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 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 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 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 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~~NO" in S12), process returns to step S2 in order to repeat steps S2 and the followings.

[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 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

information and a position indicated by the position information to which the authentication level acquired in step S~~66~~87 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 S~~66~~87 is attached is equal to or lower than the threshold value. The threshold value can be preliminarily defined as a proper value.

[0123]

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 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. 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 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 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]

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 which is a vehicle 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~~vehicle is parked, wherein,

when the parking determination section determines that the ~~movable body~~vehicle 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