DESCRIPTION

Title of Invention

WIRELESS COMMUNICATION SYSTEM AND WIRELESS COMMUNICATION METHOD

[Technical Field]

[0001]

The present disclosure relates to a wireless communication system and a wireless communication method.

[Background Art]

[0002]

In recent years, in order to perform charging processing, information distribution to a vehicle, information collection from the vehicle, and the like, road-to-vehicle communication for transmitting and receiving data between a roadside device and an in-vehicle device, and vehicle-to-vehicle communication for transmitting and receiving data between in-vehicle devices have been used (for example, see Patent Document 1).

[Citation List]

[Patent Document]

[0003]

[Patent Document 1] Japanese Patent No. 6340891

[Summary of Invention]

[Technical Subject]

[0004]

The roadside device communicates with a plurality of in-vehicle devices present in a communication region. In this case, in order to suppress a collision caused by a plurality of vehicles (in-vehicle devices) simultaneously transmitting messages to the roadside device, processing of performing the vehicle-to-vehicle communication to shift communication timings is performed. However, a communication region of the road-to-vehicle communication may be wider than a communication region of the vehicle-to-vehicle communication. For example, there is a case where two vehicles have each entered a communication region with a roadside device, but the vehicle-to-vehicle communication cannot be performed because a distance between the vehicles is large. In a case where the vehicle-to-vehicle communication cannot be performed, the processing of shifting the communication timing cannot be performed, and thus there is a possibility that the messages are simultaneously transmitted from two in-vehicle devices to the roadside device. In this case, a so-called hidden terminal problem occurs in which the roadside device cannot receive the messages from the vehicles.

[0005]

An object of the present disclosure is to provide a wireless communication system and a wireless communication method capable of suppressing collisions caused by a plurality of in-vehicle devices simultaneously transmitting messages in road-to-vehicle communication between a roadside device and the plurality of in-vehicle devices.

[Subject to be solved]

[0006]

According to an aspect of the present disclosure, a wireless communication system is a wireless communication system including: a roadside device; and an in-

vehicle device mounted on a vehicle, in which the roadside device includes a distribution unit that periodically distributes a downlink message including a usage status of each of a plurality of slots, which are obtained by dividing a transmission period of an uplink message of the in-vehicle device for each predetermined time, and an update unit that updates the usage status of the slot based on the uplink message received from the in-vehicle device, and the in-vehicle device includes a time setting unit that determines a reference time based on a satellite signal, a reception unit that receives the downlink message from the roadside device, and a transmission unit that randomly selects one slot not occupied by another in-vehicle device based on the usage status of the slot included in the downlink message and transmits the uplink message to the roadside device in the selected slot.

[0007]

According to an aspect of the present disclosure, a wireless communication method is a wireless communication method using a roadside device and an in-vehicle device mounted on a vehicle, the wireless communication method including: a step of, via the roadside device, periodically distributing a downlink message including a usage status of each of a plurality of slots, which are obtained by dividing a transmission period of an uplink message of the in-vehicle device for each predetermined time; a step of, via the roadside device, updating the usage status of the slot based on the uplink message received from the in-vehicle device; a step of, via the in-vehicle device, determining a reference time based on a satellite signal; a step of, via the in-vehicle device, receiving the downlink message from the roadside device; and a step of, via the in-vehicle device, randomly selecting one slot not occupied by another in-vehicle device based on the usage status of the slot included in the downlink message and transmitting the uplink message to the roadside device in the selected slot.

[Advantageous Effects of Invention]

[0008]

According to the aspect, it is possible to suppress the collisions caused by the plurality of in-vehicle devices simultaneously transmitting the messages in the road-to-vehicle communication between the roadside device and the plurality of in-vehicle devices.

[Brief Description of Drawings]

[0009]

FIG. 1 is a schematic diagram showing an overall configuration of a wireless communication system according to a first embodiment.

FIG. 2 is a block diagram showing a functional configuration of a roadside device according to the first embodiment.

FIG. 3 is a block diagram showing a functional configuration of an in-vehicle device according to the first embodiment.

FIG. 4 is a first sequence diagram showing a process example of the wireless communication system according to the first embodiment.

FIG. 5 is a first diagram showing an example of a downlink message according to the first embodiment.

FIG. 6 is a first diagram showing an example of an uplink message according to the first embodiment.

FIG. 7 is a second diagram showing an example of the downlink message according to the first embodiment.

FIG. 8 is a second diagram showing an example of the uplink message according to the first embodiment.

FIG. 9 is a third diagram showing an example of the downlink message

according to the first embodiment.

FIG. 10 is a second sequence diagram showing the process example of the wireless communication system according to the first embodiment.

FIG. 11 is a third diagram showing an example of the uplink message according to the first embodiment.

FIG. 12 is a fourth diagram showing an example of the uplink message according to the first embodiment.

FIG. 13 is a fifth diagram showing an example of the uplink message according to the first embodiment.

FIG. 14 is a fourth diagram showing an example of the downlink message according to the first embodiment.

FIG. 15 is a third sequence diagram showing the process example of the wireless communication system according to the first embodiment.

[Description of Embodiments]

[0010]

<First Embodiment>

Hereinafter, an embodiment will be described in detail with reference to the drawings.

[0011]

(Overall Configuration)

FIG. 1 is a schematic diagram showing an overall configuration of a wireless communication system according to a first embodiment. As shown in FIG. 1, a wireless communication system 1 includes a roadside device 10 and an in-vehicle device 20.

[0012]

The roadside device 10 is installed on a side of a road and performs wireless communication with the in-vehicle device 20 present in a communication region R1.

[0013]

The in-vehicle device 20 is mounted on a vehicle V and performs wireless communication with the roadside device 10 when the in-vehicle device 20 enters the communication region R1 of the roadside device 10. In addition, when an in-vehicle device 20 of another vehicle is present in the communication region of the in-vehicle device 20, the in-vehicle device 20 may perform vehicle-to-vehicle communication with the in-vehicle device 20.

[0014]

(Functional Configuration of Roadside Device)

FIG. 2 is a block diagram showing a functional configuration of the roadside device according to the first embodiment. As shown in FIG. 2, the roadside device 10 includes a processor 11, a memory 12, a storage 13, and a communication antenna 14.

[0015]

The processor 11 functions as a distribution unit 111 and an update unit 112 by operating according to a predetermined program.

[0016]

The distribution unit 111 periodically distributes a downlink message WSA including a usage status of each of a plurality of slots obtained by dividing a transmission period of an uplink message BSM of the in-vehicle device 20 for each predetermined time.

[0017]

The downlink message WSA is broadcast to each of the in-vehicle devices 20

present in the communication region R1. In addition, the downlink message WSA may further include a request (a transmission request for probe data, data for charging processing, or the like) for each in-vehicle device 20 or information (traffic information or the like) provided to each in-vehicle device 20. The uplink message BSM is data transmitted from the in-vehicle device 20 to the roadside device 10 at a fixed period (for example, a 1-second period) and includes various types of information requested by the roadside device 10. The uplink message BSM includes probe data (identification information, global navigation satellite system (GNSS) positioning information, or the like) of the vehicle requested by the roadside device 10, information for charging processing, or the like.

[0018]

The update unit 112 updates the usage status of the slot based on the uplink message BSM received from the in-vehicle device 20.

[0019]

The memory 12 has a memory region necessary for the operation of the processor 11.

[0020]

The storage 13 is a so-called auxiliary storage device and is, for example, a hard disk drive (HDD), a solid-state drive (SSD), or the like. The storage 13 stores data that is acquired, generated, and referred to by each unit of the processor 11 during processes.

[0021]

The communication antenna 14 transmits and receives various types of data to and from the in-vehicle device 20 via wireless communication.

[0022]

(Functional Configuration of In-Vehicle Device)

FIG. 3 is a block diagram showing a functional configuration of the in-vehicle device according to the first embodiment. As shown in FIG. 3, the in-vehicle device 20 includes a processor 21, a memory 22, a storage 23, a communication antenna 24, and a GNSS reception unit 25.

[0023]

The processor 21 functions as a time setting unit 211, a reception unit 212, and a transmission unit 213 by operating according to a predetermined program.

[0024]

The time setting unit 211 determines a reference time based on a satellite signal.

[0025]

The reception unit 212 receives the downlink message WSA from the roadside device 10.

[0026]

The transmission unit 213 randomly selects one slot not occupied by another in-vehicle device 20 based on the usage status of the slot included in the downlink message WSA, and transmits the uplink message BSM to the roadside device 10 in the selected slot.

[0027]

The memory 22 has a memory region necessary for an operation of the processor 21.

[0028]

The storage 23 is a so-called auxiliary storage device and is, for example, a hard disk drive (HDD), a solid-state drive (SSD), or the like. The storage 23 stores

data and the like acquired, generated, and referred to by each unit of the processor 21 during processes.

[0029]

The communication antenna 24 transmits and receives various types of data to and from the roadside device 10 via wireless communication.

[0030]

The GNSS reception unit 25 calculates a position, a speed, a movement direction, and the like of the vehicle V based on the satellite signal received from the GNSS satellite, and outputs the calculated position, speed, movement direction, and the like to the processor 21 as GNSS positioning information. In addition, the GNSS reception unit 25 outputs a 1 pulse per second (PPS) signal for time synchronization to the processor 21.

[0031]

(Process Example 1 of Communication System)

FIG. 4 is a first sequence diagram showing a process example of the wireless communication system according to the first embodiment. Here, a flow of a process of the wireless communication system 1 will be described in detail with reference to FIG. 4.

[0032]

First, the roadside device 10 distributes the downlink message WSA at a fixed period (step S101). FIG. 5 is a first diagram showing an example of the downlink message according to the first embodiment. The downlink message WSA includes at least information on a slot usage status. The slot usage status includes information on a slot number, an occupation flag, and identification information of each of the divided n slots. The occupation flag is represented by ON or OFF. In a case where the

occupation flag is ON, it indicates that the slot is occupied by the in-vehicle device 20. In a case where the occupation flag is OFF, it indicates that the slot is in a vacant state. The identification information is information that can be used to specify the in-vehicle device 20 (or the vehicle V) that occupies the slot. FIG. 5 shows an example of a downlink message WSA1 in a case where the in-vehicle device 20 is not present in the communication region R1 of the roadside device 10. In the downlink message WSA1, all the slots are in the vacant state (occupation flag = OFF).

[0033]

In addition, it is assumed that an in-vehicle device 20B enters the communication region R1 of the roadside device 10. In this case, the reception unit 212 of the in-vehicle device 20B receives the downlink message WSA1 distributed by the roadside device 10 (step S102).

[0034]

In a case where the downlink message WSA1 is received, the time setting unit 211 of the in-vehicle device 20B sets the reference time of the transmission slot of the uplink message BSM based on the 1 pps signal output from the GNSS reception unit 25 (step S103). A known technique may be used as a method of setting the reference time from the 1 pps signal. Accordingly, the time can be precisely synchronized among the plurality of in-vehicle devices 20, and thus, even in a case where the slots are divided into extremely short intervals on the order of milliseconds, it is possible to suppress the simultaneous transmission of data among the in-vehicle devices 20.

[0035]

Next, the transmission unit 213 of the in-vehicle device 20B checks the slot usage status in the received downlink message WSA1 and randomly selects one slot from the slots in the vacant state (occupation flag = OFF). In addition, the

transmission unit 213 of the in-vehicle device 20B starts the fixed-period transmission of the uplink message BSM to which the identification information of the in-vehicle device 20B is assigned in the selected slot (step S104). FIG. 6 is a first diagram showing an example of the uplink message according to the first embodiment. FIG. 6 shows an example of an uplink message BSM1 transmitted by the transmission unit 213 of the in-vehicle device 20B in step S104. The uplink message BSM includes a header section and a message section. The header section includes the slot number selected by the in-vehicle device 20B, the slot occupation flag, and the identification information of the in-vehicle device 20B. In the example of FIG. 6, the transmission unit 213 of the in-vehicle device 20B selects a slot 1 and transmits the uplink message BSM1 to the roadside device 10. In addition, the message section includes, for example, any message such as the probe data (GNSS positioning information) requested by the roadside device 10 or the information used for the charging processing.

[0036]

When the update unit 112 of the roadside device 10 receives the uplink message BSM1 from the in-vehicle device 20B (step S105), in a case where the usage status of the slot number included in the uplink message BSM1 is the vacant state, the update unit 112 updates the slot usage status based on the received uplink message BSM1 (step S106). FIG. 7 is a second diagram showing an example of the downlink message according to the first embodiment. In the example of FIG. 6, the in-vehicle device 20B selects the slot 1. Therefore, as shown in FIG. 7, the update unit 112 of the roadside device 10 changes the occupation flag of the slot 1 to ON in the slot usage status, and inputs the identification information (in-vehicle device 20B) received from the in-vehicle device 20B to the identification number.

[0037]

In addition, the distribution unit 111 of the roadside device 10 repeatedly performs the distribution of the downlink message WSA for each certain period. Therefore, the distribution unit 111 of the roadside device 10 distributes a downlink message WSA2 (FIG. 7) including the updated slot usage status in the next period after the slot usage status is updated (step S107). Thereafter, the in-vehicle device 20B repeatedly transmits the uplink message BSM1 to the roadside device 10 for each certain period while continuously receiving the downlink message WSA from the roadside device 10.

[0038]

In addition, it is assumed that an in-vehicle device 20A enters the communication region R1. The reception unit 212 of the in-vehicle device 20A receives the downlink message WSA2 from the roadside device 10 (step S108). In this case, the time setting unit 211 of the in-vehicle device 20A performs the same process as in step S103, and sets the reference time (step S109). The transmission unit 213 of the in-vehicle device 20A checks the slot usage status of the received downlink message WSA2 and randomly selects one slot from the slots in the vacant state (occupation flag = OFF), and starts the fixed-period transmission of an uplink message BSM2 to which the identification information of the in-vehicle device 20A is assigned (step S110). FIG. 8 is a second diagram showing an example of the uplink message according to the first embodiment. FIG. 8 shows an example of the uplink message BSM2 transmitted by the transmission unit 213 of the in-vehicle device 20A in step S110. In the example of FIG. 8, the transmission unit 213 of the in-vehicle device 20A selects a slot 5 and transmits the uplink message BSM2 to the roadside device 10.

[0039]

When the update unit 112 of the roadside device 10 receives the uplink message BSM2 from the in-vehicle device 20A (step S111), the update unit 112 updates the slot usage status based on the received uplink message BSM2 (step S112). FIG. 9 is a third diagram showing an example of the downlink message according to the first embodiment. In the example of FIG. 8, the in-vehicle device 20A selects the slot 5. Therefore, as shown in FIG. 9, the update unit 112 of the roadside device 10 changes the occupation flag of the slot 5 to ON in the slot usage status, and inputs the identification information (in-vehicle device 20A) received from the in-vehicle device 20A to the identification number. At this point, the slot 1 and the slot 5 are in the occupied state among the plurality of slots.

[0040]

In addition, the distribution unit 111 of the roadside device 10 distributes a downlink message WSA3 (FIG. 9) including the updated slot usage status in the next period after the slot usage status is updated (step S113). Thereafter, the in-vehicle device 20A repeatedly transmits the uplink message BSM2 to the roadside device 10 for each certain period while continuously receiving the downlink message WSA from the roadside device 10, as in the in-vehicle device 20B.

[0041]

(Process Example 2 of Communication System)

FIG. 10 is a second sequence diagram showing a process example of the wireless communication system according to the first embodiment. FIG. 10 shows a process example in a case where the uplink messages BSM of the two in-vehicle devices 20A and 20B collide.

[0042]

First, the roadside device 10 distributes the downlink message WSA1 at a fixed period (step S201). At this point, as shown in FIG. 5, it is assumed that all the slots are in the vacant state.

[0043]

In addition, it is assumed that the in-vehicle devices 20A and 20B enter the communication region R1 of the roadside device 10. The reception unit 212 of the in-vehicle device 20A receives the downlink message WSA1 distributed by the roadside device 10 (step S202). In a case where the downlink message WSA1 is received, the time setting unit 211 of the in-vehicle device 20A sets the reference time of the transmission slot of the uplink message BSM based on the 1 pps signal output from the GNSS reception unit 25 (step S203). Thereafter, the transmission unit 213 of the in-vehicle device 20A randomly selects one slot from the slots in the vacant state (occupation flag = OFF), and starts the fixed-period transmission of an uplink message BSM3 (FIG. 11) to which the identification information of the in-vehicle device 20A is assigned in the selected slot (step S204). FIG. 11 is a third diagram showing an example of the uplink message according to the first embodiment. As shown in FIG. 11, it is assumed that the transmission unit 213 of the in-vehicle device 20A selects the slot 1.

[0044]

Similarly, the reception unit 212 of the in-vehicle device 20B receives the downlink message WSA1 distributed by the roadside device 10 (step S205). In a case where the downlink message WSA1 is received, the time setting unit 211 of the in-vehicle device 20B sets the reference time of the transmission slot of the uplink message BSM based on the 1 pps signal output from the GNSS reception unit 25 (step S206). Thereafter, the transmission unit 213 of the in-vehicle device 20B randomly

selects one slot from the slots in the vacant state (occupation flag = OFF), and starts the fixed-period transmission of an uplink message BSM1 (FIG. 6) to which the identification information of the in-vehicle device 20B is assigned in the selected slot (step S207). As shown in FIG. 6, it is assumed that the transmission unit 213 of the in-vehicle device 20B selects the slot 1.

[0045]

In the example of FIG. 10, since both the in-vehicle devices 20A and 20B transmit the uplink message by designating the slot 1, a collision occurs. Therefore, the roadside device 10 cannot receive the uplink messages of the in-vehicle devices 20A and 20B. In this case, in the roadside device 10, the update of the slot usage status is not performed. Therefore, the distribution unit 111 of the roadside device 10 transmits the same downlink message WSA1 as that transmitted in step S201 (step S208).

[0046]

Next, the reception unit 212 of the in-vehicle device 20A receives the downlink message WSA1 from the roadside device 10 (step S209). The transmission unit 213 of the in-vehicle device 20A checks the slot usage status of the downlink message WSA1, and in a case where the identification information of the own device is not registered in the selected slot 1, the transmission unit 213 randomly selects one slot from the slots in the vacant state other than the slot 1, and starts the fixed-period transmission of an uplink message BSM4 (FIG. 12) to which the identification information of the in-vehicle device 20A is assigned in the newly selected slot (step S210). In this way, the in-vehicle device 20A can determine that the roadside device 10 was unable to receive the uplink message BSM3 of the own device because the information of the own device is not registered in the slot usage status of the downlink

message WSA1 received from the roadside device 10, and can select a different slot and retry. As shown in FIG. 12, it is assumed that the transmission unit 213 of the in-vehicle device 20A newly selects a slot 7.

[0047]

Meanwhile, the reception unit 212 of the in-vehicle device 20B receives the downlink message WSA1 from the roadside device 10 (step S211). The transmission unit 213 of the in-vehicle device 20B checks the slot usage status of the downlink message WSA1, and in a case where the identification information of the own device is not registered in the selected slot 1, the transmission unit 213 randomly selects one slot from the slots in the vacant state other than the slot 1, and starts the fixed-period transmission of an uplink message BSM5 (FIG. 13) to which the identification information of the in-vehicle device 20B is assigned in the newly selected slot (step S212). As shown in FIG. 13, it is assumed that the transmission unit 213 of the in-vehicle device 20B newly selects a slot 13.

[0048]

When the update unit 112 of the roadside device 10 receives the uplink messages BSM4 and BSM5 from the in-vehicle devices 20A and 20B, respectively (step S213), in a case where the usage status of the slot number included in the uplink messages BSM4 and BSM5 is the vacant state, the update unit 112 updates the slot usage status based on the received uplink messages BSM4 and BSM5 (step S214). FIG. 14 is a fourth diagram showing an example of the downlink message according to the first embodiment. In the example of FIG. 14, the in-vehicle device 20A selects the slot 7, and the in-vehicle device 20B selects the slot 13. Therefore, as shown in FIG. 14, the update unit 112 of the roadside device 10 changes the occupation flag of the slot 7 to ON in the slot usage status, and inputs the identification information of the

in-vehicle device 20A to the identification number. In addition, the update unit 112 changes the occupation flag of the slot 13 to ON, and inputs the identification information of the in-vehicle device 20B to the identification number.

[0049]

In addition, the distribution unit 111 of the roadside device 10 distributes a downlink message WSA4 (FIG. 14) including the updated slot usage status in the next period after the slot usage status is updated (step S215). Thereafter, the in-vehicle devices 20A and 20B repeatedly transmit the uplink messages BSM4 and BSM5 to the roadside device 10 for each certain period while continuously receiving the downlink message WSA4 from the roadside device 10.

[0050]

(Process Example 3 of Communication System)

FIG. 15 is a third sequence diagram showing a process example of the wireless communication system according to the first embodiment. FIG. 15 shows a process example of deleting the information of the in-vehicle device 20 from the slot usage status.

[0051]

As shown in FIG. 15, it is assumed that the in-vehicle devices 20A and 20B exit from the communication region R1 of the roadside device 10. In this case, when the reception units 212 of the in-vehicle devices 20A and 20B do not receive the downlink message WSA4, the transmission units 213 of the in-vehicle devices 20A and 20B stop the fixed-period transmission of the uplink messages BSM4 and BSM5 (steps S301 and S302).

[0052]

In addition, when the uplink messages BSM4 and BSM5 cannot be received

from the in-vehicle devices 20A and 20B whose identification information is registered in the slot usage status for a certain period of time or longer (step S303), the update unit 112 of the roadside device 10 deletes the registration of the in-vehicle devices 20A and 20B and updates the slot usage status (step S304). The update unit 112 of the roadside device 10 changes the occupation flag of the slot 7 to OFF in the slot usage status (FIG. 14), and deletes the identification information of the in-vehicle device 20A. Similarly, the update unit 112 changes the occupation flag of the slot 13 to OFF in the slot usage status (FIG. 14), and deletes the identification information of the in-vehicle device 20B. In this example, as shown in FIG. 5, all the slots are in the vacant state. In addition, the distribution unit 111 of the roadside device 10 distributes a downlink message WSA1 (FIG. 5) including the updated slot usage status in the next period after the slot usage status is updated (step S305). Thereafter, the distribution unit 111 of the roadside device 10 distributes the downlink message WSA1 for each certain period until the uplink message BSM is received from the new in-vehicle device 20 that has entered the communication region R1. When a new in-vehicle device 20 enters, the slot to be used by the in-vehicle device 20 is determined according to the sequence in FIG. 4 or FIG. 10.

[0053]

(Operation and Effect)

As described above, the wireless communication system 1 according to the present embodiment includes the roadside device 10 and the in-vehicle device 20 mounted on the vehicle V. The roadside device 10 includes the distribution unit 111 that periodically distributes a downlink message WSA including a usage status of each of a plurality of slots obtained by dividing a transmission period of an uplink message BSM of the in-vehicle device 20 for each predetermined time, and the update unit 112

that updates the usage status of the slot based on the uplink message BSM received from the in-vehicle device 20. The in-vehicle device 20 includes the time setting unit 211 that determines the reference time based on the satellite signal, the reception unit 212 that receives the downlink message WSA from the roadside device 10, and the transmission unit 213 that randomly selects one slot that is not occupied by another in-vehicle device based on the usage status of the slot included in the downlink message WSA, and transmits the uplink message BSM to the roadside device 10 in the selected slot.

[0054]

In this way, in the wireless communication system 1, since each of the in-vehicle devices 20 selects one slot from the plurality of slots and transmits the uplink message BSM, it is possible to suppress collisions caused by a plurality of in-vehicle devices transmitting messages at the same time. In addition, each of the in-vehicle devices 20 can reduce the possibility that the slot to be used overlaps with the slot to be used by another in-vehicle device 20 that has entered the communication region R1 of the roadside device 10 at the same time, by randomly selecting the slot in the vacant state instead of selecting the slot in the slot number order.

[0055]

In addition, in a case where an own device is not registered in the selected slot in the downlink message WSA received after the slot is selected, the transmission unit 213 of the in-vehicle device 20 newly selects another slot not occupied by the other in-vehicle device 20 and transmits the uplink message BSM to the roadside device 10 in the newly selected slot.

[0056]

In this way, in the wireless communication system 1, even in a case where the

same slot is selected between the in-vehicle devices 20 and the transmitted uplink messages BSM collide, it is possible to know that the slot cannot be occupied on the side of the in-vehicle device 20 based on the next downlink message WSA to be received. In this case, the in-vehicle device 20 can suppress the loss of the uplink message BSM due to the collision of the message by retrying the transmission of the uplink message BSM by selecting a new slot. As a result, it is possible to suppress the occurrence of the hidden terminal problem.

[0057]

In addition, in a case where no uplink message BSM has been received from the in-vehicle device 20 for a certain period of time or longer, the update unit 112 of the roadside device 10 updates a slot occupied by the in-vehicle device 20 to a vacant state.

[0058]

In this way, in a case where the uplink message BSM cannot be received due to a reason such as the exit of the in-vehicle device 20 from the communication region R1 of the roadside device 10, the wireless communication system 1 can quickly release the slot for another in-vehicle device 20.

[0059]

<Another Embodiment>

The embodiments have been described in detail above with reference to the drawings. However, the specific configuration is not limited to the above description, and various design changes and the like can be made. That is, in another embodiment, the order of the above processes may be changed as appropriate. In addition, some of the processes may be executed in parallel.

[0060]

<Supplementary Notes>

The wireless communication system and the wireless communication method described in the above-described embodiment are understood as follows, for example.

[0061]

(1) According to a first aspect, a wireless communication system 1 is a wireless communication system 1 including: a roadside device 10; and an in-vehicle device 20 mounted on a vehicle V, in which the roadside device 10 includes a distribution unit 111 that periodically distributes a downlink message WSA including a usage status of each of a plurality of slots, which are obtained by dividing a transmission period of an uplink message BSM of the in-vehicle device 20 for each predetermined time, and an update unit 112 that updates the usage status of the slot based on the uplink message BSM received from the in-vehicle device 20, and the in-vehicle device 20 includes a time setting unit 211 that determines a reference time based on a satellite signal, a reception unit 212 that receives the downlink message WSA from the roadside device 10, and a transmission unit 213 that randomly selects one slot not occupied by another in-vehicle device 20 based on the usage status of the slot included in the downlink message WSA and transmits the uplink message BSM to the roadside device 10 in the selected slot.

[0062]

In this way, in the wireless communication system 1, since each of the in-vehicle devices 20 selects one slot from the plurality of slots and transmits the uplink message BSM, it is possible to suppress collisions caused by a plurality of in-vehicle devices transmitting messages at the same time. In addition, each of the in-vehicle devices 20 can reduce the possibility that the slot to be used overlaps with the slot to be used by another in-vehicle device 20 that has entered the communication region R1

of the roadside device 10 at the same time, by randomly selecting the slot in the vacant state instead of selecting the slot in the slot number order.

[0063]

(2) According to a second aspect, in the wireless communication system 1 according to the first aspect, in a case where an own device is not registered in the selected slot in the downlink message WSA received after the slot is selected, the transmission unit 213 of the in-vehicle device 20 newly selects another slot not occupied by the other in-vehicle device 20 and transmits the uplink message BSM to the roadside device 10 in the newly selected slot.

[0064]

In this way, in the wireless communication system 1, even in a case where the same slot is selected between the in-vehicle devices 20 and the transmitted uplink messages BSM collide, it is possible to know that the slot cannot be occupied on the side of the in-vehicle device 20 based on the next downlink message WSA to be received. In this case, the in-vehicle device 20 can suppress the loss of the uplink message BSM due to the collision of the message by retrying the transmission of the uplink message BSM by selecting a new slot. As a result, it is possible to suppress the occurrence of the hidden terminal problem.

[0065]

(3) According to a third aspect, in the wireless communication system 1 according to the first or second aspect, in a case where no uplink message BSM has been received from the in-vehicle device 20 for a certain period of time or longer, the update unit 112 of the roadside device 10 updates a slot occupied by the in-vehicle device 20 to a vacant state.

[0066]

In this way, in a case where the uplink message BSM cannot be received due to a reason such as the exit of the in-vehicle device 20 from the communication region R1 of the roadside device 10, the wireless communication system 1 can quickly release the slot for another in-vehicle device 20.

[0067]

(4) According to a fourth aspect, a wireless communication method is a wireless communication method using a roadside device 10 and an in-vehicle device 20 mounted on a vehicle V, the wireless communication method including: a step of, via the roadside device 10, periodically distributing a downlink message WSA including a usage status of each of a plurality of slots, which are obtained by dividing a transmission period of an uplink message BSM of the in-vehicle device 20 for each predetermined time; a step of, via the roadside device 10, updating the usage status of the slot based on the uplink message BSM received from the in-vehicle device 20; a step of, via the in-vehicle device 20, determining a reference time based on a satellite signal; a step of, via the in-vehicle device 20, receiving the downlink message WSA from the roadside device 10; and a step of, via the in-vehicle device 20, randomly selecting one slot not occupied by another in-vehicle device 20 based on the usage status of the slot included in the downlink message WSA and transmitting the uplink message BSM to the roadside device 10 in the selected slot.

[Industrial Applicability]

[0068]

According to the aspect, it is possible to suppress the collisions caused by the plurality of in-vehicle devices simultaneously transmitting the messages in the road-to-vehicle communication between the roadside device and the plurality of in-vehicle devices.

[Reference Signs List]

[0069]

1: wireless communication system

10: roadside device

11: processor

111: distribution unit

112: update unit

12: memory

13: storage

14: communication antenna

20, 20A, 20B: in-vehicle device

21: processor

211: time setting unit

212: reception unit

213: transmission unit

22: memory

23: storage

24: communication antenna

25: GNSS reception unit

V: vehicle