

VEHICLE MANAGEMENT SYSTEM, VEHICLE MANAGEMENT DEVICE,
VEHICLE MANAGEMENT METHOD, AND PROGRAM

TECHNICAL FIELD

5 [0001]

The present invention relates to a vehicle management system, a vehicle management device, a vehicle management method, and a program.

BACKGROUND ART

10 [0002]

A technology in which an on-board device mounted in a vehicle performs wireless communication with roadside units installed on a roadside strip of a lane so that a management device determines passing a plurality of roadside units installed spaced apart from each other and calculates a toll depending on a travel section of the vehicle in a charging section on the basis of the vehicle passing the positions of the roadside units has been disclosed. For example, Patent Document 1 discloses a technology for realizing a payment method capable of performing nonstop normal charging for vehicles entering an area (charging section) which requires fee charging according to road-vehicle wireless communication.

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Citation List

Patent Document

[0003]

[Patent Document 1]

25 Japanese Unexamined Patent Application, First Publication No. 2013-338317

SUMMARY OF INVENTION

Problem to be Solved by the Invention

[0004]

5 However, there is a need for a technology for improving the reliability of information on a travel section on which a vehicle has traveled and contributing to calculation of a correct toll depending on traveling in a travel section in a predetermined charging section without the roadside units described above having to be installed on roadsides.

10 [0005]

 Accordingly, an object of the present invention is to provide a vehicle management system, a vehicle management device, a vehicle management method, and a program capable of solving the aforementioned problem.

15 Means for Solving the Problem

[0006]

 According to a first aspect of the present invention, a vehicle management system includes: an on-board device of a vehicle which transmits vehicle-to-vehicle communication information, the vehicle-to-vehicle communication information including
20 at least identification information of another vehicle located in a communication available range of vehicle-to-vehicle communication, the identification information being received from an on-board device of the other vehicle through the vehicle-to-vehicle communication; and a vehicle management device which determines presence or absence of corresponding vehicle-to-vehicle communication information by comparing
25 vehicle-to-vehicle communication information received from on-board devices of a

plurality of different vehicles.

[0007]

In the aforementioned vehicle management system, the vehicle management device may identify identification information of a plurality of other vehicles included in
5 a plurality of pieces of first vehicle-to-vehicle communication information received from an on-board device of a specific vehicle among the vehicles, the vehicle management device may identify second vehicle-to-vehicle communication information including identification information of the specific vehicle from a plurality of pieces of vehicle-to-vehicle communication information, the plurality of pieces of
10 vehicle-to-vehicle communication information being extracted based on the identified identification information of the plurality of other vehicles and being received from the on-board devices of the other vehicles, and the vehicle management device may determine correctness of at least one of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information based on a
15 corresponding relation between the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information.

[0008]

Further, in the aforementioned vehicle management system, the on-board device of the vehicle may receive positional information of the other vehicle from the on-board
20 device of the other vehicle through the vehicle-to-vehicle communication, the on-board device of the vehicle may acquire positional information of the host vehicle, and the on-board device of the vehicle may determine correctness of the positional information on any of the host vehicle and the other vehicle based on the positional information of the host vehicle, the positional information of the other vehicle, and a communication time at
25 which communication with the other vehicle has been performed through the

vehicle-to-vehicle communication.

[0009]

According to a second aspect of the present invention, a vehicle management device includes: an acquisition unit which receives vehicle-to-vehicle communication
5 information from an on-board device of a vehicle, the vehicle-to-vehicle communication information including at least identification information of another vehicle located in a communication available range of vehicle-to-vehicle communication and a communication time of the vehicle-to-vehicle communication, the identification information being received by the on-board device of the vehicle from an on-board
10 device of the other vehicle through the vehicle-to-vehicle communication; and a determination unit which determines presence or absence of corresponding vehicle-to-vehicle communication information by comparing vehicle-to-vehicle communication information received from on-board devices of a plurality of different vehicles.

15 [0010]

In the aforementioned vehicle management device, the determination unit may identify identification information of a plurality of other vehicles included in a plurality of pieces of first vehicle-to-vehicle communication information received from an on-board device of a specific vehicle among the vehicles, the determination unit may
20 identify second vehicle-to-vehicle communication information including identification information of the specific vehicle from a plurality of pieces of vehicle-to-vehicle communication information, the plurality of pieces of vehicle-to-vehicle communication information being extracted based on the identified identification information of the plurality of other vehicles and being received from the on-board devices of the other
25 vehicles, and the determination unit may determine correctness of at least one of the first

vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information based on a corresponding relation between the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information.

5 [0011]

According to a third aspect of the present invention, a vehicle management method includes: transmitting, by an on-board device of a vehicle, vehicle-to-vehicle communication information, the vehicle-to-vehicle communication information including at least identification information of another vehicle located in a communication
10 available range of vehicle-to-vehicle communication and a communication time of the vehicle-to-vehicle communication, the identification information being received from an on-board device of the other vehicle through the vehicle-to-vehicle communication; and determining, by a vehicle management device, presence or absence of corresponding vehicle-to-vehicle communication information by comparing vehicle-to-vehicle
15 communication information received from on-board devices of a plurality of different vehicles.

[0012]

According to a fourth aspect of the present invention, an acquisition unit of a vehicle management device receives, vehicle-to-vehicle communication information
20 from an on-board device of a vehicle, the vehicle-to-vehicle communication information including at least identification information of another vehicle located in a communication available range of vehicle-to-vehicle communication, the identification information being received by the on-board device of the vehicle from an on-board device of the other vehicle through the vehicle-to-vehicle communication; and a
25 determination unit of the vehicle management device determines presence or absence of

corresponding vehicle-to-vehicle communication information by comparing vehicle-to-vehicle communication information received from on-board devices of a plurality of different vehicles.

[0013]

5 According to a fifth aspect of the present invention, a program causes a computer of a vehicle management device to function as: an acquisition means which receives vehicle-to-vehicle communication information from an on-board device of a vehicle, the vehicle-to-vehicle communication information including at least identification information of another vehicle located in a communication available range
10 of vehicle-to-vehicle communication, the identification information being received by the on-board device of the vehicle from an on-board device of the other vehicle through the vehicle-to-vehicle communication; and a determination means which determines presence or absence of corresponding vehicle-to-vehicle communication information by comparing vehicle-to-vehicle communication information received from on-board
15 devices of a plurality of different vehicles.

Effect of the Invention

[0014]

 According to the present invention, it is possible to improve reliability of
20 identification of information on a travel section on which a vehicle has traveled even in cases in which roadside units are not set.

BRIEF DESCRIPTION OF DRAWINGS

[0015]

25 Fig. 1 is a schematic diagram showing a vehicle management system according

to a first embodiment.

Fig. 2 is a diagram showing a hardware configuration of an on-board device according to the first embodiment.

Fig. 3 is a functional block diagram of the on-board device according to the first
5 embodiment.

Fig. 4 is a diagram showing a processing flow of the on-board device according to the first embodiment.

Fig. 5 is a functional block diagram of a vehicle management device according to the first embodiment.

10 Fig. 6 is a diagram showing a processing flow of the vehicle management device according to the first embodiment.

Fig. 7 is a diagram showing vehicle-to-vehicle communication information transmitted and received by the on-board device in a charging section.

Fig. 8 is a functional block diagram of an on-board device according to a second
15 embodiment.

Fig. 9 is a diagram showing a processing flow of the on-board device according to the second embodiment.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

20 [0016]

<First embodiment>

Hereinafter, a vehicle management system, a vehicle management device, a vehicle management method, and a program according to a first embodiment of the present invention will be described with reference to the drawings.

25 Fig. 1 is a schematic diagram showing the vehicle management system

according to the first embodiment.

As shown in this figure, the vehicle management system 1 is configured by connecting an on-board device 10 included in a vehicle and a vehicle management device 20 through a communication network. The on-board device 10 is mounted in each vehicle traveling on a road, such as a vehicle A or a vehicle B. When the on-board device 10 of each vehicle is located within communication ranges of other on-board devices, the on-board device 10 is connected to the other on-board devices through communication to transmit and receive information. This communication is referred to as vehicle-to-vehicle communication. Each on-board device 10 is connected through communication to the vehicle management device 20 through a wireless communication network or a wired communication network. The vehicle management device 20 may be installed in a remote building. The vehicle management device 20 transmits/receives information to/from the on-board device 10. The vehicle management device 20 is connected to a database 30 through communication.

[0017]

Fig. 2 is a diagram showing a hardware configuration of the on-board device.

As shown in Fig. 2, the on-board device 10 is a computer including hardware components such as a central processing unit (CPU) 101, a read only memory (ROM) 102, a random access memory (RAM) 103, a hard disk drive (HDD) 104, a first communication module 105, a second communication module 106, and a global positioning system (GPS) device 107. Further, the first communication module 105 is hardware which performs vehicle-to-vehicle communication. In addition, the second communication module 106 is hardware which performs communication with the vehicle management device 20.

[0018]

Fig. 3 is a functional block diagram of the on-board device according to the first embodiment.

The CPU 101 of the on-board device 10 executes a program stored in the ROM 102 or the like when power is applied thereto according to starting of the vehicle.

5 Accordingly, the on-board device 10 includes functional units such as a controller 11, a first communication unit 12, a second communication unit 13, a positional information acquisition unit 14, and a clock unit 15.

[0019]

The controller 11 controls other functional units in the on-board device 10.

10 The first communication unit 12 performs processing of vehicle-to-vehicle communication.

The second communication unit 13 performs communication processing with the vehicle management device 20.

15 The positional information acquisition unit 14 acquires positional information from the GPS device 107 included in the on-board device 10.

The clock unit 15 is a processing unit which clocks a time.

[0020]

20 The on-board device 10 performs vehicle-to-vehicle communication with on-board devices of other vehicles located within a communication available range of vehicle-to-vehicle communication. The on-board device 10 transmits, to the vehicle management device 20, vehicle-to-vehicle communication information including at least IDs of other vehicles received through vehicle-to-vehicle communication and a communication time of vehicle-to-vehicle communication.

25 The vehicle management device 20 determines presence or absence of corresponding vehicle-to-vehicle communication information by comparing

vehicle-to-vehicle communication information received from on-board devices 10 of a plurality of different target vehicles.

[0021]

In a specific example of this determination, the vehicle management device 20
5 identifies IDs of a plurality of other vehicles included in a plurality of pieces of first
vehicle-to-vehicle communication information sequentially received from the on-board
device 10 of a specific vehicle as an example. In addition, the vehicle management
device 20 identifies second vehicle-to-vehicle communication information including the
ID of the specific vehicle among a plurality of pieces of vehicle-to-vehicle
10 communication information extracted on the basis of the identified IDs of the other
vehicles and received from the on-board devices 10 of the other vehicles. Then, the
vehicle management device 20 determines correctness of at least one of the first
vehicle-to-vehicle communication information and the second vehicle-to-vehicle
communication information on the basis of a corresponding relation between the first
15 vehicle-to-vehicle communication information and the second vehicle-to-vehicle
communication information.

[0022]

According to such processing, the vehicle management device 20 can identify an
on-board device 10 which has transmitted incorrect vehicle-to-vehicle communication
20 information to the vehicle management device 20 among on-board devices 10 of certain
vehicles which have performed vehicle-to-vehicle communication with on-board devices
10 of other vehicles by passing by the other vehicles during traveling. The vehicle
management device 20 identifies on-board devices 10 which have transmitted the
incorrect vehicle-to-vehicle communication information, correctly checks a travel route
25 of the vehicle having the on-board device 10 mounted therein on the basis of

vehicle-to-vehicle communication information transmitted from on-board devices 10 of other vehicles and calculates a toll of a travel section of the vehicle within a charging section with high accuracy.

[0023]

5 Fig. 4 is a diagram showing a processing flow of the on-board device according to the first embodiment.

 Hereinafter, processing of an on-board device 10A included in the vehicle A will be described. An on-board device 10 included in the vehicle B is referred to as an on-board device 10B. When the vehicle A passes by the vehicle B after starting of the
10 on-board device 10A, the on-board device 10B of the vehicle B enters a communication range of the on-board device 10A. Accordingly, the first communication unit 12 of the on-board device 10A transmits/receives signals to/from the on-board device 10B through the first communication module 105 according to vehicle-to-vehicle communication (step S101). A signal transmitted from the first communication unit 12 to the on-board
15 device 10B according to vehicle-to-vehicle communication includes the ID of the on-board device 10A and current positional information of the vehicle A. The positional information is acquired by the positional information acquisition unit 14 from a GPS device included in the vehicle A. The positional information is information of ground coordinates such as latitude, longitude, altitude and the like. Likewise, a signal
20 received by the first communication unit 12 of the on-board device 10A from the on-board device 10B includes the ID of the on-board device 10B and positional information of the vehicle B. Further, the on-board device 10A and the on-board device 10B may transmit only IDs thereof to on-board devices of other vehicles.

[0024]

25 The first communication unit 12 acquires a date and a time clocked by the clock

unit 15 when a signal is received. This date and time information indicates a communication time. When transmission and reception of signals are completed according to vehicle-to-vehicle communication, the first communication unit 12 temporarily stores vehicle-to-vehicle communication information including information included in a received signal and a communication time acquired by the clock unit 15 when the signal is received (step S102). That is, the first communication unit 12 associates the ID of the on-board device 10B with which vehicle-to-vehicle communication has been performed with positional information of the vehicle including the on-board device 10B and a communication time and stores the associated information in a storage unit such as the RAM 103. Meanwhile, the positional information of the vehicle including the on-board device 10B and the communication time associated with the ID of the on-board device 10B and stored may be detected in the on-board device 10A. In this case, the first communication unit 12 acquires a time when the on-board device 10A has received the ID of the on-board device 10B from the clock unit 15. In addition, the first communication unit 12 acquires positional information when the on-board device 10A has received the ID of the on-board device 10B from the GPS device 107. Then, the first communication unit 12 may associate the ID of the on-board device 10B with which vehicle-to-vehicle communication has been performed with the positional information of the vehicle including the on-board device 10B and the communication time and store the associated information in a storage unit such as the RAM 103. Further, the first communication unit 12 may associate the ID of the on-board device 10B with the positional information of the vehicle including the on-board device 10B and the communication time and store the associated information only when successful communication with the on-board device 10B has been confirmed. Accordingly, only information on the on-board device 10B with which communication

has been obviously performed becomes information to be stored and the reliability of the information to be stored is improved.

[0025]

The positional information acquisition unit 14 of the on-board device 10A
5 acquires positional information from the GPS device 107 at predetermined intervals.
The positional information acquisition unit 14 stores travel route information including
the acquired positional information in a storage unit such as the RAM 103.

[0026]

The on-board device 10A repeats the processing of steps S101 and S102 while
10 the vehicle A is driven. Accordingly, the on-board device 10A performs
vehicle-to-vehicle communication with the on-board devices 10B of a plurality of other
vehicles B which have approached the vehicle A by passing by the other vehicles B, or
the like and stores vehicle-to-vehicle communication information each time
vehicle-to-vehicle communication is performed. The controller 11 determines a
15 predetermined timing at which vehicle-to-vehicle communication information is
transmitted to the vehicle management device 20 (step S103). The predetermined
timing may be each timing a predetermined period elapses, a timing at which a
predetermined amount of vehicle-to-vehicle communication information has been
accumulated, a timing at which communication connection to a roadside unit which is
20 installed at a roadside strip and relays communication with the vehicle management
device 20 can be achieved, or the like. The controller 11 instructs the second
communication unit 13 to transmit vehicle-to-vehicle communication information at a
timing at which the stored vehicle-to-vehicle communication information is transmitted
to the vehicle management device 20. The second communication unit 13 transmits the
25 stored vehicle-to-vehicle communication information to the vehicle management device

20 using the second communication module 106 (step S104). The communication function (the first communication unit 12 and the first communication module 105) for performing vehicle-to-vehicle communication with other vehicles and the communication function (the second communication unit 13 and the second communication module 106) for performing transmission/reception of information to/from the vehicle management device 20 can be separated from each other to simplify communication control processing of each communication function. In addition, communication control can be performed without having the influence of heavy congestion of communication of one side on communication of the other side. The positional information acquisition unit 14 acquires travel route information indicating positions through which the vehicle including the positional information acquisition unit 14 has traveled and transmits the travel route information to the vehicle management device 20 using the second communication module 106 from the RAM 103 at the timing determined in step S103 (step S105).

15 [0027]

The controller 11 determines whether driving of the vehicle A is stopped (step S106). The processing is stopped when driving of the vehicle A is stopped and processing from step S101 is repeated when driving of the vehicle A is not stopped.

[0028]

20 Fig. 5 is a functional block diagram of a vehicle management device according to the first embodiment.

A CPU of the vehicle management device 20 executes a program stored in a ROM or the like. Accordingly, the vehicle management device 20 includes functions of at least a controller 21, a received information management unit 22, a determination unit 23 and a toll calculation unit 24.

25

The controller 21 controls each function of the vehicle management device 20.

The received information management unit 22 manages vehicle-to-vehicle communication information received from the on-board device 10.

The determination unit 23 determines presence or absence of corresponding
5 vehicle-to-vehicle communication information by comparing vehicle-to-vehicle communication information received from the on-board devices 10 of a plurality of different vehicles. The determination unit 23 determines correctness of vehicle-to-vehicle communication information acquired from the on-board device 10 according to this determination.

10 The toll calculation unit 24 calculates a charged amount based on a travel section of a vehicle in a charging section.

[0029]

Fig. 6 is a processing flow of the vehicle management device according to the first embodiment.

15 Next, processing of the vehicle management device 20 will be described in order.

The received information management unit 22 of the vehicle management device 20 receives vehicle-to-vehicle communication information and travel route information from the on-board devices 10 of a plurality of different vehicles (step S201).

20 The received information management unit 22 associates the received vehicle-to-vehicle communication information and travel route information with the IDs of the on-board devices 10 which have transmitted the information and records the associated information in the database 30 (step S202). The vehicle management device 20 repeats processing of steps S201 and S202 until a predetermined determination timing. The
25 controller 21 determines whether the determination timing arrives (step S203). The

controller 21 instructs the determination unit 23 to start determination processing at the determination timing. The determination unit 23 identifies the ID of the first on-board device 10 at the determination timing (step S204). Here, the following description will be made on the assumption that the identified ID of the on-board device 10 is the ID of the on-board device 10A.

[0030]

Identification of the ID of the on-board device 10A may be performed on the basis of an operation of a manager or information representing identification of some IDs may be acquired from other devices and the like. For example, the ID of the on-board device 10A of the vehicle A which is a target for which a charged amount for a travel section in a charging section is calculated may be acquired by the determination unit 23 from a host device or a user or may be acquired on the basis of an execution result of a predetermined program. The determination unit 23 acquires vehicle-to-vehicle communication information associated with the identified ID of the on-board device 10A and accumulated in the database 30. The vehicle-to-vehicle communication information associated with the identified ID of the on-board device 10A and accumulated in the database 30 is referred to as first vehicle-to-vehicle communication information.

[0031]

The determination unit 23 extracts, from the database 30, first vehicle-to-vehicle communication information including positional information on a position near a position of a road of the charging section among the first vehicle-to-vehicle communication information associated with the ID of the on-board device 10A (step S205). Accordingly, vehicle-to-vehicle communication information received from the on-board device 10A at positions other than the charging section can be excluded from information that is a processing target.

[0032]

Further, the determination unit 23 extracts, from the database 30, vehicle-to-vehicle communication information which has been received from other on-board devices 10B and includes the ID of the on-board device 10A identified in step S204. The vehicle-to-vehicle communication information which has been received from other on-board devices 10B and includes the identified ID of the on-board device 10 is referred to as second vehicle-to-vehicle communication information. The determination unit 23 extracts, from the database 30, second vehicle-to-vehicle communication information including positional information on a position near a road of the charging section among the second vehicle-to-vehicle communication information including the identified ID of the on-board device 10A (step S206).

[0033]

Fig. 7 is a diagram showing vehicle-to-vehicle communication information transmitted and received by an on-board device in a charging section.

It is assumed that the vehicle A passes by four vehicles, vehicles B1, B2, B3 and B4, while the vehicle A is traveling in a charging section. In this case, the on-board device 10A of the vehicle A receives vehicle-to-vehicle communication information B1-1 transmitted from the vehicle B1 when the vehicle A passes by the vehicle B1. In addition, the on-board device 10A of the vehicle A receives vehicle-to-vehicle communication information B2-1 from the on-board device 10B2 of the vehicle B2, receives vehicle-to-vehicle communication information B3-1 from the on-board device 10B3 of the vehicle B3 and receives vehicle-to-vehicle communication information B4-1 from the on-board device 10B4 of the vehicle B4 by passing by the vehicles B2, B3 and B4. The first vehicle-to-vehicle communication information B1-1, B2-1, B3-1 and B4-1 can be extracted in step S205. Timings at which the first vehicle-to-vehicle

communication information B1-1, B2-1, B3-1 and B4-1 is received by the on-board device 10A of the vehicle A are set to T1, T2, T3 and T4. Further, timing order is $T1 < T2 < T3 < T4$.

[0034]

- 5 The on-board device 10B1 of the other vehicle B1 receives vehicle-to-vehicle communication information A-1 from the on-board device 10A by passing by the vehicle A. The on-board device 10B2 of the other vehicle B2 receives vehicle-to-vehicle communication information A-2 from the on-board device 10A by passing by the vehicle A. The on-board device 10B3 of the other vehicle B3 receives vehicle-to-vehicle communication information A-3 from the on-board device 10A by passing by the vehicle A. The on-board device 10B4 of the other vehicle B4 receives vehicle-to-vehicle communication information A-4 from the on-board device 10A by passing by the vehicle A. The second vehicle-to-vehicle communication information A-1, A-2, A-3 and A-4 can be extracted in step S206. Timings at which the second vehicle-to-vehicle communication information A-1, A-2, A-3 and A-4 is received by the on-board devices 10 of the vehicles B1 to B4 are set to T1, T2, T3 and T4.

[0035]

- The determination unit 23 of the vehicle management device 20 determines correctness of at least one of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information on the basis of a corresponding relation between the first vehicle-to-vehicle communication information extracted in step S205 and the second vehicle-to-vehicle communication information extracted in step S206 (step S207).

[0036]

- 25 For example, the determination unit 23 may extract vehicle IDs from the first

vehicle-to-vehicle communication information B1-1, B2-1, B3-1 and B4-1 extracted in step S205 and sorts the vehicle IDs on the basis of communication times included in the vehicle-to-vehicle communication information from the earliest one. As a result, a vehicle ID permutation {B1, B2, B3, B4} is obtained. In addition, the determination unit 23 extracts vehicle IDs associated with the vehicle-to-vehicle communication information A-1, A-2, A-3 and A-4 extracted in step S206 and recorded in the database 30 and sorts the vehicle IDs on the basis of communication times included in the vehicle-to-vehicle communication information from the earliest one. As a result, a vehicle ID permutation {B1, B2, B3, B4} is obtained. The determination unit 23 of the vehicle management device 20 compares the two obtained vehicle ID permutations with each other and determines that correctness of the first vehicle-to-vehicle communication information extracted in step S205 and correctness of the second vehicle-to-vehicle communication information extracted in step S206 are valid when the two vehicle ID permutations are consistent with each other.

15 [0037]

On the other hand, the determination unit 23 compares the two obtained vehicle ID permutations with each other and determines that correctness of any of the first vehicle-to-vehicle communication information extracted in step S205 and the second vehicle-to-vehicle communication information extracted in step S206 is invalid when the two vehicle ID permutations are not consistent with each other. For example, the determination unit 23 may determine that the vehicle-to-vehicle communication information B3-1 and B4-1 which can be received by the on-board device 10A at the timings T3 and T4 cannot be extracted from the database 30. In this case, the determination unit 23 obtains a vehicle ID permutation {B1, B2}. In addition, the determination unit 23 extracts vehicle IDs associated with the second vehicle-to-vehicle

communication information A-1, A-2, A-3 and A-4 extracted in step S206 and recorded in the database 30, sorts the vehicle IDs on the basis of communication times included in the vehicle-to-vehicle communication information from the earliest one and obtains a vehicle ID permutation {B1, B2, B3, B4}. The determination unit 23 determines that
5 the obtained two permutations are different from each other in step S207. In this case, correctness of the first vehicle-to-vehicle communication information is invalid. For example, the correctness of the first vehicle-to-vehicle communication information may be determined to be invalid because vehicle IDs of B3 and B4 which should be obtained from the first vehicle-to-vehicle communication information are not obtained from the
10 first vehicle-to-vehicle communication information as an example.
[0038]

The determination unit 23 may determine the correctness of the first vehicle-to-vehicle communication information or the correctness of the second vehicle-to-vehicle communication information through other methods or by further
15 adding other methods. For example, the determination unit 23 compares each piece of positional information included in the first vehicle-to-vehicle communication information with each piece of positional information included in the second vehicle-to-vehicle communication information. The determination unit 23 compares the positional information included in the first vehicle-to-vehicle communication information with the
20 positional information included in the second vehicle-to-vehicle communication information at each timing. The determination unit 23 may determine that the correctness of at least one of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information is invalid when it is determined that a distance indicated by the two pieces of positional information at any
25 timing is equal to or longer than a predetermined distance.

[0039]

Further, the determination unit 23 may determine the correctness of the first vehicle-to-vehicle communication information or the second vehicle-to-vehicle communication information through other methods or by adding the methods. For example, the determination unit 23 compares a communication time included in the first vehicle-to-vehicle communication information with a communication time included in the second vehicle-to-vehicle communication information. The determination unit 23 determines that the correctness of at least one of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information is invalid when the communication time included in the first vehicle-to-vehicle communication information and the communication time included in the second vehicle-to-vehicle communication information are different from each other by a predetermined time or longer at each timing. In this determination, the predetermined time used to determine that timings of communication times are different may be a time including a gap time of time synchronization deviation in each device. Presence of correctness of vehicle-to-vehicle communication information can be defined as presence of consistency between the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information in the corresponding relation therebetween. Meanwhile, when there are some omissions in any of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information in the corresponding relation therebetween, the vehicle-to-vehicle communication information having the omissions in the corresponding relation is likely to be determined to be incorrect. However, when there are some omissions in any of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information in the

corresponding relation therebetween, there is also a case in which the vehicle-to-vehicle communication information having the omissions in the corresponding relation cannot be immediately determined to be incorrect. For example, even though the corresponding relation between the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information has some omissions for a certain short period, if the corresponding relation between the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information is present over the following long period, all of the vehicle-to-vehicle communication information may be determined to have correctness.

10 [0040]

When correctness of vehicle-to-vehicle communication information is valid, the determination unit 23 acquires travel route information received from the on-board device 10A from the database 30 on the basis of the on-board device 10A corresponding to the ID identified in step S204. The toll calculation unit 24 identifies positional information corresponding to a charging section among positional information indicated by the travel route information as positional information of a travel section on which the vehicle A has traveled in the charging section (step S208). The determination unit 23 outputs the ID of the vehicle A and the positional information to the toll calculation unit 24. The toll calculation unit 24 calculates a charged amount for a travel section on which the vehicle A has traveled within the charging section on the basis of the positional information of the travel section (step S209). The determination unit 23 determines whether the ID of the next on-board device 10 which has not been processed can be identified (step S210). The determination unit 23 repeats processing from step S204 when the ID of the next on-board device 10 which has not been processed can be identified. The determination unit 23 ends the processing when the ID of the next

on-board device 10 which has not been processed cannot be identified.

[0041]

When it is determined that the correctness of the vehicle-to-vehicle communication information is invalid in step S207, the determination unit 23 identifies positional information included in the second vehicle-to-vehicle communication information A-1, A-2, A-3 and A-4 instead of the first vehicle-to-vehicle communication information extracted in step S205 as positional information of a section that the vehicle A has traveled between a position at which the vehicle A has entered the charging section and a position at which the vehicle A has exited the charging section (step S211). That is, when there is a possibility that the first vehicle-to-vehicle communication information has been altered, the first vehicle-to-vehicle communication information is not accurate information, or there is a possibility that the first vehicle-to-vehicle communication information has not been received by the vehicle management device 20, the second vehicle-to-vehicle communication information is used for toll calculation. The determination unit 23 outputs positional information included in the second vehicle-to-vehicle communication information and the ID of the vehicle A included in the second vehicle-to-vehicle communication information to the toll calculation unit 24. The toll calculation unit 24 calculates a charged amount for the travel section on which the vehicle A has traveled in the charging section on the basis of the ID of the vehicle A and the positional information acquired from the determination unit 23 (step S212).

[0042]

Although one embodiment of the present invention has been described above, according to processing of the above-described on-board device 10 and the vehicle management device 20, it is possible to improve reliability of information on a travel section on which a vehicle has traveled and perform calculation of a charged amount

with high accuracy depending on traveling in a travel section in a predetermined charging section.

[0043]

In addition, according to processing of the above-described on-board device 10
5 and the vehicle management device 20, it is possible to identify a travel route of a specific vehicle on the basis of vehicle-to-vehicle communication information obtained from vehicles that the specific vehicle has passed by without installing roadside units in a charging section.

[0044]

10 The vehicle management device 20 may identify a travel section of a specific vehicle on the basis of vehicle-to-vehicle communication information without detecting the travel section of the specific vehicle in a charging section.

[0045]

<Second embodiment>

15 The on-board device 10A may extract positional information from a signal received from the on-board device 10B and determine a position detection error of the GPS device 107 mounted in the vehicle A along therewith on the basis of the extracted positional information.

[0046]

20 Fig. 8 is a functional block diagram of an on-board device according to a second embodiment.

The on-board device 10 according to the second embodiment further includes a function of a positional information determination unit 16 in addition to the functions described using Fig. 2.

25 [0047]

Fig. 9 is a diagram showing a processing flow of the on-board device according to the second embodiment.

Hereinafter, processing of the on-board device 10A included in the vehicle A will be described. The on-board device 10 included in the vehicle B is referred to as an on-board device 10B as in the first embodiment. When the vehicle passes by the vehicle B after starting of the on-board device 10A, the on-board device 10B of the vehicle B enters the communication range of the on-board device 10A. Accordingly, the first communication unit 12 of the on-board device 10A transmits/receives signals to/from the on-board device 10B through the first communication module 105 according to vehicle-to-vehicle communication (step S901). A signal transmitted from the first communication unit 12 to the on-board device 10B through vehicle-to-vehicle communication includes at least the ID of the on-board device 10A and current positional information of the vehicle A. The positional information is acquired by the positional information acquisition unit 14 from the GPS device 107 included in the vehicle A. The positional information is information of ground coordinates such as latitude, longitude, altitude and the like. Likewise, a signal received by the first communication unit 12 of the on-board device 10A from the on-board device 10B includes the ID of the on-board device 10B and positional information of the vehicle B.

[0048]

The first communication unit 12 of the on-board device 10A stores transmission information transmitted in step S901 in the host device (step S902). In addition, the first communication unit 12 acquires a date and a time clocked by the clock unit 15 when a signal is received. The date and time indicate a communication time. When transmission and reception of signals through vehicle-to-vehicle communication are completed, the first communication unit 12 temporarily stores vehicle-to-vehicle

communication information including information included in a received signal and a communication time acquired by the clock unit 15 when the signal is received (step S903). That is, the first communication unit 12 associates the ID of the on-board device 10B with which vehicle-to-vehicle communication has performed with the positional information of the vehicle B including the on-board device 10B and the communication time and stores the associated information in a storage unit such as the RAM 103.

[0049]

The positional information determination unit 16 acquires transmitted transmission information and vehicle-to-vehicle communication information generated on the basis of a reception signal from the other on-board device 10B received at almost the same timing as that of transmission of the transmission information. The positional information determination unit 16 compares positional information included in the acquired transmission information with positional information included in the vehicle-to-vehicle communication information generated on the basis of the corresponding reception signal (step S904).

[0050]

The positional information determination unit 16 determines correctness of positional information of the host vehicle or other vehicles on the basis of the positional information included in the transmission information and the positional information included in the vehicle-to-vehicle communication information generated on the basis of the corresponding received information (step S905). Specifically, the positional information determination unit 16 compares the positional information included in the transmission information with the positional information included in the vehicle-to-vehicle communication information generated on the basis of the reception information and determines that the GPS device mounted in the host vehicle or the GPS

device mounted in another vehicle is likely to be abnormal when a distance between the two pieces of positional information is equal to or greater than a predetermined distance at which the two pieces of positional information can be determined to be the same position.

5 [0051]

When it is determined that the distance between the positional information included in the transmission information and the positional information included in the vehicle-to-vehicle communication information generated on the basis of the corresponding reception information is equal to or greater than the predetermined distance a predetermined number of times or more or for a predetermined time, the positional information determination unit 16 may determine that the GPS device mounted in the host vehicle is abnormal. In addition, when it is determined that the distance between the positional information included in the transmission information and the positional information included in the vehicle-to-vehicle communication information generated on the basis of the reception information is equal to or greater than the predetermined distance only one time, the positional information determination unit 16 may determine that the GPS device included in the other on-board device 10B which has transmitted the reception information is abnormal. When the GPS device included in the other on-board device 10B is determined to be abnormal, the positional information determination unit 16 may immediately transmit a signal representing that the positional information is incorrect to the other on-board device 10B which has transmitted the reception information to notify the on-board device 10B that the measured positional information is abnormal.

[0052]

25 According to the above processing, the on-board device 10 can determine an

abnormality of the GPS device mounted in the host vehicle or GPS devices mounted in other vehicles through vehicle-to-vehicle communication.

[0053]

Meanwhile, each of the above-described devices includes a computer system.

- 5 In addition, each of the above-described processing procedures is stored in a computer-readable recording medium in the form of a program, and the aforementioned processing is performed by a computer reading and executing the program. Here, the computer-readable recording medium refers to a magnetic disc, a magneto-optical disc, a CD-ROM, a DVD-ROM, a semiconductor memory or the like. In addition, the
- 10 computer program may be transmitted to a computer through a communication link and the computer which has received this transmission may execute the program.

Reference Signs List

[0054]

- | | |
|----|--|
| 15 | 1 Vehicle management system |
| | 10 On-board device |
| | 20 Vehicle management device |
| | 30 Database |
| | 11 Controller |
| 20 | 12 First communication unit |
| | 13 Second communication unit |
| | 14 Positional information acquisition unit |
| | 15 Clock unit |
| | 16 Positional information determination unit |
| 25 | 21 Controller |

22 Received information management unit

23 Determination unit

24 Toll calculation unit

CLAIMS

1. A vehicle management system comprising:

an on-board device of a vehicle which transmits vehicle-to-vehicle communication information, the vehicle-to-vehicle communication information including at least identification information of another vehicle located in a communication available range of vehicle-to-vehicle communication, the identification information being received from an on-board device of the other vehicle through the vehicle-to-vehicle communication; and

a vehicle management device which determines presence or absence of corresponding vehicle-to-vehicle communication information by comparing vehicle-to-vehicle communication information received from on-board devices of a plurality of different vehicles,

wherein the vehicle management device identifies pieces of identification information of a plurality of other vehicles included in a plurality of pieces of first vehicle-to-vehicle communication information received from an on-board device of a specific vehicle among the vehicles, and sorts the pieces of identification information in order based on communication times,

the vehicle management device identifies second vehicle-to-vehicle communication information including identification information of the specific vehicle from a plurality of pieces of vehicle-to-vehicle communication information, the plurality of pieces of vehicle-to-vehicle communication information being extracted based on the identified pieces of identification information of the

plurality of other vehicles and being received from the on-board devices of the other vehicles, the vehicle management device sorting the second vehicle-to-vehicle communication information in order based on communication times,

the vehicle management device compares permutations of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information, and determines correctness of at least one of the first vehicle-to-vehicle communication information or the second vehicle-to-vehicle communication information, and

the vehicle management device calculates a charged amount for a travel section on which the vehicle has traveled within the charging section based on positional information of the travel section when correctness of the vehicle-to-vehicle communication information is valid.

2. The vehicle management system according to claim 1,

wherein the vehicle management device compares the two obtained permutations with each other and determines that correctness of each of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information is valid when the two obtained permutations are consistent with each other, and

the vehicle management device compares the two obtained permutations with each other and determines that correctness of any of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle

communication information is invalid when the two obtained permutations are not consistent with each other.

3. The vehicle management system according to claim 1 or 2,
wherein the on-board device of the vehicle receives positional information of the other vehicle from the on-board device of the other vehicle through the vehicle-to-vehicle communication,

the on-board device of the vehicle acquires positional information of the host vehicle, and

the on-board device of the vehicle determines correctness of the positional information on any of the host vehicle and the other vehicle based on the positional information of the host vehicle, the positional information of the other vehicle, and a communication time at which communication with the other vehicle has been performed through the vehicle-to-vehicle communication.

4. A vehicle management device comprising:

an acquisition unit which receives vehicle-to-vehicle communication information from an on-board device of a vehicle, the vehicle-to-vehicle communication information including at least identification information of another vehicle located in a communication available range of vehicle-to-vehicle communication and a communication time of the vehicle-to-vehicle communication, the identification information being received by the on-board device of the vehicle from an on-board device of the other vehicle through the

vehicle-to-vehicle communication;

a determination unit which determines presence or absence of corresponding vehicle-to-vehicle communication information by comparing vehicle-to-vehicle communication information received from on-board devices of a plurality of different vehicles; and

a toll calculation unit,

wherein the determination unit identifies pieces of identification information of a plurality of other vehicles included in a plurality of pieces of first vehicle-to-vehicle communication information received from an on-board device of a specific vehicle among the vehicles, and sorts the pieces of identification information in order based on communication times,

the determination unit identifies second vehicle-to-vehicle communication information including identification information of the specific vehicle from a plurality of pieces of vehicle-to-vehicle communication information, the plurality of pieces of vehicle-to-vehicle communication information being extracted based on the identified pieces of identification information of the plurality of other vehicles and being received from the on-board devices of the other vehicles, the determination unit sorting the second vehicle-to-vehicle communication information in order based on communication times, and

the determination unit compares permutations of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information, and determines correctness of at least one of the first vehicle-to-vehicle communication information or the second vehicle-to-vehicle

communication information,

the toll calculation unit calculates a charged amount for a travel section on which the vehicle has traveled within the charging section based on positional information of the travel section when correctness of the vehicle-to-vehicle communication information is valid.

5. The vehicle management device according to claim 4,

wherein the determination unit compares the two obtained permutations with each other and determines that correctness of each of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information is valid when the two obtained permutations are consistent with each other, and

the determination unit compares the two obtained permutations with each other and determines that correctness of any of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information is invalid when the two obtained permutations are not consistent with each other.

6. A vehicle management method comprising:

transmitting, by an on-board device of a vehicle, vehicle-to-vehicle communication information, the vehicle-to-vehicle communication information including at least identification information of another vehicle located in a communication available range of vehicle-to-vehicle communication and a

communication time of the vehicle-to-vehicle communication, the identification information being received from an on-board device of the other vehicle through the vehicle-to-vehicle communication; and

identifying, by a vehicle management device, pieces of identification information of a plurality of other vehicles included in a plurality of pieces of first vehicle-to-vehicle communication information received from an on-board device of a specific vehicle among the vehicles, and sorting, by the vehicle management device, the pieces of identification information in order based on communication times, identifying, by the vehicle management device, second vehicle-to-vehicle communication information including identification information of the specific vehicle from a plurality of pieces of vehicle-to-vehicle communication information, the plurality of pieces of vehicle-to-vehicle communication information being extracted based on the identified pieces of identification information of the plurality of other vehicles and being received from the on-board devices of the other vehicles, sorting, by the vehicle management device, the second vehicle-to-vehicle communication information in order based on communication times, comparing, by the vehicle management device, permutations of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information, and determining, by the vehicle management device, correctness of at least one of the first vehicle-to-vehicle communication information or the second vehicle-to-vehicle communication information, and calculating, by the vehicle management device, a charged amount for a travel section on which the vehicle has traveled within the charging section based on

positional information of the travel section when correctness of the vehicle-to-vehicle communication information is valid.

7. The vehicle management method according to claim 6, comprising:
comparing, by the vehicle management device, the two obtained permutations with each other and determining, by the vehicle management device, that correctness of each of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information is valid when the two obtained permutations are consistent with each other, and comparing, by the vehicle management device, the two obtained permutations with each other and determining, by the vehicle management device, that correctness of any of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information is invalid when the two obtained permutations are not consistent with each other.

8. A program which causes a computer of a vehicle management device to function as:

an acquisition means which receives vehicle-to-vehicle communication information from an on-board device of a vehicle, the vehicle-to-vehicle communication information including at least identification information of another vehicle located in a communication available range of vehicle-to-vehicle communication, the identification information being received by the on-board device of the vehicle from an on-board device of the other vehicle through the

vehicle-to-vehicle communication; and

a determination means which identifies pieces of identification information of a plurality of other vehicles included in a plurality of pieces of first vehicle-to-vehicle communication information received from an on-board device of a specific vehicle among the vehicles, and sorts the pieces of identification information in order based on communication times, the determination means identifying second vehicle-to-vehicle communication information including identification information of the specific vehicle from a plurality of pieces of vehicle-to-vehicle communication information, the plurality of pieces of vehicle-to-vehicle communication information being extracted based on the identified pieces of identification information of the plurality of other vehicles and being received from the on-board devices of the other vehicles, the determination means sorting the second vehicle-to-vehicle communication information in order based on communication times, the determination means comparing permutations of the first vehicle-to-vehicle communication information and the second vehicle-to-vehicle communication information, and determining correctness of at least one of the first vehicle-to-vehicle communication information or the second vehicle-to-vehicle communication information, and the determination means calculating a charged amount for a travel section on which the vehicle has traveled within the charging section based on positional information of the travel section when correctness of the vehicle-to-vehicle communication information is valid.