

{DESCRIPTION}

VEHICLE-MOUNTED DEVICE AND TOLL COLLECTION SYSTEM

{Technical Field}

{0001}

5 The present invention relates to a vehicle-mounted device
and a toll collection system.

{Background Art}

{0002}

 In recent years, as measures for alleviating traffic
10 congestion, air pollution, etc. caused by having an excessive
number of automobiles driving into large urban centers, so-
called road pricing has been realized wherein a toll charge
area is set in an urban area and a certain toll amount is
charged to vehicles that enter this toll charge area. In the
15 road pricing, for example, a gantry provided with a toll-
charging wireless communication device is provided at each
entrance/exit of the toll charge area, and toll charging
processing is performed when a vehicle passes through the
gantry. As toll charging methods, for example, a method in
20 which a certain toll amount is withdrawn from a balance in a
prepaid card inserted in a vehicle-mounted device and a
remaining amount is recorded in the prepaid card as an updated
balance, a method in which a certain toll amount is
automatically withdrawn from a preregistered bank account of a
25 user, and so on have been employed.

{0003}

The ETC (Electronic Toll Collection) system is a known automatic road usage fee collection system. The ETC system makes it possible to automatically collect tolls through
5 wireless communication between a road-side wireless unit provided in a toll booth and a vehicle-mounted device installed in a vehicle.

In such a toll collection system and ETC system related to road pricing, a toll collection method is being considered
10 for situations where the existing toll charge area is expanded.

For example, Patent Literature 1 discloses a technique in which a vehicle-mounted device detects whether or not an expanded toll charge area has been entered on the basis of
15 positional information acquired by a GPS receiver and, when entering an existing toll charge area, this detection result is reported to a toll collection device provided in the toll charge area, thereby causing the toll collection device to collect the road usage fee for the expanded toll charge area.

20 {Citation List}

{Patent Literature}

{0004}

{PTL 1} Japanese Unexamined Patent Application, Publication No. 2008-9731.

25 {Summary of Invention}

{Technical Problem}

{0005}

In a toll collection system such as that described above, because there are cases in which the road usage fee is not
5 correctly paid due to fraudulent use by users, it is necessary to ascertain vehicle positional information in order to detect such fraudulence. Although the vehicle positional information is, for example, estimated on the basis of information acquired by a GPS receiver in a vehicle-mounted device, there
10 is a problem in the above-described Patent Literature 1 in that, even if the positional information acquired from the GPS receiver is shifted from an original position, the shift cannot be detected, and thus, the vehicle position cannot be corrected.

15 {0006}

The present invention has been conceived in light of the above-described circumstances, and an object thereof is to provide a vehicle-mounted device and a toll collection system that are capable of precisely correcting a vehicle position.

20 {Solution to Problem}

{0007}

In order to solve the above-described problems, the present invention employs the following solutions.

A first aspect of the present invention provides a
25 vehicle-mounted device that is installed in a vehicle and

exchanges information regarding toll charging with a toll collection device installed at a toll booth in a toll charge area, including a storage unit that stores map information in which information about an installation position of an antenna provided in the toll collection device is associated with antenna identification information; and a positional-information acquisition unit that acquires positional information of the vehicle, wherein the antenna identification information is acquired from the toll collection device when passing near the toll collection device, and when a vehicle position estimated on the basis of the acquired antenna identification information and the map information does not match a vehicle position estimated on the basis of the positional information acquired from the positional-information acquisition unit, the positional information acquired from the positional-information acquisition unit is corrected on the basis of the vehicle position estimated from the acquired antenna identification information.

{0008}

With such a configuration, the vehicle-mounted device that is installed in the vehicle and exchanges information regarding the toll charging with the toll collection device installed at a toll booth in the toll charge area acquires the identification information of the antenna of the toll collection device from the toll collection device when passing

near the toll collection device. When the vehicle-mounted device acquires the antenna identification information, the vehicle position is estimated on the basis of the installation position of the antenna of the toll collection device and the antenna identification information included in the map information stored in the storage unit. The vehicle position estimated on the basis of the antenna identification information acquired from the toll collection device is compared with the vehicle position estimated from the positional information acquired from the positional-information acquisition unit, and when the vehicle positions do not match, the positional information acquired from the positional-information acquisition unit is corrected. In this way, the vehicle position estimated by means of the toll collection device is compared with the vehicle position estimated from the positional-information acquisition means, and, when they do not match, the positional information acquired from the positional-information acquisition means is corrected; therefore, the precision of the positional information acquired from the positional-information acquisition unit can be maintained.

{0009}

In the above-described vehicle-mounted device according to the first aspect of the present invention, in the case in which the vehicle-mounted device is communicatably connected

with a central unit, which is a superordinate device of the toll collection device, via a wide-area communication unit for utilizing wideband wireless communication and is also communicatably connected with the toll collection device via a dedicated narrowband wireless communication unit for utilizing dedicated narrowband wireless communication, the map information may be such that it can be acquired from at least one of the wide-area communication unit, the dedicated narrowband wireless communication unit, and issuance maintenance equipment, which is a device other than the wide-area communication unit that is communicatably connected with the central unit.

Because the map information is downloaded to the vehicle-mounted device via any of the wide-area communication unit, the dedicated narrowband wireless communication unit, and the issuance maintenance equipment, the vehicle-mounted device can easily acquire the information for specifying the installation position of the toll collection device.

{0010}

In the map information in the above-described vehicle-mounted device according to the first aspect of the present invention, in the case in which the map information does not include the information about the installation position of the antenna of the toll collection device that corresponds to the antenna identification information acquired from the toll

collection device, the most recent map information may be acquired from the central unit via the wide-area communication unit.

In the case in which information of the toll collection device (installation position thereof) corresponding to the antenna identification information acquired from the toll collection device is not included in the map information provided in the vehicle-mounted device, by obtaining the most recent map information, the vehicle-mounted device can ascertain the most recent position of the toll collection device in a simple manner.

{0011}

With regard to the information about the installation position of the antenna for the map information in the above-described vehicle-mounted device according to the first aspect of the present invention, the information about the installation position of the antenna in the map information may be information that indicates a relative position for obtaining the vehicle position on the basis of a calculation or information that indicates an absolute position for specifying the vehicle position.

By having the information about the antenna installation position that is the relative position for obtaining the vehicle position on the basis of the calculation or the absolute position for directly specifying the vehicle

position, the vehicle position can be specified reliably.

{0012}

With the identification information about the antenna of the above-described vehicle-mounted device according to the

5 first aspect of the present invention, the antenna

identification information may include new/old distinction

information for distinguishing between old and new

information; and in the case in which the new/old distinction

information of the antenna identification information acquired

10 from the toll collection device does not match the new/old

distinction information of the antenna identification

information included in the map information, the most recent

map information may be acquired from the central unit via the

wide-area communication unit.

15 Because the most recent map information is acquired if

the new/old distinction information does not match for the

antenna identification number acquired from the toll

collection device and the antenna identification number

included in the map information, the vehicle-mounted device

20 can be provided with the most recent map information.

Accordingly, information about the most recent and accurate

installation position of the toll collection device can be

acquired.

{0013}

25 In the above-described vehicle-mounted device according

to the first aspect of the present invention, information about the installation position of the antenna may be acquired from the antenna of the toll collection device along with the antenna identification information.

5 Accordingly, the vehicle-mounted device can acquire the information about the installation position of the toll collection device in a simple manner.

{0014}

 In the case in which the information about the
10 installation position is acquired from the toll collection device in the above-described vehicle-mounted device according to the first aspect of the present invention, in the case in which information about an installation position of the toll collection device is acquired from the toll collection device,
15 information about an installation position of the toll collection device included in the map information may be replaced therewith.

 In the case in which there are changes in the installation position due to changes in the physical position
20 of the toll collection device, the information about the installation position of the toll collection device included in the map information in the vehicle-mounted device can be updated in a simple manner.

{0015}

25 A second aspect of the present invention provides toll

collection system including a vehicle-mounted device according to the first aspect of the present invention, wherein the antenna identification information includes new/old distinction information for distinguishing between new and old information, and, when the new/old distinction information for the antenna identification information acquired from the toll collection device does not match the new/old distinction information for the antenna identification information included in the map information, the most recent map information is acquired from the central unit via the wide-area communication unit; and the central unit that outputs the most recent map information to the vehicle-mounted device in accordance with an acquisition request for the most recent map information from the vehicle-mounted device, wherein, of the most recent map information, the central unit outputs to the vehicle-mounted device, as the most recent map information, only information corresponding to the antenna for which the new/old distinction information for an identification number of the antenna included in the map information in the vehicle-mounted device differs.

{0016}

In the case in which the new/old distinction information for the antenna identification number acquired from the toll collection device differs from the new/old distinction information that corresponds to the antenna identification

number included in the map information, the vehicle-mounted device according to the first aspect of the present invention acquires the antenna identification number that corresponds to the antenna for which the new/old distinction information
5 differs and the information about the antenna installation position from the central unit. Accordingly, when outputting the most recent map information to the vehicle-mounted device from the central unit, it is possible to reduce the load exerted on a communication medium.

10 {Advantageous Effects of Invention}
{0017}

The present invention affords an advantage in that it is possible to precisely correct a vehicle position.

{Brief Description of Drawings}
15 {0018}

Fig. 1 is a diagram showing the overall configuration of a toll collection system according to an embodiment of the present invention.

Fig. 2 is a block diagram showing, in outline, the toll
20 collection system according to the embodiment of the present invention.

Fig. 3 is a diagram in which an entry lane into a toll charge area is viewed from a road shoulder.

Fig. 4 is a diagram showing an example of marking laid
25 down below a vehicle detection device shown in Fig. 3.

Fig. 5 is a diagram showing the marking shown in Fig. 4 when a vehicle passes through.

Fig. 6 is a block diagram showing, in outline, the configuration of a vehicle-mounted device according to the
5 embodiment of the present invention.

Fig. 7 is a block diagram showing, in outline, the configuration of a central unit according to the embodiment of the present invention.

Fig. 8 is a diagram for explaining a case in which the
10 vehicle-mounted device passes through the toll charge area.

Fig. 9 is a diagram for simply explaining the operation of the vehicle-mounted device according to the embodiment of the present invention.

{Description of Embodiments}

15 {0019}

An embodiment of a vehicle-mounted device and a toll collection system according to the present invention will be described below with reference to the drawings.

Fig. 1 is a diagram showing the overall configuration of
20 the toll collection system according to the embodiment of the present invention.

As shown in Fig. 1, at all roads passing through the boundary of a toll charge area A, which is an area to which road pricing is applied, the toll collection system 1 is
25 provided with toll collection devices (not shown) that detect

entry of a vehicle 3 into the toll charge area A and/or its exit from the toll charge area A. For example, the toll collection devices are provided so as to individually correspond to entry lanes on which the vehicle 3 enters the toll charge area A and exit lanes on which the vehicle 3 exits the toll charge area A, and to exchange vehicle-mounted-device information with the vehicle-mounted device installed in the vehicle 3 that passes on the corresponding entry lane and exit lane.

10 {0020}

Fig. 2 is a block diagram showing, in outline, the configuration of the toll collection system. As shown in Fig. 2, a toll collection device 2 is provided with a first antenna 5, a camera 6, a vehicle detection device 7, and a second antenna 8. Furthermore, the toll collection device 2 is provided with a first antenna controller 9 that is connected to the first antenna 5, a camera controller 10 that is connected to the camera 6, a vehicle detection controller 11 that is connected to the vehicle detection device 7, and a second antenna controller 12 that is connected to the second antenna 8. Furthermore, the toll collection device 2 is provided with a central controller 13, an environmental controller 14 that is connected to the central controller 13, and a communication controller 15 that is connected to the central controller 13. The first antenna controller 9, the

camera controller 10, the vehicle detection controller 11, the second antenna controller 12, and the central controller 13 described above are connected with each other via a bus 16, thus establishing a state in which information can be

5 exchanged therebetween. In addition, the communication controller 15 is communicatably connected with a central unit 17, which is a superordinate device.

{0021}

In the toll collection device 2 having the above-
10 described configuration, the first antenna 5, the camera 6, the vehicle detection device 7, and the second antenna 8 are attached to gate-shaped support columns disposed so as to cross a road at the boundary of the toll charge area A. Fig. 3 is a diagram in which a driving lane is viewed from the
15 side. The first antenna 5 and the second antenna 8 are installed so that signals from the vehicle-mounted device in the vehicle 3 that is driven in the corresponding driving lane can be easily received. The first antenna 5 and the second antenna 8 are installed, for example, so that antenna beams
20 thereof are directed toward the corresponding driving lane.

{0022}

The first antenna 5 and the second antenna 8 acquire the vehicle-mounted-device information when the vehicle-mounted device passes near the area boundary of the toll charge area
25 A. Specifically, when a vehicle enters the toll charge area A

from an expanded toll charge area B (details of which will be described later) and/or when the vehicle exits the toll charge area A into the expanded toll charge area B, the first antenna 5 and the second antenna 8 output request signals to the vehicle-mounted device and acquire identification information of the vehicle-mounted device from the vehicle-mounted device. The identification information of the vehicle-mounted device includes the current time (for example, year, month, and day) at the time of entry/exit, a vehicle-mounted-device number pre-assigned to the vehicle-mounted device, a number on an IC card inserted into an IC card interface of the vehicle-mounted device, and so on. In addition, the first antenna 5 and the second antenna 8 are provided with a distance of about 10 m to 15 m therebetween. This is for the purpose of ensuring a sufficient processing time until the vehicle-mounted device outputs a response signal to the second antenna 8 in accordance with a signal (for example, the request signal for the identification information of the vehicle-mounted device) that the vehicle-mounted device has received from the first antenna 5.

The first antenna 5 and the second antenna 8 send their own antenna identification information to the vehicle-mounted device.

{0023}

In the case in which a fraudulent vehicle is detected,

the camera 6 acquires an image of a license plate of the fraudulent vehicle. Fraudulent vehicles refer to, for example, vehicles in which vehicle-mounted devices are not installed, vehicles in which vehicle-mounted devices corresponding to the vehicle type are not installed, vehicles in which IC cards are not inserted into the vehicle-mounted devices, vehicles for which a toll cannot be charged correctly because the balance recorded on the IC cards is lower than the amount to be collected, vehicles in which forged vehicle-mounted devices or forged IC cards are installed, and so on. Although whether or not a vehicle is fraudulent is judged on the basis of the identification information of the vehicle-mounted device, etc. acquired from the vehicle-mounted device by the first antenna 5 and the second antenna 8, a method for judging fraudulent vehicles will be described in detail later.

The vehicle detection device 7 detects the passage of the vehicle 3. For example, as shown in Fig. 4, a stripe-pattern marking is provided on the road below the vehicle detection device 7. The vehicle detection device 7 monitors the stripe pattern from above and detects the passage of the vehicle 3 when the stripe pattern cannot be detected normally as shown in Fig. 5.

{0024}

As shown in Fig. 1, the newly set expanded toll charge area B is set outside the toll charge area A. For example,

the expanded toll charge area B is an area set-up at a later time when there is a demand for expanding the toll charge area A that originally existed. The expanded toll charge area B may be provided so as to surround the toll charge area A, it
5 may be provided so that a portion thereof is in contact with the toll charge area A, or it may be an area that is separately provided without being in contact with the toll charge area A.

Unlike the above-described toll charge area A, the
10 expanded toll charge area B is not provided with the toll collection devices at the entry lanes and the exit lanes at the area boundary. Instead, the vehicle-mounted device installed in the vehicle 3 detects entry/exit thereinto/therefrom.

15 {0025}

Fig. 6 is a block diagram showing, in outline, the configuration of the vehicle-mounted device according to this embodiment. As shown in Fig. 6, a vehicle-mounted device 50 is provided with a power source circuit 23 that is connected
20 to a vehicle power source 21 and a built-in battery 22; a first wide-area communication unit 32; a GPS receiver (positional information acquisition unit) 24 that acquires information regarding positional information from GPS satellites and detects a current position; a vehicle-mounted-
25 device storage device (storage unit) 25 that stores various

information; a control unit 26; a communication unit 27 that communicates with the first antenna 5, the second antenna 8, etc. of the toll collection devices 2; a display unit 28; a notification unit 29, such as a buzzer, an LED, etc.; an IC card insertion portion 30 into which an IC card is inserted; an IC card interface (shown as "IC card I/F" in Fig. 6) provided in the IC card insertion portion 30; a correcting unit 33; and a communication port 34.

{0026}

In Fig. 6, the individual constituent elements, such as the GPS receiver 24, etc., need not necessarily be built into the interior of the vehicle-mounted device 50. For example, it suffices so long as the individual constituent elements are configured in such a way that they can exchange information.

As an example, it is possible to employ a configuration in which a portable terminal device having a GPS function is connected via an external terminal, and the GPS function provided in this portable terminal device is utilized as the GPS receiver 24.

The first wide-area communication unit 32 communicates with external devices and is communicatably connected with, for example, the central unit 17 (see Fig. 2), which is a superordinate device of the toll collection device 2.

{0027}

The power source circuit 23 controls a voltage mainly

supplied from the vehicle power source 21 to a voltage appropriate for the vehicle-mounted device 50 and supplies it to the individual portions that form the vehicle-mounted device 50. The built-in battery 22 is provided so that

5 sufficient power for communication is ensured even in the case in which the power supply from the vehicle power source 21 is interrupted.

Map information for the expanded toll charge area B set outside the toll charge area A is stored in the vehicle-mounted-device storage device 25. The map information in the
10 vehicle-mounted-device storage device 25 stores information about the installation positions of the antennas provided in the toll collection device 2 and the antenna identification information in association with each other.

15 {0028}

Information, such as vehicle information including vehicle owner information, vehicle type information, vehicle ID, and so on, information on vehicle current position, vehicle-mounted-device identification information, balance
20 information read out from the IC card, card information, etc., which is necessary for calculating the toll amount and for judging whether a vehicle is fraudulent, to be described later, is saved in the vehicle-mounted-device storage device 25. The information on the current position of the vehicle 3
25 is information that indicates the current position of the

vehicle 3 estimated at the control unit 26 on the basis of the map information and the positional information acquired by the GPS receiver 24.

{0029}

5 The IC card inserted into the IC card insertion portion 30 is, for example, a contact-type IC card containing an IC chip in which a flash memory or an MPU is installed. In addition to the card information, such as card ID number, etc., balance, use history, and so on are also stored in this
10 IC card. The information stored in the IC card can be read out/written by means of the control unit 26 via the IC card interface 31.

{0030}

 In such a vehicle-mounted device 50, when the IC card is
15 inserted into the IC card insertion portion 30, the control unit 26 reads out the IC card information and balance stored in the IC card via the IC card interface 31, writes them in into the vehicle-mounted-device storage device 25, and displays the balance on the display unit 28 for a certain
20 amount of time (for example, about 10 seconds). In the case in which the information can be correctly read out from the IC card, the control unit 26 activates the notification unit 29 in order to notify the correct operation to a user. Accordingly, the correct state is notified, for example, by a
25 sound emitted from a buzzer in the case in which the

notification unit 29 is a buzzer, and, if it is an LED or the like, by lighting the LED.

On the other hand, in the case in which the information cannot be read from the IC card, the control unit 26 displays
5 on the display unit 28 that an error has occurred, and also notifies the error to the user by activating the notification unit 29, thus prompting re-insertion of the IC card or the like. Note that notification methods used by the notification unit 29 differ between the time of correct operation and
10 abnormal operation.

{0031}

When the control unit 26 acquires the request signal from the toll collection device 2, it reads out the identification information of the vehicle-mounted device 50 and the vehicle
15 information stored in the vehicle-mounted-device storage device 25 and also outputs them to the toll collection device 2 as a response signal to the request signal. Upon acquiring the request signal from the toll collection device 2, the control unit 26 detects entry/exit information, which is entry
20 information for the case in which the vehicle 3 enters the toll charge area A from the expanded toll charge area B and/or exit information for the case in which it exits from the toll charge area A into the expanded toll charge area B, and outputs it to the central unit 17 via the first wide-area
25 communication unit 32. Together with the entry/exit

information, the control unit 26 outputs to the central unit 17 the current position information and the vehicle information used when detecting the entry/exit information.
{0032}

5 As shown in Fig. 7, the central unit 17 is provided with a second wide-area communication unit 18, a fraud judging unit 19, and a calculation unit 20. The second wide-area communication unit 18 communicates with external devices and, for example, communicatably connects with the vehicle-mounted
10 device. Although this second wide-area communication unit 18 will be described as being built into the central unit 17 in this embodiment, it is not limited thereto, and, for example, a mobile communication terminal, such as a mobile phone or the like, may be employed by connecting it to a connection
15 terminal provided in the central unit 17.
{0033}

 The fraud judging unit 19 judges whether a vehicle (hereinafter, referred to as "fraudulent vehicle") fraudulent (for example, manipulating the route traveled, etc.) on the
20 basis of the entry/exit information of the vehicle 3 acquired from the vehicle-mounted device via the second wide-area communication unit 18 and the entry/exit information of the vehicle 3 based on the vehicle-mounted-device identification information and the vehicle information acquired from the toll
25 collection device 2.

A case in which toll collection devices 2x, 2y, and 2z are provided at the area boundary between the expanded toll charge area B and the toll charge area A, as shown in Fig. 8, will be described as an example. The fraud judging unit 19 of the central unit 17 detects the response signal received from the vehicle 3 (whose vehicle ID is assumed be, for example, "C") by the toll collection device 2y and, on the basis of this response signal, detects that it has exited from the toll charge area A by means of the toll collection device 2y. In this case, of the entry/exit information acquired via the second wide-area communication unit 18, the fraud judging unit 19 detects the entry/exit information associated with the vehicle ID "C".

{0034}

Here, because the entry/exit information associated with the vehicle ID "C", which is acquired by the fraud judging unit 19 via the second wide-area communication unit 18, is determined on the basis of the actual vehicle position detected by means of GPS, the fraud judging unit 19 compares a vehicle position of the vehicle 3 having the vehicle ID "C" estimated from this entry/exit information with a vehicle position based on the response signal acquired from the toll collection device. On the basis of the information acquired from both sources described above, it is judged whether the detected (estimated) vehicle positions match. In the case in

which the positions do not match as a result of the judgment (for example, the position of the toll collection device 2z is detected in the entry/exit information, and so on), the fraud judging unit 19 judges that the vehicle having the vehicle ID "C" is a fraudulent vehicle because it is presumed that the response signal output from the vehicle 3 has been fraudulently manipulated, or the like.

{0035}

Furthermore, from the response signal acquired from the toll collection device 2, the fraud judging unit 19 judges whether or not the vehicle 3 is a fraudulent vehicle on the basis of whether or not it is equipped with the vehicle-mounted device 50 that corresponds to its vehicle type. For example, in the case in which the vehicle-type information detected from the vehicle-mounted-device identification information indicates "small size", such as a light automobile, etc., despite the indication of "large size", such as a truck, etc., in the vehicle information for the vehicle type, the vehicle is judged to be a fraudulent vehicle because a vehicle-mounted device differing from the actual vehicle type is installed.

In this way, the fraud judging unit 19 outputs the judgment result as to whether or not a vehicle is fraudulent, as described above, to the calculation unit 20.

{0036}

On the basis of the acquired entry/exit information, the calculation unit 20 calculates the toll amount for a vehicle user as a road usage fee for the user of the vehicle 3. In addition, the calculation unit 20 calculates the toll amount on the basis of the judgment result as to whether or not the vehicle is fraudulent, acquired from the fraud judging unit 19. For example, the calculation unit 20 calculates a toll amount to which a benefit, such as a discount or the like, is applied for the vehicle 3 that has been judged not to be a fraudulent vehicle, and calculates a toll amount to which a benefit, such as a discount or the like, is not applied for the vehicle 3 that has been judged to be a fraudulent vehicle and also registers the vehicle on a blacklist in which information regarding fraudulent vehicles is recorded.

{0037}

Specifically, the calculation unit 20 is provided with a central-unit storage device 37 that stores a blacklist 34 in which the information regarding fraudulent vehicles is registered, a first toll charge table (first toll charge information) 35, in which toll charge information regarding the expanded toll charge area B is registered, and a second toll charge table (second toll charge information) 36, in which toll charge information regarding the toll charge area A is registered, and an amount determining unit 38 that, on the basis of the entry/exit information received from the vehicle-

mounted device 50, determines the toll amount for the vehicle 3 in which the vehicle-mounted device 50 is installed.

{0038}

In the first toll charge table 35, for example, amounts to be collected in accordance with vehicle types (classified as large size, medium size, small size, etc.) are registered as first toll amounts. The registered information is for example, 0.8 dollars for the small size, one dollar for the medium size, two dollars for the large size, and so on.

In the second toll charge table 36, the amounts to be collected are registered in accordance with the vehicle types, as described above, and, furthermore, second toll amounts which are separated into amounts to be collected for the case in which the expanded toll charge area B has been entered and amounts to be collected for the case in which it has not been entered are registered. For example, for the medium-size vehicles, 0.5 dollars for the case in which the expanded toll charge area B has been entered and one dollar for the case in which it has not been entered are registered.

In this way, by differentiating amounts for the case in which the expanded toll charge area B has been entered and those for the case in which it has not been entered and by setting amounts to which a benefit, such as a discount or the like, is applied in accordance with a route, distance, etc., it is made possible to give a driver, etc. of the vehicle 3

that has passed through the expanded toll charge area B a sense of getting a good deal.

{0039}

When passing near the toll collection device, the
5 correcting unit 33 acquires the antenna identification
information from the toll collection device, and, when the
vehicle position estimated on the basis of the acquired
antenna identification information and the map information
does not match with the position of the vehicle 3 estimated on
10 the basis of the positional information acquired from the GPS
receiver 24, the correcting unit 33 corrects the positional
information acquired from the GPS receiver 24 on the basis of
the position of the vehicle 3 estimated from the acquired
antenna identification information.

15 {0040}

The communication port 34 is an interface for
communicating with external devices, and is connectable with,
for example, a wireless or wired communication medium. In
this embodiment, the communication port is assumed to be
20 connected to issuance maintenance equipment via a wired
network (for example, Ethernet (registered trade name)). The
issuance maintenance equipment 35 is communicatably connected
with the central unit 17, and a medium for communicatably
connecting with the central unit 17 is not particularly
25 limited.

{0041}

Next, operation specifics of the above-described vehicle-mounted device 50 in the case in which the vehicle 3 enters the toll charge area A after entering the expanded toll charge area B will be described by using Figs. 6 and 9.

As shown in Fig. 9, the GPS receiver 24 of the vehicle-mounted device 50 acquires positional information regarding the current position from a plurality of GPS satellites during driving. When the GPS receiver 24 outputs the acquired positional information to the control unit 26, the control unit 26 detects the current positional information of the vehicle 3 on the basis of the positional information and the map information stored in the vehicle-mounted-device storage device 25 and also stores it in the vehicle-mounted-device storage device 25. Subsequently, upon receiving the request signal from the first antenna 5 of the toll collection device 2 in response to the passage of the vehicle 3 near the toll collection device 2, the control unit 26 detects the entry/exit information of the vehicle 3 on the basis of the current positional information stored in the vehicle-mounted-device storage device 25.

{0042}

For example, in the case in which the current positional information stored in the vehicle-mounted-device storage device 25 is the "expanded toll charge area B" and the control

unit 26 detects that new current positional information after receiving the request signal from the first antenna 5 is the "toll charge area A", "entry to the toll charge area A from the expanded toll charge area B" is detected for the vehicle 5 3, and this is used as the entry/exit information. In addition, for example, in the case in which the current positional information stored in the vehicle-mounted-device storage device 25 is the "toll charge area A" and the control unit 26 detects that new current positional information after 10 receiving the request signal from the first antenna 5 is the "expanded toll charge area B", "exit from the toll charge area A to the expanded toll charge area B" is detected for the vehicle 3, and this is used as the entry/exit information.

{0043}

15 The control unit 26 outputs the entry/exit information (for example, "entry to the toll charge area A from the expanded toll charge area B") detected in this way to the central unit 17 via the first wide-area communication unit 32.

20 The central unit 17 determines the toll amount to be collected from the user of the vehicle 3 as a road usage fee based on the entry/exit information obtained via the second wide-area communication unit and sends the information about the determined toll amount to the vehicle-mounted device 50. Upon receiving the information about the toll amount via the 25 first wide-area communication unit 32, the control unit 26 of

the vehicle-mounted device 50 subtracts the amount in accordance with the acquired information about the toll amount from the balance recorded on the IC card, and the balance thereof is recorded on the IC card as an updated balance.

5 {0044}

Next, the operation in the case in which the above-described vehicle-mounted device 50 corrects the positional information of the vehicle (vehicle-mounted device) will be described.

10 When the vehicle 3 passes near the toll collection device 2, the antenna identification information is sent to the vehicle-mounted device 50 from the first antenna 5 provided in the toll collection device 2. The control unit 26 of the vehicle-mounted device 50 outputs the acquired identification
15 information for the antenna (for example, first antenna 5) of the toll collection device 2 and the map information read out from the storage device 25 to the correcting unit 33. Because the installation position information for the antennas provided in the toll collection device 2 is associated with
20 the antenna identification information in the map information, a first current position of the vehicle-mounted device 50 is estimated at the correcting unit 33 on the basis of the map information and the acquired antenna identification
information.

25 {0045}

In addition, the positional information is acquired from the GPS receiver 24 of the vehicle-mounted device 50, and a second current position of the vehicle-mounted device 50 is estimated at the correcting unit 33 on the basis of this positional information. Furthermore, the correcting unit 33 compares the first current position and the second current position, and in the case in which they do not match, it corrects the positional information from the GPS receiver 24 by correcting the second current position on the basis of the first current position. Accordingly, it is possible to improve the precision of the position detected by the vehicle-mounted device 50.

{0046}

In addition, in the case in which installation positions of the toll collection devices 2 are changed due to construction, etc., in the case in which new toll collection devices 2 are installed, and so on, the positional information of the toll collection devices 2 registered in the map information stored in the storage device 25 of the vehicle-mounted device 50 becomes outdated information, and thus, there are cases in which correction of the positional information cannot be performed correctly. Accordingly, it is preferable that, before correcting the positional information, the vehicle-mounted device 50 judge whether or not the map information provided in the storage device 25 of the vehicle-

mounted device 50 is the most recent information, and that it acquires the most recent map information in the case in which the most recent map information is not provided in the vehicle-mounted device 50.

5 {0047}

For example, when judging whether or not the map information is the most recent information, new/old distinction information (for example, update information that indicates at what point in time the information is for) for
10 the antenna installation positions, such as version numbers, etc., is included in the identification information of the antennas (for example, the first antennas 5) of the toll collection devices 2, and it is judged whether or not this new/old distinction information (update information) of the
15 antenna installation positions match between when the information is acquired from the toll collection devices 2 and when it is read out from the map information. When they do not match, the vehicle-mounted device 50 acquires the most recent map information included in the map information from
20 the central unit. The most recent map information may also be acquired when the acquired antenna identification information cannot be obtained from the map information in addition to the case in which the new/old distinction information (update information), such as version numbers, etc., do not match, as
25 described above.

{0048}

In the above description, the case in which the vehicle-mounted device 50 acquires the most recent map information has been described assuming that the entire map information
5 provided in the central unit is downloaded; however, it is not limited thereto. For example, the vehicle-mounted device 50 may report to the central unit the information about the positional information with respect to the identification information of the antenna selected by the vehicle-mounted
10 device 50 as a download target, and, of the entire map information, the central unit may output only the information about the positional information corresponding to the identification information of the reported antenna. By exchanging only the positional information corresponding to
15 the identification information of the selected antenna between the central unit and the vehicle-mounted device 50 in this way, it is possible to reduce the communication load between the central unit and the vehicle-mounted device 50.

{0049}

20 In addition, the vehicle-mounted device 50 downloads the most recent map information having correct installation position information of the toll collection devices 2 from at least one of the first wide-area communication unit 32, a dedicated narrowband wireless communication unit (DSRC;
25 Dedicated Short Range Communication), and the issuance

maintenance equipment, which is a device other than the first wide-area communication unit that is communicatably connected with the central unit. Accordingly, the vehicle-mounted device 50 can easily acquire the information for specifying the installation positions of the toll collection devices 2 from a plurality of pathways.

{0050}

As has been described above, with the vehicle-mounted device 50 and the toll collection device 2 according to this embodiment, when passing near the toll collection device 2, the vehicle-mounted device 50, which is installed in the vehicle 3 and exchanges information regarding toll charging with the toll collection devices installed at toll booths of the toll charge area A, acquires the identification information of the antennas of the toll collection device 2 from the toll collection device 2. When the vehicle-mounted device 50 acquires the antenna identification information, the position of the vehicle 3 is estimated on the basis of the installation position of the antennas of the toll collection device 2 and the antenna identification information included in the map information stored in the storage device 25. The vehicle position estimated on the basis of the antenna identification information acquired from the toll collection device 2 is compared with the vehicle position estimated from the positional information acquired from the GPS receiver 24,

and, when the vehicle positions do not match, the positional information acquired from the GPS receiver 24 is corrected. In this way, the vehicle position estimated by means of the toll collection device 2 and the vehicle position estimated by means of the GPS receiver 24 are compared and, when they do not match, the positional information acquired from the GPS receiver 24 is corrected; therefore, the precision of the positional information acquired from the GPS receiver 24 can be maintained.

10 {0051}

The positional information that indicates the information about the antenna installation positions in the map information in this embodiment may be information that indicates relative positions for obtaining vehicle positions based on calculations, or it may be information that indicates absolute positions for specifying the vehicle positions. Accordingly, regardless of whether the information is about relative positions or absolute positions, the information about the antenna installation positions can reliably specify vehicle positions.

{0052}

{Modification}

In the above-described embodiment, whether or not the map information provided in the storage device 25 is the most recent information is judged on the basis of the update

information (for example, version numbers) of the antenna identification information, and, when it is not the most recent, the most recent map information is obtained by externally downloading it; however, there is no particular
5 limitation to the method with which the vehicle-mounted device
50 acquires the most recent map information.

{0053}

For example, the antenna identification information output from the toll collection device 2 may include the
10 information about the antenna installation positions. In such a case, the vehicle-mounted device 50 that has acquired the antenna identification information including the information about the antenna installation positions updates, of the map information stored in the vehicle-mounted-device storage
15 device 25, the information about the antenna installation positions corresponding to the acquired antenna identification information. Alternatively, priority orders are set in advance on the basis of the predetermined conditions for the information about the antenna installation positions acquired
20 along with the antenna identification information and the information about the antenna installation positions that corresponds to the antenna identification information stored in the vehicle-mounted-device storage device 25, and the map information may be updated on the basis of the priority
25 orders.

Accordingly, the amount of time for comparing the updating information of the antennas in the vehicle-mounted device 50 can be reduced, and the information about the antenna installation positions can be quickly obtained.

- 5 {Reference Signs List}
- {0054}
- 1 toll collection system
- 3 vehicle
- 17 central unit
- 10 18 second wide-area communication unit
- 24 GPS receiver
- 25 vehicle-mounted-device storage device
- 32 first wide-area communication unit
- 33 correcting unit
- 15 34 communication port
- 35 issuance maintenance equipment
- 50 vehicle-mounted device

{CLAIMS}

{Claim 1}

A vehicle-mounted device that is installed in a vehicle
5 and exchanges information regarding toll charging with a toll
collection device installed at a toll booth in a toll charge
area, comprising:

a storage unit that stores map information in which
information about an installation position of an antenna
10 provided in the toll collection device is associated with
antenna identification information; and

a positional-information acquisition unit that acquires
positional information of the vehicle,

wherein the antenna identification information is
15 acquired from the toll collection device when passing near the
toll collection device, and when a vehicle position estimated
on the basis of the acquired antenna identification
information and the map information does not match a vehicle
position estimated on the basis of the positional information
20 acquired from the positional-information acquisition unit, the
positional information acquired from the positional-
information acquisition unit is corrected on the basis of the
vehicle position estimated from the acquired antenna
identification information.

{Claim 2}

A vehicle-mounted device according to Claim 1, wherein,
in the case in which the vehicle-mounted device is
communicatably connected with a central unit, which is a
5 superordinate device of the toll collection device, via a
wide-area communication unit for utilizing wideband wireless
communication and is also communicatably connected with the
toll collection device via a dedicated narrowband wireless
communication unit for utilizing dedicated narrowband wireless
10 communication,

the map information can be acquired from at least one of
the wide-area communication unit, the dedicated narrowband
wireless communication unit, and issuance maintenance
equipment which is a device other than the wide-area
15 communication unit that is communicatably connected with the
central unit.

{Claim 3}

A vehicle-mounted device according to Claim 2, wherein,
20 in the case in which the map information does not include the
information about the installation position of the antenna of
the toll collection device that corresponds to the antenna
identification information acquired from the toll collection
device, the most recent map information is acquired from the
25 central unit via the wide-area communication unit.

{Claim 4}

A vehicle-mounted device according to Claim 1 or 2,
wherein the information about the installation position of the
5 antenna in the map information is information that indicates a
relative position for obtaining the vehicle position on the
basis of a calculation or information that indicates an
absolute position for specifying the vehicle position.

10 {Claim 5}

A vehicle-mounted device according to any one of Claims 2
to 4, wherein

the antenna identification information includes new/old
distinction information for distinguishing between old and new
15 information; and

in the case in which the new/old distinction information
of the antenna identification information acquired from the
toll collection device does not match the new/old distinction
information of the antenna identification information included
20 in the map information, the most recent map information is
acquired from the central unit via the wide-area communication
unit.

{Claim 6}

25 A vehicle-mounted device according to any one of Claims 1

to 5, wherein information about the installation position of the antenna is acquired from the antenna of the toll collection device along with the antenna identification information.

5

{Claim 7}

A vehicle-mounted device according to Claim 6, wherein, in the case in which information about an installation position of the toll collection device is acquired from the toll collection device, information about the installation position of the toll collection device included in the map information is replaced therewith.

{Claim 8}

15 A toll collection system comprising:

a vehicle-mounted device according to any one of Claims 2 to 4, wherein the antenna identification information includes new/old distinction information for distinguishing between new and old information, and, when the new/old distinction information for the antenna identification information acquired from the toll collection device does not match the new/old distinction information for the antenna identification information included in the map information, the most recent map information is acquired from the central unit via the wide-area communication unit; and

25

the central unit that outputs the most recent map information to the vehicle-mounted device in accordance with an acquisition request for the most recent map information from the vehicle-mounted device,

5 wherein, of the most recent map information, the central unit outputs to the vehicle-mounted device, as the most recent map information, only information corresponding to the antenna for which the new/old distinction information for an identification number of the antenna included in the map
10 information in the vehicle-mounted device differs.