DESCRIPTION

Title of Invention

COMMUNICATION SYSTEM, COMMUNICATION METHOD, ROADSIDE DEVICE, AND ONBOARD EQUIPMENT

[Technical Field]

[0001]

The present disclosure relates to a communication system, a communication method, a roadside unit, and an onboard unit.

[Background Art]

[0002]

PTL1 discloses a configuration for making it difficult for vehicle-to-infrastructure communication to be hindered by vehicle-to-vehicle communication in a communication system in which vehicle-to-vehicle communication and vehicle-to-infrastructure communication are performed using a carrier wave having the same carrier frequency and a carrier sense multiple access/collision avoidance method is adopted as an access method. In the communication system disclosed in PTL 1, when an onboard communication terminal (hereinafter, referred to as an onboard unit) is present in a transmission prohibited area of a roadside unit, transmission of data for vehicle-to-vehicle communication is stopped. In this case, a determination as to whether or not the onboard unit is present in the transmission prohibited area is made in the onboard unit based on a reception level of a signal received from the roadside unit or based on location information of the onboard unit and area information indicating a range in which the transmission prohibited area is set. In addition, the transmission

prohibited area is set to, for example, within a certain distance from an installation position of the roadside unit, and is set according to, for example, a distance at which a signal transmitted by the onboard unit reaches while maintaining a level (or a carrier sense level) at which the signal can be decoded. In addition, in the vehicle-to-infrastructure communication, communication using a broadcast method or communication using a unicast method is performed between the onboard unit and the roadside unit. In addition, in the communication using the broadcast method, for example, response request data or the like is transmitted to all the onboard units present in a wireless communication area (a range to which the signal to be transmitted reaches).

[Citation List]

[Patent Document]

[0003]

[PTL 1] Japanese Unexamined Patent Application Publication No. 2015-207940

[Summary of Invention]

[Technical Subject]

[0004]

In the communication system disclosed in PTL 1, when a range in which vehicle-to-infrastructure communication is performed is set such that, for example, a radius centered on an installation position of a roadside unit is equal to a distance at which a signal transmitted by an onboard unit can be detected, there is a subject that a hidden terminal subject may occur. The hidden terminal subject is a subject in which, in wireless communication, two transmission terminals (onboard units) simultaneously transmit signals to a reception terminal (roadside unit) located, for example, in the middle thereof, and thus collisions between the signals occur, and the reception terminal

(roadside unit) cannot receive the signals. The hidden terminal subject occurs due to the fact that the transmission terminals (onboard units) cannot detect each other's transmission signals.

[0005]

The present disclosure has been made to solve the above-described subjects, and an object of the present disclosure is to provide a communication system, a communication method, a roadside unit, and an onboard unit that can reduce collisions between signals transmitted by a plurality of onboard units.

[Subject to be solved]

[0006]

In order to solve the above-described subjects, a communication system according to the present disclosure includes a roadside unit that transmits, at a predetermined cycle, a response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas, and that receives a response signal to the response request signal, and a plurality of onboard units that each receive the response request signal, that each recognize the area in which the onboard unit is located, and that each transmit the response signal within the communicable time assigned to the recognized area.

[0007]

A communication method according to the present disclosure includes a step of transmitting, via a roadside unit, at a predetermined cycle, a response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas, a step of receiving, via an onboard unit, the response request signal,

recognizing the area in which the onboard unit is located, and transmitting, via the onboard unit, a response signal within the communicable time assigned to the recognized area, and a step of receiving, via the roadside unit, the response signal.

[0008]

A roadside unit according to the present disclosure transmits, at a predetermined cycle, a response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas, and receives each response signal transmitted by one or a plurality of onboard units that each receive the response request signal, that each recognize the area in which the onboard unit is located, and that each transmit the response signal, within the communicable time assigned to the recognized area.

[0009]

An onboard unit according to the present disclosure receives a response request signal transmitted by a roadside unit that transmits, at a predetermined cycle, the response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas, recognizes the area in which the onboard unit is located, and transmits a response signal within the communicable time assigned to the recognized area.

[Advantageous Effects of Invention]

[0010]

According to the communication system, the communication method, the roadside unit, and the onboard unit of the present disclosure, it is possible to reduce collisions between signals transmitted by a plurality of onboard units.

[Brief Description of Drawings]

[0011]

FIG. 1 is a block diagram showing a configuration example of a communication system according to an embodiment of the present disclosure.

FIG. 2 is a plan view schematically showing an installation example of the communication system according to the embodiment of the present disclosure.

FIG. 3 is a plan view schematically showing an installation example of the communication system according to the embodiment of the present disclosure.

FIG. 4 is a timing chart showing an operation example of the communication system according to the embodiment of the present disclosure.

FIG. 5 is a schematic diagram showing a configuration example of a response request signal according to the embodiment of the present disclosure.

FIG. 6 is a schematic diagram showing a configuration example of a response signal according to the embodiment of the present disclosure.

FIG. 7 is a timing chart showing an operation example of the communication system according to the embodiment of the present disclosure.

FIG. 8 is a flowchart showing an operation example of the roadside unit according to the embodiment of the present disclosure.

FIG. 9 is a flowchart showing an operation example of the roadside unit according to the embodiment of the present disclosure.

FIG. 10 is a flowchart showing an operation example of the onboard unit according to the embodiment of the present disclosure.

FIG. 11 is a schematic block diagram showing a configuration of a computer according to the embodiment of the present disclosure.

[Description of Embodiments]

[0012]

Hereinafter, a communication system, a communication method, a roadside unit, and an onboard unit according to an embodiment of the present disclosure will be described with reference to FIGS. 1 to 11. FIG. 1 is a block diagram showing a configuration example of a communication system according to an embodiment of the present disclosure. FIGS. 2 and 3 are plan views schematically showing an installation example of the communication system according to the embodiment of the present disclosure. FIGS. 4 and 7 are timing charts showing operation examples of the communication system according to the embodiment of the present disclosure. FIG. 5 is a schematic diagram showing a configuration example of a response request signal according to the embodiment of the present disclosure. FIG. 6 is a schematic diagram showing a configuration example of a response signal according to the embodiment of the present disclosure. FIGS. 8 and 9 are flowcharts showing operation examples of the roadside unit according to the embodiment of the present disclosure. FIG. 10 is a flowchart showing an operation example of the onboard unit according to the embodiment of the present disclosure. FIG. 11 is a schematic block diagram showing a configuration of a computer according to the embodiment of the present disclosure. In the drawings, the same reference signs are used for the same or corresponding configurations, and description thereof will be omitted as appropriate.

[0013]

(Configuration of Communication System)

As shown in FIG. 1, a communication system 1 according to the embodiment of the present disclosure includes, for example, one roadside unit 2 and a plurality of onboard units 3. For example, as shown in FIG. 2, the roadside unit 2 transmits and receives predetermined information to and from each of the onboard units 3 mounted on

a plurality of vehicles 4a to 4m located on roads 10a or 10b that intersect at an intersection 11, for example, by dedicated short-range communications (DSRC). The vehicles 4a to 4m are collectively referred to as a vehicle 4. In addition, there may be a plurality of roadside units 2 for one intersection 11. In addition, the roadside unit 2 may be installed to perform wireless communication with each of the onboard units 3 mounted on one or a plurality of vehicles 4 located outside (for example, one road) the vicinity (periphery) of the intersection 11.

[0014]

As shown in FIG. 1, the roadside unit 2 includes a control unit 21, a communication unit 22, and a storage unit 23 as functional blocks configured by hardware, a combination of hardware and software, or the like. The control unit 21 controls each unit in the roadside unit 2, and transmits and receives predetermined information to and from the plurality of onboard units 3 via the communication unit 22, for example, or transmits and receives predetermined information to and from an external server (not shown) using a wide area communication network or the like, for example. The communication unit 22 includes an antenna 221 and performs wireless communication with the plurality of onboard units 3. The storage unit 23 stores identification information of the roadside unit 2 (hereinafter, also referred to as the roadside unit 2), location information of the roadside unit 2, information indicating an area described later, or the like, or stores information received from the onboard unit 3, for example, in response to an instruction from the control unit 21.

[0015]

The onboard unit 3 is a device that has at least a function of performing vehicle-to-infrastructure wireless communication with the roadside unit 2, and is a device mounted on the vehicle 4. The onboard unit 3 may have a function of performing

vehicle-to-vehicle wireless communication with another one of the onboard units 3. In addition, the onboard unit 3 may be configured as a part of another electronic control unit mounted on the vehicle 4, or may function by using a part of a configuration provided in another electronic control unit.

[0016]

As shown in FIG. 1, the onboard unit 3 includes a control unit 31, a location information acquisition unit 32, a communication unit 33, and a storage unit 34 as functional blocks configured by hardware, a combination of hardware and software, or the like. The control unit 31 controls each unit in the onboard unit 3, and transmits and receives predetermined information to and from the roadside unit 2 via the communication unit 33, for example.

[0017]

The location information acquisition unit 32 includes, for example, a global navigation satellite system (GNSS) reception device or the like, and acquires location information (latitude, longitude, altitude, and the like) by using GNSS. However, the location information acquisition unit 32 may acquire the position based on a detection signal of a vehicle speed sensor, an angular velocity sensor, or the like, a reception signal of a wide area communication network, or the like, instead of (or in addition to) using GNSS.

[0018]

The communication unit 33 includes an antenna 331 and performs wireless communication with the roadside unit 2 or the like. In addition, the communication unit 33 has a collision avoidance function 332 for a radio signal. Here, the collision avoidance function 332 is a function of avoiding collisions between response signals, which will be described later, transmitted by the onboard unit 3 to the roadside unit 2 by

detecting a signal transmitted by another one of the onboard units 3. The collision avoidance function 332 can be realized by, for example, a well-known carrier sense multiple access/collision avoidance (CSMA/CA). CSMA/CA is used as a protocol of a data link layer (or a medium access control (MAC) layer, which is a part of the data link layer) of an open systems interconnection (OSI) reference model. In CSMA/CA, in order to avoid collisions between radio signals (frames, packets, or the like), when attempting to transmit a radio signal, the usage status of a carrier (carrier wave) is monitored in advance, and transmission is started when the medium is not used for a predetermined frame interval and a random time, which are different depending on the priority. On the other hand, when the medium is being used, the transmission is delayed by entering a standby state until the medium becomes unused.

[0019]

The storage unit 23 stores identification information of the onboard unit 3 (hereinafter, also referred to as the onboard unit 3), information such as a vehicle type of the vehicle 4 on which the onboard unit 3 is mounted, location information for a predetermined time, or the like, or stores information received from, for example, the roadside unit 2, another one of the onboard units 3, an external server, or the like in response to an instruction from the control unit 31.

[0020]

(Example of Area Setting of Communication System)

In the communication system 1 of the present embodiment, as shown in FIG. 2, a plurality of areas 1 (CPA1) to 5 (CPA5) are set in the communication area 2CA of the roadside unit 2 (hereinafter, also referred to as the areas CPA1 to CPA5), and the roadside unit 2 performs wireless communication with the onboard unit 3 located in each of the areas CPA1 to CPA5 in a time division manner for each of the areas CPA1 to

CPA5. The communication area 2CA is a range in which the roadside unit 2 can perform wireless communication with the onboard unit 3, and the roadside unit 2 can receive a radio signal transmitted by each onboard unit 3 located in the communication area 2CA, and each onboard unit 3 located in the communication area 2CA can receive a radio signal transmitted by the roadside unit 2. In the example shown in FIG. 2, the antenna 221 of the roadside unit 2 (or the entire roadside unit 2 or the like) is installed at the center (upper side) of the intersection 11.

[0021]

In addition, the area CPA1 indicated by hatching with a downward right diagonal line is a rectangular area centered on the antenna 211. A vehicle 4l running on the road 10b from the lower side to the upper side is located in the area CPA1.

[0022]

In addition, the area CPA2 indicated by hatching with an upward right diagonal line is a rectangular area set on the upper side of the intersection 11 of the road 10b. A vehicle 4m running on the road 10b from the lower side to the upper side is located in the area CPA2.

[0023]

In addition, the area CPA3 indicated by hatching with an upward right diagonal line is a rectangular area set on the right side of the intersection 11 of the road 10a. Vehicles 4a, 4b, 4c, and 4d running on the road 10a from the right side to the left side and vehicles 4e and 4f running on the road 10a from the left side to the right side are located in the area CPA3.

[0024]

In addition, the area CPA4 indicated by hatching with an upward right diagonal line is a rectangular area set on the lower side of the intersection 11 of the road 10b. A

vehicle 4j running on the road 10b from the lower side to the upper side and a vehicle 4k running on the road 10b from the upper side to the lower side are located in the area CPA4.

[0025]

In addition, the area CPA5 indicated by hatching with an upward right diagonal line is a rectangular area set on the left side of the intersection 11 of the road 10a. A vehicle 4g running on the road 10a from the right side to the left side and vehicles 4h and 4i running on the road 10a from the left side to the right side are located in the area CPA5.

[0026]

In the present embodiment, each of the areas CPA1 to CPA5 is set such that, within each of the areas CPA1 to CPA5, detection of a signal transmitted by another one of the onboard units 3 is enabled. For example, for the onboard unit 3 of the vehicle 4d located in the area CPA3, all of the onboard units 3 of the other vehicles 4a to 4c and 4e to 4f located in the area CPA3 are included in the communication area 4dCA of the onboard unit 3 of the vehicle 4d. Here, the communication area 4dCA is a range in which the onboard unit 3 of the vehicle 4d can perform wireless communication with the roadside unit 2 or another one of the onboard units 3 located in the communication area 4dCA (or a range in which a carrier of a radio signal transmitted by the roadside unit 2 or another one of the onboard units 3 can be detected). Therefore, the onboard unit 3 of the vehicle 4d can detect the radio signals transmitted by the onboard units 3 of the other vehicles 4a to 4c and 4e to 4f located in the area CPA3, and can avoid collisions between the radio signals by the collision avoidance function 332. On the other hand, for example, the onboard unit 3 of the vehicle 4l located in the area CPA1 is located outside the communication area 4dCA, and thus the onboard unit 3 of the vehicle

4d cannot detect the radio signal transmitted by the onboard unit 3 of the vehicle 4l. When the onboard unit 3 of the vehicle 4 located in the area CPA1 and the onboard unit 3 of the vehicle 4 located in the area CPA3 perform transmission in the same time zone, there is a possibility that collisions between transmission signals occur. However, in the present embodiment, since the time during which transmission can be performed in a time division manner is set for each of the areas CPA1 to CPA5, the onboard unit 3 of the vehicle 4 located in the area CPA1 and the onboard unit 3 of the vehicle 4 located in the area CPA3 do not transmit radio signals in the same time zone. Therefore, for example, it is possible to reduce the possibility that the radio signal transmitted by the onboard unit 3 of the vehicle 4 located in the area CPA1 and the radio signal transmitted by the onboard unit 3 of the vehicle 4 located in the area CPA3 collide with each other.

[0027]

It is desirable that each of the areas CPA1 to CPA5 is set such that, within a predetermined range from another one of the areas CPA1 to CPA5 (excluding the self-area) within each of the areas CPA1 to CPA5, detection of a signal transmitted by another one of the onboard units 3 within the other one of the areas CPA1 to CPA5 (excluding the self-area) is enabled. For example, as shown in FIG. 3, it is conceivable that the onboard unit 3 of the vehicle 4a is correctly located in the area CPA3, but is erroneously recognized as being located in the area CPA1 due to an influence of an acquisition error of the location information, a running speed, or the like. In this case, the onboard unit 3 of the vehicle 4a transmits a radio signal within the communicable time assigned to the area CPA1. In this case, when the communication area 4aCA of the onboard unit 3 of the vehicle 4a does not include the entire area of the area CPA1, there is a possibility that the radio signal transmitted by the onboard unit 3 of the vehicle 4a and the radio signal transmitted by another one of the onboard units 3 located outside the

communication area 4aCA within the area CPA1 collide with each other. Therefore, in the present embodiment, for example, within a predetermined range CPA1A (in this example, a rectangular range in which the length of each side is extended upward, downward, leftward, and rightward by a distance LA from the area CPA1) from the area CPA1 within the area CPA3, the area CPA1 is set such that detection of a signal transmitted by another one of onboard units 3 (for example, the onboard unit 3 of the vehicle 4l) within the area CPA1 is enabled. In this example, the area CPA1 is set such that the communication area 4aCA of the onboard unit 3 of the vehicle 4a located within the range CPA1A within the area CPA3 can cover the entire area CPA1. However, unlike the examples shown in FIGS. 2 and 3, for example, when a sufficient interval for avoiding an influence of erroneous detection of the location information is set between the areas, the collisions of the radio signals with the other areas may not be considered.

[0028]

(Example of Radio Signal in Communication System)

In the present embodiment, as described above, for example, five areas CPA1 to CPA5 are set in the communication area 2CA of the roadside unit 2, and the roadside unit 2 performs wireless communication with the onboard unit 3 located in each of the areas CPA1 to CPA5 in a time division manner for each of the areas CPA1 to CPA5. FIG. 4 shows an example of a correspondence relationship between a response request signal transmitted by the roadside unit 2 and each of the communicable times T1a to T5a assigned to each of the areas CPA1 to CPA5. The horizontal axis is a time axis. The onboard unit 3 located in each of the areas CPA1 to CPA5 transmits a response signal to the response request signal within each of the communicable times T1a to T5a assigned to each of the areas CPA1 to CPA5.

[0029]

The response request signal is a radio signal transmitted by the roadside unit 2 at a predetermined cycle T1, and is a broadcast signal requesting each onboard unit 3 to transmit a response signal. As shown in FIG. 5, for example, the response request signal 50 includes information 51 for determining the area 1 (CPA1) to the area 5 (CPA5), information 52 indicating the communicable time T1a of the area 1 (CPA1), information 53 indicating the communicable time T2a of the area 2 (CPA2), information 54 indicating the communicable time T3a of the area 3 (CPA3), information 55 indicating the communicable time T4a of the area 4 (CPA4), and information 56 indicating the communicable time T5a of the area 5 (CPA5).

[0030]

The information 51 for determining the area 1 (CPA1) to the area 5 (CPA5) can be, for example, information indicating latitudes and longitudes of a plurality of vertices of a rectangular area. Alternatively, when information (coordinate information or the like) on each area of the roadside unit 2 in the vicinity of the running position is transmitted in advance to each onboard unit 3 and stored using, for example, broadband communication or the like, the information 51 for determining the area 1 (CPA1) to the area 5 (CPA5) can be only identification information of the roadside unit 2.

[0031]

As shown in FIG. 4, the information 52 to 56 indicating the communicable times T1a to T5a of the area 1 (CPA1) to the area 5 (CPA5) can be each information indicating times (hereinafter, start times) T1s to T5s from a reference time, which is the end time of the response request signal of the time T2, to the start times of the communicable times T1a to T5a, and times (hereinafter, end times) T1e to T5e from the reference time to the end times of the communicable times T1a to T5a. In the example shown in FIG. 4, a gap time Tg is provided between each of the communicable times T1a to T5a. Each

time obtained by adding the start times T1s to T5s to the reference time and each time obtained by adding the end times T1e to T5e to the reference time are each start time and each end time of the communicable times T1a to T5a.

[0032]

FIG. 6 shows an example of the response signal transmitted by the onboard unit 3 to the roadside unit 2. In the example shown in FIG. 6, the response signal 60 includes onboard unit identification information 61 and location information 62. However, FIG. 6 shows an example of the configuration of the response signal 60, and the response signal 60 may include, for example, information indicating a vehicle type, a running direction, a running speed, and the like in addition to the location information (or without the location information).

[0033]

In the example shown in FIG. 4, the lengths of the communicable times T1a to T5a are equal to each other, but the lengths of the communicable times T1a to T5a may be different from each other. The communicable times T1a to T5a may be changed, for example, according to a measured value or an estimated value of a communication traffic for each of the areas CPA1 to CPA5. FIG. 7 shows an example in which the lengths of the communicable times T1a to T5a are different from each other. In the example shown in FIG. 7, as compared with the example shown in FIG. 4, the lengths of the communicable times T1a, T2a, and T4a are set to 2/3, the length of the communicable time T3a is set to twice, and the length of the communicable time T5a is set to be the same. The measured value of the communication traffic can be, for example, the number of response signals received from each of the areas CPA1 to CPA5 in a predetermined time (one or a plurality of times T1). In addition, the estimated value of the communication traffic can be calculated (predicted), for example, based on

the communication traffic expected based on the past record, whether it is a day of the week or a holiday, a time zone, and the like.

[0034]

(Operation Example of Roadside Unit and Onboard Unit)

FIG. 8 shows a flow of processing executed by the roadside unit 2 in the period T1. In the processing shown in FIG. 8, the roadside unit 2 (for example, the control unit 21) determines whether or not the adjustment of the communicable times T1a to T5a is necessary (step S11). Here, the case where the adjustment is necessary is, for example, a case where a change of a predetermined amount or more occurs in the measured value or the estimated value of the communication traffic after the previous adjustment. When the adjustment is necessary (step S11: YES), the roadside unit 2 adjusts the communicable times T1a to T5a, for example, according to the amount of change in the communication traffic (step S12). When the adjustment is not necessary (step S11: NO) or when the adjustment is performed (step S12), the roadside unit 2 transmits the response request signal 50 including the information for specifying the plurality of areas CPA1 to CPA5 set in the communication area 2CA of the roadside unit 2 and the information indicating each of the communicable times T1a to T5a assigned to each of the areas CPA1 to CPA5 (step S13), and ends the processing shown in FIG. 8.

[0035]

In addition, FIG. 9 shows a flow of processing started by the roadside unit 2 when the roadside unit 2 receives the response signal 60 from the onboard unit 3. In the processing shown in FIG. 9, the roadside unit 2 (for example, the control unit 21) executes processing on the response signal (step S21), and ends the processing shown in FIG. 9. The processing on the response signal can be, for example, processing of

accumulating information included in the response signal in the storage unit 23 for a predetermined cycle, processing of calculating a communication traffic (the number of vehicles per unit time) for each predetermined cycle and transmitting the communication traffic to an external server or the like, and the like.

[0036]

In addition, FIG. 10 shows a flow of processing started when the onboard unit 3 receives the response request signal from the roadside unit 2. In the processing shown in FIG. 10, the onboard unit 3 (for example, the control unit 31) acquires the location information of the onboard unit 3 by the location information acquisition unit 32 (step S31). Next, the onboard unit 3 determines whether or not the onboard unit 3 is located in any area (any of the areas CPA1 to CPA5) based on the response request signal (step S32). When the onboard unit 3 is not located in any of the areas CPA1 to CPA5 (step S32: NO), the onboard unit 3 ends the processing shown in FIG. 10.

[0037]

When the onboard unit 3 is located in any of the areas CPA1 to CPA5 (step S32: YES), the onboard unit 3 repeatedly determines whether or not the current time is within the communicable time set in the area until the current time is within the communicable time set in the area (until step S33: YES) (repetition of step S33: NO). When the current time is within the communicable time set in the area (step S33: YES), the onboard unit 3 determines whether or not the communicable time of the area is ended (step S34). When the communicable time of the area has ended (step S34: YES), the onboard unit 3 ends the processing shown in FIG. 10 (however, the initial determination result of step S34 is NO). When the communicable time of the area has not ended (step S34: NO), the onboard unit 3 transmits the response signal by the communication unit 33 (step S35). In step S35, the communication unit 33 monitors whether or not another

one of the onboard units 3 is transmitting the response signal by the collision avoidance function 332, and when another one of the onboard units 3 is transmitting the response signal, the communication unit 33 waits until another one of the onboard units 3 ends the transmission and a predetermined time elapses after the end, and transmits the response signal when another response signal is not detected. Therefore, the communication unit 33 determines whether or not the transmission of the response signal is completed or the standby state is continued, at each predetermined time after starting the processing for transmitting the response signal in step S35 (step S36), and when the standby state is continued (step S36: standby), the communication unit 33 determines again whether or not the communicable time of the area is ended in step S34 (step S34). On the other hand, when the transmission of the response signal is completed (for example, when an ACK (acknowledgment) for the response signal is sent from the roadside unit 2) (step S36: completed), the onboard unit 3 ends the processing shown in FIG. 10.

[0038]

(Operation and Effect)

The communication system 1 according to the present embodiment includes the roadside unit 2 that transmits, at the predetermined cycle, the response request signal including the information for specifying the plurality of areas set within the communication area of the roadside unit 2 and the information indicating each communicable time assigned to each of the areas and that receives the response signal to the response request signal, and the plurality of onboard units 3 that receive the response request signal, that recognize the area in which the onboard unit 3 is located, and that transmit the response signal within the communicable time assigned to the recognized area. In addition, the communication method according to the present

embodiment includes a step of transmitting, by the roadside unit 2, at the predetermined cycle, the response request signal including the information for specifying the plurality of areas set within the communication area of the roadside unit 2 and the information indicating each communicable time assigned to each of the areas, a step of receiving, by an onboard unit 3, the response request signal, recognizing the area in which the onboard unit 3 is located, and transmitting, by the onboard unit 3, the response signal within the communicable time assigned to the recognized area, and a step of receiving, by the roadside unit 2, the response signal. In addition, the roadside unit 2 according to the present embodiment transmits, at a predetermined cycle, the response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit 2 and information indicating each communicable time assigned to each of the areas, and receives each response signal transmitted by one or a plurality of onboard units that each receive the response request signal, that each recognize the area in which the onboard unit is located, and that each transmit the response signal, within the communicable time assigned to the recognized area. In addition, the onboard unit 3 according to the present disclosure receives a response request signal transmitted by a roadside unit that transmits, at a predetermined cycle, the response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas, recognizes the area in which the onboard unit 3 is located, and transmits a response signal within the communicable time assigned to the recognized area.

[0039]

Therefore, according to the communication system, the communication method, the roadside unit, and the onboard unit of the present embodiment, it is possible to reduce

collisions between signals transmitted by a plurality of onboard units.

[0040]

(Other Embodiments)

Although the embodiments of the present disclosure have been described in detail with reference to the drawings, the specific configuration is not limited to the embodiments and includes design changes and the like within a scope not departing from the gist of the present disclosure.

In the above-described embodiment, a case where the intersection 11 is a crossroad has been described as an example, but the intersection at which the roadside unit 2 is installed may be a four-way intersection other than the crossroad, or may be a three-way intersection or a five-way intersection or more. For example, in a case of a five-way intersection, a new area may be set on the third road, or the setting of the range covered by each area may be changed such that any of the five areas shown in FIG. 2 covers the third road. In addition, in the example shown in FIG. 2, two areas are set on each of the roads 10a and 10b with the area CPA1 interposed therebetween, but a plurality of areas of three or more may be set.

In addition, in the above-described embodiment, the shape of the area is a rectangle, but is not limited to a rectangle. For example, when the shape of the area is a circle, the information for specifying the area can be configured with, for example, information indicating center coordinates and a length of a radius. In addition, each area may include an overlapping portion with each other. In this case, regarding which area is to be determined for an overlapping portion, it is possible to cope with the issue by, for example, including, in the response request signal, information indicating a priority among the areas, or by previously defining a method of determining which area is to be selected.

[0041]

<Computer Configuration>

FIG. 11 is a schematic block diagram showing a configuration of a computer according to the present embodiment.

A computer 90 includes a processor 91, a main memory 92, a storage 93, and an interface 94.

The roadside unit 2 and the onboard unit 3 described above are mounted on the computer 90. The operations of the respective processing units described above are stored in the storage 93 in the form of a program. The processor 91 reads the program from the storage 93, loads the program into the main memory 92, and executes the above processing in accordance with the program. The processor 91 also allocates, in the main memory 92, storage areas corresponding to the respective storage units described above in accordance with the program.

[0042]

The program may be for implementing part of the functions to be exhibited by the computer 90. For example, the program may cause the functions to be exhibited in combination with another program already stored in the storage, or in combination with another program implemented in another device. In another embodiment, the computer may include, in addition to the above configuration or instead of the above configuration, a custom large scale integrated circuit (LSI) such as a programmable logic device (PLD). Examples of the PLD include a programmable array logic (PAL), a generic array logic (GAL), a complex programmable logic device (CPLD), and a field-programmable gate array (FPGA). In this case, a part or all of the functions implemented by the processor may be implemented by the integrated circuit.

[0043]

Examples of the storage 93 include a hard disk drive (HDD), a solid-state drive (SSD), a magnetic disk, a magneto-optical disk, a compact disc read-only memory (CD-ROM), a digital versatile disc read-only memory (DVD-ROM), and a semiconductor memory. The storage 93 may be an internal medium directly connected to a bus of the computer 90, or may be an external medium connected to the computer 90 via the interface 94 or a communication line. When the program is distributed to the computer 90 via a communication line, the computer 90 having received the distribution may load the program into the main memory 92 and execute the above processing. In at least one embodiment, the storage 93 is a non-transitory tangible storage medium.

[0044]

<Supplementary Note>

The communication system 1 described in each embodiment is understood as follows, for example.

[0045]

(1) A communication system 1 according to a first aspect includes a roadside unit 2 that transmits, at a predetermined cycle T1, a response request signal 50 including information 51 for specifying a plurality of areas CPA1 to CPA5 set within a communication area 2CA of the roadside unit 2 and information 52 to 56 indicating each communicable time T1a to T5a assigned to each of the areas, and that receives a response signal 60 to the response request signal 50, and a plurality of onboard units 3 that each receive the response request signal 50, that each recognize the area in which the onboard unit 3 is located, and that each transmit the response signal 60 within the communicable time assigned to the recognized area. According to the present aspect and each of the following aspects, it is possible to reduce collisions between signals transmitted by a plurality of onboard units.

[0046]

(2) The communication system 1 according to a second aspect is the communication system according to (1), in which each of the onboard units has a function (collision avoidance function 332) of avoiding a collision between the response signals by detecting a signal transmitted by another one of the onboard units, and each of the areas is set such that, within each area, detection of a signal transmitted by another one of the onboard units is enabled, and is set such that, within a predetermined range CPA1A from another one of the areas within each area, detection of a signal transmitted by another one of the onboard units within the other one of the areas is enabled. According to the present aspect, for example, it is possible to improve the degree of freedom in setting the intervals between the plurality of areas CPA1 to CPA5.

[0047]

(3) The communication system 1 according to a third aspect is the communication system according to (1) or (2), in which a length of each of the communicable times is changed according to a measured value or an estimated value of communication traffic for each of the areas. According to the present aspect, it is possible to appropriately set the length of the communicable time according to the communication traffic.

[0048]

(4) The communication system 1 according to a fourth aspect is the communication system according to any one of (1) to (3), in which the communication area includes an intersection at which a plurality of roads intersect. According to the present aspect, it is possible to reduce collisions between signals transmitted by a plurality of onboard units on a road where a plurality of roads intersect.

[Industrial Applicability]

[0049]

According to each aspect of the present invention, it is possible to reduce collisions between signals transmitted by a plurality of onboard units.

[Reference Signs List]

[0050]

1: communication system

2: roadside unit

3: onboard unit

4: vehicle

2CP: communication area

CPA1 to CPA5: area (area 1 to area 5)

T1a to T5a: communicable time

Claims

[Claim 1]

A communication system comprising:

a roadside unit that transmits, at a predetermined cycle, a response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas, and that receives a response signal to the response request signal; and

a plurality of onboard units that each receive the response request signal, that each recognize the area in which the onboard unit is located, and that each transmit the response signal within the communicable time assigned to the recognized area.

[Claim 2]

The communication system according to Claim 1,

wherein each of the onboard units has a function of avoiding collisions between the response signals by detecting a signal transmitted by another one of the onboard units, and

each of the areas is set such that, within each area, detection of a signal transmitted by another one of the onboard units is enabled, and is set such that, within a predetermined range from another one of the areas within each area, detection of a signal transmitted by another one of the onboard units within the other one of the areas is enabled.

[Claim 3]

The communication system according to Claim 2,

wherein a length of each of the communicable times is changed according to a measured value or an estimated value of communication traffic for each of the areas.

[Claim 4]

The communication system according to Claim 3,

wherein the communication area includes an intersection at which a plurality of roads intersect.

[Claim 5]

A communication method comprising:

a step of transmitting, via a roadside unit, at a predetermined cycle, a response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas;

a step of receiving, via an onboard unit, the response request signal, recognizing the area in which the onboard unit is located, and transmitting, via the onboard unit, a response signal within the communicable time assigned to the recognized area; and

a step of receiving, via the roadside unit, the response signal.

[Claim 6]

A roadside unit that transmits, at a predetermined cycle, a response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas, and that receives each response signal transmitted by one or a plurality of onboard units that each receive the response request signal, that

each recognize the area in which the onboard unit is located, and that each transmit the response signal, within the communicable time assigned to the recognized area.

[Claim 7]

An onboard unit that receives a response request signal transmitted by a roadside unit that transmits, at a predetermined cycle, the response request signal including information for specifying a plurality of areas set within a communication area of the roadside unit and information indicating each communicable time assigned to each of the areas, that recognizes the area in which the onboard unit is located, and that transmits a response signal within the communicable time assigned to the recognized area.