

TOLL COLLECTION SYSTEM

{Technical Field}

 $\{0001\}$

5 The present invention relates to a toll collection system, and it relates, in particular, to a toll collection system that collects a predetermined fee from an owner of a vehicle that enters a toll road, a toll charge area, or the like.

10 {Background Art}

 $\{0002\}$

In recent years, as measures for alleviating traffic congestion, air pollution, etc. caused by having an excessive number of automobiles drive into large urban centers, so-called road pricing has been realized wherein a toll charge area is set up in an urban area and a certain toll amount is charged to vehicles that enter this toll charge area. In the 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 As toll charging methods, for example, a method in which a certain toll amount is withdrawn from a balance in a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amount is recorded in the prepaid card as an updated balance, a method in which a certain toll amount is automatically withdrawn from a preregistered bank account of a user, and so on have been employed.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 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 related to the road pricing and the ETC system, a toll collection method is being considered 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 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.

{Citation List}

{Patent Literature}

{0004}

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

{Summary of Invention}

{Technical Problem}

{0005}

- 10 However, because information that indicates whether
or not the expanded toll charge area has been entered is
indicated by a flag in the method of the above-described
Patent Literature 1, there is a problem in that
alteration work needs to be done on existing toll
15 collection devices in order to allow the toll collection
devices to distinguish whether or not the expanded toll
charge area has been entered in accordance with the
presence/absence of the flag.

{0006}

- 20 The present invention has been conceived in light of
the above-described circumstances, and an object thereof
is to provide a toll collection system that is capable of
expanding a toll charge area without requiring an
alteration to existing toll collection devices.

{Solution to Problem}

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

5 A first aspect of the present invention provides a toll collection system including a central unit that is a superordinate device of a toll collection device provided at a toll booth of a toll charge area; and a vehicle-mounted device that is provided in a vehicle and that
10 exchanges information with the central unit, wherein the vehicle-mounted device is provided with a storage unit that stores map information of an expanded toll charge area that is newly set up outside the toll charge area; a positional-information acquisition unit that acquires
15 positional information of the vehicle; and a control unit that, on the basis of the map information and the positional information, detects entry/exit information, which is entry information about the vehicle entering the toll charge area from the expanded toll charge area
20 and/or exit information about the vehicle exiting the toll charge area into the expanded toll charge area, and that outputs the entry/exit information to the central unit, and wherein the central unit is provided with a calculation unit that calculates a toll amount on the

basis of the acquired entry/exit information.

{0008}

With such a configuration, the vehicle-mounted device, which is provided in a vehicle and exchanges
5 information with the toll collection device provided at the toll booth in the toll charge area, detects the entry/exit information, which is the information about entry into the toll charge area from the expanded toll charge area and/or exit from the toll charge area into
10 the expanded toll charge area, on the basis of the map information of the expanded toll charge area, which is newly set up outside the toll charge area, and the acquired positional information, and the entry/exit information is output to the central unit. In addition,
15 the central unit calculates the toll amount on the basis of the acquired entry/exit information.

{0009}

Because the toll amount is calculated at the central unit in this way on the basis of the map information, the
20 positional information, and the information about the entry/exit between the expanded toll charge area and the toll charge area, it is not necessary to perform flag setting, etc. for allowing the toll collection device to judge whether or not the expanded toll charge area has

been entered, as has been conventionally done. Because of this, the toll collection devices do not have to be altered for making it possible to perform flag assessment, distinguish the entry/exit information, etc.,
5 and the toll charge area can be expanded while utilizing the existing toll collection device without any change.
{0010}

In the case in which the entry/exit information detected by the vehicle-mounted device is output to the
10 central unit, the case in which the information about the toll amount calculated at the central unit is output to the vehicle-mounted device, and so on, the exchange of the information between the vehicle-mounted device and the central unit may be performed via the toll collection
15 device or a device (for example, a wide-area communication unit) that directly exchanges the information between the vehicle-mounted device and the central unit; a route of exchanging the information between the vehicle-mounted device and the central unit
20 is not limited.
{0011}

A second aspect of the present invention provides a toll collection system including a central unit that is a superordinate device of a toll collection device provided

at a toll booth of a toll charge area; and a vehicle-mounted device that is provided in a vehicle and that exchanges information with the central unit, wherein the vehicle-mounted device is provided with a storage unit
5 that stores map information of an expanded toll charge area that is newly set up outside the toll charge area; a positional-information acquisition unit that acquires positional information of the vehicle; and a calculation unit that, in the case in which entry/exit information is
10 detected on the basis of the map information and the positional information, calculates a toll amount on the basis of the detection result, where the entry/exit information is entry information about the vehicle entering the toll charge area from the expanded toll
15 charge area and/or exit information about the vehicle exiting the toll charge area into the expanded toll charge area.

{0012}

With such a configuration, the vehicle-mounted
20 device, which is provided in a vehicle and exchanges information with the toll collection device provided at the toll booth in the toll charge area, detects entry from the expanded toll charge area into the toll charge area on the basis of the map information of the expanded

toll charge area, which is newly set up outside the toll charge area, and the acquired positional information, and the toll amount is calculated on the basis of this detection result. Because the toll amount is calculated at the vehicle-mounted device in this way on the basis of the map information, the positional information, and the information about entry/exit between the expanded toll charge area and the toll charge area, it is not necessary to perform flag setting, etc. for allowing the toll collection device to judge whether or not the expanded toll charge area has been entered.

{0013}

Because the toll amount is calculated at the vehicle-mounted device in this way, the toll collection devices do not have to be altered for making it possible to perform flag assessment, distinguish the entry/exit information, etc., and the toll charge area can be expanded while utilizing the existing toll collection device without any change.

In addition, in the case in which the toll amount calculated at the vehicle-mounted device is output to the central unit, the information may be output to the central unit via the toll collection device or it may be output to the central unit via a device (for example, a

wide-area communication unit) that directly exchanges the information with the central unit; a route for exchanging information between the vehicle-mounted device and the central unit is not limited.

5 {0014}

The vehicle-mounted device of the above-described toll collection system may be provided with a payment requesting unit that, when the information about the toll amount is acquired, requests payment of the toll amount
10 from a user in accordance with the information about the toll amount.

Because the vehicle-mounted device requests the payment of the toll amount from the user, the payment processing can be performed from an electromagnetic
15 medium, for example, an IC card or the like, installed in the vehicle-mounted device.

{0015}

The central unit of the above-described toll collection system may be provided with a payment
20 requesting unit that, when the information about the toll amount is acquired, requests payment of the toll amount from a user in accordance with the information about the toll amount.

Because the central unit requests the payment of the

toll amount from the user, the payment processing can be performed, for example, through processing for withdrawal from an bank account of the user, etc. via the central unit.

5 {0016}

The vehicle-mounted device of the above-described toll collection system may be provided with a first wide-area communication unit that exchanges the entry/exit information with the central unit; the central unit may
10 be provided with a second wide-area communication unit that exchanges the entry/exit information with the vehicle-mounted device; and the central unit is provided with may be provided with a fraud judging unit that compares the entry/exit information of the vehicle-
15 mounted device for the toll charge area acquired from the vehicle-mounted device via the toll collection device and the entry/exit information acquired from the vehicle-mounted device via the first wide-area communication unit and the second wide-area communication unit, and that
20 judges that the entry/exit information includes fraudulent information when the comparison result indicates a mismatch.

By comparing the entry/exit information for the toll charge area acquired from the toll collection device and

the entry/exit information for the toll charge area acquired from the wide-area communication unit, for example, in the case in which the entry/exit information has been manipulation, etc., fraud such as a manipulation
5 can be detected in a simple manner.

{0017}

The calculation unit of the above-described toll collection system may be provided with a storage device that stores first toll charge information with regard to
10 the expanded toll charge area newly set up outside the toll charge area and second toll charge information related to the toll charge area; and an amount determining unit that determines the toll amount on the basis of the entry/exit information, the first toll
15 charge information, and the second toll charge information.

{0018}

In this way, in the case in which the expanded toll charge area has been entered, the toll amount for the
20 expanded toll charge area and the toll amount for the toll charge area can be collected with a single payment. Accordingly, the toll collection can be performed for both the expanded toll charge area and the toll charge area with one unit of the calculation unit. As a result,

because it is not necessary to provide a new toll collection device for the expanded toll charge area, equipment cost can be reduced. Therefore, a new expanded toll charge area can be easily set up.

5 {0019}

The first toll charge information of the above-described toll collection system may include a toll charge table in which duration of stay in the expanded toll charge area is a parameter; and, when the duration
10 of stay in the expanded toll charge area is received from the vehicle-mounted device, the amount determining unit may determine the toll amount for the expanded toll charge area by using the duration of stay and the toll charge table.

15 Because the duration of stay in the expanded toll charge area is taken into consideration in the process of calculating the toll amount, it is possible to set a toll amount that is more reflective of the road usage situation.

20 {0020}

The first toll charge information of the above-described toll collection system may include a toll charge table in which distance traveled in the expanded toll charge area is a parameter; and, when the distance

traveled in the expanded toll charge area is received from the vehicle-mounted device, the amount determining unit may determine the toll amount for the expanded toll charge area by using the traveled distance and the toll charge table.

Because the distance traveled in the expanded toll charge area is taken into consideration in the process of calculating the toll amount, it is possible to set a toll amount that is more reflective of the road usage situation.

{0021}

With the above-described toll collection system, in the case in which a plurality of the expanded toll charge areas are set up, the first toll charge information may be provided corresponding to each of the expanded toll charge areas; the entry/exit information may be associated with identification information for the individual expanded toll charge areas; and the amount determining unit may determine the toll amount by using the first toll charge information for the expanded toll charge areas into which the vehicle has entered, which is determined on the basis of entry/exit information associated with the identification information of the expanded toll charge areas.

{0022}

In the case in which the plurality of the expanded toll charge area are set up, because the first toll charge information that corresponds to the individual expanded toll area is registered, it is possible to set a detailed toll amount for each of the expanded toll charge areas. Furthermore, even in the case in which the vehicle has entered a plurality of the expanded toll charge areas, the toll collection can be performed with a single payment.

{0023}

With the toll charge area of the above-described toll collection system, in the case in which the toll charge area is an area where a certain fee is collected at the time of entry regardless of a road usage situation, an award point table in which the duration of stay in the toll charge area is a parameter may be included; and, when the duration of stay in the toll charge area is received from the vehicle-mounted device, the amount determining unit may determine award points by using the duration of the stay and the award point table, and gives the award points to an owner of the vehicle.

{0024}

In the case in which the toll charge area is an area

where a certain amount of fee is collected at the time of entry regardless of the road usage situation, as in the road pricing or the like, because points in accordance with the duration of stay in the toll charge area is
5 awarded to the vehicle owner, it is possible to provide a financial relief to users who have entered the toll charge area by mistake or the like.

{Advantageous Effects of Invention}

{0025}

10 The present invention affords an advantage in that a toll charge area can be expanded without requiring an alteration to existing toll collection devices.

{Brief Description of Drawings}

{0026}

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

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

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

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

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

Fig. 10 is a diagram showing a processing procedure of communication performed among the vehicle-mounted device, the central unit, and the toll collection device in the first embodiment of the present invention.

Fig. 11 is a block diagram showing, in outline, the configuration of a vehicle-mounted device according to a second embodiment of the present invention.

Fig. 12 is a block diagram showing, in outline, the configuration of a central unit according to the second

embodiment of the present invention.

Fig. 13 is a diagram for simply explaining the operation of the vehicle-mounted device according to a third embodiment of the present invention.

5 Fig. 14 is a block diagram showing, in outline, the configuration of a vehicle-mounted device according to the third embodiment of the present invention.

Fig. 15 is a block diagram showing, in outline, the configuration of a central unit according to the third
10 embodiment of the present invention.

Fig. 16 is a block diagram showing, in outline, the configuration of a vehicle-mounted device according to a fourth embodiment of the present invention.

Fig. 17 is a block diagram showing, in outline, the
15 configuration of a vehicle-mounted device according to a fifth embodiment of the present invention.

Fig. 18 is a block diagram showing, in outline, the configuration of a vehicle-mounted device according to a sixth embodiment of the present invention.

20 Fig. 19 is a diagram showing an example point table.

{Description of Embodiments}

{0027}

Embodiments of a toll collection system according to the present invention will be described below with

reference to the drawings.

{First Embodiment}

A first embodiment of the present invention will be described below by using Fig. 1. Fig. 1 is an overall configuration diagram of a toll collection system
5 according to this embodiment.

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
10 1 is 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
15 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.

20 {0028}

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 exchanged therebetween. The communication controller 15 is communicatably connected with a central unit 17, which is a superordinate device.

20 {0029}

In the toll collection device 2 having the above-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 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 thereof are directed toward the corresponding driving lane.

10 {0030}

In addition, the first antenna 5 and the second antenna 8 acquire the vehicle-mounted-device information when the vehicle-mounted device passes near the boundary of the toll charge area 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,

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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. 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.

{0031}

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 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.

15 {0032}

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

{0033}

Fig. 6 is a block diagram showing, in outline, the
10 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 to a vehicle power source 21 and a built-in battery 22; a first wide-area communication unit 32; a
15 GPS receiver (positional information acquisition unit) 24 that acquires information regarding positional information from GPS satellites and detects a current position; a vehicle-mounted-device storage device (storage unit) 25 that stores various information; a
20 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 (payment requesting

unit) 30 into which an IC card is inserted; and an IC card interface 31 provided in the IC card insertion portion 30.

{0034}

5 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
10 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 this portable terminal device provided with the GPS function is utilized as the GPS
15 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
20 collection device 2.

{0035}

 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 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. Information, such as vehicle information including vehicle owner information, vehicle type information, vehicle ID, and so on, current positional information of the vehicle, vehicle-mounted-device identification information, balance 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 current positional information of the vehicle 3 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.

{0036}

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 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.

{0037}

In such a vehicle-mounted device 50, when the IC card is 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 into the vehicle-mounted-device storage device 25, and displays the balance on the display unit 28 for a certain 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 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 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-
5 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 abnormal operation.

{0038}

10 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 and the vehicle information stored in the vehicle-mounted-device storage device 25 and also outputs them to
15 the toll collection device 2 as a response signal to the request signal. In addition, upon acquiring the request signal from the toll collection device 2, the control unit 25 detects entry/exit information, which is entry information for the case in which the vehicle 3 enters
20 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 communication unit 32. Together with the

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

5 {0039}

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
10 external devices and, for example, communicatably connects with the vehicle-mounted 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,
15 a mobile communication terminal, such as a mobile phone or the like, may be employed by connecting it to a connection terminal provided in the central unit 17.

{0040}

The fraud judging unit 19 judges whether a vehicle
20 (hereinafter, referred to as "fraudulent vehicle") fraudulent (for example, manipulating the route traveled, etc.) on the 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 collection device 2.

5 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
10 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
15 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".

{0041}

20 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.

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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
5 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.

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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. The calculation unit 20 calculates the toll
15 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
20 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 to a blacklist in which information

regarding fraudulent vehicles is recorded.

{0044}

Specifically, the calculation unit 20 is provided with a central-unit storage device 37 that stores a
5 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
10 (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
15 the vehicle 3 in which the vehicle-mounted device 50 is installed.

{0045}

In the first toll charge table 35, for example, amounts to be collected in accordance with vehicle types
20 (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.

{0046}

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.

20 {0047}

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 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 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.

15 {0048}

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.

The central unit 17 determines the toll amount to be collected from the user of the vehicle 3 as a road usage fee 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 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.

{0049}

Next, details of communication processing performed between the toll collection device 2 and the vehicle-mounted device 50 when the toll charge area A is entered will be described by using Fig. 10.

First, when the area boundary of the toll charge area A is approached, the control unit 26 of the vehicle-mounted device 50 receives a request signal for the identification information of the vehicle-mounted device which is emitted from the first antenna 5 of the toll collection device 2 (step SA1 in Fig. 10) via the communication unit 27. Upon receiving the request signal, the control unit 26 reads out the identification information of the vehicle-mounted device and the vehicle information from the vehicle-mounted-device storage device 25 as response signals and sends the response signals to the toll collection device 2 via the

communication unit 27 (step SA2 in Fig. 10).

{0050}

The control unit 26 that has received the request signal detects the entry/exit information on the basis of the current positional information stored in the vehicle-mounted-device storage device 25 and also outputs the entry/exit information to the central unit 17 via the first wide-area communication unit 32 (step SA3 in Fig. 10). The toll collection device 2 outputs the acquired response signals to the central unit 17 in association with identification information of the toll collection device 2 itself (step SA4 in Fig. 10).

The central unit 17, which is a superordinate device of the toll collection device 2, determines an amount (toll amount) to be collected from a vehicle user on the basis of the response signals acquired from the toll collection device 2 and the entry/exit information acquired from the vehicle-mounted device 50. The central unit 17 judges, on the basis of the response signals, whether or not the vehicle 3 is provided with the vehicle-mounted device 50 corresponding to its vehicle type, and it judges a vehicle provided with the vehicle-mounted device 50 that does not correspond to its vehicle type to be a fraudulent vehicle.

{0051}

In the case in which the result of the above-described judgment as to whether or not a vehicle is a fraudulent indicates that it is not fraudulent vehicle,
5 the central unit 17 calculates the toll amount on the basis of the above-described toll charge table 35 and the toll charge table 36. On the other hand, in the case in which the vehicle is fraudulent, the central unit 17 registers the identification information of the vehicle-
10 mounted device installed in the vehicle 3 judged to be a fraudulent vehicle in the black list 34 and also calculates the toll amount for the vehicle 3 on the basis of the first toll amount and the second toll amount to which a benefit, such as a discount, etc., is not
15 applied.

{0052}

The central unit 17 calculates the toll amount to be collected from the user on the basis of the entry/exit information acquired from the vehicle-mounted device 50
20 and the identification information of the vehicle-mounted device, etc. acquired from the toll collection device 2, and outputs information about the calculated toll amount to the vehicle-mounted device 50 via the second wide-area communication unit 18 (step SA5 in Fig. 10). For example,

in the case in which the vehicle type is medium size and the expanded toll charge area B has been entered, an amount of one dollar is extracted from the first toll charge table as the first toll amount and an amount of 5 0.5 dollars is extracted from the second toll charge table as the second toll amount, and 1.5 dollars, which is the sum of the first toll amount and the second toll amount, is calculated as the toll amount to be charged to the user of the vehicle 3 as the road usage fee. Then, 10 the information about the calculated toll amount is sent to the vehicle-mounted device 50 via the second wide-area communication unit 18.

{0053}

Upon receiving the information about the toll amount 15 via the first wide-area communication unit 32, the vehicle-mounted device 50 sends an affirmative signal indicating the completion of communication to the second wide-area communication unit 18 (step SA6 in Fig. 10) and updates the balance on the IC card by subtracting the 20 toll amount from the balance on the IC card (step SA7 in Fig. 10). In the case in which the balance updating processing is correctly performed, the control unit 26 subsequently reads the updated balance and authenticator data from the IC card (step SA8 in Fig. 10). Here, the

authenticator data is information for reporting that the toll collection has been performed correctly.

{0054}

As has been described above, with the toll collection system 1 according to this embodiment, the vehicle-mounted device 50, which is provided in a vehicle and exchanges information with the toll collection devices 2 provided at the toll booths in the toll charge area A, detects the entry/exit information, which is the information about entry into the toll charge area A from the expanded toll charge area B and/or exit from the toll charge area A into the expanded toll charge area B, on the basis of the map information of the expanded toll charge area B, which is newly set up outside the toll charge area A, and the acquired positional information, and the entry/exit information is output to the central unit 17. In addition, the central unit 17 calculates the toll amount on the basis of the acquired entry/exit information. Because the toll amount is calculated at the central unit 17 in this way on the basis of the map information, the positional information, and the information about the entry/exit between the expanded toll charge area B and the toll charge area A, it is not necessary to perform flag setting, etc. for allowing the

toll collection devices 2 to judge whether or not the expanded toll charge area has been entered, as has been conventionally done. Because of this, the toll collection devices 2 do not have to be altered for making it possible to perform flag assessment, etc., and the toll charge area can be expanded while utilizing the existing toll collection devices 2 without any change.

{0055}

Because the central unit 17 judges the presence/absence of a fraudulent vehicle when the vehicles 3 pass by the toll collection devices 2 on the basis of the identification information of the vehicle-mounted devices acquired from the toll collection devices 2 and entry/exit information for the vehicles acquired from the vehicles 3 via the second wide-area communication unit 18, it is possible to enhance the accuracy of detecting a fraudulent vehicle.

{0056}

Although this embodiment has been described assuming that the payment requesting unit is provided in the vehicle-mounted device 50, that the information about the toll amount calculated at the central unit 17 is output to the vehicle-mounted device 50, and that payment clearance processing is performed at the vehicle-mounted

device 50, it is not limited thereto. For example, the payment requesting unit may be provided in the central unit. In this case, the central unit 17 may perform processing, such as direct withdrawal from a bank account of the user of the vehicle 3, by means of a payment processing device (not shown) connected to the central unit 17 on the basis of the information about the toll amount calculated at the central unit 17. By completing the payment clearance via the processing at the central unit 17 in this way instead of performing the payment clearance at the vehicle-mounted device 50, it is possible to reduce a communication load exerted on the wide-area wireless communication medium connecting the first wide-area communication unit 32 and the second wide-area communication unit 18.

{0057}

{Second Embodiment}

Next a toll collection system according to a second embodiment of the present invention will be described.

The toll collection system according to this embodiment differs from that of the first embodiment described above in that the calculation unit that calculates the toll amount to be charged to a vehicle as the road usage fee is provided in the vehicle-mounted

device. The toll collection system according to this embodiment will be described below mainly with regard to the differences, and descriptions will be omitted for aspects in common with those of the first embodiment. As
5 in the above-described first embodiment, the payment clearance processing may be performed at the vehicle-mounted device or it may be performed at the central unit; however, this embodiment will be described assuming that the payment clearance processing for the toll amount
10 calculated at the vehicle-mounted device is performed at the central unit.

{0058}

As shown in Fig. 11, a vehicle-mounted device 50a according to this embodiment is provided with the
15 calculation unit 20 that calculates a toll amount on the basis of a detection result when entry/exit information is detected. Specifically, when the entry/exit information, which is information about entry of a vehicle that has entered the toll charge area from the
20 expanded toll charge area and/or exit of a vehicle from the toll charge area into the expanded toll charge area, is detected on the basis of the map information stored in the vehicle-mounted-device storage device 25 and the positional information, the calculation unit 20

calculates the toll amount on the basis of this detection result. Because various parts included in the calculation unit 20 and processing performed at the various parts are the same as the contents described in the above-described first embodiment, detailed descriptions thereof will be omitted.

{0059}

As shown in Fig. 12, a central unit 17a is provided with the second wide-area communication unit 18, the fraud judging unit 19, and a payment requesting unit 40.

The payment requesting unit 40 requests payment of the toll amount from the vehicle user as the road usage fee. For example, the payment requesting unit 40 notifies the information about the toll amount to a payment clearance device 41 connected to the central unit 17a to cause the payment clearance device 41 to collect from the vehicle an amount in accordance with the acquired information about the toll amount. The payment clearance device 41 is, for example, a device that performs processing of withdrawing the toll amount from a bank account of the vehicle user, or the like.

{0060}

Next, the specifics of the operation of the above-described vehicle-mounted device 50a will be described by

using Figs. 11 and 12 for the case in which the vehicle enters the toll charge area after entering the expanded toll charge area.

When the vehicle enters the toll charge area from
5 the expanded toll charge area, the first antenna 5 of the toll collection device sends a request signal for the identification information of the vehicle-mounted device 50a, and the vehicle-mounted device sends the
identification information of the vehicle-mounted device
10 50a via the communication unit 27. The current positional information of the vehicle is stored in the vehicle-mounted-device storage device 25 on the basis of the positional information detected by the GPS receiver 24 of the vehicle-mounted device 50a and the map information
15 stored in the vehicle-mounted-device storage device 25.
{0061}

When the entry/exit information for the entry of the vehicle into the toll charge area from the expanded toll charge area is detected on the basis of the current
20 positional information, the entry/exit information indicating the entry from the expanded toll charge area into the toll charge area is output to the central unit 17a via the first wide-area communication unit 32 of the vehicle-mounted device 50a. The central unit 17a judges

whether or not the vehicle is a fraudulent vehicle on the basis of the entry/exit information for the vehicle estimated from the identification information of the vehicle-mounted device 50a acquired from the toll collection device and the entry/exit information acquired via the second wide-area communication unit 18. The central unit 17a sends the judgment result as to whether or not the vehicle is fraudulent to the vehicle-mounted device 50a via the second wide-area communication unit 18.

{0062}

The calculation unit 20 of the vehicle-mounted device 50a determines the toll amount to be collected from the user of the vehicle 3 as the road usage fee on the basis of the judgment result as to whether or not the vehicle is fraudulent acquired from the central unit 17a and the entry/exit information detected at a control unit 26a. The control unit 26a of the vehicle-mounted device 50a sends the information about the toll amount to the central unit 17a via the first wide-area communication unit 32. When the central unit 17a acquires the information on the toll amount via the second wide-area communication unit 18, the payment requesting unit 40 of the central unit 17a notifies the payment clearance

device 41 connected to the central unit 17a about the toll amount. The payment clearance device 41 collects the amount in accordance with the information about the toll amount from the vehicle user.

5 {0063}

As has been described above, with the toll collection system according to this embodiment, the vehicle-mounted device 50a, which is provided in a vehicle and exchanges information with the toll
10 collection devices provided at the toll booths in the toll charge area, detects entry from the expanded toll charge area into the toll charge area on the basis of the map information of the expanded toll charge area, which is newly set up outside the toll charge area, and the
15 acquired positional information, and the toll amount is calculated on the basis of this detection result. Because the toll amount is calculated at the vehicle-mounted device 50a in this way on the basis of the map information, the positional information, and the
20 information about entry/exit between the expanded toll charge area and the toll charge area, it is not necessary to perform flag setting, etc. for allowing the toll collection devices to judge whether or not the expanded toll charge area has been entered. Furthermore, the toll

amount calculated at the vehicle-mounted device 50a is notified to the central unit 17a via the first wide-area communication unit 32. Because of these features, the toll collection devices do not have to be altered for making it possible to distinguish the entry/exit information, etc., and the toll charge area can be expanded while utilizing the existing toll collection devices without any change.

{0064}

10 {Third Embodiment}

Next a toll collection system according to a third embodiment of the present invention will be described.

The toll collection system according to this embodiment differs from those of the first embodiment and the second embodiment described above in that a plurality of expanded toll charge areas are provided. The toll collection system according to this embodiment will be described below mainly with regard to the differences, and descriptions will be omitted for aspects in common with those of the first embodiment and the second embodiment.

{0065}

Fig. 13 shows a situation in which a plurality of expanded toll charge areas B1 and B2 are set up, and the

vehicle 3 enters the expanded toll charge area B2 from the expanded toll charge area B1, and then enters the toll charge area A.

As shown in Fig. 14, map information of the individual expanded toll charge areas B1 and B2 is stored in a vehicle-mounted-device storage device 25b of a vehicle-mounted device 50b in association with identification information b1 and b2 assigned to the individual expanded toll charge areas B1 and B2. As shown in Fig. 15, first toll charge tables 35b1 and 35b2 related to the individual expanded toll charge areas B1 and B2 are stored in a central-unit storage device 37b of the central unit 17b in association with the identification information b1 and b2 assigned to the individual expanded toll charge areas B1 and B2.

In Figs. 13 and 15, when the vehicle 3 enters the expanded toll charge area B1, a control unit 26b of the vehicle-mounted device 50b detects that the vehicle 3 has entered the expanded toll charge area B1 on the basis of the information received by the GPS receiver 24 and the map information stored in the vehicle-mounted-device storage device 25b, and causes the vehicle-mounted-device storage device 25b to store this information as the entry/exit information.

{0066}

When the vehicle 3 subsequently enters the expanded toll charge area B2, the control unit 26b detects this information and causes the vehicle-mounted-device storage device 25b to store this information indicating that the expanded toll charge area B2 has been entered, as the entry/exit information. When subsequently entering the toll charge area A, upon acquiring a request signal via the communication unit 27, the control unit 26b of the vehicle-mounted device 50b outputs the identification information of the vehicle-mounted device 50b of the vehicle-mounted device 50b to the toll collection device from the vehicle-mounted-device storage device 25b. The control unit 26b outputs the entry/exit information, which is detected on the basis of the current positional information stored in the vehicle-mounted-device storage device 25b to the central unit 17b via the first wide-area communication unit 32.

The central unit 17b judges whether or not the vehicle is fraudulent on the basis of the entry/exit information acquired via the second wide-area communication unit 18 and the identification information of the vehicle-mounted device acquired from the toll collection device, and also calculates the toll amount in

accordance with the judgment result.

{0067}

Specifically, as shown in Fig. 15, an amount
determining unit 38b of the central unit 17b acquires
5 first toll amounts for the expanded toll charge areas B1
and B2 by referring to the individual first toll charge
tables 35b1 and 35b2, which are associated with the
identification information b1 and b2 for the expanded
toll charge areas B1 and B2, and also acquires a second
10 toll amount for the toll charge area A by referring to
the second toll charge table 36. Then, by summing these
first toll amounts and the second toll amount, the toll
amount for the vehicle 3 is calculated as the road usage
fee. The information about the toll amount is
15 subsequently sent to the vehicle-mounted device 50b via
the second wide-area communication unit 18.

Upon receiving the information about the toll amount
via the first wide-area communication unit 32, the
control unit 26b of the vehicle-mounted device 50b
20 subtracts the above-described toll amount from the
balance recorded in the IC card, and records the
remaining amount in the IC card as an updated balance. It
is assumed that the details of the communication are in
accordance with the processing procedure shown in Fig.

10.

{0068}

As has been described above, with the toll collection system according to this embodiment, because
5 toll amounts that correspond to the individual expanded toll charge areas are provided in the case in which the plurality of expanded toll charge areas are set up, and because the information about entry/exit into/from the individual expanded toll charge areas is sent to the
10 central unit 17b from the vehicle-mounted device 50b in association with the identification information of the individual expanded toll charge areas, the central unit 17b can easily identify the expanded toll charge areas. Accordingly, it is possible to quickly determine the toll
15 amounts, that is, the road usage fee, for the expanded toll charge areas the vehicle has entered. Furthermore, because the first toll charge tables 35b1 and 35b2 corresponding to the individual expanded toll areas B1 and B2 are stored in the central-unit storage device 37b,
20 it is possible to set detailed toll amounts for the individual expanded toll charge areas. Additionally, even in the case in which the vehicle 3 has entered a plurality of the expanded toll charge areas, toll collection can be performed with a single payment.

Although this embodiment has been described for the case in which two expanded toll charge areas are set up, there is no limitation to the number of the expanded toll charge areas B. In addition, the plurality of the
5 expanded toll areas B may be set up adjacent to each other.

{0069}

{Fourth Embodiment}

Next a toll collection system according to a fourth
10 embodiment of the present invention will be described.

The toll collection system according to this embodiment differs from the toll collection systems of the first embodiment and the second embodiment described above in that the road usage fee for the expanded toll
15 charge area B is determined in accordance with the duration of stay therein. The toll collection system according to this embodiment will be described below mainly with regard to the differences, and descriptions will be omitted for aspects in common with those of the
20 first embodiment and the second embodiment.

{0070}

As shown in Fig. 16, a vehicle-mounted device 50c according to this embodiment is additionally provided with a timer 33 for clocking the duration of stay in the

expanded toll charge area B. In addition, with regard to a central unit according to this embodiment, in the configuration diagram of the central unit 17 shown in Fig. 7, the first toll charge table 35 provided in the central-unit storage device 37 is a toll charge table (not shown) in which the duration of stay is a parameter.

{0071}

As shown in Fig. 16, when the vehicle 3 enters the expanded toll charge area B, a control unit 26c of the vehicle-mounted device 50c detects that the expanded toll charge area B has been entered and activates the timer 33. Accordingly, the duration of stay in the expanded toll charge area B is clocked by the timer 33. When the toll charge area A is entered subsequently, the control unit 26c of the vehicle-mounted device 50c sends the duration of stay clocked by the timer 33 to the central unit 17 via the first wide-area communication unit 32 in addition to the vehicle information, etc. For example, when the request signal is received from the first antenna of the toll collection device, the control unit 26c stops the operation of the timer 33 and also reads out the duration of stay at that point and sends it to the central unit 17.

{0072}

The central unit 17 detects the entry/exit information indicating that the expanded toll charge area has been entered and notifies the amount determining unit 38. The amount determining unit 38 calculates the first
5 toll amount in accordance with the duration of stay in the expanded toll charge area B by using the first toll charge table 35, which is represented by a function with respect to the duration of stay, also extracts the second toll amount appropriate for the vehicle 3 from the second
10 toll charge table 36 for the toll charge area A, and, by summing these, calculates the toll amount for the vehicle 3. Then information about the determined toll amount is sent to the vehicle-mounted device 50c via the second wide-area communication unit 18.

15 Upon receiving the information about the toll amount in accordance with the duration of stay via the first wide-area communication unit 32, the control unit 26c of the vehicle-mounted device 50c subtracts the amount in accordance with the information about the above-described
20 toll amount from the balance recorded in the IC card, records the remaining amount in the IC card as an updated balance, and also clears the value in the timer 33. It is assumed that the details of the communication between the central unit 17 and the vehicle-mounted device 50c

described above are in accordance with the processing procedure shown in Fig. 10.

{0073}

As has been described above, with the toll
5 collection system according to this embodiment, because the duration of stay in the expanded toll charge area B is sent to the central unit 17, the central unit 17 can calculate a toll amount that is the road usage fee in which the duration of stay in the expanded toll charge
10 area B is taken into consideration. Accordingly, it is possible to set a road usage fee that is more reflective of the road usage situation.

Although the timer 33 is employed as means for detecting the duration of stay, the duration of stay may
15 be clocked, alternatively, by using time data included in GPS data acquired by the GPS receiver 24.

{0074}

In addition, because the toll amount in this embodiment is determined in accordance with the duration
20 of stay in the expanded toll charge area B, if the vehicle is parked at the parking lot that exists in the expanded toll charge area B, the duration of stay is clocked by the timer 33, and the corresponding amount is reflected in the road usage fee. Therefore, the operation

of the timer 33 is stopped for the period of parking in the parking lot in the expanded toll charge area B.

For example, the control unit 26c of the vehicle-mounted device 50c stops the operation of the timer 33 when an inquiry signal is received from an entrance antenna provided at the entrance of the parking lot, and the control unit 26c activates the timer 33 when a confirmation signal indicating that parking fee has been received is received from an exit antenna provided at the exit of the parking lot. Accordingly, the timer 33 is stopped for the period of parking in the parking lot, and it is possible to prevent the parking time from being included in the duration of stay.

{0075}

{Fifth Embodiment}

Next a toll collection system according to a fifth embodiment of the present invention will be described.

The toll collection system according to this embodiment differs from the toll collection system of the fourth embodiment described above, in which the toll amount is determined in accordance with the duration of stay, in that the toll amount is determined in accordance with distance traveled in the expanded toll charge area B. The toll collection system according to this

embodiment will be described below only with regard to the differences, and descriptions will be omitted for aspects in common with those of the fourth embodiment.

{0076}

5 As shown in Fig. 17, a vehicle-mounted device 50d according to this embodiment is provided with a traveled-distance accumulator 34 that accumulates the traveled distance instead of the timer 33 of the vehicle-mounted device 50c according to the fourth embodiment. The
10 traveled-distance accumulator 34 accumulates the traveled distance by using information based on vehicle-speed pulses, etc. output from the GPS receiver 24 and a gyro 42 installed in the vehicle-mounted device and the vehicle 3. With regard to the central unit 17 according
15 to this embodiment in Fig. 7, the first toll charge table 35 provided in the central-unit storage device 37 is a toll charge table in which the traveled distance is a parameter.

{0077}

20 In Fig. 17, when the vehicle 3 enters the expanded toll charge area B, a control unit 26d of the vehicle-mounted device 50d detects that the expanded toll charge area B has been entered and also activates the traveled-distance accumulator 34. Accordingly, the distance

traveled in the expanded toll charge area B is accumulated by the traveled-distance accumulator 34. When the toll charge area A is entered subsequently, the control unit 26d of the vehicle-mounted device 50d sends the traveled distance accumulated by the traveled-distance accumulator 34 to the central unit 17 via the first wide-area communication unit 32 in addition to the vehicle information, etc. For example, when the request signal is received from the first antenna 5 of the toll collection device 2, the control unit 26d stops the operation of the traveled-distance accumulator 34 and also reads out the traveled distance at that point and sends it to the central unit 17.

{0078}

15 The entry into the expanded toll charge area B is detected at the central unit 17 and is notified to the amount determining unit 38. The amount determining unit 38 calculates the first toll amount that is the road usage fee in accordance with the distance traveled in the expanded toll charge area B by using the first toll charge table 35, which is represented by a function with respect to the traveled distance, also extracts the second toll amount from the second toll charge table 36 for the toll charge area A in accordance with the vehicle

type of the vehicle 3, and, by summing these, calculates the toll amount for the vehicle 3. Then, information about the determined toll amount is sent to the vehicle-mounted device 50d via the second wide-area communication unit 18.

{0079}

When the toll amount in accordance with the traveled distance is received via the first wide-area communication unit 32, the control unit 26d of the vehicle-mounted device 50d subtracts the above-described toll amount from the balance recorded in the IC card, records the remaining amount in the IC card as an updated balance, and also clears the value in the traveled-distance accumulator 34. It is assumed that the details of the communication between the central unit 17 and the vehicle-mounted device 50d described above are in accordance with the processing procedure shown in Fig. 10.

{0080}

As has been described above, with the toll collection system according to this embodiment, because the distance traveled in the expanded toll charge area B is sent to the central unit 17, the central unit 17 can calculate a toll amount in which the distance traveled in

the expanded toll charge area B is taken into consideration. Accordingly, it is possible to set a road usage fee that is more reflective of the road usage situation.

5 In this embodiment, in order to prevent fraudulent activities, such as manipulation of information, wiretapping, and so on, the communication data exchanged between the vehicle-mounted device 50d and the central unit 17, which includes the traveled distance, may be
10 encrypted.

{0081}

{Sixth Embodiment}

Next a toll collection system according to a sixth embodiment of the present invention will be described.

15 The toll collection system according to this embodiment is targeted at the toll charge area A, wherein a certain of fee is collected simply by entering a certain area, as in a road pricing scheme or the like.

 In this embodiment, in consideration of a case in
20 which the toll charge area A is entered by mistake, the case in which, although the toll charge area A is entered, it is exited immediately, or the like, points in accordance with that period of stay are awarded to the user in the case in which a period of stay in the toll

charge area A is equal to or less than a predetermined period. The toll collection system according to this embodiment will be described below only with regard to the differences, and descriptions will be omitted for aspects in common with those of the fourth embodiment.

5 {0082}

In Fig. 18, when the vehicle 3 enters the toll charge area A and, additionally, a processing sequence with regard to toll charging, described above, is

10 completed between a control unit 26e of a vehicle-mounted device 50e and the first wide-area communication unit 32, the control unit 26e resets the value in the timer 33 and subsequently activates the timer 33 again. Accordingly, the duration of stay in the toll charge area A is

15 clocked.

{0083}

When the vehicle 3 subsequently exits the toll charge area A, the control unit 26e of the vehicle-mounted device 50e detects this and stops the operation

20 of the timer 33. Subsequently, the duration of stay in the toll charge area A is acquired by reading out the time clocked by the timer 33, and this duration of stay is sent to the central unit 17 via the first wide-area communication unit 32 in association with the vehicle

information, etc. Upon receiving the duration of stay associated with the vehicle information, etc., the central unit 17 determines points that correspond to this duration of stay on the basis of an award point table.

5 Here, an example of the award point table is shown in Fig. 19. In Fig. 19, the horizontal axis is the duration of stay, and the vertical axis is the award points. In this way, the award point table is set up so that the award points decrease with an increase in the duration of stay for a period in which the duration of stay is equal to or less than T_{max} . Although Fig. 19 shows a case in which the relationship between the duration of stay and the award points is inversely proportional, this is merely an example, and the relationship is not restricted
10 by this example. For example, the relationship may be set up such that the duration of stay is divided into levels of several steps, and the award points may be changed stepwise according to the individual levels.

{0084}

20 Returning to Fig. 18, when award points $P1$ corresponding to duration of stay $T1$ are determined at the central unit 17 on the basis of the above-described award points, the central unit 17 sends the award points to the vehicle-mounted device 50e. Upon receiving the

award points via the first wide-area communication unit 32, the control unit 26e of the vehicle-mounted device 50e causes the vehicle-mounted-device storage device 25 to store the award points. At this time, if award points are already stored in the vehicle-mounted-device storage device 25, the award points P1 are added to those award points, thus updating the record.

Then, in an information exchange performed with the central unit 17, the next time the vehicle 3 enters the toll charge area A, the control unit 26e sends the award point recorded in the vehicle-mounted-device storage device 25 along with the information such as the vehicle information, etc. Accordingly, a toll amount from which an amount in accordance with the award points is deducted is calculated at the central unit 17.

{0085}

As has been described above, for the toll charge area A wherein a certain of fee is collected at the time of entry regardless of the road usage situation, as in a road pricing scheme or the like, because points in accordance with the duration of stay in the toll charge area A are awarded to the vehicle owner, with the toll collection system according to this embodiment, it is possible to provide a financial relief to a user who has

entered the toll charge area A by mistake, or the like.

In addition, in the case in which the vehicle 3 is parked in a parking lot in the toll charge area A, it is possible to prevent the parking time from being included in the duration of stay by stopping the operation of the timer 33.

{0086}

Furthermore, although the award points in this embodiment are determined in accordance with the duration of stay in the toll charge area A, alternatively, the award points may be determined in accordance with the distance traveled in the toll charge area A. In this case, it suffices to include the traveled-distance accumulator 34 (see Fig. 17) instead of the above-described timer 33 in Fig. 16, and the control unit 26e accumulates the distance traveled in the toll charge area A by activating the traveled-distance accumulator 34 at the same timing as the timing at which the above-described timer 33 is activated.

Although this embodiment has been described assuming that the point awards table is provided in the central unit 17, it is not limited thereto. For example, in the case in which the payment clearance processing is performed at the vehicle-mounted device 50e, the point

awards table may be provided in the vehicle-mounted device 50e.

{0087}

{Other Application Examples}

5 Although the above descriptions have been given for the cases in which the toll collection systems of the present invention are applied to road pricing, the present invention can also be applied to the ETC system. For example, when expanding the toll charge area

10 (existing toll road) A, the GPS receiver 24 of the vehicle-mounted device 50 detects the entry into the expanded toll charge area (expanded toll road) B. In this case, the vehicle-mounted device sends the entry/exit information at an exit toll booth along with the vehicle

15 information, etc. By doing so, because the entry into the toll charge area A from the expanded toll charge area B can be recognized by the central unit 17, which is the superordinate device in the ETC system, a road usage fee (toll amount) is calculated by taking into consideration

20 the fee for the expanded toll charge area B.

{Reference Signs List}

{0088}

1 toll collection system

3 vehicle

- 17 central unit
- 18 second wide-area communication unit
- 19 fraud judging unit
- 20 calculation unit
- 5 24 GPS receiver
- 25 vehicle-mounted-device storage device
- 31 IC card inserting portion
- 32 first wide-area communication unit
- 35, 35b1, 35b2 first toll charge table
- 10 36 second toll charge table
- 37, 37b central-unit storage device
- 38, 38b amount determining unit
- 40 payment requesting unit
- 50, 50a, 50b, 50c, 50d, 50e vehicle-mounted device
- 15 A toll charge area
- B expanded toll charge area

{CLAIMS}

{Claim 1}

A toll collection system comprising:

5 a central unit that is a superordinate device of a
toll collection device provided at a toll booth of a toll
charge area; and

 a vehicle-mounted device that is provided in a
vehicle and that exchanges information with the central
10 unit,

 wherein the vehicle-mounted device is provided with
 a storage unit that stores map information of an
expanded toll charge area that is newly set up outside
the toll charge area;

15 a positional-information acquisition unit that
acquires positional information of the vehicle; and

 a control unit that, on the basis of the map
information and the positional information, detects
entry/exit information, which is entry information about
20 the vehicle entering the toll charge area from the
expanded toll charge area and/or exit information about
the vehicle exiting the toll charge area into the
expanded toll charge area, and that outputs the
entry/exit information to the central unit, and

wherein the central unit is provided with a calculation unit that calculates a toll amount on the basis of the acquired entry/exit information.

5 {Claim 2}

A toll collection system comprising:

a central unit that is a superordinate device of a toll collection device provided at a toll booth of a toll charge area; and

10 a vehicle-mounted device that is provided in a vehicle and that exchanges information with the central unit,

wherein the vehicle-mounted device is provided with

a storage unit that stores map information of an
15 expanded toll charge area that is newly set up outside the toll charge area;

a positional-information acquisition unit that acquires positional information of the vehicle; and

a calculation unit that, in the case in which
20 entry/exit information is detected on the basis of the map information and the positional information, calculates a toll amount on the basis of the detection result, where the entry/exit information is entry information about the vehicle entering the toll charge

area from the expanded toll charge area and/or exit information about the vehicle exiting the toll charge area into the expanded toll charge area.

5 {Claim 3}

A toll collection system according to Claim 1 or 2,
wherein the vehicle-mounted device is provided with a
payment requesting unit that, when the information about
the toll amount is acquired, requests payment of the toll
10 amount from a user in accordance with the information
about the toll amount.

{Claim 4}

A toll collection system according to Claim 1 or 2,
15 wherein the central unit is provided with a payment
requesting unit that, when the information about the toll
amount is acquired, requests payment of the toll amount
from a user in accordance with the information about the
toll amount.

20

{Claim 5}

A toll collection system according to any one of Claims 1
to 4, wherein

the vehicle-mounted device is provided with a first

wide-area communication unit that exchanges the entry/exit information with the central unit;

the central unit is provided with a second wide-area communication unit that exchanges the entry/exit

5 information with the vehicle-mounted device; and

the central unit is provided with

a fraud judging unit that compares the entry/exit information of the vehicle-mounted device for the toll charge area acquired from the vehicle-mounted device via
10 the toll collection device and the entry/exit information acquired from the vehicle-mounted device via the first wide-area communication unit and the second wide-area communication unit, and that judges that the entry/exit information includes fraudulent information when the
15 comparison result indicates a mismatch.

{Claim 6}

A toll collection system according to any one of Claims 1 to 5, wherein the calculation unit is provided with

20 a storage device that stores first toll charge information with regard to the expanded toll charge area newly set up outside the toll charge area and second toll charge information related to the toll charge area; and
an amount determining unit that determines the toll

amount on the basis of the entry/exit information, the first toll charge information, and the second toll charge information.

5 {Claim 7}

A toll collection system according to Claim 6, wherein

the first toll charge information includes a toll charge table in which duration of stay in the expanded toll charge area is a parameter; and,

10 when the duration of stay in the expanded toll charge area is received from the vehicle-mounted device, the amount determining unit determines the toll amount for the expanded toll charge area by using the duration of stay and the toll charge table.

15

{Claim 8}

A toll collection system according to Claim 6, wherein

the first toll charge information includes a toll charge table in which distance traveled in the expanded toll charge area is a parameter; and,

20

when the distance traveled in the expanded toll charge area is received from the vehicle-mounted device, the amount determining unit determines the toll amount for the expanded toll charge area by using the traveled

distance and the toll charge table.

{Claim 9}

A toll collection system according to any one of Claims 6
5 to 8, wherein, in the case in which a plurality of the
expanded toll charge areas are set up,

the first toll charge information is provided
corresponding to each of the expanded toll charge areas;

the entry/exit information is associated with
10 identification information for the individual expanded
toll charge areas; and

the amount determining unit determines the toll
amount by using the first toll charge information for the
expanded toll charge areas into which the vehicle has
15 entered, which is determined on the basis of entry/exit
information associated with the identification
information of the expanded toll charge areas.

{Claim 10}

20 A toll collection system according to any one of Claims 6
to 9, wherein, in the case in which the toll charge area
is an area where a certain fee is collected at the time
of entry regardless of a road usage situation,

an award point table in which the duration of stay

in the toll charge area is a parameter is included; and,
when the duration of stay in the toll charge area is
received from the vehicle-mounted device, the amount
determining unit determines award points by using the
5 duration of the stay and the award point table, and gives
the award points to an owner of the vehicle.