

DESCRIPTION

TITLE OF INVENTION: DEVICE WITH POSITIONING FUNCTION,
POSITIONING RESULT RECEIVING DEVICE, AND POSITIONING RESULT
UTILIZING SYSTEM

5

CROSS REFERENCE TO RELATED APPLICATION

[0001]

This application is based on Japanese Patent Application No.
2014-021628 filed on February 6, 2014, the disclosure of which is
10 incorporated herein by reference.

TECHNICAL FIELD

[0002]

The present disclosure relates to a device with a positioning function
15 which measures a position of the device on the basis of signals received from
an artificial satellite used in a satellite positioning system. The present
disclosure also relates to a positioning result receiving device which receives
information about a position measured by the device with a positioning
function. The present disclosure further relates to a positioning result
20 utilizing system which includes the device with a positioning function and the
positioning result receiving device.

BACKGROUND ART

[0003]

25 There is conventionally known a technique that measures a position of
a host device by permitting a receiver to receive signals from an artificial
satellite used in a satellite positioning system.

[0004]

In recent years, however, for example, a repeater adapted to
30 reproduce signals from an artificial satellite and a simulator capable of
generating artificial satellite signals in a pseudo manner have been developed.
This causes a problem in which a malicious person falsifies position
information or performs position information spoofing.

[0005]

Meanwhile, a technique disclosed in Patent Literature 1 authenticates whether a signal received by a host device is a legitimate signal from an artificial satellite used in a satellite positioning system. The technique
5 disclosed in Patent Literature 1 permits a receiver to access a database in an authentication center by using a satellite number and satellite time included in the signal received by the host device from the artificial satellite, and acquires data to be used to authenticate the artificial satellite. The receiver then uses
10 the data acquired from the authentication center to authenticate whether the signal received by the host device is a legitimate signal from the artificial satellite used in the satellite positioning system.

[0006]

When the technique disclosed in Patent Literature 1 is used, in each positioning operation, the receiver needs to authenticate whether individual
15 signals from multiple artificial satellites used for positioning are legitimate signals. Therefore, when authentication needs to be performed to the signals from all of the artificial satellites used for positioning, a significant amount of waiting time is required before the completion of authentication. This is because, for example, it is time-consuming for accessing the
20 authentication center to acquire data.

[0007]

Suppose that positioning result received by the receiver is to be used by an application or system that needs position information. For example, the positioning result is required to be highly reliable in a system that bills
25 parking fee depending on position information. Thus, the system needs to wait until the above-described authentication is entirely completed. Meanwhile, an application such as a game that uses position information does not require the positioning results to be highly reliable. Thus, in a game application, a significant amount of time is wasted when the positioning result
30 received by the receiver is outputted after entire completion of the above-described authentication.

PRIOR ART LITERATURE

PATENT LITERATURE

[0008]

Patent Literature 1: JP 2013-130395 A

5 SUMMARY OF INVENTION

[0009]

The present disclosure has been made in view of the above circumstances. An object of the present disclosure is to provide a device with a positioning function, a positioning result receiving device, and a
10 positioning result utilizing system each of which enables flexible utilization of positioning result by a system or an application corresponding to a positioning result reliability required by the application or the system. Herein, the system or the application operates based on the positioning result derived from signals transmitted from artificial satellites of a satellite positioning
15 system.

[0010]

According to a first aspect of the present disclosure, a device with a positioning function includes a satellite receiver, a positioning section, an authentication information acquisition section, an authentication section, an
20 authentication level calculation section, and a positioning result transmission processing section. The satellite receiver receives signals from artificial satellites used in a satellite positioning system. The positioning section measures a position of a host device based on the signals received by the satellite receiver from the artificial satellites. The authentication information
25 acquisition section acquires authentication information from an authentication center disposed outside of the host device, and the authentication information is used to authenticate whether the signals from the artificial satellites are legitimate signals. The authentication section authenticates, based on the authentication information, whether the signals received by the satellite
30 receiver are the legitimate signals from the artificial satellites. The authentication level calculation section calculates an authentication level based on at least one of a quantity of artificial satellites authenticated by the authentication section or a ratio of the artificial satellites authenticated by the

authentication section to the artificial satellites used for positioning the host device by the positioning section. The positioning result transmission processing section successively transmits a positioning result measured by the positioning section to a different device other than the host device, and the
5 positioning result transmission processing section attaches the authentication level calculated by the authentication level calculation section to the positioning result before transmitting the positioning result.

[0011]

The above-described device with a positioning function enables a
10 positioning result receiving device (hereinafter referred to as the receiving-end device) to acquire the authentication level. The authentication level is obtained based on the number of artificial satellites successfully authenticated by the authentication information acquired from the authentication center to the artificial satellites that are used for positioning by
15 the positioning unit, or the authentication level is obtained based on a ratio of artificial satellites successfully authenticated by the authentication information acquired from the authentication center to artificial satellites that are used for positioning by the positioning unit. It takes a considerable amount of time to complete authentication by using the authentication information acquired
20 from the authentication center. Therefore, there may frequently arise a situation where only some of the artificial satellites used for positioning by the positioning unit are authenticated by using the authentication information. Even when only some of the artificial satellites used for positioning are authenticated as mentioned above, the receiving-end device is capable of
25 determining the degree of reliability of the positioning result by the authentication level. Thus, whether or not to execute an application or system that uses the positioning result can be determined based on the authentication level. For example, when the authentication level is low, an application or system which requires low positioning result reliability may be
30 determined to be executable.

[0012]

Consequently, the positioning result can be flexibly utilized based on the positioning result reliability required for an application or system that uses

the positioning result derived from signals transmitted from multiple artificial satellites used in a satellite positioning system.

[0013]

According to a second aspect of the present disclosure, a positioning
5 result receiving device includes a positioning result reception processing
section, an execution section, and a utilization determination section. The
positioning result reception processing section receives a positioning result
transmitted from a device with a positioning function. The device with a
positioning function authenticates whether signals received by a satellite
10 receiver are legitimate signals that are transmitted from artificial satellites
used in a satellite positioning system. The positioning result received by the
positioning result reception processing section is attached with an
authentication level calculated based on at least one of a quantity of artificial
satellites that are authenticated or a ratio of the artificial satellites that are
15 authenticated to artificial satellites used in measuring of the position result by
the device with a positioning function. The execution section executes a
positioning result utilization process, which is a process which utilizes the
positioning result received by the positioning result reception processing
section. The utilization determination section determines, based on the
20 authentication level attached to positioning result received by the positioning
result reception processing section, whether to utilize the positioning result in
the positioning result utilization process.

[0014]

With the above-described positioning result receiving device, when
25 only some of artificial satellites used for positioning by the device with a
positioning function are authenticated, the positioning result receiving device
is capable of determining the degree of reliability of positioning result based
on the authentication level. This enables the utilization determination unit to
determine, based on the authentication level, whether or not to execute an
30 application or system that uses the positioning result. For example, when
the authentication level is low, an application or system which requires low
positioning result reliability may be determined to be executable.

[0015]

Consequently, the positioning result can be flexibly utilized based on the positioning result reliability required for an application or system that uses the positioning result derived from signals transmitted from multiple artificial satellites used in a satellite positioning system.

5 [0016]

According to a third aspect of the present disclosure, a positioning result utilizing system includes a device with a positioning function according to the first aspect of the present disclosure and a positioning result receiving device according to the second aspect of the present disclosure.

10 [0017]

With the above-described positioning result utilizing system, the positioning result can be flexibly utilized based on the positioning result reliability required for an application or system that uses the positioning result derived from signals transmitted from multiple artificial satellites used in a
15 satellite positioning system.

[0018]

According to a fourth aspect of the present disclosure, a device with a positioning function includes a satellite receiver, a positioning section, an authentication information acquisition section, an authentication section, an
20 authentication level calculation section, an execution section, and a utilization determination section. The satellite receiver receives signals from artificial satellites used for a satellite positioning system. The positioning section measures a position of a host device based on the signals received by the satellite receiver from the artificial satellites. The authentication information
25 acquisition section acquires authentication information from an authentication center disposed outside of the host device. The authentication information is used to authenticate whether the signals from the artificial satellites are legitimate signals. The authentication section authenticates, based on the authentication information, whether the signals received by the satellite
30 receiver are legitimate signals from the artificial satellites. The authentication level calculation section calculates an authentication level based on at least one of a quantity of artificial satellites authenticated by the authentication section or a ratio of the artificial satellites authenticated by the

authentication section to the artificial satellites used for positioning the host device by the positioning section. The execution section executes a positioning result utilization process, which is a process which utilizes a positioning result measured by the positioning section. The utilization
5 determination section determines, based on the authentication level calculated by the authentication level calculation section, whether to utilize the positioning result measured by the positioning section in the positioning result utilization process.

[0019]

10 The above-described device with a positioning function enables a positioning result receiving device (hereinafter referred to as the receiving-end device) to acquire the authentication level. The authentication level is obtained based on the number of artificial satellites successfully authenticated by the authentication information acquired from the
15 authentication center to the artificial satellites that are used for positioning by the positioning unit, or the authentication level is obtained based on a ratio of artificial satellites successfully authenticated by the authentication information acquired from the authentication center to artificial satellites that are used for positioning by the positioning unit. It takes a considerable amount of time to
20 complete authentication by using the authentication information acquired from the authentication center. Therefore, there may frequently arise a situation where only some of the artificial satellites used for positioning by the positioning unit are authenticated by using the authentication information. Even when only some of the artificial satellites used for positioning are
25 authenticated as mentioned above, the receiving-end device is capable of determining the degree of reliability of the positioning result by the authentication level. Thus, whether or not to execute an application or system that uses the positioning result can be determined based on the authentication level. For example, when the authentication level is low, an
30 application or system which requires low positioning result reliability may be determined to be executable.

[0020]

Consequently, the positioning result can be flexibly utilized based on

the positioning result reliability required for an application or system that uses the positioning result derived from signals transmitted from multiple artificial satellites used in a satellite positioning system.

5 BRIEF DESCRIPTION OF DRAWINGS

[0021]

The above and other objects, features, and advantages of the present disclosure will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

10 FIG. 1 is a diagram illustrating an exemplary outline configuration of a positioning result utilizing system according to a first embodiment of the present disclosure;

FIG. 2 is a block diagram illustrating an exemplary outline configuration of an authentication center;

15 FIG. 3 is a block diagram illustrating an exemplary outline configuration of an in-vehicle apparatus according to the first embodiment;

FIG. 4 is a flowchart illustrating an example of an authentication related process in the in-vehicle apparatus according to the first embodiment;

20 FIG. 5 is a flowchart illustrating an example of a position information transmission related process in the in-vehicle apparatus according to the first embodiment;

FIG. 6 is a flowchart illustrating an example of a position information utilization related process in a roadside apparatus according to the first embodiment;

25 FIG. 7 is a flowchart illustrating an example of a road billing related process in the roadside apparatus according to a second modification of the present disclosure;

FIG. 8A is a schematic diagram illustrating continuous position information;

30 FIG. 8B is a schematic diagram illustrating discontinuous position information;

FIG. 9 is a flowchart illustrating an example of a parking billing related process in the roadside apparatus according to a third modification of the

present disclosure;

FIG. 10 is a diagram illustrating an exemplary outline configuration of a positioning result utilizing system according to a second embodiment of the present disclosure;

5 FIG. 11 is a block diagram illustrating an exemplary outline configuration of a position information utilization device;

FIG. 12 is a diagram illustrating an exemplary outline configuration of a positioning result utilizing system according to a third embodiment of the present disclosure;

10 FIG. 13 is a block diagram illustrating an exemplary outline configuration of a mobile terminal;

FIG. 14 is a flowchart illustrating an example of a position information utilization related process in the mobile terminal according to the third embodiment;

15 FIG. 15 is a flowchart illustrating an example of a road billing related process in the mobile terminal according to the second modification; and

FIG. 16 is a flowchart illustrating an example of a road billing related process in the mobile terminal according to the third modification of the present disclosure.

20

EMBODIMENTS FOR CARRYING OUT INVENTION

[0022]

Embodiments of the present disclosure will now be described with reference to the accompanying drawings.

25 [0023]

(First Embodiment)

As illustrated in FIG. 1, a positioning result utilizing system 1 according to a first embodiment includes a monitoring station 110, an authentication center 120, a master control station 130, an in-vehicle apparatus 200, and a roadside apparatus 300. The in-vehicle apparatus 200 corresponds to a device with a positioning function. The roadside apparatus 300 corresponds to a positioning result receiving device.

30

[0024]

The monitoring station 110 receives GPS radio waves transmitted from GPS satellites 2a-2c included in a GPS, which is a satellite positioning system. The GPS satellites 2a-2c correspond to artificial satellites. When there is no need to distinguish the GPS satellites 2a-2c from one another, the GPS
5 satellites are referred to as the GPS satellites 2 hereinafter. As is well known, each of the GPS radio waves includes a navigation message (NAVI MSG). The monitoring station 110 demodulates a received GPS radio wave, extracts a navigation message, and transmits the extracted navigation message to the authentication center 120. The navigation message corresponds to a signal
10 from an artificial satellite. When GPS radio waves are received from multiple GPS satellites 2, for each of the received GPS radio waves, the navigation message is extracted from the GPS radio wave and is transmitted to the authentication center 120.

[0025]

15 The authentication center 120 generates parity data based on the navigation message and an H matrix. The H matrix is an encryption key. The authentication center 120 then transmits a signal including the parity data to the master control station 130. Further, the authentication center 120 communicates with the in-vehicle apparatus 200. The authentication center
20 120 will be described in detail later with reference to FIG. 2.

[0026]

The master control station 130 transmits the parity data, which is received from the authentication center 120, to a quasi-zenith satellite (hereinafter referred to as the QZS) 3. The QZS 3 broadcasts a navigation
25 message including the parity data toward the ground.

[0027]

The in-vehicle apparatus 200 is a navigation message authentication type in-vehicle apparatus for a vehicle or a movable body. The in-vehicle apparatus 200 communicates with the authentication center 120 and
30 authenticates whether the navigation message received from a GPS satellite 2 is legitimate. Authentication is successively performed to all of the GPS satellites 2 that are used for positioning. However, performing authentication for each GPS satellite 2 takes a certain amount of time.

Therefore, before a completion of authentication to all of the GPS satellites 2 used for positioning, some of the GPS satellites 2 are in authenticated states. Satellite authentication will be described in detail later with reference to FIG. 4.

5 [0028]

Further, the in-vehicle apparatus 200 measures its current position by using navigation messages received from multiple GPS satellites 2. For the measurement of the current position, it is necessary to use the navigation messages received from at least three GPS satellites 2.

10 [0029]

Furthermore, the in-vehicle apparatus 200 calculates the ratio of the number of GPS satellites 2 whose navigation messages are authenticated to the number of GPS satellites 2 which are used for positioning a host device to which the positioning function is provided. The ratio of the number of GPS satellites 2 whose navigation messages are authenticated to the number of GPS satellites 2 which are used for positioning is hereinafter referred to as an authentication level (AUTH LV). If, for instance, one GPS satellite 2 is authenticated in a situation where three GPS satellites 2 are used for positioning, the authentication level is $1/3$ (that is, 33.3%). The calculated authentication level is then attached to position information (POSI INFO) indicative of the measured current position, and the position information together with the authentication level is wirelessly transmitted toward outside. The in-vehicle apparatus 200 will be described in detail with reference to FIG. 3.

25 [0030]

The roadside apparatus 300 is a terminal of a system that uses the position information transmitted from the in-vehicle apparatus 200 to perform a process of providing a predetermined service. A typical process of providing a service is, for example, a billing process that is performed to automatically bill a user of a vehicle when the vehicle is parked in a pay parking lot or the vehicle travels on a toll road.

30 [0031]

Further, based on the authentication level attached to the position

information transmitted from the in-vehicle apparatus 300, the roadside apparatus 300 determines whether or not to use the position information in a position information utilization process. Based on the determination result, the roadside apparatus 300 uses or does not use the position information.

5 [0032]

As illustrated in FIG. 2, the authentication center 120 includes a control unit 122, a data storage unit 124, and a communication unit 126.

[0033]

The control unit 122 is provided by a computer that includes a central
10 processing unit (CPU), a read-only memory (ROM), and a random-access memory (RAM). The control unit 122 controls the data storage unit 124 and the communication unit 126. Further, the control unit 122 functions as an RAND message generation section 1221, a SEED value generation section 1222, an H-matrix calculation section 1223, a parity calculation section 1224,
15 and a signal processing section 1225 by permitting the CPU to use a temporary storage function of the RAM and execute programs stored in the ROM. The functions of these sections 1221-1225 may be configured to similar to a configuration disclosed in Patent Literature 1.

[0034]

20 The RAND message generation section 1221 generates an RAND message (RAND MSG) from the navigation message acquired from the monitoring station 110. RAND is an acronym for Reference Authentication Navigation Data. The RAND message includes TOW (time of week), TOC (time of clock), clock correction coefficient AF0, and clock correction
25 coefficient AF1 in sequential order. The TOW, TOC, clock correction coefficient AF0, and clock correction coefficient AF1 are extracted from a navigation message bit string, and are used to identify the time of signal generation. Further, the RAND message includes an AS flag (anti-spoof flag) and a PRN (pseudo-random noise) ID, which is a satellite number, and AS flag
30 and PRN ID are added to an end of the RAND message. It can be said that RAND having a TOW and PRN ID indicates when a transmission is made from which GPS satellite. Further, as the TOW changes at 6 second intervals and the RAND message includes the PRN ID, the RAND is generated for each GPS

satellite 2 whose signal is received by the monitoring station 110 and at 6 second intervals.

[0035]

5 The SEED value generation section 1222 generates a SEED value by generating a random number based on an input of a PC clock.

[0036]

10 The H-matrix calculation section 1223 uses the SEED value generated by the SEED value generation section 1222 to calculate an H-matrix that corresponds to the SEED value on a one-to-one basis. A well-known hash function may be used as the H-matrix. For example, a parity check matrix for LDPC (low density parity check) encoding may be used as the H-matrix. Further, a matrix determined based on the parity check matrix may be used as the H-matrix.

[0037]

15 The parity calculation section 1224 calculates parity data on the basis of the RAND message generated by the RAND message generation section 1221 and the H-matrix calculated by the H-matrix calculation section 1223. More specifically, the parity data is calculated by multiplying the RAND message by the H-matrix.

20 [0038]

The signal processing section 1225 inserts the parity data, which is calculated by the parity calculation section 1224, and the RAND message, which is used to calculate the parity data, into the navigation message that is to be transmitted from the QZS 3. The signal processing section 1225 then
25 transmits the processed navigation message to the master control station 130.

[0039]

Further, at the time of the above signal insertion, the signal processing section 1225 associates the parity data calculated by the parity calculation
30 section 1224, the RAND message used to calculate the parity data, the H-matrix, and the SEED value used to calculate the H-matrix with one another, and stores the associated data in the data storage unit 124.

[0040]

Each time the RAND message is generated by the RAND message generation section 1221, the signal processing section 1225 inserts the RAND message and parity data into the navigation message that is to be transmitted from the QZS 3. Therefore, each of the RAND message generation section
5 1221, the SEED value generation section 1222, the H-matrix calculation unit 1223, and the parity calculation section 1224 performs a process in response to each generation of the RAND message by the RAND message generation section 1221.

[0041]

10 When the communication unit 126 receives the PRN ID, TOW, and public key transmitted from the in-vehicle apparatus 200, an H-matrix selection section 1226 checks H-matrices stored in the data storage unit 124 and selects an H-matrix associated with the received PRN ID and TOW. The H-matrix selection section 1226 then encrypts the selected H-matrix by using
15 the public key and returns the encrypted H-matrix to the in-vehicle apparatus 200.

[0042]

As illustrated in FIG. 3, the in-vehicle apparatus 200 includes a communication unit 210, a control unit 220, and a satellite receiver 230. The
20 navigation message broadcast from the QZS 3 is received by a reception unit 211 included in the communication unit 210 of the in-vehicle apparatus 200.

[0043]

The communication unit 210 includes the reception unit 211 and a transmission unit 212. The communication unit 210 has a narrow-area
25 communication function and a wide-area communication function. The narrow-area communication function has a communication range of, for example, several hundred meters. The wide-area communication function has a communication range of, for example, several kilometers. The wide-area communication function makes it possible to establish
30 communication with a base station of a public communication network in order to communicate with a remote communication instrument within the communication range of the public communication network. The narrow-area communication function is exercised to communicate with a

communication unit 310 of the roadside apparatus 300. The wide-area communication function is exercised to communicate with the communication unit 126 in the authentication center 120.

[0044]

5 The satellite receiver 230 receives, at predetermined time intervals, radio waves transmitted from the GPS satellites 2 and the QZS 3.

[0045]

10 The control unit 220 is provided by a computer that includes a CPU, a ROM, and a RAM, and controls the communication unit 210 and the satellite receiver 230. Further, the control unit 220 performs an authentication related process illustrated in FIG. 4 and a position information transmission related process illustrated in FIG. 5 by permitting the CPU to use a temporary storage function of the RAM and execute programs stored in the ROM.

[0046]

15 The following will describe the authentication related process with reference to the flowchart of FIG. 4. The authentication related process is performed by the control unit 220 of the in-vehicle apparatus 200 in order to authenticate whether a signal received by the satellite receiver 230 is a legitimate navigation message from a GPS satellite 2. For example, the
20 process illustrated in the flowchart of FIG. 4 may be performed each time the satellite receiver 230 receives GPS radio waves from three or more GPS satellites 2.

[0047]

25 Here, it is assumed that a signal from a repeater, which reproduces a signal from a GPS satellite 2, or a signal from a simulator, which is capable of generating a signal from a GPS satellite 2 in a pseudo manner, may be inadvertently received by the satellite receiver 230 as a navigation message included in a GPS radio wave.

[0048]

30 First of all, in step S1, the current position of a host device is measured based on the navigation messages included in the GPS radio waves received from three or more GPS satellites 2. S1 corresponds to a positioning section.

[0049]

In step S2, the navigation message received from the QZS 3 is acquired from the reception unit 211.

[0050]

5 In step S3, the PRN ID and TOW are extracted from the navigation message acquired in step S1.

[0051]

In step S4, the PRN ID and TOW, which were extracted in step S3, and the public key are transmitted from the transmission unit 212 to the authentication center 120. As mentioned earlier, the authentication center 120 encrypts the H-matrix, which is defined by the PRN ID and TOW, by using the public key, and then transmits the encrypted H-matrix to the in-vehicle apparatus 200.

[0052]

15 In step S5, the H-matrix transmitted from the authentication center 120 is acquired from the reception unit 211. S5 corresponds to an authentication information acquisition section. In step S6, the encrypted H-matrix acquired in step S5 is decrypted by using a secret key.

[0053]

20 In step S7, among the GPS radio waves received from the GPS satellites 2, a navigation message including a PRN ID identical to the PRN ID transmitted in step S4 is selected, and a RAND message is generated based on the selected navigation message.

[0054]

25 In step S8, comparative parity data is generated from the RAND message generated in step S7 and the H-matrix decrypted in step S6.

[0055]

In step S9, a check is performed to determine whether the comparative parity data generated in step S8 is identical with the parity data extracted in step S3.

[0056]

30 The H-matrix decrypted in step S6 is identical to the H-matrix used by the authentication center 120 to generate the parity data. The parity

calculation section 1224 of the authentication center 120 calculates the parity data on the basis of the H-matrix and the RAND message.

[0057]

Consequently, when the comparative parity data generated in step S8
5 is identical with the parity data extracted in step S3, the RAND message generated in step S7 can be considered the same as the RAND message generated by the authentication center 120.

[0058]

Thus, when the comparative parity data generated in step S8 is
10 identical with the parity data extracted in step S3 ("YES" in S9), the process proceeds to step S10. In step S10, it is determined that authentication is successful. When, by contrast, the two parity data are not identical to each other ("NO" in S9), the process proceeds to step S11. In step S11, it is determined that authentication is failed. S9 to S11 correspond to an
15 authentication section. Upon completion of step S10 or S11, the process proceeds to step S12.

[0059]

In step S12, when all the navigation messages used for positioning in
step S1 have been determined to be either successfully authenticated or
20 unsuccessfully authenticated ("YES" in S12), the process illustrated in FIG. 4 is ended. When, by contrast, all the navigation messages used for positioning in step S1 have not been determined to be successfully authenticated or unsuccessfully authenticated ("YES" in S12), process returns to step S2 in order to repeat steps S2 and the followings.

25 [0060]

The position information transmission related process will now be described with reference to the flowchart of FIG. 5. The position information transmission related process is performed by the control unit 220 of the in-vehicle apparatus 200 in order to transmit the position information to the
30 roadside apparatus 300. The position information transmission related process is performed to transmit both the position information, which indicates the current position measured by the in-vehicle apparatus 200, and the authentication level, which indicates the number or ratio of successfully

authenticated GPS satellites 2 among the GPS satellites 2 used for positioning. The process illustrated in the flowchart of FIG. 5 may be initiated when a request signal for position information is received from the communication unit 310 of the roadside apparatus 300, or may be performed at
5 predetermined time intervals.

[0061]

The process illustrated in the flowchart of FIG. 5 and the process illustrated in the flowchart of FIG. 4 are performed in parallel. Even when all the navigation messages used for positioning are not completely
10 authenticated, the control unit 220 starts the process illustrated in the flowchart of FIG. 5.

[0062]

First of all, the current position of the host device, which is measured in step S2 in the flowchart of FIG. 4, is acquired in step S21. The acquired
15 current position is then stored in an electrically rewritable memory included in the control unit 220, such as a RAM or an EEPROM. When the acquired current position is to be stored in the memory, a timestamp, which is information indicative of time at which the current position was measured, is attached to the acquired current position.

20 [0063]

In step S22, the authentication level is calculated. The authentication level is the ratio of the number of GPS satellites 2 authenticated as illustrated in the flowchart of FIG. 4 to the number of GPS satellites 2 used for the measurement of the current position acquired in step
25 S21. For instance, when one GPS satellite 2 is authenticated in a situation where three GPS satellites 2 are used for positioning, the authentication level is 33.3%. Step S22 corresponds to an authentication level calculation section.

[0064]

30 The present embodiment has been described on the assumption that the authentication level represents the ratio of the number of authenticated GPS satellites 2 to the number of GPS satellites 2 used for positioning. Alternatively, the authentication level may represent the number of

authenticated GPS satellites 2. For example, when four GPS satellites 2 are used for positioning and four GPS satellites are authenticated in a situation where such an alternative scheme is used, the authentication level is defined as 4. For another example, a value defined based on the number of
5 authenticated GPS satellites 2 and the ratio of the authenticated GPS satellites among the GPS satellites 2 used for positioning may be used as the authentication level. For another example, a value defined based on the number of authenticated GPS satellites 2 and an arrangement of the authenticated GPS satellites 2 may be used as the authentication level. As
10 described above, a value defined by the number of authenticated GPS satellites 2 and/or the ratio of authenticated GPS satellites 2 may be used as the authentication level.

[0065]

In step S23, the current position and the timestamp, which were
15 stored in the memory in step S21, is read out. Then, transmission data is generated in a standard format. The transmission data having standard format includes position information indicative of the readout current position, the timestamp, and the authentication level calculated in step S22.

[0066]

20 The transmission data may additionally include the traveling direction and speed of the vehicle in which the in-vehicle apparatus 200 is mounted. The speed of the vehicle may be based on a value detected by a wheel speed sensor or determined by calculating the distance traveled by the vehicle per unit time from position information on multiple chronologically arranged
25 points. The traveling direction of the vehicle may be determined from the result of detection by a geomagnetic sensor or based on the extension direction of an approximate line determined by the least square method from the position information on multiple chronologically arranged points.

[0067]

30 In step S24, the transmission data, which was generated in step S23 and includes the position information, the timestamp, and the authentication level, is transmitted toward outside through the transmission unit 212. Upon completion of S24, the process is ended. S24 corresponds to a positioning

result transmission processing section.

[0068]

The roadside apparatus 300 includes the communication unit 310 and a control unit 320. The communication unit 310 wirelessly communicates
5 with the communication unit 126 of the authentication center 120, and the communication unit 310 also wirelessly communicates with the communication unit 210 of the in-vehicle apparatus 200.

[0069]

The control unit 320 is provided by a computer that includes a CPU, a
10 ROM, and a RAM, and controls the communication unit 310. Further, the control unit 320 performs a utilization determination related process illustrated in FIG. 6 by permitting the CPU to use a temporary storage function of the RAM and execute programs stored in the ROM.

[0070]

15 The utilization determination related process will now be described with reference to the flowchart of FIG. 6. The utilization determination related process is performed by the control unit 320 of the roadside apparatus 300 in order to determine the utilization of the position information transmitted from the in-vehicle apparatus 200. The utilization determination
20 related process is performed based on the authentication level attached to the position information transmitted from the in-vehicle apparatus 200 to determine whether or not to use the position information in the position information utilization process, which is a process of utilizing the position information. The process illustrated in the flowchart of FIG. 6 may be
25 initiated when, for example, transmission data transmitted from the in-vehicle apparatus 200 is received by the communication unit 310 of the roadside apparatus 300. The position information utilization process corresponds to a positioning result utilization process.

[0071]

30 First of all, in step S41, the authentication level based on position information reliability required for the position information utilization process, that is, the authentication level required for the position information utilization process, is specified. The authentication level required for the position

information utilization process is hereinafter referred to as the required authentication level (REQ AUTH LV).

[0072]

In a case where the roadside apparatus 300 performs only one type of position information utilization process and the required authentication level is a fixed value, the fixed value may be determined as the required authentication level. In a case where the roadside apparatus 300 performs multiple different types of position information utilization processes, the required authentication level appropriate for the position information utilization process to be performed by the roadside apparatus 300 may be determined by referencing a predefined relationship between different position information utilization processes and corresponding required authentication levels.

[0073]

For example, when the position information utilization process is a billing process that is performed to bill the user for the vehicle parking in a pay parking lot or traveling on a toll road, the required authentication level is set to a high level because it is necessary to avoid incorrect billing. When the position information utilization process is, for example, a process for a game that uses the position information but does not require highly reliable position information, the required authentication level is set to a low level because an immediate start of the game is preferred without waiting an increase of the reliability to a high level. As described above, the higher the position information reliability required for the position information utilization process, the higher the required authentication level.

[0074]

When the required authentication level is a predetermined fixed value, the fixed value may be preliminarily specified in the roadside apparatus without specifying the required authentication level in step S41 of the position information utilization process.

[0075]

In step S42, the transmission data received by the communication unit 310 is acquired from the communication unit 310 to obtain the position

information, timestamp, and authentication level included in the transmission data. Step S42 corresponds to a positioning result reception processing section.

[0076]

5 In step S43, a check is performed to determine whether the authentication level acquired in step S42 becomes equal to the required authentication level determined in step S41. Suppose that the position information utilization process is a billing process that bills the user for the vehicle parking in a pay parking lot or traveling on a toll road and the required
10 authentication level is 100%. In this case, when the authentication level acquired in step S42 is lower than 100%, the process determines that the required authentication level is not achieved. Suppose that the position information utilization process is a process for a game that uses the position information and the required authentication level is 33%. In this case, even
15 when the authentication level acquired in step S42 is lower than 100%, the process determines that the required authentication level is achieved in response to an increase of the authentication level to 33%.

[0077]

 In step S43, when determining that the required authentication level
20 is achieved ("YES" in S43), the process proceeds to step S44. In step S44, the position information acquired in step S41 is determined to be usable in the position information utilization process. In step S43, when determining that the required authentication level is not achieved ("NO" in S43), the process proceeds to step 45. In step 45, the position information acquired in step
25 S42 is not usable in the position information utilization process. Steps S43 to S45 correspond to a utilization determination section.

[0078]

 In the position information utilization process, the control unit 320
does not use the position information that is determined in the utilization
30 determination related process to be not usable in the position information utilization process. Meanwhile, the position information that is determined in the utilization determination related process to be usable in the position information utilization process will be used in the position information

utilization process. As an example, a billing process for billing the user for the vehicle parking in a pay parking lot or traveling on a toll road is explained below.

[0079]

5 The position information determined in the utilization determination related process to be not usable in the position information utilization process will not be targeted for billing and will not be subjected to billing even when the position defined by the position information is included in a billing region. Meanwhile, the position information determined in the utilization
10 determination related process to be usable in the position information utilization process will be targeted for billing and subjected to billing when the position defined by the position information is included in a billing region. The control unit 320 corresponds to an execution section.

[0080]

15 According to the first embodiment, the roadside apparatus 300, which performs a process of utilizing the position information transmitted from the in-vehicle apparatus 200, is capable of determining, based on the authentication level attached to the position information, whether or not to perform a position information utilization process. For example, a billing
20 process which requires high position information reliability will not be performed when the received authentication level is lower than the required authentication level. However, in a process related to a game which requires low position information reliability, even though the position information has a low authentication level, the position information can be used in the process
25 related to the game.

[0081]

Consequently, in an application (APP) or a system which uses positioning result derived from navigation messages transmitted from GPS satellites 2 used in a satellite positioning system, the positioning result can be
30 flexibly utilized based on positioning result reliability required for the application or the system.

[0082]

(First Modification)

The first embodiment has been described on the assumption that the roadside apparatus 300 is used as the positioning result receiving device. The positioning result receiving device is not limited to the roadside apparatus 300. Alternatively, the positioning result receiving device may be a mobile
5 device that is mounted, for example, in a different vehicle other than the vehicle in which the in-vehicle apparatus 200 is mounted. The position information utilization process performed by such a mobile device may be a follow-up traveling process that utilizes the position information received from the in-vehicle apparatus 200 to perform a follow-up traveling while
10 maintaining an appropriate vehicle-to-vehicle distance from a vehicle in which the in-vehicle apparatus 200 is mounted. For the follow-up traveling process, which requires highly reliable position information, the required authentication level should be set to a high level.

[0083]

15 (Second Modification)

The first embodiment has been described with reference to a case where the position information utilization process is a billing process of billing a user for a vehicle traveling on a toll road (hereinafter referred to as the road billing process). When the vehicle is actually traveling on a toll road, the
20 configuration of the first embodiment fails to perform billing when the authentication level attached to the position information received from the in-vehicle apparatus 200 mounted in the vehicle by the roadside apparatus 300 is lower than the authentication level required for the road billing process.

[0084]

25 To avoid the above failure, the configuration of a second modification described below may be adopted. The second modification is similar to the first embodiment except a part of process executed by the control unit 320 of the roadside apparatus 300. More specifically, the second modification differs from the first embodiment in that the control unit 320 according to the
30 second modification performs a road billing related process, and does not perform the utilization determination related process or position information utilization process in the first embodiment.

[0085]

The road billing related process according to the second modification will now be described with reference to the flowchart of FIG. 7. In the road billing related process, position information obtained when the authentication level is lower than the required authentication level is additionally stored in a successive manner so that position information records that are previously stored and continuous with the position information obtained when the authentication level becomes equal to the required authentication level are also subjected to the road billing process.

[0086]

10 The process illustrated in the flowchart of FIG. 7 may be initiated when, for example, transmission data transmitted from the in-vehicle apparatus 200 is received by the communication unit 310 on the roadside apparatus 300. The following description is given on the assumption that the required authentication level appropriate for the road billing process has been
15 preliminarily determined.

[0087]

First of all, in step S61, the transmission data received by the communication unit 310 is acquired from the communication unit 310 to obtain, for example, the position information, timestamp, and authentication
20 level included in the transmission data. Step S61 also corresponds to the positioning result reception processing section.

[0088]

In step S62, a check is performed to determine whether a road billing condition is satisfied. When a position indicated by the position information acquired in step S61 is within a region targeted for road billing, it is determined that the road billing condition is satisfied. When the position indicated by the position information acquired in step S61 is not within the region targeted for road billing, it is determined that the road billing condition is not satisfied. When it is determined that the road billing condition is
25 satisfied ("YES" in S62), the process proceeds to step S63. When it is determined that the road billing condition is not satisfied ("NO" in S62), the process is ended.

[0089]

In step S63, a check is performed to determine whether the authentication level acquired in step S61 becomes equal to the required authentication level for the road billing process. When it is determined that the required authentication level is achieved ("YES" in S63), the position information acquired in step S61 is handled as a target for the road billing process, and the process proceeds to step S73. When it is determined that the required authentication level is not achieved ("NO" in S63), the position information acquired in step S61 is tentatively excluded from the road billing process, and the process proceeds to step 64. Step S63 corresponds to the utilization determination section.

[0090]

In step S64, a notification process is performed to notify the user of the possibility that the position information may be handled as a target for billing later. In the notification process, for example, information including an instruction for notifying the user of the possibility that the position information may be handled as a billing target later is transmitted to the in-vehicle apparatus 200 through the communication unit 310. The in-vehicle apparatus 200 then uses a display device (not shown) or an audio output device (not shown) to notify the user of the possibility that the position information may be handled as a billing target later. Step S64 corresponds to a notification processing section.

[0091]

With the above-described configuration, even when the received authentication level is lower than the required authentication level at present time and the position information is not handled as a target for road billing currently, the user can recognize the possibility that the position information may be handled as a billing target later. As a result, even when the authentication level will be up to the required authentication level in the future so that a travel section not targeted for road billing will become a target for road billing, such a change will not be an unexpected result for the user. In another example, step S64 may be skipped.

[0092]

In step S65, the position information and other data acquired in step

S61 are stored in an electrically-rewritable memory in the control unit 320, such as a RAM or an EEPROM. Step S65 corresponds to a storage processing section.

[0093]

5 In step S66, a check is performed to determine whether new transmission data is received from the in-vehicle apparatus 200. If new transmission data is received ("YES" in S66), the newly received data, such as the position information, timestamp, and authentication level, is acquired, and the process proceeds to step S67. When no new transmission data is
10 received ("NO" in S66), step S66 is repeated.

[0094]

In step S67, a check is performed to determine whether the road billing condition becomes unsatisfied. When it is determined that the road billing condition becomes unsatisfied ("YES" in S67), the process is ended.
15 When it is determined that the road billing condition is still in satisfied state ("NO" in S67), the process proceeds to step S68.

[0095]

In step S68, a check is performed to determine whether the authentication level acquired in step S66 becomes equal to the required
20 authentication level for the road billing process. When it is determined that the required authentication level is achieved ("YES" in S68), the position information acquired most recently in step S66 is handled as a target for the road billing process, and the process proceeds to step S69. When it is determined that the required authentication level is not achieved ("NO" in
25 S68), the position information acquired most recently in step S66 is tentatively excluded from the target of the road billing process, and the process returns to step 65. In step S65, the position information and other data acquired in step S66 are stored in the memory, and process is repeated. Step S68 also corresponds to the utilization determination section.

30 [0096]

In step S69, a check is performed to determine whether the position information to which the authentication level acquired in step S66 is attached is continuous with the previous position information records stored in step S65.

When determining a presence of continuity between the two, an error between a position estimated from the previous position information and a position indicated by the position information to which the authentication level acquired in step S66 is attached may be determined whether to be greater
5 than a threshold value or not. The threshold value can be preliminarily defined as a proper value.

[0097]

The estimated position is a position estimated from the position information and other data successively stored in step S65. If a vehicle
10 speed and traveling direction are acquired from the in-vehicle apparatus 200 in addition to the position information, the estimated position at a time point indicated by the timestamp for the position information to which the authentication level acquired in step S66 is attached may be obtained by estimating from the previous position information and the vehicle speed and
15 traveling direction. Even if the vehicle speed and traveling direction are not acquired from the in-vehicle apparatus 200, the vehicle speed and traveling direction may be calculated, as mentioned earlier, from the position information about multiple points successively stored in step S65 in order to estimate the position based on the position information.

20 [0098]

In step S70, a check is performed to determine whether there is continuity. When it is determined that there is continuity ("YES" in S70), the process proceeds to step S71, and the previous position information stored in step S65 is also handled as a target for the road billing process. When it is
25 determined that there is no continuity ("NO" in S70), the process proceeds to step S72, and the previous position information stored in step S65 is excluded from the target of the road billing process. Step S70 corresponds to a continuity determination section.

[0099]

30 As illustrated in FIG. 8A, when the position information (refer to a black circle marked HV in FIG. 8A) to which the authentication level acquired in step S66 is attached is continuous with the position information records (refer to white circle in FIG. 8A) successively stored in step S65, the previous

position information records successively stored in step S65 are also handled as targets for the road billing process because such position information is considered to be highly reliable.

[0100]

5 As illustrated in FIG. 8B, when the position information (refer to a black circle marked HV in FIG. 8B) to which the authentication level acquired in step S66 is attached is discontinuous with or deviated from the position information records (refer to white circles in FIG. 8B) successively stored in step S65, the previous position information records successively stored in step
10 S65 are excluded from the road billing process because such position information is not considered to be highly reliable.

[0101]

Upon completion of step S71 or S72, the process proceeds to step S73. In step S73, a check is performed to determine whether new transmission
15 data is received from the in-vehicle apparatus 200. When new transmission data is received ("YES" in S73), the newly received data, such as the position information, timestamp, and authentication level, is acquired, and the process proceeds to step S74. When no new transmission data is received ("NO" in S73), step S73 is repeated.

20 [0102]

In step S74, a check is performed to determine whether the road billing condition becomes unsatisfied. When it is determined that the road billing condition becomes unsatisfied ("YES" in S74), the process proceeds to step S75. When it is determined that the road billing condition is still in the
25 satisfied state ("NO" in S74), process returns to step S73 in order to repeat step S73 and the followings.

[0103]

In step S75, a billing process is performed on the basis of a section of a toll road that is traveled by the vehicle in which the in-vehicle apparatus 200
30 is mounted. Upon completion of step S75, the road billing related process is ended. Step S75 corresponds to the execution section. When the received maintains equal to or higher than the required authentication level during the time interval from an instant at which the road billing condition is determined

to be satisfied to an instant at which the road billing condition is determined to be unsatisfied, a billing process is performed to a section corresponding to the time interval from the instant at which the road billing condition is determined to be satisfied to the instant at which the road billing condition is determined to be unsatisfied.

[0104]

Further, when the received authentication level is lower than the required authentication level for a time period during the time interval from the instant at which the road billing condition is determined to be satisfied to the instant at which the road billing condition is determined to be unsatisfied and the time period included in the time interval is selected in step S71 as a target for the road billing process, a billing process is also performed to the section corresponding to the time interval from the instant at which the road billing condition is determined to be satisfied to the instant at which the road billing condition is determined to be unsatisfied.

[0105]

When the received authentication level is lower than the required authentication level for a time period during the time interval from the instant at which the road billing condition is determined to be satisfied to the instant at which the road billing condition is determined to be unsatisfied and the time period included in the time interval is excluded in step S72 from the road billing process, the road billing process is performed to a remaining section obtained by excluding a section corresponding to the time period during which the received authentication level is lower than the required authentication level from a section corresponding to the time interval from the instant at which the road billing condition is determined to be satisfied to the instant at which the road billing condition is determined to be unsatisfied.

[0106]

With the above configuration, it is possible to reduce the failure to perform billing when the vehicle is actually traveling on a toll road.

[0107]

(Third Modification)

The first embodiment has been described with reference to a case

where the position information utilization process is a billing process (hereinafter referred to as the parking billing process) of billing a user for a vehicle parking in a pay parking lot. However, even if the vehicle is actually parked in a pay parking lot, the configuration of the first embodiment fails to perform billing when the authentication level attached to the position information received from the in-vehicle apparatus 200 mounted in the vehicle by the roadside apparatus 300 is lower than the authentication level required for the parking billing process.

[0108]

To avoid the above failure, the configuration of a third modification described below may be adopted. The third modification is similar to the first embodiment except that a part of process executed by the control unit 320 of the roadside apparatus 300 is different from the first embodiment. More specifically, the third modification differs from the first embodiment in that the control unit 320 according to the third modification performs a parking billing related process, and does not perform the utilization determination related process or position information utilization process described in the first embodiment.

[0109]

Further, in the third modification, the control unit 220 of the in-vehicle apparatus 200 continuously performs the above-described authentication related process even when a parking of the host vehicle is detected. The control unit 220 may be adapted to detect a parking of the host vehicle when, for instance, a parking brake is on, an ignition power is off, or the successively measured current position remains unchanged for a predetermined period of time.

[0110]

The parking billing related process according to the third modification will now be described with reference to the flowchart of FIG. 9. In the parking billing related process, the position information obtained when the authentication level is lower than the required authentication level is successively stored so that previously obtained position information continuous with the position information obtained when the authentication

level becomes equal to the required authentication level is also handled as a target for the parking billing related process.

[0111]

The process illustrated in the flowchart of FIG. 9 may be initiated
5 when, for example, transmission data transmitted from the in-vehicle
apparatus 200 is received by the communication unit 310 of the roadside
apparatus 300. The following description is given on the assumption that the
required authentication level appropriate for the parking billing process has
been preliminarily determined.

10 [0112]

First of all, in step S81, the position information, timestamp, and
authentication level, and other data included in the transmission data received
by the communication unit 310 are acquired, as is the case with
above-described step S61. Step S81 also corresponds to the positioning
15 result reception processing section.

[0113]

In step S82, a check is performed to determine whether the vehicle in
which the in-vehicle apparatus 200 is mounted is parked. When the vehicle
speed is acquired from the in-vehicle apparatus 200 in addition to the position
20 information, a parking of the vehicle may be determined by checking whether
the vehicle speed decreases approximately to zero. Alternatively, the parking
of the vehicle may be determined by checking whether the current position
indicated by the successively acquired position information remains
unchanged for a predetermined period of time. Step S82 corresponds to a
25 parking determination section.

[0114]

In step S83, a check is performed to determine whether a parking
billing condition is satisfied. When a position indicated by the position
information acquired in step S81 is within a region targeted for parking billing,
30 it is determined that the parking billing condition is satisfied. When the
position indicated by the position information acquired in step S81 is not
within the region targeted for parking billing, it is determined that the parking
billing condition is not satisfied. When it is determined that the parking

billing condition is satisfied ("YES" in S83), the process proceeds to step S84. When it is determined that the parking billing condition is not satisfied ("NO" in S83), the process is ended.

[0115]

5 In step S84, a check is performed to determine whether the authentication level acquired in step S81 becomes equal to the required authentication level for the parking billing process. When it is determined that the required authentication level is achieved ("YES" in S84), the position information acquired in step S81 is handled as a target for the parking billing
10 process, and the process proceeds to step S94. When it is determined that the required authentication level is not achieved ("NO" in S84), the position information acquired in step S81 is tentatively excluded from the parking billing process, and the process proceeds to step 85. Step S84 corresponds to the utilization determination section.

15 [0116]

 In step S85, the notification process is performed to notify the user of the possibility that the position information may be handled as a target for billing later, as is the case with above-described step S64. Step S85 corresponds to the notification processing section.

20 [0117]

 With the above configuration, even when the authentication level is lower than the required authentication level at present time and the position information is not handled as a target for parking billing, the user can recognize the possibility that position information may be handled as a billing
25 target later. As a result, even when the authentication level will be up to the required authentication level in the future so that a time period not targeted for parking billing will become a target for parking billing, such a change will not be an unexpected result for the user. In another example, step S85 may be skipped.

30 [0118]

 In step S86, the position information and other data acquired in step S81 are stored in an electrically-rewritable memory in the control unit 320, such as a RAM or an EEPROM. Step S86 corresponds to the storage

processing section.

[0119]

In step S87, a check is performed to determine whether new transmission data is received from the in-vehicle apparatus 200. When new
5 transmission data is received ("YES" in S87), the newly received data, such as the position information, timestamp, authentication level, is acquired, and the process proceeds to step S88. When no new transmission data is received ("NO" in S87), step S87 is repeated.

[0120]

10 In step S88, a check is performed to determine whether the parking billing condition becomes unsatisfied. When it is determined that the parking billing condition becomes unsatisfied ("YES" in S88), the process is ended. When it is determined that the road billing condition is still in the satisfied state ("NO" in S88), the process proceeds to step S89.

15 [0121]

In step S89, a check is performed to determine whether the authentication level acquired in step S87 becomes equal to the required authentication level for the parking billing process. When it is determined that the required authentication level is achieved ("YES" in S89), the position
20 information acquired most recently in step S87 is handled as a target for the parking billing process, and the process proceeds to step S90. When it is determined that the required authentication level is not achieved ("NO" in S89), the position information acquired most recently in step S87 is tentatively excluded from the parking billing process, and the process returns to step 86.
25 In returned step S86, the position information and other data acquired in step S87 are stored in the memory, and the process is repeated. Step S89 also corresponds to the utilization determination section.

[0122]

In step S90, a check is performed to determine whether the position
30 information to which the authentication level acquired in step S87 is attached is continuous with previous position information stored in step S86. Whether the two position information are continuous with each other is determined by comparing an error between a position indicated by the previous position

information and a position indicated by the position information to which the authentication level acquired in step S66 is attached with a threshold value. As an example, the two position information are determined to be continuous when the error between the position indicated by the previous position information initially stored in the memory in step S86 and the position indicated by the position information to which the authentication level acquired in step S66 is attached is equal to or lower than the threshold value. The threshold value can be preliminarily defined as a proper value.

[0123]

10 In step S91, a check is performed to determine whether there is continuity. When it is determined that there is continuity ("YES" in S91), the process proceeds to step S92, and the previous position information stored in step S86 is also handled as a target for the parking billing process. When it is determined that there is no continuity ("NO" in S91), the process proceeds to
15 step S93, and the previous position information stored in step S86 is excluded from the target of the parking billing process. Step S91 corresponds to the continuity determination section.

[0124]

Upon completion of step S92 or S93, the process proceeds to step S94.
20 In step S94, a check is performed to determine whether new transmission data is received from the in-vehicle apparatus 200. When new transmission data is received ("YES" in S94), the newly received data, such as the position information, timestamp, and authentication level, is acquired, and the process proceeds to step S95. When no new transmission data is received ("NO" in
25 S94), step S94 is repeated.

[0125]

In step S95, a check is performed to determine whether the parking billing condition becomes unsatisfied. When it is determined that the parking billing condition becomes unsatisfied ("YES" in S95), the process proceeds to
30 step S96. When it is determined that the parking billing condition is still in satisfied state ("NO" in S95), processing returns to step S94 in order to repeat step S94 and the followings.

[0126]

In step S96, a billing process is performed on the basis of elapsed time after the vehicle in which the in-vehicle apparatus 200 is mounted has been parked. Upon completion of step S96, the parking billing related process is ended. Step S96 corresponds to the execution section. When the received authentication level maintains equal to or higher than the required authentication level during the time interval from the instant at which the parking billing condition is determined to be satisfied to the instant at which the parking billing condition is determined to be unsatisfied, the billing process is performed on the basis of a time interval from the instant at which the parking billing condition is determined to be satisfied to the instant at which the parking billing condition is determined to be unsatisfied. The time interval may be calculated by using the timestamp of the position information.

[0127]

Further, when the required authentication level is not continuously achieved during the time interval from the instant at which the parking billing condition is determined to be satisfied to the instant at which the parking billing condition is determined to be unsatisfied, and the time interval between such instants is selected in step S92 as a target for the parking billing process, a billing process is also performed on the basis of the time interval from the instant at which the parking billing condition is determined to be satisfied to the instant at which the parking billing condition is determined to be unsatisfied.

[0128]

Suppose that the received authentication level becomes lower than the required authentication level for a time period during the time interval from the instant at which the parking billing condition is determined to be satisfied to the instant at which the parking billing condition is determined to be unsatisfied. In this case, the time period during which the received authentication level becomes lower than the required authentication level is excluded in step S93 from the parking billing process. Thus, the billing process is performed to a remaining time segment obtained by excluding the time period during which the received authentication level is lower than the required authentication level from the time interval from the instant at which

the parking billing condition is determined to be satisfied to the instant at which the parking billing condition is determined to be unsatisfied.

[0129]

With the above configuration, it is possible to reduce the failure to
5 perform billing when the vehicle is actually parked in a pay parking lot.

[0130]

(Second Embodiment)

While the first embodiment of the present disclosure has been described above, the present disclosure is not limited to the first embodiment.
10 A second embodiment, which will be described below, is also included in the technical scope of the present disclosure. The second embodiment will now be described with reference to the accompanying drawings. For the sake of convenience of explanation, members having the same function as the members depicted in the drawings used to describe the foregoing
15 embodiment will be designated by the same reference symbols as their counterparts and will not be redundantly described.

[0131]

As illustrated in FIG. 10, a positioning result utilizing system 1a according to the second embodiment is similar to the positioning result
20 utilizing system 1 according to the first embodiment except that positioning result utilizing system 1a according to the second embodiment includes a position information utilization device 400. The position information utilization device 400 acts as the positioning result receiving device provided by the roadside apparatus 300 in the first embodiment. In the present
25 embodiment, the position information utilization device 400 is used for a vehicle in which the in-vehicle apparatus 200 is mounted. In the present embodiment, the position information utilization device 400 corresponds to the positioning result receiving device.

[0132]

30 The position information utilization device 400 may be, for example, an in-vehicle navigation device or a mobile terminal used for a vehicle. The mobile terminal provided as the position information utilization device 400 may have, for example, a GPS function, but not perform the above-described

authentication related process.

[0133]

As illustrated in FIG. 11, the position information utilization device 400 is connected to the in-vehicle apparatus 200 through, for example, an in-vehicle LAN, and includes a communication unit 410 and a control unit 420. The communication unit 410 communicates with the communication unit 210 in the in-vehicle apparatus 200. The following description is given on the assumption that the in-vehicle apparatus 200 communicates with the position information utilization device 400 through the in-vehicle LAN. In another example, the in-vehicle apparatus 200 may wirelessly communicate with the position information utilization device 400.

[0134]

The control unit 420 is provided by a computer that includes a CPU, a ROM, and a RAM and controls the communication unit 410. Further, the control unit 420 performs processes similar to the utilization determination related process described in the first embodiment, the road billing process described in the second modification, and the parking billing process described in the third modification by permitting the CPU to use a temporary storage function of the RAM and execute programs stored in the ROM. Thus, the control unit 420 corresponds to the positioning result reception processing section, the utilization determination section, the execution section, the storage processing section, the continuity determination section, and the parking determination section.

[0135]

Whether a host vehicle is parked may be determined by the control unit 420 on the basis of a parking brake or ignition power signal. The parking brake or the ignition power signal can be acquired through the in-vehicle LAN.

[0136]

As is the case with the first embodiment, the second embodiment enables the position information utilization device 400, which performs a process of using the position information transmitted from the in-vehicle apparatus 200, to determine, based on the authentication level attached to

the position information, whether or not to perform the process which utilizes the position information. Consequently, in an application or a system that uses positioning result derived from navigation messages transmitted from GPS satellites 2 used in a satellite positioning system, the positioning result
5 can be flexibly utilized based on positioning result reliability required for the application or the system.

[0137]

(Third Embodiment)

The present disclosure is not limited to the first and second
10 embodiments. A third embodiment, which will be described below, is also included in the technical scope of the present disclosure. The third embodiment will now be described with reference to the accompanying drawings. For the sake of convenience of explanation, members having the same function as the members depicted in the drawings used to describe the
15 foregoing embodiments will be designated by the same reference symbols as their counterparts and will not be redundantly described.

[0138]

As illustrated in FIG. 12, a positioning result utilizing system 1b according to the third embodiment is similar to the positioning result utilizing
20 system 1 according to the first embodiment except that the positioning result utilizing system 1b according to the third embodiment includes a mobile terminal 500, and does not include the in-vehicle apparatus 200, the roadside apparatus 300, or the position information utilization device 400. The mobile terminal 500 acts as a substitute for the in-vehicle apparatus 200, the
25 roadside apparatus 300, and the position information utilization device 400.

[0139]

As is the case with the in-vehicle apparatus 200, the mobile terminal 500 communicates with the authentication center 120 to perform the above-described authentication related process. Further, as is the case with
30 the in-vehicle apparatus 200, the mobile terminal 500 uses the navigation messages received from multiple GPS satellites 2 to measure its current position and calculate the above-described authentication level. Furthermore, the mobile terminal 500 uses the measured current position to

execute applications that provide predetermined services. The applications include an application that performs the above-described road billing process or parking billing process and a game that uses the position information.

[0140]

5 For example, a smartphone or other multifunctional mobile phone may be used as the mobile terminal 500. A navigation device or other in-vehicle apparatus that has the GPS function and performs the above-described authentication related process may be used in place of the mobile terminal 500.

10 [0141]

As illustrated in FIG. 13, the mobile terminal 500 includes a communication unit 510, a control unit 520, and a satellite receiver 530. The navigation message broadcast from the QZS 3 is received by a reception unit 511 included in the communication unit 510 of the mobile terminal 500.

15 [0142]

The communication unit 510 includes the reception unit 511 and a transmission unit 512, and performs the same function as the above-described communication unit 210 of the in-vehicle apparatus 200. The satellite receiver 530 performs the same function as the above-described
20 satellite receiver 230.

[0143]

The control unit 520 is provided by a computer that includes a CPU, a ROM, and a RAM and controls the communication unit 510 and the satellite receiver 530. Further, the control unit 520 performs an authentication
25 related process similar to the authentication related process described in the first embodiment and a position information utilization related process illustrated in FIG. 14 by permitting the CPU to use a temporary storage function of the RAM and execute programs stored in the ROM. In the authentication related process executed by the control unit 520, step S1
30 corresponds to the positioning section, step S5 corresponds to the authentication information acquisition section, and steps S9 to S11 correspond to the authentication section.

[0144]

The position information utilization related process will now be described with reference to the flowchart of FIG. 14. The position information utilization related process is performed by the control unit 520 of the mobile terminal 500 in order to use the measured current position. The position information utilization related process is performed to calculate the authentication level, which is the number or ratio of authenticated GPS satellites 2 that are used to measure the current position, and determines, based on the calculated authentication level, whether or not to use the acquired current position in a position utilization application, which utilizes the current position.

[0145]

The process illustrated in the flowchart of FIG. 14 may be initiated when the position utilization application is in activated state and the current position of the mobile terminal 500 is measured by the control unit 520 of the mobile terminal 500. The current position of the mobile terminal 500 is measured based on the navigation messages included in GPS radio waves that are received from three or more GPS satellites 2.

[0146]

In the present embodiment, authentication related process similar to the process described in the first embodiment is carried out, and this authentication related process is carried out in parallel with the process illustrated in the flowchart of FIG. 14. Even when only a part of the navigation messages used for positioning are authenticated, the process illustrated in the flowchart of FIG. 14 may start.

[0147]

First of all, in step S101, the current position of the mobile terminal 500, which is measured based on the navigation messages included in the GPS radio waves received from three or more GPS satellites 2, is acquired. The acquired current position is then stored in an electrically-rewritable memory in the control unit 520, such as a RAM or an EEPROM. When the acquired current position is to be stored in the memory, a timestamp, which is information indicative of time at which the current position was measured, is attached to the acquired current position.

[0148]

In step S102, the authentication level is calculated, as is the case with above-described step S22. The authentication level is the ratio of the number of GPS satellites 2 currently authenticated in the authentication
5 related process to the number of GPS satellites 2 used for the measurement of the acquired current position. Step S102 corresponds to the authentication level calculation section. The authentication level may alternatively be the number of authenticated GPS satellites 2.

[0149]

10 In step S103, the required authentication level, which is required for the currently operating position utilization application, is determined. For example, the required authentication level may be determined by referencing a predefined relationship between different position utilization applications and corresponding required authentication levels. As is the case with
15 above-described step S41, step S103 is performed on the assumption that the higher the position information reliability required for the position utilization application, the higher the required authentication level. When the required authentication level is a predetermined fixed value, step S103 may be skipped.

20 [0150]

In step S104, a check is performed to determine whether the authentication level calculated in step S102 becomes equal to the required authentication level determined in step S103, as is the case with above-described step S42. When it is determined that the required
25 authentication level is achieved ("YES" in S104), the process proceeds to step S105. In step S105, the position information acquired in step S101 is handled as a target for the position utilization application. When it is determined that the required authentication level is not achieved ("NO" in S104), the process proceeds to step S106. In step S106, the position
30 information acquired in step S101 is not handled as a target for the position utilization application. Steps S104 to S106 correspond to the utilization determination section.

[0151]

When it is determined in the position information utilization related process that the position information is not handled as a target for the position utilization application, the control unit 520 does not use the position information for the position utilization application. When it is determined in
5 the position information utilization related process that the position information is handled as a target for the position utilization application, the control unit 520 uses the position information in the position utilization application. The following description is given on the assumption that the position utilization application performs the above-described road billing
10 process or parking billing process.

[0152]

When the position information is determined in the position information utilization related process to be not handled as a target for the position utilization application, the position indicated by the position
15 information will not be targeted for billing and will not be subjected to billing even when it is included in a region targeted for billing. When the position information is determined in the position information utilization related process to be handled as a target for the position utilization application, the position indicated by the position information will be targeted for billing and
20 subjected to billing when it is included in a region targeted for billing. The control unit 520 corresponds to the execution section.

[0153]

According to the third embodiment, the mobile terminal 500 determines, based on the authentication level of a navigation message of a
25 GPS satellite 2 used for the measurement of the current position, whether or not to execute the position utilization application. Therefore, a billing process which requires high position information reliability will not be performed when the calculated authentication level is low. However, a process for, for example, a game which requires low position information
30 reliability can be performed even when the authentication level is low.

[0154]

Consequently, in an application or a system that uses positioning result derived from navigation messages transmitted from GPS satellites 2

used in a satellite positioning system, the positioning result can be flexibly utilized based on positioning result reliability required for the application or the system.

[0155]

5 The mobile terminal 500 need not always be disposed and used for a vehicle, but may be carried by a person. When the mobile terminal 500 is carried by a person, the position utilization application may provide a game, such as an orienteering race or a stamp-collecting rally, or perform a billing process by determining the entry into a theme park or the use of an
10 amusement ride in the theme park on the basis of the current position.

[0156]

(Fourth Modification)

The third embodiment has been described with reference to a case where the position utilization application provides a road billing process of
15 billing a user for a vehicle traveling on a toll road. However, even if the vehicle is actually traveling on a toll road, the configuration of the third embodiment may fail to perform billing when the authentication level is lower than the authentication level required for the road billing process.

[0157]

20 To avoid the above-described failure, a configuration of a fourth modification described below may be adopted. The fourth modification is similar to the second modification except that a process according to the fourth modification is performed by the control unit 520 of the mobile terminal 500.

25 [0158]

The road billing related process according to the fourth modification will now be described with reference to the flowchart of FIG. 15. The process illustrated in the flowchart of FIG. 15 may be initiated when, for example, an application for the road billing related process is in activated state
30 and the current position of the mobile terminal 500 is measured by the control unit 520 of the mobile terminal 500. The current position of the mobile terminal 500 is measured based on the navigation messages included in GPS radio waves that are received from three or more GPS satellites 2.

[0159]

First of all, in step S121, the current position of the mobile terminal 500, which is measured based on the navigation messages included in the GPS radio waves received from three or more GPS satellites 2, is acquired. A
5 timestamp is attached to the acquired current position, and the position information together with the timestamp is stored in the memory.

[0160]

Steps S122 to S135 are similar to steps S62 to S75 of the second modification. The fourth modification differs from the second modification in
10 that a check is performed in steps S126 and S133 to determine whether new positioning results are acquired, and that a display device (not shown) or an audio output device (not shown) included in the mobile terminal 500 notifies in step S124 the user of the possibility that the position information may be handled as a billing target later. Thus, steps S123 and S128 correspond to
15 the utilization determination section, step S124 corresponds to the notification processing section, step S125 corresponds to the storage processing section, step S129 corresponds to the continuity determination section, and step S135 corresponds to the execution section. In another example, step S124 may be skipped.

20 [0161]

With the above configuration, it is possible to reduce the failure to perform billing when the vehicle is actually traveling on a toll road.

[0162]

(Fifth Modification)

25 The third embodiment has been described with reference to a case where the position utilization application provides a parking billing process of billing a user for a vehicle parking in a pay parking lot. However, even if the vehicle is actually parked in a pay parking lot, the configuration of the third embodiment may fail to perform billing when the authentication level is lower
30 than the authentication level required for the parking billing process.

[0163]

To avoid the above failure, the configuration of a fifth modification described below may be adopted. The fifth modification is similar to the

third modification except that a process according to the fifth modification is performed by the control unit 520 of the mobile terminal 500.

[0164]

The parking billing related process according to the fifth modification
5 will now be described with reference to the flowchart of FIG. 16. The process illustrated in the flowchart of FIG. 16 may be initiated when, for example, an application for the parking billing related process is in activated state and the current position of the mobile terminal 500 is measured based on the navigation messages included in GPS radio waves that are received
10 from three or more GPS satellites 2 by the control unit 520 of the mobile terminal 500.

[0165]

First of all, in step S141, the current position of the mobile terminal 500, which is measured based on the navigation messages included in the
15 GPS radio waves received from three or more GPS satellites 2, is acquired. A timestamp is attached to the acquired current position, and the position information together with the time stamp is stored in the memory.

[0166]

Steps S142 to S155 are similar to steps S82 to S96 of the third
20 modification. The fifth modification differs from the third modification in that a check is performed in steps S147 and S154 to determine whether new positioning results are acquired, and that a display device (not shown) or an audio output device (not shown) included in the mobile terminal 500 notifies in step S145 the user of the possibility of the position information being later
25 handled as a billing target. Thus, step S142 corresponds to the parking determination section, steps S144 and S149 correspond to the utilization determination section, step S145 corresponds to the notification processing section, step S146 corresponds to the storage processing section, step S150 corresponds to the continuity determination section, and step S156
30 corresponds to the execution section. In another example, step S145 may be skipped.

[0167]

With the above configuration, it is possible to reduce the failure to

perform billing when the vehicle is actually parked in a pay parking lot.

[0168]

It is noted that a flowchart or the processing of the flowchart in the present disclosure includes sections (also referred to as steps), each of which is represented, for instance, as S1. Further, each section can be divided into several sub-sections while several sections can be combined into a single section. Furthermore, each of thus configured sections can be also referred to as a circuit, device, module, or means.

[0169]

Each or any combination of sections explained in the above can be achieved as (i) a software section in combination with a hardware unit (e.g., computer) or (ii) a hardware section, including or not including a function of a related apparatus; furthermore, the hardware section (e.g., integrated circuit, hard-wired logic circuit) may be constructed inside of a microcomputer.

[0170]

(Other Embodiments)

The foregoing embodiments have been described with reference to a case where positioning is performed by using only the navigation messages received from the GPS satellites 2. In an alternative configuration, the navigation messages received from the QZS 3 may be used for positioning purposes. In such an alternative configuration, the navigation messages received from the QZS 3 may be authenticated in the same manner as for the navigation messages received from the GPS satellites 2.

[0171]

In an exemplary alternative configuration, an RAND message may be generated from a navigation message received from the QZS 3 by the monitoring station 110 in order to control the authentication center 120 to generate parity data from the RAND message. The generated parity data is then transmitted to the master control station 130 in order to control the master control station 130 transmit the parity data to the QZS 3. The QZS 3 broadcasts a navigation message including the parity data toward the ground.

[0172]

The in-vehicle apparatus 200 may generate an RAND message from

the navigation message received from the QZS 3, and generate comparative parity data from the RAND message and the H-matrix acquired from the authentication center 120. The generated comparative parity data is then compared with the parity data received from the QZS 3 to perform authentication.

[0173]

The authentication methods described in conjunction with the foregoing embodiments are merely examples. It is obvious that an alternative authentication method may be used.

[0174]

While the disclosure has been described with reference to preferred embodiments thereof, it is to be understood that the disclosure is not limited to the preferred embodiments and constructions. The disclosure is intended to cover various modification and equivalent arrangements. In addition, while the various combinations and configurations, which are preferred, other combinations and configurations, including more, less or only a single element, are also within the spirit and scope of the disclosure.

CLAIMS

1. A device with a positioning function comprising:
 - a satellite receiver (230) that receives signals from artificial satellites used in a satellite positioning system;
 - a positioning section (S1) that measures a position of a host device based on the signals received by the satellite receiver from the artificial satellites;
 - an authentication information acquisition section (S5) that acquires authentication information from an authentication center (120) disposed outside of the host device, wherein the authentication information is used to authenticate whether the signals from the artificial satellites are legitimate signals;
 - an authentication section (S9, S10, S11) that authenticates, based on the authentication information, whether the signals received by the satellite receiver are the legitimate signals from the artificial satellites;
 - an authentication level calculation section (S22) that calculates an authentication level based on at least one of a quantity of artificial satellites authenticated by the authentication section or a ratio of the artificial satellites authenticated by the authentication section to the artificial satellites used for positioning the host device by the positioning section; and
 - a positioning result transmission processing section (S24) that successively transmits a positioning result measured by the positioning section to a different device other than the host device, wherein the positioning result transmission processing section attaches the authentication level calculated by the authentication level calculation section to the positioning result before transmitting the positioning result.
2. The device with a positioning function according to claim 1, wherein
 - the device with a positioning function is used for a movable body, and
 - the positioning result transmission processing section transmits the positioning result and the authentication level to the different device which is

disposed outside of the movable body.

3. The device with a positioning function according to claim 1, wherein

the device with a positioning function is used for a movable body, and
the positioning result transmission processing section transmits the positioning result and the authentication level to the different device which is disposed in the movable body.

4. A device with a positioning function comprising:

a satellite receiver (530) that receives signals from artificial satellites used for a satellite positioning system;

a positioning section (S1) that measures a position of a host device based on the signals received by the satellite receiver from the artificial satellites;

an authentication information acquisition section (S5) that acquires authentication information from an authentication center disposed outside of the host device, wherein the authentication information is used to authenticate whether the signals from the artificial satellites are legitimate signals;

an authentication section (S9, S10, S11) that authenticates, based on the authentication information, whether the signals received by the satellite receiver are legitimate signals from the artificial satellites;

an authentication level calculation section (S102) that calculates an authentication level based on at least one of a quantity of artificial satellites authenticated by the authentication section or a ratio of the artificial satellites authenticated by the authentication section to the artificial satellites used for positioning the host device by the positioning section;

an execution section (S135, S156) that executes a positioning result utilization process, wherein the positioning result utilization process is a process which utilizes a positioning result measured by the positioning section; and

a utilization determination section (S104, S105, S106, S123, S128,

S144, S149) that determines, based on the authentication level calculated by the authentication level calculation section, whether to utilize the positioning result measured by the positioning section in the positioning result utilization process.

5. The device with a positioning function according to claim 4, wherein,

when a reliability of the positioning result required for the positioning result utilization process increases, the utilization determination section increases a reference level with which the authentication level is compared for permitting a utilization of the positioning result in the positioning result utilization process, and

the positioning result utilization process is executed by the execution section and the positioning result is measured by the positioning section.

6. The device with a positioning function according to claim 4 or 5, wherein the device with a positioning function is used for a movable body, the device with a positioning function further comprising:

a storage processing section (S125, S146) that successively stores, under a condition that an activation condition of the positioning result utilization process is satisfied and the authentication level calculated by the authentication level calculation section is lower than an authentication level required for the positioning result utilization process, the positioning results measured by the positioning section from a time point at which the activation condition of the positioning result utilization process is satisfied; and

a continuity determination section (S129, S150) that determines, under a condition that the authentication level calculated by the authentication level calculation section becomes equal to the authentication level required for the positioning result utilization process, whether the positioning result, which is obtained when the authentication level calculated by the authentication level calculation section becomes equal to the authentication level required for the positioning result utilization process, is continuous with the positioning results that have been successively stored by

the storage processing section,

wherein, when the continuity determination section determines a presence of continuity, the execution section additionally utilizes the positioning results that have been successively stored by the storage processing section in the positioning result utilization process.

7. The device with a positioning function according to claim 6, wherein the movable body for which the device with a positioning function is used is a vehicle, the device with a positioning function further comprising:

a parking determination section (S142) that determines whether the vehicle is parked, wherein,

when the authentication level calculated by the authentication level calculation section is lower than the authentication level required for the positioning result utilization process, the authentication section repeatedly authenticates the signals from the artificial satellites even when the parking determination section determines that the vehicle is parked,

when the parking determination section determines that the vehicle is parked, the activation condition of the positioning result utilization process is satisfied, and the authentication level calculated by the authentication level calculation section is lower than the authentication level required for the positioning result utilization process, the storage processing section successively stores the positioning results measured by the positioning section from the time point at which the activation condition of the positioning result utilization process is satisfied, and

when the authentication level calculated by the authentication level calculation section becomes equal to the authentication level required for the positioning result utilization process, the continuity determination section determines whether a difference between the positioning result obtained when the authentication level calculated by the authentication level calculation section becomes equal to the authentication level required for the positioning result utilization process and the positioning result previously stored by the storage processing section is smaller than a predetermined value for determining the presence of continuity.

8. The device with a positioning function according to claim 6 or 7, wherein

the positioning result utilization process is a billing process that bills a user when the movable body is placed within a predetermined region,

when an activation condition of the billing process is satisfied and the authentication level calculated by the authentication level calculation section is lower than an authentication level required for the billing process, the execution section does not execute the billing process until the authentication level calculated by the authentication level calculation section becomes equal to the authentication level required for the billing process,

when the authentication level calculated by the authentication level calculation section becomes equal to the authentication level required for the billing process and the continuity determination section determines the presence of continuity, the execution section additionally utilizes the positioning results that have been successively stored by the storage processing section in the billing process, and

the device with a positioning function further includes a notification processing section (S124, S145) that notifies the user of a possibility for a billing later on when the activation condition of the billing process is satisfied and the authentication level calculated by the authentication level calculation section is lower than the authentication level required for the billing process.

9. A positioning result receiving device comprising:

a positioning result reception processing section (S42, S61, S81) that receives a positioning result transmitted from a device (200) with a positioning function, wherein the device with a positioning function authenticates whether signals received by a satellite receiver (230) are legitimate signals that are transmitted from artificial satellites used in a satellite positioning system, and the positioning result received by the positioning result reception processing section is attached with an authentication level calculated based on at least one of a quantity of artificial satellites that are authenticated or a ratio of the artificial satellites that are

authenticated to artificial satellites used in measuring of the position result by the device with a positioning function;

an execution section (S75, S96) that executes a positioning result utilization process, wherein the positioning result utilization process is a process which utilizes the positioning result received by the positioning result reception processing section; and

a utilization determination section (S43, S44, S45, S63, S68, S84, S89) that determines, based on the authentication level attached to positioning result received by the positioning result reception processing section, whether to utilize the positioning result in the positioning result utilization process.

10. The positioning result receiving device according to claim 9, wherein,

when a reliability of the positioning result required for the positioning result utilization process increases, the utilization determination section increases a reference level with which the authentication level is compared for permitting a utilization of the positioning result in the positioning result utilization process, and

the positioning result utilization process is executed by the execution section and the positioning result is received by the positioning result reception processing section.

11. The positioning result receiving device according to claim 9 or 10, wherein the device with a positioning function is used for a movable body and the positioning result reception processing section receives, from the device with a positioning function, the positioning result to which the authentication level is attached, the positioning result receiving device further comprising:

a storage processing section (S65, S86) that successively stores, under a condition that an activation condition of the positioning result utilization process is satisfied and the authentication level received by the positioning result reception processing section is lower than the authentication level required for the positioning result utilization process, the positioning results received after the activation condition of the positioning

result utilization process is satisfied; and

a continuity determination section (S70, S91) that determines, under a condition that the authentication level received by the positioning result reception processing section becomes equal to the authentication level required for the positioning result utilization process, whether the positioning result to which the authentication level is attached is continuous with the positioning results that have been successively stored by the storage processing section,

wherein, when the continuity determination section determines a presence of continuity, the execution section additionally utilizes the positioning results that have been successively stored by the storage processing section in the positioning result utilization process.

12. The positioning result receiving device according to claim 11, wherein the device with a positioning function is used for the movable body and the positioning result reception processing section receives, from the device with a positioning function, the positioning result to which the authentication level is attached, the positioning result receiving device further comprising:

a parking determination section (S82) that determines whether the movable body is parked, wherein,

when the parking determination section determines that the movable body is parked, the activation condition of the positioning result utilization process is satisfied, and the authentication level received by the positioning result reception processing section is lower than the authentication level required for the positioning result utilization process, the storage processing section successively stores the positioning results received after the activation condition of the positioning result utilization process is satisfied, and

when the authentication level received by the positioning result reception processing section becomes equal to the authentication level required for the positioning result utilization process, the continuity determination section determines whether a difference between the positioning results to which the authentication level is attached and the

positioning result previously stored by the storage processing section is smaller than a predetermined value for determining the presence of continuity.

13. The positioning result receiving device according to claim 11 or 12, wherein

the positioning result utilization process is a billing process that bills a user when the movable body is placed within a predetermined region,

when an activation condition of the billing process is satisfied and the authentication level received by the positioning result reception processing section is lower than the authentication level required for the billing process, the execution section does not execute the billing process until the authentication level received by the positioning result reception processing section becomes equal to the authentication level required for the billing process,

when the authentication level received by the positioning result reception processing section becomes equal to the authentication level required for the billing process and the continuity determination section determines the presence of continuity, the execution section additionally utilizes the positioning results that have been successively stored by the storage processing section in the billing process, and

the positioning result receiving device further includes a notification processing section (S64, S85) that notifies the user of a possibility for a billing later on when the activation condition of the billing process is satisfied and the authentication level received by the positioning result reception processing section is lower than the authentication level required for the billing process.

14. A positioning result utilizing system comprising:

a device (200) with a positioning function; and

a positioning result receiving device (300, 400), wherein

the device (200) with a positioning function includes:

a satellite receiver (230) that receives signals from artificial satellites used in a satellite positioning system;

a positioning section (S1) that measures a position of a host device based on the signals received by the satellite receiver from the artificial satellites;

an authentication information acquisition section (S5) that acquires authentication information from an authentication center disposed outside of the host device, the authentication information being used to authenticate whether the signals from the artificial satellites are legitimate signals;

an authentication section (S9, S10, S11) that authenticates, based on the authentication information, whether the signals received by the satellite receiver are the legitimate signals from the artificial satellites;

an authentication level calculation section (S22) that calculates an authentication level based on at least one of a quantity of artificial satellites authenticated by the authentication section or a ratio of the artificial satellites authenticated by the authentication section to the artificial satellites used for positioning the host device by the positioning section; and

a positioning result transmission processing section (S24) that successively transmits a positioning result measured by the positioning section to a different device other than the host device, the positioning result transmission processing section attaching the authentication level calculated by the authentication level calculation section to the positioning result before transmitting the positioning result, and

the positioning result receiving device (300, 400) includes:

a positioning result reception processing section (S42, S61, S81) that receives positioning result successively transmitted from the device (200) with a positioning function, the authentication level being attached to the positioning result;

an execution section (S75, S96) that executes a positioning result utilization process which utilizes the positioning result received by the positioning result reception processing section; and

a utilization determination section (S43, S44, S45, S63, S68, S84, S89) that determines, based on the authentication level attached to positioning result received by the positioning result reception processing

section, whether to utilize the positioning result in the positioning result utilization process.