[DESCRIPTION]

[TITLE OF INVENTION]

ON-BOARD DEVICE, COMMUNICATION METHOD OF ON-BOARD DEVICE, AND PROGRAM

[Technical Field]

[0001]

The present invention relates to an on-board device, a communication method of an onboard device, and a program.

[Background Art]

[0002]

A toll collection system that collects tolls of a road has been proposed, demonstrated, or put into practical use. For example, in Singapore, electronic road pricing (ERP) in which a gate installed on a road communicates with an on-board device mounted in a vehicle and automatically collects a toll from a user is used. In the ERP, the gate additionally transmits data which is acquired from each vehicle to a center that collects information for vehicles. For example, the 3G mobile communication system is used for the communication. Since the gate transmits information of vehicles in this way, a communication traffic volume increases with an increase of a vehicle traffic volume.

[0003]

In order to curb an increase of a volume of communication traffic due to an increase of an amount of information (probe information) from on-board devices in this way, a technique in which a center groups vehicles under similar traveling conditions on the basis of information transmitted from the on-board devices and collects the probe information from a representative on-board device of the group has been proposed (for

example, see Patent Literature 1).

[0004]

However, in the technique described in Patent Literature 1, the center performs grouping and selection of a representative after the on-board devices have communicated with the center. Accordingly, in the technique described in Patent Literature 1, there is a problem in that a volume of communication traffic between the on-board devices and the center increases with a vehicle traffic volume.

[Citation List]

[Patent Literature]

[0005]

[Patent Literature 1]

Japanese Unexamined Patent Application, First Publication No. 2012-89088

[Summary of Invention]

[Technical Problem]

[0006]

The invention has been made in consideration of the above-mentioned problem and an objective thereof is to provide an on-board device, a communication method of an on-board device, and a program that can decrease a volume of communication traffic with a center.

[Solution to Problem]

[0007]

In order to achieve the above-mentioned objective, an on-board device (2) according to an aspect of the invention includes a control unit (26) configured to calculate vehicle information (for example, speed information) of a host vehicle in a vehicle information area (a speed calculation target area) which the host vehicle enters

before the host vehicle enters a transmission on-board device determination area (a transmission on-board device determination area) in which an on-board device that is to transmit vehicle information of vehicles in which on-board devices are mounted to a center is determined, to request communication from an on-board device mounted in an other vehicle when the host vehicle has entered the transmission on-board device determination area, to receive vehicle information of the other vehicle from the other on-board device not satisfying a representative vehicle condition in the transmission on-board device determination area by performing vehicle-to-vehicle communication which is performed between the host vehicle and the other vehicle when the vehicle-to-vehicle communication has been established after the representative vehicle condition has been satisfied, and to transmit the vehicle information of the host vehicle to the other on-board device satisfying the representative vehicle condition by performing the vehicle-to-vehicle communication when the vehicle-to-vehicle communication has been established before the representative vehicle condition in the transmission on-board device determination area is satisfied.

With this configuration, an on-board device mounted in a vehicle satisfying the representative vehicle condition receives vehicle information from an on-board device mounted in a vehicle other than a representative vehicle by vehicle-to-vehicle communication which is performed between an on-board device mounted in a vehicle entering the transmission on-board device determination area and an on-board device mounted in an other vehicle. The on-board device mounted in the vehicle not satisfying the representative vehicle condition transmits vehicle information of the host vehicle to the representative vehicle. As a result, vehicle information of the host vehicle and the other vehicle is accumulated in the on-board device mounted in the vehicle satisfying the representative vehicle condition. A communication network of a mobile

communication system is not used in the vehicle-to-vehicle communication. Since an on-board device other than a representative does not transmit vehicle information to the center, a volume of communication traffic with the center is not generated.

As a result, it is possible to decrease a volume of communication traffic with the center.

[0008]

In the on-board device according to the aspect of the invention, the control unit is configured to transmit the vehicle information of the host vehicle and the vehicle information of the other vehicle received from the other on-board device to the center configured to acquire the vehicle information when the representative vehicle condition is satisfied.

With this configuration, since an on-board device which is not a representative does not transmit vehicle information to the center and an on-board device which is a representative transmits vehicle information of the host vehicle and vehicle information of a vehicle which is not a representative to the center, it is possible to decrease the number of communications with the center. Accordingly, since a header and the like which are generated for each communication can be decreased, it is possible to decrease a volume of communication traffic with the center.

[0009]

In the on-board device according to the aspect of the invention, the control unit is configured to set a transmission/reception state indicating a state in which transmission of the vehicle information of the host vehicle is performed or a state in which reception of the vehicle information of the other vehicle is performed to a first state (iii) in which the representative vehicle condition is not satisfied when the host vehicle has entered the transmission on-board device determination area. The control unit is configured to set

the transmission/reception state to a second state (ii) in which the representative vehicle condition is not satisfied when the vehicle information of the host vehicle has been transmitted to the other on-board device satisfying the representative vehicle condition before the representative vehicle condition has been satisfied. The control unit is configured to set a boundary position at which the transmission/reception state is changed in the transmission on-board device determination area and set the transmission/reception state to a third state (i) in which the representative vehicle condition is satisfied when the set boundary position is crossed and the transmission/reception state is the first state. The control unit is configured to transmit information indicating the transmission/reception state to the other on-board device in correlation with the vehicle information of the host vehicle.

With this configuration, since the representative on-board device changes the transmission/reception state to the third state in which the vehicle information of the host vehicle can be transmitted to the center at the time of crossing the boundary position even when the representative on-board device does not transmit the vehicle information of the host vehicle to other on-board device and the transmission/reception state is in the first state, it is possible to prevent the vehicle information from not being transmitted to the center. With this configuration, it is possible to determine whether received vehicle information of other vehicle is to be acquired on the basis of the transmission/reception state included in the vehicle information of the other vehicle which is transmitted from the other on-board device. Accordingly, the representative on-board device can be prevented from acquiring vehicle information from one on-board device twice. An on-board device of which the transmission/reception state is not the first state does not have to transmit vehicle information to the center.

[0010]

In the on-board device according to the aspect of the invention, the control unit is configured not to receive information from an area other than the transmission on-board device determination area in which the host vehicle in which the on-board device of the host vehicle is mounted is traveling on the basis of information on the transmission on-board device determination area (information indicating a link ID) included in a signal transmitted from the other on-board device when the vehicle-to-vehicle communication with the other on-board device is performed.

With this configuration, the on-board device can determine whether vehicle information is to be acquired on the basis of the information on the transmission on-board device determination area. Accordingly, with this configuration, for example, when vehicle information of other vehicle is received from an on-board device mounted in the other vehicle traveling in the opposite lane, it is possible to prevent acquisition of vehicle information of the other vehicle traveling in the opposite lane.

[0011]

In the on-board device according to the aspect of the invention, the control unit is configured not to request communication from the on-board device mounted in the other vehicle when the host vehicle in which the on-board device of the host vehicle is mounted is stopped.

With this configuration, since the other on-board device mounted in a stopped vehicle does not transmit vehicle information to the representative on-board device, it is possible to decrease a volume of communication traffic of vehicle-to-vehicle communication and to prevent the representative on-board device from acquiring vehicle information of other vehicle which is stopped. With this configuration, since unnecessary vehicle information is not transmitted to the center, the center can appropriately process a plurality of pieces of vehicle information of the transmission on-

board device determination area.

[0012]

In the on-board device according to the aspect of the invention, the control unit is configured to transmit information indicating a first vehicle information area in which the vehicle information of the host vehicle is calculated to the other on-board device in correlation with the vehicle information of the host vehicle. The control unit is configured not to receive the vehicle information from a vehicle information area other than the first vehicle information area when the vehicle-to-vehicle communication with the other on-board device is performed.

With this configuration, vehicle information from a vehicle information area other than the first vehicle information area in which the vehicle in which the on-board device is mounted has calculated the vehicle information is not received. Accordingly, even when there are a plurality of areas (transmission on-board device determination areas) which a vehicle enters before the vehicle enters the transmission on-board device determination area, it is possible to prevent the on-board device from erroneously transmitting vehicle information from areas other than the area in which the vehicle information has been calculated to the center.

[0013]

In order to achieve the aforementioned objective, a communication method of an on-board device according to an aspect of the invention includes: causing a control unit to calculate vehicle information of a host vehicle in a vehicle information area which the host vehicle enters before the host vehicle enters a transmission on-board device determination area in which an on-board device that is to transmit vehicle information of a vehicle in which an on-board device is mounted to a center is determined; causing the control unit to request communication from an on-board device mounted in an other

vehicle when the host vehicle has entered the transmission on-board device determination area; causing the control unit to determine whether a representative vehicle condition in the transmission on-board device determination area has been satisfied; causing the control unit to receive vehicle information of the other vehicle from the other on-board device not satisfying the representative vehicle condition in the transmission on-board device determination area by performing vehicle-to-vehicle communication which is performed between the host vehicle and the other vehicle when the vehicle-to-vehicle communication has been established after the representative vehicle condition has been satisfied; causing the control unit to transmit the vehicle information of the host vehicle to the other on-board device satisfying the representative vehicle condition by performing the vehicle-to-vehicle communication when the vehicle-to-vehicle communication has been established before the representative vehicle condition in the transmission on-board device determination area is satisfied; and causing the control unit to transmit the vehicle information of the host vehicle and the vehicle information of the other vehicle received from the other on-board device to the center configured to acquire the vehicle information after the determination that the representative vehicle condition in the transmission on-board device determination area has been satisfied.

[0014]

In order to achieve the aforementioned objective, a program according to an aspect of the invention causes a computer of an on-board device which is mounted in a vehicle to perform: a step of calculating vehicle information of a host vehicle in a vehicle information area which the host vehicle enters before the host vehicle enters a transmission on-board device determination area in which an on-board device that is to transmit vehicle information of a vehicle in which an on-board device is mounted to a center is determined; a step of requesting communication from an on-board device

mounted in an other vehicle when the host vehicle has entered the transmission on-board device determination area; a step of determining whether a representative vehicle condition in the transmission on-board device determination area has been satisfied; a step of receiving vehicle information of the other vehicle from the other on-board device not satisfying the representative vehicle condition in the transmission on-board device determination area by performing vehicle-to-vehicle communication which is performed between the host vehicle and the other vehicle when the vehicle-to-vehicle communication has been established after the representative vehicle condition has been satisfied; a step of transmitting the vehicle information of the host vehicle to the other on-board device satisfying the representative vehicle condition by performing the vehicle-to-vehicle communication when the vehicle-to-vehicle communication has been established before the representative vehicle condition in the transmission on-board device determination area is satisfied; and a step of transmitting the vehicle information of the host vehicle and the vehicle information of the other vehicle received from the on-board device of the other vehicle to the center configured to acquire the vehicle information after the determination that the representative vehicle condition in the transmission on-board device determination area has been satisfied.

[Advantageous Effects of Invention]

[0015]

The on-board device according to the invention can decrease a volume of communication traffic with the center.

[Brief Description of Drawings]

[0016]

FIG. 1 is a diagram schematically illustrating an example of a configuration of a toll collection system according to an embodiment.

FIG. 2 is a diagram illustrating an example of a configuration of an on-board device according to the embodiment.

FIG. 3 is a diagram illustrating an example of a speed calculation target area and a transmission on-board device determination area according to the embodiment.

FIG. 4 is a diagram illustrating an example of processes in on-board devices in a speed calculation target area according to the embodiment.

FIG. 5 is a diagram illustrating an example of processes in on-board devices in a transmission on-board device determination area according to the embodiment.

FIG. 6 is a diagram illustrating an example of a first transmission signal according to the embodiment.

FIG. 7 is a diagram illustrating an example of a second transmission signal according to the embodiment.

FIG. 8 is a diagram illustrating an example of a center-transmitted signal which an on-board device transmits to a center device according to the embodiment.

FIG. 9 is a diagram illustrating an example of information which is stored in a storage unit of an on-board device according to the embodiment.

FIG. 10 is a diagram illustrating an example of a process which is performed by a control unit in transmission/reception states which are stored in a storage unit of an on-board device according to the embodiment.

FIG. 11 is a diagram illustrating an example of communication times between on-board devices according to the embodiment.

FIG. 12 is a flowchart illustrating an example of a process flow which is performed by an on-board device in a speed calculation target area according to the embodiment.

FIG. 13 is a flowchart illustrating an example of a process flow which is

performed by an on-board device in a transmission on-board device determination area according to the embodiment.

FIG. 14 is a diagram illustrating an example of a speed calculation target area and a transmission on-board device determination area according to a third modified example.

FIG. 15 is a diagram illustrating an example in which an on-board device mounted in a vehicle stopped on a road side transmits speed information to an on-board device mounted in another vehicle.

FIG. 16 is a diagram illustrating an example in which a road in a travel direction in front of a speed calculation target area branches in a first direction and a second direction.

FIG. 17 is a diagram illustrating an example in which two speed calculation target areas merge into a transmission on-board device determination area.

[Description of Embodiments]

[0017]

Hereinafter, an embodiment of the invention will be described with reference to the accompanying drawings.

[0018]

<Overall configuration of vehicle information collection system>

FIG. 1 is a diagram schematically illustrating an example of a configuration of a vehicle information collection system 1 according to an embodiment. As illustrated in FIG. 1, the vehicle information collection system 1 includes on-board devices 2a, 2b, 2c, … and a center device 3. The on-board device 2a is mounted in a vehicle 20a. The on-board device 2b is mounted in a vehicle 20b. The on-board device 2c is mounted in a vehicle 20c.

In the following description, each of the vehicles 20a, 20b, 20c, … is referred to as a vehicle 20 when a specific one is not distinguished. In the following description, each of the on-board devices 2a, 2b, 2c, … is referred to as an on-board device 2 when a specific one is not distinguished.

[0019]

In the following description, it is assumed that vehicle information is speed information of a vehicle 20. Vehicle information is not limited to speed information and may be a state of charge of a battery (not illustrated) which is mounted in a vehicle 20, or the like, for example, when the vehicle 20 is an electric vehicle. Vehicle information may be information indicating a vehicle type (such as an automobile, a truck, a bus, or a motorbike).

[0020]

The vehicle 20 is an automobile, a truck, a bus, a motorbike, or the like.

The center device 3 collects speed information of the vehicles 20 which is transmitted by the on-board devices 2. The center device 3 calculates an average speed of vehicles which are traveling in a speed calculation target area (also referred to as a vehicle information area) in which speed calculation is performed. The center device 3 performs communication with the on-board devices 2, for example, using a mobile communication system.

[0021]

In this embodiment, each on-board device 2 calculates speed information of a host vehicle 20 on the basis of a result of reception from a positioning information receiving unit 29 (FIG. 2) which will be described later in the speed calculation target area in which speed calculation is performed. Thereafter, when the vehicle 20 in which the on-board device 2 is mounted enters a transmission on-board device determination

area (a transmission on-board device determination area), the on-board device 2 determines whether it is an on-board device 2 that is to transmit speed information to the center device 3. The on-board device 2 determined to be an on-board device 2 that is to transmit speed information to the center device 3 receives speed information from an on-board device 2 mounted in another vehicle 20 and transmits the received speed information of the other vehicle 20 and the speed information of the host vehicle 20 to the center device 3. The method of determining an on-board device 2 that is to transmit speed information to the center device 3 will be described later.

[0022]

In the example illustrated in FIG. 1, each on-board device 2 detects that a vehicle 20 in which the on-board device 2 is mounted enters a speed calculation target area on the basis of a result received by the positioning information receiving unit 29 (FIG. 2). The on-board device 2 detects that the vehicle 20 exits the speed calculation target area on the basis of a result received by the positioning information receiving unit 29. Then, the on-board device 2 calculates speed information of the vehicle 20 in the speed calculation target area on the basis of the result received by the positioning information receiving unit 29.

[0023]

In the example illustrated in FIG. 1, the on-board device 2a entering a transmission on-board device determination area which will be described later after exiting the speed calculation target area is determined to be the on-board device 2 that is to transmit speed information to the center device 3.

The on-board device 2a and the on-board device 2b communicate with each other and the on-board device 2a acquires speed information of the vehicle 20b from the on-board device 2b. The on-board device 2a and the on-board device 2c communicate

with each other and the on-board device 2a acquires speed information of the vehicle 20c from the on-board device 2c. In the example illustrated in FIG. 1, the on-board device 2a transmits the speed information of the host vehicle 20a, the speed information of the vehicle 20b, and the speed information of the vehicle 20c to the center device 3. The order of communication and the method of determining the on-board device 2 that is to transmit speed information to the center device 3 will be described later.

[0024]

<Vehicle-to-vehicle communication>

Communication which is performed between two on-board devices 2 will be described below.

Two on-board devices 2 perform transmission and reception of speed information by radio communication which is vehicle-to-vehicle (V2V) communication without using a base station. The standard of radio communication is, for example, a communication standard based on the Wi-Fi communication standard or the 802.11 standard. Accordingly, a communication fee for a communication carrier or the like is not generated between the two on-board devices 2. The communication standard which is used for the vehicle-to-vehicle communication is not limited thereto and, for example, RFID communication or infrared communication may be used as long as it does not use a base station and a communication fee is not generated.

[0025]

<Configuration of on-board device>

FIG. 2 is a diagram illustrating an example of a configuration of an on-board device 2 according to this embodiment.

As illustrated in FIG. 2, the on-board device 2 includes a transmission antenna 21, a transmission unit 22, a reception antenna 23, a reception unit 24, a storage unit 25, a

control unit 26, an antenna 27, a communication unit 28, and a positioning information receiving unit 29. The on-board devices 2a, 2b, 2c, … illustrated in FIG. 1 have the same configuration as illustrated in FIG. 2.

[0026]

The transmission antenna 21 converts a transmission signal which is output from the transmission unit 22 into transmission radio waves and causes the converted transmission radio waves to propagate in a space.

[0027]

The transmission unit 22 acquires transmission information which is output from the control unit 26. The transmission information is classified into a first transmission signal including a request for establishment of communication and a second transmission signal including speed information of a vehicle 20. The transmission information will be described later. The transmission unit 22 generates a transmission signal by performing encoding or modulation based on the communication standard on the acquired transmission information and outputs the generated transmission signal to the transmission antenna 21.

[0028]

The reception antenna 23 receives radio waves having propagated in the space. The reception antenna 23 converts the received radio waves into a signal and outputs the converted signal as a reception signal to the reception unit 24.

[0029]

The reception unit 24 acquires the reception signal which is output from the reception antenna 23. The reception unit 24 extracts reception information by performing decoding or demodulation based on the communication standard on the acquired reception signal, and outputs the extracted reception information to the control

unit 26. The reception information includes speed information of another vehicle 20 received from another on-board device 2.

[0030]

The storage unit 25 stores map information of roads. The map information includes nodes indicating crossings and nodal points in expression of a road network and links indicating road sections between nodes. A unique identification number is set for each node. A unique identification number is set for each link. The storage unit 25 stores node IDs and identification information of links (hereinafter referred to as link IDs) in a speed calculation target area. The speed calculation target area will be described later. The storage unit 25 stores node IDs and link IDs in a transmission on-board device determination area. The transmission on-board device determination area will be described later. The storage unit 25 stores information indicating a transmission/reception state of the on-board device 2. The transmission/reception state of the on-board device 2 will be described later. The storage unit 25 stores a link ID in which the speed of the host vehicle 20 has been measured. The storage unit 25 stores speed information of the host vehicle 20. The storage unit 25 stores speed information of another vehicle 20 when the speed information of the other vehicle 20 is received from another on-board device 2 by the on-board device 2. The storage unit 25 also stores processes which are performed by the control unit 26. The transmission/reception state and processes which are performed in the transmission/reception state will be described later. The storage unit 25 stores conditions for setting a boundary position which will be described later. The conditions for setting a boundary position include, for example, a distance or a time. The boundary position will be described later.

[0031]

The control unit 26 calculates, for example, an average speed in a speed

calculation target area and stores information indicating the calculated average speed as speed information in the storage unit 25. For example, the control unit 26 measures the speed of the host vehicle 20 using position information and time information which are output from the positioning information receiving unit 29 in a period in which the host vehicle is traveling in the link ID1. Processes which are performed in the speed calculation target area will be described later.

The control unit 26 performs vehicle-to-vehicle communication with an on-board device 2 mounted in another vehicle 20 in a transmission on-board device determination area. The control unit 26 transmits the speed information of the host vehicle 20 to the other on-board device 2 or receives speed information of the other vehicle 20 in which the other on-board device 2 is mounted from the other on-board device 2 on the basis of the transmission/reception state. When the on-board device 2 of the host vehicle 20 is determined to be an on-board device 2 that is to transmit speed information, the control unit 26 transmits the speed information of the host vehicle 20 and the acquired speed information of the other vehicle 20 to the center device 3 via the communication unit 28 and the antenna 27 at the time of exiting the transmission on-board device determination area. In the following description, an on-board device 2 that transmits the speed information of the host vehicle 20 and the speed information of another vehicle 20 to the center device 3 is referred to as a representative on-board device 2. The control unit 26 sets a boundary position which will be described later on the basis of information stored in the storage unit 25, and determines the on-board device 2 of the host vehicle 20 as the representative on-board device 2 when vehicle information is not transmitted to another on-board device 2 until the set boundary position is crossed. That is, the boundary position is a position at which an on-board device 2 that does not transmit speed information to another on-board device 2 is determined as the

representative on-board device 2. When the host vehicle has entered the transmission on-board device determination area, the control unit 26 sets the transmission/reception state of speed information to an initial state and then changes the transmission/reception state with transmission of the speed information to another vehicle or with reception of the speed information from another vehicle. Processes which are performed in the transmission on-board device determination area will be described later.

[0032]

The antenna 27 converts radio waves which are received from the center device 3 into an electrical signal and outputs the converted electrical signal as a center reception signal to the communication unit 28. The antenna 27 converts a center transmission signal which is output from the communication unit 28 into transmission radio waves and causes the converted transmission radio waves to propagate in a space.

[0033]

The communication unit 28 performs, for example, communication via a base station with the center device 3. The communication unit 28 generates a center transmission signal by performing encoding or modulation based on the communication standard with the center device 3 on the speed information which is output from the control unit 26, and outputs the generated center transmission signal to the antenna 27. The communication unit 28 acquires the center reception signal which is output from the antenna 27. The communication unit 28 extracts center reception information by performing decoding or demodulation based on the communication standard on the acquired center reception signal, and outputs the extracted center reception information to the control unit 26. The center reception information includes, for example, an ACK (ACKnowledgement) response indicating that the center transmission signal has been received from the on-board device 2.

[0034]

The positioning information receiving unit 29 is a reception unit that receives positioning information from satellites (not illustrated) of a global navigation satellite system (GNSS). The positioning information receiving unit 29 calculates a current position using the information received from the satellites of the GNSS and outputs position information indicating the calculated current position to the control unit 26. The positioning information receiving unit 29 extracts current time information from the received information and outputs the extracted current time information to the control unit 26.

[0035]

<Speed calculation target area and transmission on-board device determination area>

FIG. 3 is a diagram illustrating an example of a speed calculation target area and a transmission on-board device determination area according to this embodiment. In FIG. 3, a traveling direction (a moving direction) of the vehicle 20 is defined as an x-axis direction and a direction perpendicular to the x axis is defined as a y-axis direction. In the example illustrated in FIG. 3, two lanes in which a vehicle travels extend in the y-axis direction.

[0036]

Numerals 101 to 103 denote nodes. Identification information of the node 101 is defined as a node ID1. Identification information of the node 102 is defined as a node ID2. Identification information of the node 103 is defined as a node ID3.

Numerals 151 and 152 denote links. The link 151 is a road section between the node ID1 and the node ID2. The link 152 is a road section between the node ID2 and the node ID3. Identification information of the link 151 is defined as a link ID1.

Identification information of the link 152 is defined as a link ID2.

[0037]

An area indicated by numeral 111 is a speed calculation target area. The speed calculation target area is an area in which an on-board device 2 of a vehicle 20 having entered the area calculates, for example, an average speed in the area.

An area indicated by numeral 112 is a transmission on-board device determination area. The transmission on-board device determination area is an area in which it is determined which on-board device 2 out of on-board devices 2 mounted in a plurality of vehicles 20 having entered the area is to transmit speed information of a host vehicle 20 and speed information of other vehicles 20 to the center device 3.

In this way, a speed calculation target area in this embodiment is an area which a vehicle enters before the vehicle enters a transmission on-board device determination area.

[0038]

Reference numeral 121 indicates a boundary position at which a transmission/reception state of an on-board device 2 is changed when the transmission/reception state is an initial state. In the example illustrated in FIG. 3, the boundary position 121 is set to a position which is separated L1 (m) in the x-axis direction from the node ID2. For example, the distance L1 from the node ID2 is randomly determined by the control unit 26 of each on-board device 2. Accordingly, the boundary position 121 differs depending on the on-board devices 2. For example, the distance L1 for the on-board device 2a is 20 m, the distance L1 for the on-board device 2b is 15 m, and the distance L1 for the on-board device 2c is 25 m.

[0039]

<Process of on-board device in speed calculation target area>

FIG. 4 is a diagram illustrating an example of processes in on-board devices 2 in a speed calculation target area 111 according to this embodiment. The coordinates thereof are the same as illustrated in FIG. 3. The traveling direction of a vehicle 20 is a positive direction of the x-axis direction. FIG. 4(A) illustrates an example in which a vehicle 20a enters the speed calculation target area 111. FIG. 4(B) illustrates an example in which a vehicle 20a and a vehicle 20b enter the speed calculation target area 111. FIG. 4(C) illustrates an example in which a vehicle 20a, a vehicle 20b, and a vehicle 20c enter the speed calculation target area 111.

[0040]

First, as illustrated in FIG. 4(A), the vehicle 20a enters the link ID1 which is the speed calculation target area 111. With reference to the position information output from the positioning information receiving unit 29 and the information stored in the storage unit 25, the on-board device 2a detects that the host vehicle has entered the link ID1, that is, that the host vehicle has entered the speed calculation target area 111, when the vehicle 20a crosses the position of the node ID1. In a section of the link ID1, that is, in a section between the nodes ID1 and ID2, the on-board device 2a measures the speed of the host vehicle 20a using the position information and the time information which are output from the positioning information receiving unit 29. The control unit 26 calculates, for example, a time difference between the time at which the host vehicle has crossed the node ID1 and the time at which the host vehicle has crossed the node ID2, that is, a time required for passing through the link ID1. The control unit 26 calculates a distance of the link ID1 using the position information of the node ID1 and the position information of the node ID2. The control unit 26 calculates an average speed in the section of the link ID1 using the calculated distance of the link ID1 and the time required for passing through the link ID1.

[0041]

Then, as illustrated in FIG. 4(B), the vehicle 20b enters the link ID1 which is the speed calculation target area 111. With reference to the position information output from the positioning information receiving unit 29 and the information stored in the storage unit 25, the on-board device 2b detects that the host vehicle has entered the link ID1, that is, that the host vehicle has entered the speed calculation target area 111, when the vehicle 20b crosses the position of the node ID1. In the section of the link ID1, that is, in the section between the nodes ID1 and ID2, the on-board device 2b measures the speed of the host vehicle 20b using the position information and the time information which are output from the positioning information receiving unit 29.

[0042]

Then, as illustrated in FIG. 4(C), the vehicle 20c enters the link ID1 which is the speed calculation target area 111. With reference to the position information output from the positioning information receiving unit 29 and the information stored in the storage unit 25, the on-board device 2c detects that the host vehicle has entered the link ID1, that is, that the host vehicle has entered the speed calculation target area 111, when the vehicle 20c crosses the position of the node ID1. In the section of the link ID1, that is, in the section between the nodes ID1 and ID2, the on-board device 2c measures the speed of the host vehicle 20c using the position information and the time information which are output from the positioning information receiving unit 29.

[0043]

The control unit 26 sets the transmission/reception state to a state other than the transmission/reception states (i) to (iii), for example, a transmission/reception state (0), in the speed calculation target area. Accordingly, even when the on-board device 2 in the transmission/reception state (i) has received the second transmission signal from another

on-board device 2 traveling in the speed calculation target area, the on-board device 2 does not acquire speed information of the other vehicle 20 on the basis of the transmission/reception state. In the speed calculation target area, the control unit 26 may not transmit the second transmission signal or may not add the speed information of the host vehicle 20 to the second transmission signal when it is transmitted.

[0044]

When a vehicle 20 or an on-board device 2 includes a vehicle speed sensor, the on-board device 2 may calculate the speed information on the basis of a detection value detected by the vehicle speed sensor. Alternatively, when a vehicle 20 includes an acceleration sensor, the on-board device 2 may calculate the speed information by integrating a measured value from the acceleration sensor. Alternatively, the on-board device 2 may acquire the speed information from the vehicle 20.

[0045]

<Process of on-board device in transmission on-board device determination area>

FIG. 5 is a diagram illustrating an example of processes in on-board devices 2 in a transmission on-board device determination area 112 according to this embodiment. The coordinates thereof are the same as illustrated in FIG. 3. The traveling direction of a vehicle 20 is a positive direction of the x-axis direction. FIG. 5(A) illustrates an example in which a vehicle 20a enters the transmission on-board device determination area 112. FIG. 5(B) illustrates an example in which a vehicle 20a and a vehicle 20b enter the transmission on-board device determination area 112. FIG. 5(C) illustrates an example in which a vehicle 20a, a vehicle 20b, and a vehicle 20c enter the transmission on-board device determination area 112.

[0046]

First, as illustrated in FIG. 5(A), the vehicle 20a in which an on-board device 2a is mounted enters the link ID2 which is the transmission on-board device determination area 112. With reference to the position information output from the positioning information receiving unit 29 and the information stored in the storage unit 25, the on-board device 2a detects that the host vehicle has entered the link ID2, that is, that the host vehicle has entered the transmission on-board device determination area 112, when the vehicle 20a crosses the position of the node ID2. Accordingly, the on-board device 2a sets the transmission/reception state to the transmission/reception state (iii) (a first state) which is an initial state. The transmission/reception state (iii) is a state in which the speed information is not transmitted to another on-board device 2, that is, a state in which transmission of the speed information is not determined. Subsequently, the on-board device 2a starts transmission of a first transmission signal in the positive direction (forward) of the x-axis direction. The first transmission signal includes at least a request for establishment of communication and information indicating the transmission/reception state. As illustrated in FIG. 5(A), since another vehicle 20 capable of communication does not travel in the positive direction of the x-axis direction of the vehicle 20a, the on-board device 2a cannot establish communication with another on-board device 2.

[0047]

Then, the control unit 26 of the on-board device 2a sets a boundary position 121 of the on-board device 2a on the basis of the information stored in the storage unit 25. Then, as illustrated in FIG. 5(B), the vehicle 20a crosses the set boundary position 121. The on-board device 2a measures a travel distance from the node ID2 using the position information output from the positioning information receiving unit 29 and a travel distance output from the vehicle 20a, and detects that the host vehicle has crossed the

boundary position 121 on the basis of the result of measurement. The on-board device 2a starts measurement of the travel distance at the position of the node 2, acquires information of the travel distance from the vehicle 20a every predetermined time, and measures the travel distance. The control unit 26 continues to measure the travel distance until the measured distance becomes a distance from the node 2 to the boundary position 121.

[0048]

In this way, when the on-board device 2a cannot perform vehicle-to-vehicle communication with another on-board device 2 until crossing the boundary position 121, the on-board device 2a changes the transmission/reception state from the transmission/reception state (iii) to the transmission/reception state (i). The transmission/reception state (i) (a third state) is a state in which the speed information is determined to be transmitted to the center device 3, that is, a state in which the speed information is to be transmitted.

[0049]

As illustrated in FIG. 5(B), the vehicle 20b in which an on-board device 2b is mounted enters the link ID2 which is the transmission on-board device determination area 112. The on-board device 2b sets the transmission/reception state to the transmission/reception state (iii) which is an initial state.

Then, the vehicle 20b in which the on-board device 2b is mounted starts transmission of a first transmission signal in the positive direction of the x-axis direction. As illustrated in FIG. 5(B), the vehicle 20a in which the on-board device 2a capable of communication is mounted is traveling in the positive direction of the x-axis direction of the vehicle 20b.

[0050]

Subsequently, the on-board device 2a establishes communication with the on-board device 2b on the basis of a request included in the first transmission signal transmitted from the on-board device 2b. After the communication has been established, the on-board device 2b transmits a second transmission signal to the on-board device 2a. The second transmission signal includes the link ID2 in which the vehicle 20b is currently traveling and speed information in the section of the link ID1. When the transmission/reception state of the on-board device 2a of the host vehicle 20a is (i) and the transmission/reception state included in the first transmission information received from the on-board device 2b is (iii), the on-board device 2a receives the speed information transmitted from the on-board device 2b. Subsequently, the on-board device 2a transmits reception completion information indicating that the speed information has been received to the on-board device 2b.

[0051]

Subsequently, the on-board device 2a stores the speed information of the vehicle 20b included in the second transmission information received from the on-board device 2b in the storage unit 25. Accordingly, the speed information of the host vehicle 20a and the speed information of the vehicle 20b are stored in the storage unit 25 of the on-board device 2a.

Subsequently, when the reception completion information has been received from the on-board device 2a, it means that the speed information has been transmitted to the other on-board device 2, and thus the on-board device 2b changes the transmission/reception state from the transmission/reception state (iii) to the transmission/reception state (ii). The transmission/reception state (ii) (a second state) is a state in which the speed information has been transmitted to another on-board device 2, that is, a non-targeted state in which speed information has not been transmitted to the

center device 3. When the transmission/reception state (iii) is maintained until the vehicle having the on-board device 2b mounted therein reaches the boundary position 121, the on-board device 2b changes the transmission/reception state from (iii) to (i). As described above, the boundary position 121 of the on-board device 2a and the boundary position 121 of the on-board device 2b are different from each other. The control unit 26 of the on-board device 2b sets the boundary position 121 of the on-board device 2b.

[0052]

As illustrated in FIG. 5(C), the vehicle 20c in which an on-board device 2c is mounted enters the link ID2 which is the transmission on-board device determination area 112. The on-board device 2c sets the transmission/reception state to the transmission/reception state (iii) which is an initial state.

[0053]

Then, as illustrated in FIG. 5(C), the vehicle 20c in which the on-board device 2c is mounted starts transmission of a first transmission signal in the positive direction of the x-axis direction. As illustrated in FIG. 5(C), the vehicle 20a in which the on-board device 2a capable of communication is mounted and the vehicle 20b in which the on-board device 2b is mounted are traveling in the positive direction of the x-axis direction of the vehicle 20c.

[0054]

The on-board device 2b establishes communication with the on-board device 2c on the basis of a request included in the first transmission signal transmitted from the on-board device 2c. After the communication has been established, the on-board device 2c transmits a second transmission signal to the on-board device 2b. Since the transmission/reception state of the on-board device 2b is (ii), the on-board device 2b does

not receive the speed information transmitted from the on-board device 2c and transmits reception incomplete information indicating that the speed information has not been received to the on-board device 2c. The on-board device 2b may not transmit an ACK signal to the on-board device 2c.

[0055]

When the reception incomplete information has been received from the on-board device 2b or when an ACK signal has not been received within a predetermined time after the speed information has been transmitted, the on-board device 2c determines that transmission has failed.

[0056]

Subsequently, the on-board device 2a establishes communication with the on-board device 2c on the basis of a request included in the first transmission signal. After the communication has been established, the on-board device 2c transmits a second transmission signal to the on-board device 2a. When the transmission/reception state of the on-board device 2a is (i) and the transmission/reception state included in the first transmission signal received from the on-board device 2c is (iii), the on-board device 2a receives the speed information transmitted from the on-board device 2c. Subsequently, the on-board device 2 transmits reception completion information indicating that the speed information has been received to the on-board device 2c.

[0057]

Subsequently, the on-board device 2a stores the speed information of the vehicle 20c received from the on-board device 2c in the storage unit 25. Accordingly, the speed information of the vehicle 20c is additionally stored in the storage unit 25 of the on-board device 2a.

Subsequently, when the reception completion information has been received

from the on-board device 2a, it means that the speed information has been transmitted to the other on-board device 2, and thus the on-board device 2c changes the transmission/reception state from the transmission/reception state (iii) to the transmission/reception state (ii). When the transmission/reception state (iii) is maintained until the vehicle having the on-board device 2c mounted therein reaches the boundary position 121, the on-board device 2c changes the transmission/reception state from (iii) to (i). As described above, the boundary position 121 of the on-board device 2c is different from the boundary position 121 of the on-board device 2a and is also different from the boundary position 121 of the on-board device 2b. The control unit 26 of the on-board device 2c sets the boundary position 121 of the on-board device 2c on the basis of the information stored in the storage unit 25.

[0058]

Subsequently, when the host vehicle exits the transmission on-board device determination area 112 of the link ID2, the on-board device 2a transmits the speed information of the host vehicle 20a, the speed information of the vehicle 20b, and the speed information of the vehicle 20c which are stored in the storage unit 25 of the on-board device 2a to the center device 3.

[0059]

In this way, in this embodiment, for example, after the on-board device 2c has transmitted the speed information of the vehicle 20a to the on-board device 2a, the on-board device 2c changes the transmission/reception state from the transmission/reception state (iii) to the transmission/reception state (ii). Accordingly, even when the on-board device 2c has performed vehicle-to-vehicle communication with the on-board device 2a again, the on-board device 2a does not receive the second transmission signal which has been re-transmitted from the on-board device 2c on the basis of the

transmission/reception state (ii) included in the first transmission signal transmitted from the on-board device 2c.

[0060]

<First transmission signal>

FIG. 6 is a diagram illustrating an example of a first transmission signal according to this embodiment. As illustrated in FIG. 6, the first transmission signal includes a header, a request, and information indicating a transmission/reception state. The first transmission signal illustrated in FIG. 6 is only an example and the invention is not limited thereto.

[0061]

<Second transmission signal>

FIG. 7 is a diagram illustrating an example of a second transmission signal according to this embodiment. As illustrated in FIG. 7, the second transmission signal includes a header, information indicating a link ID, speed information of a vehicle in which an on-board device 2 is mounted, and information indicating a transmission/reception state. The second transmission signal illustrated in FIG. 7 is only an example and the invention is not limited thereto.

[0062]

<Center transmission signal transmitted from on-board device 2 to center device 3>

FIG. 8 is a diagram illustrating an example of a center transmission signal which is transmitted from an on-board device 2 to the center device 3 according to this embodiment. As illustrated in FIG. 8, the center transmission signal includes a header, information indicating a link ID in which a speed has been measured, speed information of a first vehicle 20a, speed information of a second vehicle 20b, …, and speed

information of an n-th (where n is an integer equal to or greater than 1) vehicle 20. For example, in the example illustrated in FIG. 5(C), center information which is transmitted by the on-board device 2a includes a header, information indicating the link ID1, the speed information of the vehicle 20a, the speed information of the vehicle 20b, and the speed information of the vehicle 20c. The center transmission signal illustrated in FIG. 8 is only an example and the invention is not limited thereto. The center transmission signal may include speed information which is an average value of the speeds of ten vehicles and information indicating that it is the average speed of ten vehicles instead of the speed information of the vehicles 20.

[0063]

<Information stored in storage units 25 of two on-board devices 2>

FIG. 9 is a diagram illustrating an example of information which is stored in a storage unit 25 of an on-board device 2 according to this embodiment. In the example illustrated in FIG. 9, a transmission/reception state of an on-board device 2 is (i) and speed information has already been received from n on-board devices 2.

As illustrated in FIG. 9, the on-board device 2 stores speed information of a host vehicle 20 and received speed information of other vehicles 20 in correlation with information indicating a link ID in which a speed has been measured.

[0064]

The control unit 26 transmits second transmission information with the speed information of the vehicles 20 stored in the storage unit 25 added thereto. The control unit 26 may transmit, for example, speed information of ten vehicles to the center device 3 for each vehicle 20. Alternatively, the control unit 26 may transmit speed information which is an average value of the speeds of the ten vehicles to the center device 3 along with information indicating that it is the average speed of the ten vehicles.

[0065]

FIG. 10 is a diagram illustrating an example of a process which is performed by the control unit 26 in the transmission/reception states stored in the storage unit 25 of an on-board device 2 according to this embodiment.

As illustrated in FIG. 10, when the transmission/reception state of the on-board device 2 is (i) and the transmission/reception state of a communication partner is (i) or (ii), the storage unit 25 stores information indicating that the control unit 26 has not acquired speed information. When the transmission/reception state of the on-board device 2 is (i) and the transmission/reception state of the communication partner is (iii), the storage unit 25 stores information indicating that the control unit 26 acquires speed information.

[0066]

When the transmission/reception state of the on-board device 2 is (ii) and the transmission/reception state of the communication partner is (i) or (ii) or (iii), the storage unit 25 stores information indicating that the control unit 26 does not acquire speed information.

[0067]

When the transmission/reception state of the on-board device 2 is (iii) and the transmission/reception state of the communication partner is (i) or (ii) or (iii), the storage unit 25 stores information indicating that the control unit 26 does not acquire speed information.

[0068]

That is, when the transmission/reception state of the on-board device 2 is (i) and the transmission/reception state of the on-board device 2 of the communication partner is (iii), the control unit 26 of the on-board device 2 acquires speed information of the

communication partner.

[0069]

<Communication time between on-board devices 2>

FIG. 11 is a diagram illustrating an example of communication times between on-board devices 2 according to this embodiment.

In the example illustrated in FIG. 11, the on-board device 2a performs communication with another on-board device 2 with a period T1. The control unit 26 of the on-board device 2a sets the period T1, for example, in at least one of the time when the on-board device 2a is powered on, the time when the on-board device 2a is powered on for the first time, and the time when the on-board device 2a has been initialized.

[0070]

The on-board device 2b performs communication with another on-board device 2 with a period T2 which is shorter than the period T1. The control unit 26 of the on-board device 2b sets the period T2, for example, in at least one of when the on-board device 2b is powered on, when the on-board device 2b is powered on for the first time, and when the on-board device 2b has been initialized.

[0071]

The on-board device 2c performs communication with another on-board device 2 with a period T3 which is longer than the period T1. The control unit 26 of the on-board device 2c sets the period T3, for example, in at least one of the time when the on-board device 2c is powered on, the time when the on-board device 2c is powered on for the first time, and the time when the on-board device 2c has been initialized.

The order of lengths of the periods P1 to P3 in FIG. 11 is an example and the invention is not limited thereto.

[0072]

In this embodiment, since the communication times between the on-board devices 2 are set to be different in this way, there is a time at which the communication time therebetween does not overlap. Accordingly, when the communication times do not overlap, two on-board devices 2 receive a request from the communication partner and establishes communication.

[0073]

<Process flow of on-board device 2>

An example of a process flow in a speed calculation target area will be first described below.

FIG. 12 is a flowchart illustrating an example of a process flow which is performed by an on-board device 2 in a speed calculation target area according to the embodiment.

[0074]

(Step S1) The control unit 26 determines whether a vehicle 20 in which an on-board device 2 is mounted has entered a speed calculation target area on the basis of position information output from the positioning information receiving unit 29 and information stored in the storage unit 25. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has not entered the speed calculation target area (Step S1: NO), the control unit 26 repeatedly performs the process of Step S1. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has entered the speed calculation target area (Step S1: YES), the control unit 26 performs the process of Step S2.

[0075]

(Step S2) The control unit 26 sets the transmission/reception state to (iii).

[0076]

(Step S3) The control unit 26 determines whether the vehicle 20 in which the on-board device 2 is mounted has exited the speed calculation target area on the basis of the position information output from the positioning information receiving unit 29 and the information stored in the storage unit 25. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has not exited the speed calculation target area (Step S2: NO), the control unit 26 repeatedly performs the process of Step S2. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has exited the speed calculation target area (Step S2: YES), the control unit 26 performs the process of Step S3.

[0077]

(Step S4) The control unit 26 calculates an average speed in the speed calculation target area using the position information and time information output from the positioning information receiving unit 29. Subsequently, the control unit 26 stores information indicating the calculated average speed in the storage unit 25 as speed information of the host vehicle 20.

[0078]

An example of a process flow in a transmission on-board device determination area will be described below.

FIG. 13 is a flowchart illustrating an example of a process flow which is performed by an on-board device 2 in a transmission on-board device determination area according to this embodiment.

[0079]

(Step S11) The control unit 26 determines whether the vehicle 20 in which the on-board device 2 is mounted has entered a transmission on-board device determination area on the basis of position information output from the positioning information

receiving unit 29 and information stored in the storage unit 25. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has not entered the transmission on-board device determination area (Step S11: NO), the control unit 26 repeatedly performs the process of Step S11. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has entered the transmission on-board device determination area (Step S11: YES), the control unit 26 performs the process of Step S12.

[0080]

(Step S12) The control unit 26 determines whether the vehicle 20 in which the on-board device 2 is mounted has crossed a boundary position on the basis of the position information output from the positioning information receiving unit 29 and the information stored in the storage unit 25. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has crossed the boundary position (Step S12: YES), the control unit 26 performs the process of Step S13. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has not crossed the boundary position (Step S12: NO), the control unit 26 performs the process of Step S14.

[0081]

(Step S14) The control unit 26 determines whether a communication time has come. When it is determined that a communication time has not come (Step S4: NO), the control unit 26 returns to the process of Step S12. When it is determined that a communication time has come (Step S14: YES), the control unit 26 performs the process of Step S15.

[0082]

(Step S15) The control unit 26 transmits a first transmission signal including a request to another on-board device 2 via the transmission unit 22 and the transmission

antenna 21 and receives an ACK signal in response to the first transmission signal from the other on-board device 2. Alternatively, when a first transmission signal has been received from another on-board device 2, the control unit 26 transmits an ACK signal to the other on-board device 2.

[0083]

(Step S16) The control unit 26 determines whether communication with another on-board device 2 has been established. When it is determined that communication with another on-board device 2 has not been established (Step S16: NO), the control unit 26 returns to the process of Step S12. When it is determined that communication with another on-board device 2 has been established (Step S16: YES), the control unit 26 performs the process of Step S17.

[0084]

(Step S17) The control unit 26 reads the transmission/reception state of the on-board device 2 of the host vehicle 20 from the storage unit 25. Subsequently, the control unit 26 determines whether the transmission/reception state of the on-board device 2 of the host vehicle 20 is (i) or (ii) or (iii). When it is determined that the transmission/reception state of the on-board device 2 of the host vehicle 20 is (i) (Step S17: (i)), the control unit 26 performs the process of Step S18. When it is determined that the transmission/reception state of the on-board device 2 of the host vehicle 20 is (ii) (Step S17: (ii)), the control unit 26 performs the process of Step S24. When it is determined that the transmission/reception state of the on-board device 2 of the host vehicle 20 is (iii) (Step S17: (iii)), the control unit 26 performs the process of Step S27.

[0085]

(Step S18) The control unit 26 determines whether a second transmission signal has been received from an on-board device 2 mounted in another vehicle 20. When it is

determined that a second transmission signal has not been received from an on-board device 2 mounted in another vehicle 20 (Step S18: NO), the control unit 26 repeatedly performs the process of Step S18. When it is determined that a second transmission signal has been received from an on-board device 2 mounted in another vehicle 20 (Step S18: YES), the control unit 26 performs the process of Step S19.

[0086]

(Step S19) The control unit 26 extracts a link ID included in the received second transmission signal. Subsequently, the control unit 26 determines whether the extracted link ID matches a link ID in which the host vehicle is currently traveling. When it is determined that the extracted link ID does not match the link ID in which the host vehicle is currently traveling (Step S19: NO), the control unit 26 returns to the process of Step S14. When it is determined that the extracted link ID matches the link ID in which the host vehicle is currently traveling (Step S19: YES), the control unit 26 performs the process of Step S20.

[0087]

(Step S20) The control unit 26 extracts information indicating the transmission/reception state from the received first transmission signal. Subsequently, the control unit 26 determines whether the transmission/reception state of the other on-board device 2 is (i) or (ii) or (iii). When it is determined that the transmission/reception state of the other on-board device 2 is (i) or (ii) (Step S20: (i) or (ii)), the control unit 26 performs the process of Step S26. When it is determined that the transmission/reception state of the other on-board device 2 is (iii) (Step S20: (iii)), the control unit 26 performs the process of Step S21.

[0088]

(Step S21) The control unit 26 acquires speed information from the received

second transmission signal and stores the acquired speed information in the storage unit 25. Subsequently, the control unit 26 transmits reception completion information to the other on-board device 2 via the transmission unit 22 and the transmission antenna 21. Thereafter, the control unit 26 performs the process of Step S22.

[0089]

(Step S22) The control unit 26 determines whether the vehicle 20 in which the on-board device 2 is mounted has exited the transmission on-board device determination area on the basis of the position information output from the positioning information receiving unit 29 and the information stored in the storage unit 25. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has not exited the transmission on-board device determination area (Step S22: NO), the control unit 26 returns to the process of Step S14. When it is determined that the vehicle 20 in which the on-board device 2 is mounted has exited the transmission on-board device determination area (Step S22: YES), the control unit 26 performs the process of Step S23.

[0090]

(Step S23) The control unit 26 transmits the speed information of the host vehicle 20 and the speed information of the other vehicle 20 which are stored in the storage unit 25 to the center device 3 via the transmission unit 28 and the antenna 27. Thereafter, the control unit 26 ends the process flow.

[0091]

(Step S24) The control unit 26 determines whether a second transmission signal has been received from an on-board device 2 mounted in another vehicle 20. When it is determined that a second transmission signal has not been received from an on-board device 2 mounted in another vehicle 20 (Step S24: NO), the control unit 26 repeatedly

performs the process of Step S24. When it is determined that a second transmission signal has been received from an on-board device 2 mounted in another vehicle 20 (Step S24: YES), the control unit 26 performs the process of Step S25.

[0092]

(Step S25) The control unit 26 extracts a link ID included in the received second transmission signal. Subsequently, the control unit 26 determines whether the extracted link ID matches a link ID in which the host vehicle is currently traveling. When it is determined that the extracted link ID does not match the link ID in which the host vehicle is currently traveling (Step S25: NO), the control unit 26 returns to the process of Step S14. When it is determined that the extracted link ID matches the link ID in which the host vehicle is currently traveling (Step S25: YES), the control unit 26 performs the process of Step S26.

[0093]

(Step S26) The control unit 26 does not acquire speed information from the received second transmission signal and transmits reception incompletion information to the other on-board device 2 via the transmission unit 22 and the transmission antenna 21. Thereafter, the control unit 26 returns to the process of Step S14.

[0094]

(Step S27) The control unit 26 transmits a second transmission signal including the speed information to the other on-board device 2 via the transmission unit 22 and the transmission antenna 21. Thereafter, the control unit 26 performs the process of Step S28.

[0095]

(Step S28) The control unit 26 determines whether reception completion information or reception incompletion information has been received. When it is

determined that reception incompletion information has been received (Step S28: reception incompletion information), the control unit 26 returns to the process of Step S12. When it is determined that reception completion information has been received (Step S28: reception completion information), the control unit 26 performs the process of Step S29.

[0096]

(Step S29) The control unit 26 sets the transmission/reception state to (ii) and returns to the process of Step S14.

[0097]

The process flow illustrated in FIG. 13 is an example and the invention is not limited thereto. For example, the control unit 26 may perform some processes of the process flow in parallel.

In the example illustrated in FIG. 13, when the transmission/reception states of two on-board devices 2 are both (iii), the speed information is not acquired, but the invention is not limited thereto. When second transmission information including speed information has been received from another on-board device 2 in the transmission/reception state (iii), the on-board device 2 in the transmission/reception state (iii) may acquire the speed information and change the transmission/reception state to (i).

[0098]

In the aforementioned example, the link ID included in the second transmission information is used as the link ID in which the host vehicle is traveling, but the invention is not limited thereto. The link ID included in the second transmission information may be a link ID of a speed calculation target area in which speed information has been calculated. In this case, between Steps S19 and S25, the control unit 26 may compare

the extracted link ID with the link ID in which the speed information has been calculated.

[0099]

<First modified example>

In the aforementioned example, an on-board device 2 communicates with an on-board device 2 mounted in another vehicle 20 even when the transmission/reception state of the on-board device 2 is (i) or (ii) or (iii), but the invention is not limited thereto. The control unit 26 may determine whether to perform vehicle-to-vehicle communication with the on-board device 2 mounted in another vehicle 20 on the basis of the transmission/reception state.

[0100]

For example, the control unit 26 of the on-board device 2 of the host vehicle 20 may not transmit the first transmission signal when a communication time has come after the transmission/reception state has been changed to (ii) due to completion of transmission of the speed information of the host vehicle 20 to another on-board device 2.

When the first transmission signal has been received from another on-board device 2 at a communication time after the transmission/reception state has been changed to (ii), the control unit 26 may not transmit an ACK signal in response to the first transmission signal to the other on-board device 2.

[0101]

The control unit 26 may not transmit the first transmission signal even when a communication time has come after the transmission/reception state has been changed to (i).

When the first transmission signal has been received from another on-board device 2 at a communication time after the transmission/reception state has become (iii),

the control unit 26 may not transmit an ACK signal in response to the first transmission signal to the other on-board device 2.

[0102]

The control unit 26 may not perform communication in an area other than the transmission on-board device determination area.

[0103]

<Second modified example>

In the aforementioned example, the control unit 26 sets the boundary position to a position which is separated L1 [m] from a start point of the nodes of the transmission on-board device determination area, but the invention is not limited thereto. The control unit 26 may set the boundary position to a position which is separated L1 [m] from an end point of the nodes of the transmission on-board device determination area.

The control unit 26 may set L1 [m] on the basis of the length of the transmission on-board device determination area. For example, when the length of the transmission on-board device determination area is greater than a predetermined value, the control unit 26 may increase L1 by multiplying L1 by a predetermined coefficient which is equal to or greater than 1. For example, when the length of the transmission on-board device determination area is less than the predetermined value, the control unit 26 may decrease L1 by multiplying L1 by a predetermined coefficient which is equal to or less than 1.

[0104]

<Third modified example>

In the examples illustrated in FIGS. 3 to 5, the lane (or lanes) is one-way traffic for the purpose of simplification of description, but the lanes may include an opposite lane.

FIG. 14 is a diagram illustrating an example of a speed calculation target area

and a transmission on-board device determination area according to a third modified example. In FIG. 3, a traveling direction of the upper lane is defined as the x-axis direction and a direction perpendicular to the x axis is defined as a y-axis direction. The same nodes and links as in FIG. 3 will be referred to by the same reference numerals and description thereof will not be repeated.

[0105]

Numerals 201 to 203 denote nodes. Identification information of the node 201 is defined as a node ID201. Identification information of the node 202 is defined as a node ID202. Identification information of the node 203 is defined as a node ID203.

Numerals 251 and 252 denote links. The link 251 is a road section between the node ID201 and the node ID202. The link 252 is a road section between the node ID202 and the node ID203. Identification information of the link 251 is defined as a link ID201. Identification information of the link 252 is defined as a link ID202.

[0106]

An area indicated by numeral 211 is a speed calculation target area.

An area indicated by numeral 212 is a transmission on-board device determination area.

Numeral 221 denotes a boundary position at which the transmission/reception state is changed when the transmission/reception state of an on-board device 2 is an initial state.

[0107]

In the example illustrated in FIG. 14, a vehicle 20a travels in the positive direction of the x-axis direction on a lane including a speed calculation target area 111 and a transmission on-board device determination area 112, and a vehicle 20b travels in the negative direction of the x-axis direction on a lane including a speed calculation

target area 211 and a transmission on-board device determination area 212. In this example, since the on-board device 2a of the vehicle 20a has calculated speed information of the host vehicle 20a in the speed calculation target area 111 and the host vehicle has crossed the boundary position 121 in the transmission on-board device determination area 112, the transmission/reception state is changed to (i). In this example, speed information of the host vehicle 20b has been calculated in the speed calculation target area 211 and the transmission/reception state is changed to (iii) after the vehicle 20b has entered the transmission on-board device determination area 212.

[0108]

Here, it is assumed that the on-board device 2b mounted in the vehicle 20b has transmitted a request to the on-board device 2a mounted in the vehicle 20a.

In this case, the on-board device 2a establishes communication with the on-board device 2b on the basis of the request from the on-board device 2b. Subsequently, the on-board device 2b transmits a second transmission signal to the on-board device 2a. The on-board device 2a extracts a link ID included in the received second transmission signal. In the example illustrated in FIG. 14, the link ID in which the on-board device 2a is traveling is 2 and the link ID in which the speed information of the host vehicle 20a has been calculated is 1. On the other hand, the link ID in which the on-board device 2b is traveling is 202 and the link ID in which the speed information of the host vehicle 20b has been calculated is 201. Accordingly, the control unit 26 of the on-board device 2a determines that the link ID extracted from the second transmission signal received from the on-board device 2b does not match the link ID in which the host vehicle is traveling. By ascertaining the link ID in this way, the control unit 26 of the on-board device 2a in the transmission/reception state (i) can be prevented from acquiring speed information of a vehicle 20 which is traveling on the opposite lane.

[0109]

<Fourth modified example>

As illustrated in FIG. 15, it is assumed that a vehicle 20 stops on a road side. FIG. 15 is a diagram illustrating an example in which an on-board device 2b mounted in a vehicle 20b stopping on a road side transmits speed information to an on-board device 2a mounted in another vehicle 20a.

In this case, the speed information of the vehicle 20b may be substantially 0 [km/s^2] depending on a position at which the vehicle 20b stops or a period in which the vehicle 20b is stopping. However, the link ID of the on-board device 2a of the vehicle 20a which is traveling in a transmission on-board device determination area matches the link ID of the on-board device 2b of the vehicle 20b stopping on the road side of the transmission on-board device determination area. Accordingly, in Steps S19 and S25 of FIG. 14, it may not be possible to prevent acquisition of speed information from the on-board device 2b mounted in the vehicle 20b in the stopped state.

[0110]

Accordingly, when an ignition key of the vehicle 20b is in an off state, the control unit 26 performs control such that it does not communicate with another on-board device 2.

When the ignition key of the vehicle 20b is in an on state, the control unit 26 may acquire speed information from the vehicle 20, determine that the vehicle 20 stops when the acquired speed information is equal to or less than a predetermined value, and perform control such that it does not transmit the speed information of the host vehicle 20b to another on-board device 2.

Alternatively, the center device 3 may exclude speed information which is equal to or less than a predetermined value from speed information received from the on-board

devices 2, and calculate an average speed in the speed calculation target area.

[0111]

It is assumed that a vehicle 20 stops in a speed calculation target area. For example, when a vehicle 20 stops on a road side of a speed calculation target area for 5 minutes, speed information which is different from actual speed information in the speed calculation target area is calculated.

In order to curb erroneous speed information including such a stopped period, the on-board device 2 may transmit a second transmission signal including stop position information indicating a position at which the vehicle stops in the speed calculation target area. In this case, the control unit 26 determines that a position at which a vehicle speed is equal to or less than a predetermined value is a stop position on the basis of the position information which is output from the positioning information receiving unit 29. When stop position information can be extracted from the second transmission signal, the control unit 26 of the on-board device 2 having received the second transmission signal may not store the speed information in the storage unit 25 and may not transmit the speed information to the center device 3. In this case, the control unit 26 of the on-board device 2 having received the second transmission signal transmits reception completion information to another on-board device 2. Accordingly, the on-board device 2 having received the reception completion information can change the transmission/reception state from (iii) to (ii). When there are two or more stop positions, the number of pieces of information indicating the stop positions may be two or more. The control unit 26 may calculate stop time information indicating the time in which the vehicle stops in the speed calculation target area on the basis of the time information which is output from the positioning information receiving unit 29, and transmit the second transmission signal including the acquired stop time information.

[0112]

<When transmission on-board device determination area branches>

In the examples illustrated in FIGS. 3 and 14, the number of speed calculation target areas and the number of transmission on-board device determination areas are one, but the invention is not limited thereto. For example, when a road in a travel direction in front of a speed calculation target area 111 branches into a first direction and a second direction as illustrated in FIG. 16, a first transmission on-board device determination area112 may be provided on the road in the first direction and a second transmission on-board device determination area 113 may be provided on the road in the second direction. FIG. 16 is a diagram illustrating an example in which a road in a travel direction in front of a speed calculation target area 111 branches into a first direction and a second direction.

[0113]

In the example illustrated in FIG. 16, it is assumed that a vehicle 20a in which an on-board device 2a is mounted and a vehicle 20b in which an on-board device 2b is mounted travel in a speed calculation target area 111.

Thereafter, it is assumed that the vehicle 20a has entered the first transmission on-board device determination area 112 and the vehicle 20b has entered the second transmission on-board device determination area 113. It is also assumed that a vehicle 20c in which an on-board device 2c is mounted is traveling in the first transmission on-board device determination area 112 and the transmission/reception state of the on-board device 2c is (i). It is also assumed that a vehicle 20d in which an on-board device 2d is mounted is traveling in the second transmission on-board device determination area 113 and the transmission/reception state of the on-board device 2d is (i).

[0114]

The control unit 26 of the on-board device 2a calculates an average speed of the host vehicle 20a in a period in which the host vehicle is in the speed calculation target area 111 using the position information and the time information which are output from the positioning information receiving unit 29, and sets the transmission/reception state to (iii) when the host vehicle has entered the first transmission on-board device determination area 112. After having entered the first transmission on-board device determination area 112, the control unit 26 of the on-board device 2a transmits the speed information of the host vehicle 20a to the on-board device 2c in the transmission/reception state (i) in the first transmission on-board device determination area 112. In this case, the on-board device 2c transmits the speed information of the host vehicle 20c and the speed information of the vehicle 20a to the center device 3.

[0115]

The control unit 26 of the on-board device 2b calculates an average speed of the host vehicle 20b in a period in which the host vehicle is in the speed calculation target area 111 using the position information and the time information which are output from the positioning information receiving unit 29, and sets the transmission/reception state to (iii) when the host vehicle has entered the second transmission on-board device determination area 113. After having entered the second transmission on-board device determination area 113, the control unit 26 of the on-board device 2b transmits the speed information of the host vehicle 20b to the on-board device 2d in the transmission/reception state (i) in the second transmission on-board device determination area 113. In this case, the on-board device 2d transmits the speed information of the host vehicle 20d and the speed information of the vehicle 20b to the center device 3.

[0116]

<When two speed calculation target areas merge into transmission on-board

device determination area>

FIG. 17 is a diagram illustrating an example in which two speed calculation target areas merge into a transmission on-board device determination area 112. That is, FIG. 17 illustrates an example in which a first speed calculation target area 111 and a second speed calculation target area 114 merge into one transmission on-board device determination area 112. In other words, in the example illustrated in FIG. 17, a speed calculation target area which is an area which a vehicle 20 enters before the vehicle enters the transmission on-board device determination area 112 branches into two or more areas with a node 102 at which the vehicle enters the transmission on-board device determination area 112 at a start point.

[0117]

In the example illustrated in FIG. 17, it is assumed that a vehicle 20a in which an on-board device 2a is mounted and a vehicle 20c in which an on-board device 2c is mounted are traveling in the first speed calculation target area 111. It is also assumed that a vehicle 20b in which an on-board device 2b is mounted is traveling in the second speed calculation target area 114. Thereafter, it is assumed that the vehicle 20a and the vehicle 20b enter the transmission on-board device determination area 112. It is also assumed that the vehicle 20c in which the on-board device 2c is mounted is traveling in the transmission on-board device determination area 112 and the transmission/reception state of the on-board device 2c is (i).

[0118]

In the example illustrated in FIG. 17, the on-board device 2a mounted in the vehicle 20a calculates speed information of the host vehicle 20a in the period in which the host vehicle is in the first speed calculation target area 111 using the position information and the time information which are output from the positioning information

receiving unit 29, and sets the transmission/reception state to (iii) when the host vehicle has entered the transmission on-board device determination area 112. The on-board device 2b mounted in the vehicle 20b calculates speed information of the host vehicle 20b in the period in which the host vehicle is in the second speed calculation target area 114 using the position information and the time information which are output from the positioning information receiving unit 29, and sets the transmission/reception state to (iii) when the host vehicle has entered the transmission on-board device determination area 112.

[0119]

In this case, when the on-board device 2c traveling in the first speed calculation target area 111 receives the speed information from the on-board device 2b traveling in the second speed calculation target area 114 and transmits the speed information of the host vehicle 20c and the speed information of the vehicle 20b to the center device 3, the center device 3 cannot calculate a correct average speed in the first speed calculation target area 111. Accordingly, the on-board device 2a sets the link ID included in the second transmission signal as the link ID of the first speed calculation target area 111 in which the speed information has been calculated. The on-board device 2b sets the link ID included in the second transmission signal as the link ID of the second speed calculation target area 114 in which the speed information has been calculated.

[0120]

Then, the on-board device 2c extracts information indicating the link ID included in the second transmission information received from another on-board device 2 at the time of vehicle-to-vehicle communication with the other on-board device 2, and acquires speed information when the link ID in which the on-board device 2c has calculated the speed information of the vehicle 20c matches the extracted link ID. As a

result, the on-board device 2c acquires the speed information from the on-board device 2a traveling in the same first speed calculation target area 111 as the vehicle 20c, and does not acquire the speed information from the on-board device 2b traveling in the second speed calculation target area 114 which is different from the area in which the vehicle 20c travels. The on-board device 2c can transmit the speed information of the host vehicle 20c and another vehicle 20a in the first speed calculation target area 111 to the center device 3 by transmitting the speed information of the vehicle 20c and the speed information of the vehicle 20a to the center device 3. In this case, since the on-board device 2b fails to transmit the speed information to the on-board device 2a, the on-board device 2b changes the transmission/reception state from (iii) to (i) when the host vehicle crosses the boundary position, and transmits the speed information of the host vehicle 20b to the center device 3.

[0121]

In the aforementioned example, one on-board device 2 transmits second transmission information to the other on-board device 2 after two on-board devices 2 have established communication on the basis of the first transmission signal, but the invention is not limited thereto. The first transmission information to which a header, a request, information indicating the transmission/reception state, information indicating the link ID, and the speed information are added may be transmitted. Accordingly, an on-board device 2 having received the first transmission signal may not establish communication with an on-board device 2 which is not a communication partner on the basis of the information indicating the transmission/reception state and the information indicating the link ID which are included in the first transmission information.

[0122]

In the examples illustrated in FIGS. 3 and 14, a speed calculation target area and

a transmission on-board device determination area are located close to each other, but the invention is not limited thereto. The speed calculation target area and the transmission on-board device determination area may be separated distant from each other as long as the speed calculation target area is located in front of the transmission on-board device determination area in the travel direction of a vehicle 20.

In the aforementioned example, the control unit 26 detects the node IDs of the speed calculation target area and the transmission on-board device determination area on the basis of the position information received by the positioning information receiving unit 29 and the information stored in the storage unit 25, but the invention is not limited thereto. For example, a road-side unit may be provided on a road and the road-side unit may transmit node IDs to a vehicle. The on-board device 2 may extract the node IDs from a transmission signal transmitted from the road-side unit and detect the speed calculation target area and the transmission on-board device determination area.

[0123]

In the aforementioned embodiments, all or some of the processes which are performed by the on-board device 2 are stored in the form of a program in a computer-readable recording medium, and the processes are performed by causing a computer to read and execute the program. Examples of the computer-readable recording medium include a magnetic disk, a magneto-optical disc, a CD-ROM, a DVD-ROM, a semiconductor memory. The computer program may be transmitted to a computer via a communication line and the computer having received the program may execute the program.

[0124]

The program may be provided for realizing some of the aforementioned functions. The program may be a program which can realize the aforementioned

functions in combination with a program which is recorded in a computer system in advance, that is, a so-called differential file (a differential program).

[0125]

While some embodiments of the invention have been described above, these embodiments are presented as an example and are not intended to limit the scope of the invention. These embodiments can be modified in various other forms and can be subjected to various omissions, substitutions, and changes without departing from the gist of the invention. The embodiments and the modifications thereof belong to the scope or gist of the invention and also similarly belong to the configurations described in the appended claims and a scope equivalent thereto.

[Reference Signs List]

[0126]

1 Vehicle information collection system

2, 2a, 2b, 2c, 2d On-board device

3 Center device

20, 20a, 20b, 20c, 20d Vehicle

21 Transmission antenna

22 Transmission unit

23 Reception antenna

24 Reception unit

25 Storage unit

26 Control unit

27 Antenna

28 Communication unit

29 Positioning information receiving unit

101, 102, 103, 201, 202, 203 Node

111, 114, 211 Speed calculation target area

112, 113, 212 Transmission on-board device determination area

121, 221 Boundary position

151, 152, 251, 252 Link

L1 Distance

(i), (ii), (iii) State

T1, T2, T3 Period

[CLAIMS]

[Claim 1]

An on-board device comprising a control unit configured to:

calculate vehicle information of a host vehicle in a vehicle information area which the host vehicle enters before the host vehicle enters a transmission on-board device determination area in which an on-board device that is to transmit vehicle information of a vehicle in which an on-board device is mounted to a center is determined;

request communication from an on-board device mounted in an other vehicle when the host vehicle has entered the transmission on-board device determination area;

receive vehicle information of the other vehicle from the other on-board device not satisfying a representative vehicle condition in the transmission on-board device determination area by performing vehicle-to-vehicle communication which is performed between the host vehicle and the other vehicle when the vehicle-to-vehicle communication has been established after the representative vehicle condition has been satisfied; and

transmit the vehicle information of the host vehicle to the other on-board device satisfying the representative vehicle condition by performing the vehicle-to-vehicle communication when the vehicle-to-vehicle communication has been established before the representative vehicle condition in the transmission on-board device determination area is satisfied.

[Claim 2]

The on-board device according to claim 1, wherein the control unit is configured to transmit the vehicle information of the host vehicle and the vehicle information of the other vehicle received from the other on-board device to the center configured to acquire

the vehicle information when the representative vehicle condition is satisfied.

[Claim 3]

The on-board device according to claim 1 or 2, wherein the control unit is configured to set a transmission/reception state indicating a state in which transmission of the vehicle information of the host vehicle is performed or a state in which reception of the vehicle information of the other vehicle is performed to a first state in which the representative vehicle condition is not satisfied when the host vehicle has entered the transmission on-board device determination area,

wherein the control unit is configured to set the transmission/reception state to a second state in which the representative vehicle condition is not satisfied when the vehicle information of the host vehicle has been transmitted to the other on-board device satisfying the representative vehicle condition before the representative vehicle condition has been satisfied,

wherein the control unit is configured to set a boundary position at which the transmission/reception state is changed in the transmission on-board device determination area and set the transmission/reception state to a third state in which the representative vehicle condition is satisfied when the set boundary position is crossed and the transmission/reception state is the first state, and

wherein the control unit is configured to transmit information indicating the transmission/reception state to the other on-board device in correlation with the vehicle information of the host vehicle.

[Claim 4]

The on-board device according to any one of claims 1 to 3, wherein the control unit is configured not to receive information from an area other than the transmission on-board device determination area in which the host vehicle in which the on-board device

of the host vehicle is mounted is traveling on the basis of information on the transmission on-board device determination area included in a signal transmitted from the other on-board device when the vehicle-to-vehicle communication with the other on-board device is performed.

[Claim 5]

The on-board device according to any one of claims 1 to 4, wherein the control unit is configured not to request communication from the on-board device mounted in the other vehicle when the host vehicle in which the on-board device of the host vehicle is mounted is stopped.

[Claim 6]

The on-board device according to any one of claims 1 to 5, wherein the control unit is configured to transmit information indicating a first vehicle information area in which the vehicle information of the host vehicle is calculated to the other on-board device in correlation with the vehicle information of the host vehicle, and

wherein the control unit is configured not to receive the vehicle information from a vehicle information area other than the first vehicle information area when the vehicle-to-vehicle communication with the other on-board device is performed.

[Claim 7]

A communication method of an on-board device, comprising:

causing a control unit to calculate vehicle information of a host vehicle in a vehicle information area which the host vehicle enters before the host vehicle enters a transmission on-board device determination area in which an on-board device that is to transmit vehicle information of a vehicle in which an on-board device is mounted to a center is determined;

causing the control unit to request communication from an on-board device

mounted in an other vehicle when the host vehicle has entered the transmission on-board device determination area;

causing the control unit to determine whether a representative vehicle condition in the transmission on-board device determination area has been satisfied;

causing the control unit to receive vehicle information of the other vehicle from the other on-board device not satisfying the representative vehicle condition in the transmission on-board device determination area by performing vehicle-to-vehicle communication which is performed between the host vehicle and the other vehicle when the vehicle-to-vehicle communication has been established after the representative vehicle condition has been satisfied;

causing the control unit to transmit the vehicle information of the host vehicle to the other on-board device satisfying the representative vehicle condition by performing the vehicle-to-vehicle communication when the vehicle-to-vehicle communication has been established before the representative vehicle condition in the transmission on-board device determination area is satisfied; and

causing the control unit to transmit the vehicle information of the host vehicle and the vehicle information of the other vehicle received from the other on-board device to the center configured to acquire the vehicle information after the determination that the representative vehicle condition in the transmission on-board device determination area has been satisfied.

[Claim 8]

A program causing a computer of an on-board device which is mounted in a vehicle to perform:

a step of calculating vehicle information of a host vehicle in a vehicle information area which the host vehicle enters before the host vehicle enters a

transmission on-board device determination area in which an on-board device that is to transmit vehicle information of a vehicle in which an on-board device is mounted to a center is determined;

a step of requesting communication from an on-board device mounted in an other vehicle when the host vehicle has entered the transmission on-board device determination area;

a step of determining whether a representative vehicle condition in the transmission on-board device determination area has been satisfied;

a step of receiving vehicle information of the other vehicle from the other on-board device not satisfying the representative vehicle condition in the transmission on-board device determination area by performing vehicle-to-vehicle communication which is performed between the host vehicle and the other vehicle when the vehicle-to-vehicle communication has been established after the representative vehicle condition has been satisfied;

a step of transmitting the vehicle information of the host vehicle to the other on-board device satisfying the representative vehicle condition by performing the vehicle-to-vehicle communication when the vehicle-to-vehicle communication has been established before the representative vehicle condition in the transmission on-board device determination area is satisfied; and

a step of transmitting the vehicle information of the host vehicle and the vehicle information of the other vehicle received from the other on-board device to the center configured to acquire the vehicle information after the determination that the representative vehicle condition in the transmission on-board device determination area has been satisfied.