GPS satellites), weather conditions, the GPS receiver used, GPS antenna performance, and positioning timeout value.

Note that since MCDL does not cover the area where GPS positioning is possible, the accuracy of positioning remains unchanged from the conventional value.

3. Overview of MCDL Prediction Logic

The principles of MCDL logic and the prediction flowchart are described below.

3.1 Prediction from Time Transition

The number of visible satellites at positioning timeout time is predicted from the relation between the number of visible satellites and the positioning passage time. For example, if the number of visible satellites at a point halfway through positioning is 0, GPS positioning is predicted as being impossible since the number of visible satellites is predicted as being less than N, even at positioning timeout time.

Figure 2 shows the positioning time in given environments, and transition in the number of visible satellites (average of multiple acquisitions). In environment A, the number of visible satellites increases with positioning time, reaches N at approximately t sec-

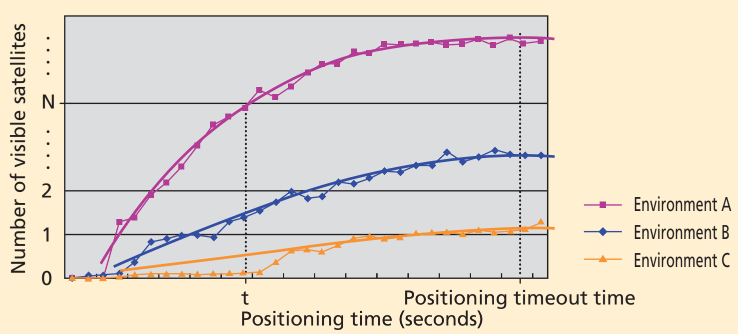

Figure 2 Trends in number of visible satellites

onds, and GPS positioning succeeds. In contrast, the number of visible satellites increases with positioning time in environments B and C, with N not being reached within the positioning timeout time. Thus, predicting the number of visible satellites at positioning timeout time is possible given the transition in the number of visible satellites for the positioning passage time.

3.2 Prediction from Stability Degree

The number of visible satellites at the positioning timeout time can be predicted from the stability degree of GPS satellite acquisition status. In particular, the ID of visible satellites, the signal level of invisible satellites, changes in the alignment of satellites, and whether time synchronization is used are taken into account, with these amount of changes used in predicting the stability degree for current measurement. When the number of visible satellites is less than N and the stability degree is high, the possibility of any further improvement in measurement status is considered low, and thus GPS positioning is predicted as being impossible.

3.3 MCDL Prediction Flowchart

Figure 3 shows the MCDL prediction flowchart. First, GPS satellite acquisition information is acquired from the GPS positioning unit, with the number of visible satellites being predicted. The result is used for "prediction based on time transition" and "prediction based on stability degree," and the system then halts positioning if GPS positioning is predicted as being impossible. Otherwise, positioning continues and GPS location information is reacquired from the GPS positioning unit as described in Chapter 5. The processing flow is repeated until a prediction is made to halt positioning or until a positioning timeout.

4. MCDL Performance

4.1 MCDL Performance Evaluation Indices

The following three MCDL performance indices are used.

- Time reduction ratio

  The ratio of time to reach a prediction of GPS positioning being impossible (number of visible satellites less than N) to the positioning timeout time (ratio of time reduction).

- Halt prediction ratio

  The ratio of predictions of GPS positioning being impossible.

- Prediction error ratio

  The ratio of possible cases of GPS positioning (number of visible satellites of N or greater) mistakenly predicted as halted positioning. A high value affects the GPS positioning success rate.

4.2 Verification

Verification was based on 200,000 samples of data collected at approximately 100 indoor locations.

Figure 4 shows the relation between positioning location and positioning time following the introduction of MCDL. The time reduction ratio increases as locations where GPS positioning is difficult are approached, and provides a maximum reduction of approximately 60%, and an average reduction of approximately 30%. There

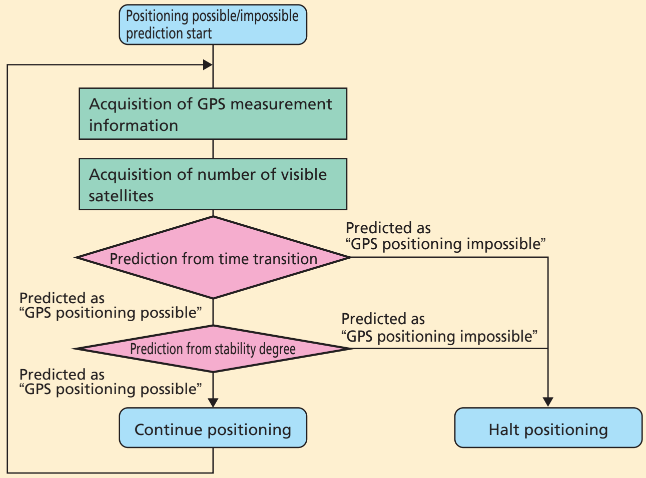

Figure 3 Flow of MCDL prediction

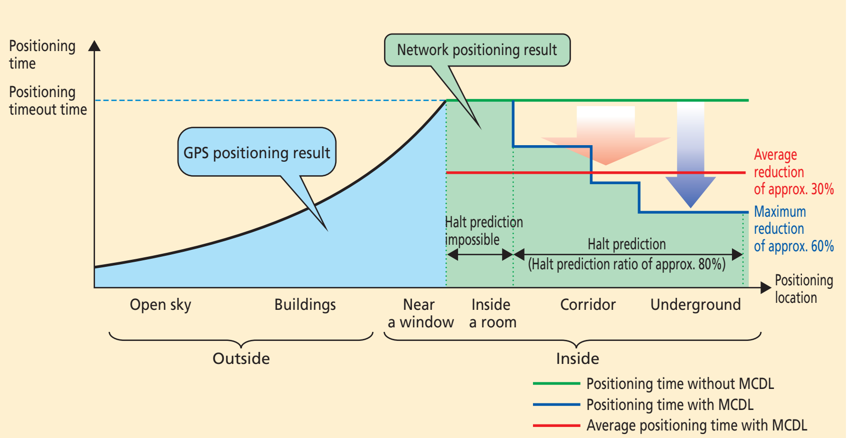

Figure 4 Relation between positioning location and positioning time with MCDL

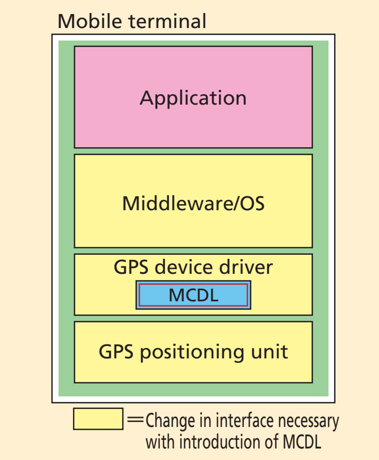

Figure 5 GPS function block

was a similar tendency in the halt prediction ratio, providing a maximum reduction of 99%, and an average reduction of approximately 80% in locations where GPS positioning is difficult.

The prediction error ratio remained constant at less than 0.5%, regardless of the environment.

5. GPS Function Block and Sequence

Figure 5 shows the mobile terminal GPS function block at MCDL introduction. MCDL is installed in the GPS device driver. The yellow section indicates the part of software requiring update with the introduction of MCDL.

Figure 6 shows the basic sequence of operation between the middleware/OS and the GPS positioning unit. After the start of GPS positioning, MCDL periodically predicts the GPS information output from the GPS positioning unit (Fig. 3), and reports the prediction result ("continue positioning" or "halt positioning") to the GPS device driver. When "halt positioning" is output, the GPS device driver notifies the middleware/OS of said condition, and terminates the MCDL and GPS positioning unit. In this case, the middleware/OS reports positioning halted to the application, and when positioning starts, the application is notified of the network positioning result received from the network. The application then verifies the current location by using maps, navigation, etc., issues notification of the current position, and pro-

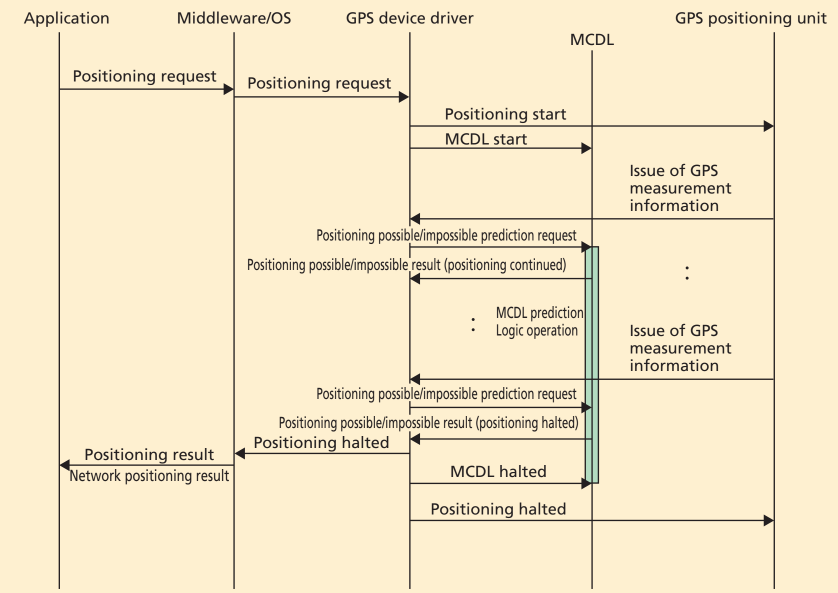

Figure 6 Basic sequence

vides the position [1]–[3] .

6. Conclusion

This article described an overview of MCDL. The introduction of MCDL has effectively reduced the positioning time at locations where GPS positioning is not possible, and improved the usability without having any negative effects on existing GPS performance, such as positioning accuracy and positioning success rate.

References

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