

DESCRIPTION

Title of Invention

WIRELESS COMMUNICATION SYSTEM, CONTROL METHOD THEREOF, AND PROGRAM

5 Technical Field

[0001]

The present invention relates to a wireless communication system in which wireless communication with a vehicle traveling in a road is performed, a control method thereof, and a program.

10 Priority is claimed on Japanese Patent Application No. 2012-035563, filed February 21, 2012, the content of which is incorporated herein by reference.

Background Art

[0002]

In intelligent transport systems (ITS), there is a wireless access in vehicular environments (WAVE) communication standard as a standard of a communication system commonly used in various traffic-related services including road pricing. In-vehicle devices according to the WAVE communication standard (hereinafter, referred to as a "WAVE") perform road-to-vehicle communication or vehicle-to-vehicle communication. Here, there is road pricing as an application example of the road-to-vehicle communication. In this communication, a wireless communication device installed on a road performs communication with an in-vehicle device equipped in a vehicle using a control channel, and after the communication according to the control channel is completed, communication with the in-vehicle device is performed on a service channel. In other words, communication is performed such that a transmission and reception control period between a wireless communication device installed on a

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road and an in-vehicle device is divided into a transmission and reception control period on the control channel and a transmission and reception control period on the service channel. A technique related to the WAVE is disclosed in PTL 1.

Citation List

5 Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Application, First Publication No. 2010-239607

Summary of Invention

Technical Problem

10 [0004]

Meanwhile, each of the wireless communication devices performing communication with the in-vehicle devices using the WAVE technique is installed directly above a corresponding lane so as to be able to perform communication with vehicles traveling thereon, for example, to correspond to a plurality of lanes formed on a road, respectively. FIG. 6 is a diagram showing a wireless communication system using a WAVE technique according to a related art. In FIG. 6, a reference numeral 1 represents a wireless communication device, and a wireless communication region 3 formed by radio waves transmitted from each wireless communication device 1 is present in a lane corresponding to each wireless communication device 1. Here, when the wireless communication devices 1 perform communication with vehicles 2 on a control channel or a service channel at the same timing, a radio wave interference region is likely to occur at a range in which the wireless communication regions 3 of the adjacent wireless communication devices 1 overlap.

[0005]

25 It is an object of the invention to provide a wireless communication system, a

control method thereof, and a program, which are capable of reducing the occurrence of the radio wave interference region.

Solution to Problem

[0006]

5 According to the present invention, provided is a wireless communication system that includes a plurality of wireless communication devices each of which performs wireless communication with a vehicle traveling in one of a plurality of lanes formed on a road, each of the plurality of wireless communication devices corresponding to one of the plurality of lanes, wherein the wireless communication device performs
10 transmission and reception with the vehicle traveling in the corresponding lane such that the timing of a transmission and reception control period in which transmission and reception with the vehicle is performed on a control channel which is a first frequency and the timing of a transmission and reception control period in which transmission and reception with the vehicle is performed through a service channel which is a frequency
15 different from the first frequency are shifted from the timings of another wireless communication device.

[0007]

 Further, according to the present invention, in the wireless communication system, the wireless communication device may perform transmission and reception with
20 the vehicle traveling in the corresponding lane such that the timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on the control channel and the timing of the transmission and reception control period in which transmission and reception with the vehicle is performed through the service channel are shifted from the timings of another adjacent wireless
25 communication device.

[0008]

Further, according to the present invention, in the wireless communication system, the wireless communication device may perform transmission and reception with the vehicle traveling in the corresponding lane such that the timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on the control channel and the timing of the transmission and reception control period in which transmission and reception with the vehicle is performed through a service channel of the same frequency among the service channels of a plurality of frequencies are shifted from the timings of another first adjacent wireless communication device adjacent thereto and the timings of a second adjacent wireless communication device adjacent to the first adjacent wireless communication device.

[0009]

Further, according to the present invention, in the wireless communication system, the wireless communication device may perform transmission and reception with the vehicle on a service channel of a frequency different from a frequency of the service channel used by the another adjacent wireless communication device.

[0010]

Further, according to the present invention, provided is a control method of a wireless communication system including a plurality of wireless communication devices each of which performs wireless communication with a vehicle traveling in one of a plurality of lanes formed on a road, each of the plurality of wireless communication devices corresponding to the one of plurality of lanes, and the control method includes performing, by the wireless communication device, transmission and reception with the vehicle traveling in the corresponding lane such that the timing of a transmission and reception control period in which transmission and reception with the vehicle is

performed on a control channel which a first frequency is and the timing of a transmission and reception control period in which transmission and reception with the vehicle is performed on a service channel which is a frequency different from the first frequency are shifted from the timings of another wireless communication device.

5 [0011]

Further, according to the present invention, in the control method, the wireless communication device may perform transmission and reception with the vehicle traveling in the corresponding lane such that the timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on a control channel and the timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on a service channel are shifted from the timings of another adjacent wireless communication device.

[0012]

Further, according to the present invention, in the control method, the wireless communication device may perform transmission and reception with the vehicle traveling in the corresponding lane such that a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on a control channel and a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on a service channel of the same frequency among the service channels of a plurality of frequencies are shifted from the timings of another first adjacent wireless communication device adjacent thereto and a timing of a second adjacent wireless communication device adjacent to the first adjacent wireless communication device.

[0013]

25 Further, according to the present invention, in the control method, the wireless

communication device may perform transmission and reception with the vehicle on a service channel of a frequency different from a frequency of the service channel used by the another adjacent wireless communication device.

[0014]

5 Further, according to the present invention, provided is a program causing a computer of each of a plurality of wireless communication devices that performs wireless communication with a vehicle traveling in one of a plurality of lanes formed on a road, each of the plurality of wireless communication devices corresponding to one of the plurality of lanes, to function as a unit configured to perform transmission and reception
10 with the vehicle traveling in the corresponding lane such that a timing of a transmission and reception control period in which transmission and reception with the vehicle is performed on a control channel which is a first frequency and a timing of a transmission and reception control period in which transmission and reception with the vehicle is performed on a service channel which is a frequency different from the first frequency
15 are shifted from the timings of another wireless communication device.

Advantageous Effects of Invention

[0015]

According to the present invention, adjacent wireless communication devices alternately transmit wireless signals on different frequencies, and thus it is possible to
20 reduce the occurrence of a radio wave interference region in a range in which the wireless communication regions overlap.

Brief Description of Drawings

[0016]

FIG. 1 is a schematic diagram of a wireless communication system.

25 FIG. 2A is a first diagram showing transmission control of wireless signals of

wireless communication devices.

FIG. 2B is a first diagram showing transmission control of wireless signals of wireless communication devices.

FIG. 3 is a second diagram showing transmission control of wireless signals of wireless communication devices.

FIG. 4 is a diagram showing an overview of a synchronous operation of communication between a wireless communication device and a vehicle.

FIG. 5 is a diagram showing an overview of a communication process between a wireless communication device and a vehicle.

FIG. 6 is a diagram showing a wireless communication system using a WAVE technique according to a related art.

Description of Embodiments

[0017]

Hereinafter, a wireless communication device according to an embodiment of the present invention will be described with reference to the appended drawings.

FIG. 1 is a schematic diagram of a wireless communication system according to the embodiment.

FIG. 1 is shown wireless communication devices 1a to 1d, a vehicle 2, a transmission control device 10, a road 50, and lanes 60a to 60d. Further, in the following description, the wireless communication devices 1a to 1d are referred to collectively as a “wireless communication device 1” and the lanes 60a to 60d are referred to collectively as a “lane 60.” In the wireless communication system according to the present embodiment, each of the wireless communication devices 1a to 1d correspond to and are installed directly above one of the plurality of lanes 60a to 60d formed on road 50. The wireless communication devices 1a to 1d are connected to the transmission control

device 10 so that communication can be performed therebetween, and transmit wireless signals specified in the WAVE communication standard on the lanes formed at corresponding positions on the road 50 based on control of the transmission control device 10.

5 [0018]

The transmission control device 10 includes a communication unit 11, a transmission control unit 12, and a storage unit 13 as shown in FIG. 1. The communication unit 11 is a processing unit that performs communication with the wireless communication devices 1a to 1d. The transmission control unit 12 is a
10 processing unit that controls transmission timings of wireless signals that are transmitted on the control channel or the service channel by the wireless communication devices 1a to 1d. The storage unit 13 stores various types of information for processing.

[0019]

Further, in the wireless communication system according to the present
15 embodiment, based on control of the transmission control device 10, the wireless communication device 1 performs transmission and reception with the in-vehicle device of the vehicle 2 traveling in a corresponding lane such that a timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed on the control channel which is a first frequency and a
20 timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed on the service channel which is a frequency different from the first frequency are shifted from the timings of the another wireless communication devices.

Accordingly, a wireless communication system capable of reducing the
25 occurrence of the radio wave interference region is provided.

[0020]

FIGS. 2A and 2B are first diagrams showing transmission control of wireless signals of the wireless communication devices.

The transmission control of the wireless signal shown in FIG. 2A is an example
5 in which the wireless communication device 1 performs transmission and reception with the in-vehicle device of the vehicle 2 traveling in a corresponding lane such that a timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed on the control channel and a timing of a transmission and reception control period in which transmission and reception with the
10 in-vehicle device of the vehicle 2 is performed on the service channel are shifted from the timings of the other adjacent wireless communication devices 1.

[0021]

In other words, in the example of FIG. 2A, the wireless communication device 1a causes the timings of the transmission and reception control periods according to the
15 control channel and the service channel to be different from those of the adjacent wireless communication device 1b.

Further, in the example of FIG. 2A, the wireless communication device 1b causes the timings of the transmission and reception control periods on the control channel and the service channel to not overlap those of the adjacent wireless
20 communication devices 1a and 1c.

Further, in the example of FIG. 2A, the wireless communication device 1c causes the timings of the transmission and reception control periods on the control channel and the service channel to not overlap those of the adjacent wireless communication devices 1b and 1d.

25 Further, in the example of FIG. 2A, the wireless communication device 1d

causes the timings of the transmission and reception control periods according to the control channel and the service channel not to overlap that of the adjacent wireless communication device 1c.

[0022]

5 When such transmission control is performed, the transmission control unit 12 of the transmission control device 10 reads network addresses of the wireless communication devices 1a to 1d connected via communication from the storage unit 13, and transmits a communication start request signal to give an instruction to start communication control with the vehicle 2 to the wireless communication devices 1a to
10 1d.

[0023]

 Here, in the wireless communication device 1a and the wireless communication device 1c, information to instruct transmission of a wireless signal on the control channel when the count is an odd number and instruct transmission of a wireless signal on the
15 service channel when the count is an even number is recorded in a memory or the like in advance. Meanwhile, in the wireless communication device 1b and the wireless communication device 1d, information to instruct transmission of a wireless signal on the control channel when the count is an even number and instruct transmission of a wireless signal on the service channel when the count is an odd number is recorded in a memory
20 or the like in advance.

[0024]

 Upon receiving the communication start request signal from the transmission control device 10, control units of the wireless communication devices 1a to 1d start counting. For example, a count interval is 20 msec. Further, the control units of the
25 wireless communication device 1a and the wireless communication device 1c perform

control such that the wireless signal on the control channel is transmitted when a count is an odd number.

Further, the control units of the wireless communication device 1a and the wireless communication device 1c perform control such that the wireless signal on the service channel is transmitted when a count is an even number.

[0025]

Meanwhile, the control units of the wireless communication device 1b and the wireless communication device 1d perform control such that the wireless signal on the service channel is transmitted when a count is an odd number. Further, the control units of the wireless communication device 1b and the wireless communication device 1d perform control such that the wireless signal on the control channel is transmitted when a count is an even number.

[0026]

Through such processing, the adjacent wireless communication devices 1 alternately transmit wireless signals of different frequencies, and thus it is possible to reduce the occurrence of the radio wave interference region in the range in which the wireless communication regions 3 overlap.

[0027]

Further, the transmission control unit 12 of the transmission control device 10 may determine the transmission timing of the wireless signal on the control channel and the transmission timing of the wireless signal on the service channel in each of the wireless communication devices 1 based on counting and transmit each timing to the wireless communication device 1 each time. In this case, each of the wireless communication devices 1 sequentially transmits the wireless signal on the control channel and the wireless signal on the service channel based on the transmission timing

received from the transmission control device 10.

[0028]

The wireless communication device 1 may perform the transmission control of the wireless signal shown in FIG. 2B instead of the transmission control of the wireless
5 signal shown in FIG. 2A.

The transmission control of the wireless signal shown in FIG. 2B is an example in which the wireless communication device 1 performs transmission and reception with the in-vehicle device of the vehicle 2 traveling in a corresponding lane such that the timing of a transmission and reception control period in which transmission and
10 reception with the in-vehicle device of the vehicle 2 is performed on a control channel and a timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed on a service channel are shifted from timings of the other adjacent wireless communication devices 1. Further, in the example of the transmission control of the wireless signal shown in FIG.
15 2B, the two adjacent wireless communication devices 1 perform transmission and reception with the in-vehicle devices of the vehicles 2 traveling in corresponding lanes on the service channels of different frequencies.

[0029]

In other words, in the example of FIG. 2B, the wireless communication device
20 1a cause the timings of the transmission and reception control periods on the control channel and on the service channel to not overlap those of the adjacent wireless communication device 1b, and performs transmission and reception with the in-vehicle device of the vehicle 2 on a service channel of a frequency different from a frequency on the service channel used by the wireless communication device 1b.

25 Further, in the example of FIG. 2B, the wireless communication device 1b

causes the timings of the transmission and reception control periods on the control channel and on the service channel to not overlap those of the adjacent wireless communication devices 1a and 1c, and performs transmission and reception with the in-vehicle device of the vehicle 2 on the service channel of a frequency different from
5 frequencies of the service channels used by the wireless communication devices 1a and 1c.

Further, in the example of FIG. 2B, the wireless communication device 1c causes the timings of the transmission and reception control periods on the control channel and on the service channel to not overlap those of the adjacent wireless
10 communication devices 1b and 1d, and performs transmission and reception with the in-vehicle device of the vehicle 2 on the service channel of a frequency different from the frequencies of the service channels used by the wireless communication devices 1b and 1d.

Further, in the example of FIG. 2B, the wireless communication device 1d
15 causes the timings of the transmission and reception control periods on the control channel and on the service channel to not overlap those of the adjacent wireless communication device 1c, and performs transmission and reception with the in-vehicle device of the vehicle 2 on the service channel of a frequency different from a frequency of the service channel used by the wireless communication device 1c.

20 [0030]

When such transmission control is performed, the transmission control unit 12 of the transmission control device 10 reads network addresses of the wireless communication devices 1a to 1d connected via communication from the storage unit 13, and transmits a communication start request signal to give an instruction to start
25 communication control with the vehicle 2 to the wireless communication devices 1a to 1d,

similarly to the process of the example shown in FIG. 2A.

[0031]

Here, in the wireless communication device 1a and the wireless communication device 1c, information to instruct transmission of a wireless signal on the control channel when the count is an odd number and instruct transmission of a wireless signal on the service channel when the count is an even number is recorded in a memory or the like in advance. Further, in the wireless communication device 1a and the wireless communication device 1c, information to give an instruction to use a frequency F1 as the service channel is recorded in a memory or the like. Meanwhile, in the wireless communication device 1b and the wireless communication device 1d, information to instruct transmission of a wireless signal on the control channel when the count is an even number and instruct transmission of a wireless signal on the service channel when the count is an odd number is recorded in a memory or the like in advance. Further, in the wireless communication device 1b and the wireless communication device 1d, information to give an instruction to use a frequency F2 as the service channel is recorded in a memory or the like.

[0032]

Upon receiving the communication start request signal from the transmission control device 10, control units of the wireless communication devices 1a to 1d start counting. For example, a count interval is 20 msec. Further, the control units of the wireless communication device 1a and the wireless communication device 1c perform control such that the wireless signal on the control channel is transmitted when the count is an odd number.

Further, the control units of the wireless communication device 1a and the wireless communication device 1c perform control such that the wireless signal on the

service channel which is the frequency F1 is transmitted when the count is an even number.

[0033]

Meanwhile, the control units of the wireless communication device 1b and the
5 wireless communication device 1d perform control such that the wireless signal on the service channel which is the frequency F2 is transmitted when the count is an odd number. Further, the control units of the wireless communication device 1b and the wireless communication device 1d perform control such that the wireless signal on the control channel is transmitted when the count is an even number.

10 [0034]

Through such processing, the adjacent wireless communication devices 1 alternately transmit wireless signals on different frequencies, and thus it is possible to reduce the occurrence of the radio wave interference region in the range in which the wireless communication regions 3 overlap.

15 [0035]

FIG. 3 is a second diagram showing transmission control of wireless signals of the wireless communication devices.

The transmission control of the wireless signal shown in FIG. 3 is an example in which the wireless communication device 1 performs transmission and reception with the
20 in-vehicle device of the vehicle 2 traveling in a corresponding lane such that the timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed on the control channel and the timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed on the service channel which is the
25 same as the service channels of each of a plurality of frequencies are shifted from the

timing of a first adjacent wireless communication device adjacent thereto and a timing of a second adjacent wireless communication device that is another wireless communication device adjacent to the first adjacent wireless communication device.

[0036]

5 In other words, in the example of FIG. 3, the wireless communication device 1a performs transmission and reception with the in-vehicle device of the vehicle 2 such that timings of the transmission and reception control periods by a control channel and a service channel of the same frequency among service channels of a plurality of frequencies do not overlap those of the wireless communication device 1b (the first
10 adjacent wireless communication device) and the wireless communication device 1c (the second adjacent wireless communication device).

 Further, in the example of FIG. 3, the wireless communication device 1b performs transmission and reception with the in-vehicle device of the vehicle 2 such that timings of the transmission and reception control periods on a control channel and a
15 service channel of the same frequency among service channels of a plurality of frequencies do not overlap those of the adjacent wireless communication device 1a (the first adjacent wireless communication device), the wireless communication device 1c (the first adjacent wireless communication device), and the wireless communication device 1d (the second adjacent wireless communication device).

20 Further, in the example of FIG. 3, the wireless communication device 1c performs transmission and reception with the in-vehicle device of the vehicle 2 such that timings of the transmission and reception control periods on a control channel and a service channel of the same frequency among service channels of a plurality of frequencies do not overlap those of the adjacent wireless communication device 1b (the
25 first adjacent wireless communication device), the wireless communication device 1d

(the first adjacent wireless communication device), and the wireless communication device 1a (the second adjacent wireless communication device).

Further, in the example of FIG. 3, the wireless communication device 1d performs transmission and reception with the in-vehicle device of the vehicle 2 such that
5 timings of the transmission and reception control periods by a control channel and a service channel of the same frequency among service channels of a plurality of frequencies do not overlap those of the adjacent wireless communication device 1c (the first adjacent wireless communication device) and the wireless communication device 1b (the second adjacent wireless communication device).

10 [0037]

When such transmission control is performed, the transmission control unit 12 of the transmission control device 10 reads network addresses of the wireless communication devices 1a to 1d connected via communication from the storage unit 13, and transmits a communication start request signal to give an instruction to start
15 communication control with the vehicle 2 to the wireless communication devices 1a to 1d, similarly to the processes of the examples shown in FIGS. 2A and 2B.

[0038]

In the wireless communication devices 1a and 1d, information to give an instruction to transmit the wireless signal on the control channel at a first count, transmit
20 the wireless signal on the service channel of the frequency F1 on a second count, and transmit the wireless signal on the service channel of the frequency F2 on a third count is recorded in a memory or the like in advance.

Further, in the wireless communication device 1b, information to give an instruction to transmit the wireless signal on the service channel of the frequency F2 on a
25 first count, transmit the wireless signal on the control channel on a second count, and

transmit the wireless signal on the service channel of the frequency F1 on a third count is recorded in a memory or the like in advance.

Further, in the wireless communication device 1c, information to give an instruction to transmit the wireless signal on the service channel of the frequency F1 on a first count, transmit the wireless signal on the service channel of the frequency F2 on a second count, and transmit the wireless signal on the control channel on a third count is recorded in a memory or the like in advance.

[0039]

Upon receiving the communication start request signal from the transmission control device 10, control units of the wireless communication devices 1a to 1d start counting. For example, the count interval is 20 msec. Further, the control units of the wireless communication devices 1a and 1d perform control such that the wireless signal on the control channel is transmitted when the count is a first count. Further, the control units of the wireless communication devices 1a and 1d perform control such that the wireless signal on the service channel of the frequency F1 is transmitted when the count is a second count. Further, the control units of the wireless communication devices 1a and 1d perform control such that the wireless signal of the service channel of the frequency F2 is transmitted when the count is a third count. Further, the control units of the wireless communication devices 1a and 1d repeatedly perform the transmission control of the first to third counts at each count.

[0040]

Further, the control unit of the wireless communication device 1b performs control such that the wireless signal of the service channel of the frequency F2 is transmitted when the count is the first count. Further, the control unit of the wireless communication device 1b performs control such that the wireless signal of the control

channel is transmitted when the count is the second count. Further, the control unit of the wireless communication device 1b performs control such that the wireless signal on the service channel of the frequency F1 is transmitted when the count is the third count. Further, the control unit of the wireless communication device 1b repeatedly performs the transmission control of the first to third counts at each count.

[0041]

Further, the control unit of the wireless communication device 1c performs control such that the wireless signal on the service channel of the frequency F1 is transmitted when the count is the first count. Further, the control unit of the wireless communication device 1c performs control such that the wireless signal on the service channel of the frequency F2 is transmitted when the count is the second count. Further, the control unit of the wireless communication device 1c performs control such that the wireless signal on the control channel is transmitted when the count is the third count. Further, the control unit of the wireless communication device 1c repeatedly performs the transmission control of the first to third counts at each count.

[0042]

Further, the wireless communication device 1 may perform transmission and reception with the in-vehicle device of the vehicle 2 traveling in a corresponding lane such that the timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed on a control channel and a timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed through a service channel of the same frequency among service channels of a plurality of frequencies are shifted from the timings of other adjacent wireless communication devices that are sequentially adjacent and equal in number to frequencies.

For example, the wireless communication device 1a may perform transmission and reception with the in-vehicle device of the vehicle 2 traveling in a corresponding lane such that a timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed on a control channel and a timing of a transmission and reception control period in which transmission and reception with the in-vehicle device of the vehicle 2 is performed through a service channel of the same frequency among service channels of a plurality of frequencies (three frequencies F1, F2, and F3) are shifted from the timings of (3) other adjacent wireless communication devices (the wireless communication devices 1b, 1c, and 1d) that are sequentially adjacent and equal in number to frequencies.

[0043]

Through such processing, a plurality of wireless communication devices 1 that are sequentially adjacent alternately transmit wireless signals on different frequencies, and thus it is possible to reduce the occurrence of the radio wave interference regions in the range in which the wireless communication regions 3 of the plurality of wireless communication devices 1 overlap.

[0044]

FIG. 4 is a diagram showing an overview of a synchronous operation of communication between the wireless communication device and the vehicle.

As shown in FIG. 4, the wireless communication device 1 repeatedly performs transmission of the wireless signal on the control channel (CCH) and transmission of the wireless signal on the service channel (SCH) at certain count intervals. The count interval is referred to as an interval, and a wireless signal non-transmission period called a guard band is set during a certain period from a start timing of the interval in the interval of the wireless signal in each of the control channel and the service channel.

Meanwhile, the vehicle 2 repeats a control channel reception mode at intervals equal to those of the wireless communication device 1 until the wireless signal on the control channel transmitted from the wireless communication device 1 is received. Then, when the vehicle enters the wireless communication region 3 of the wireless signal transmitted from the wireless communication device 1, the in-vehicle device of the vehicle 2 receives the wireless signal on the control channel in the control channel reception mode, and repeats transmission and reception of the wireless signals on the service channel and the control channel in a subsequent interval.

[0045]

FIG. 5 is a diagram showing an overview of a communication process between the wireless communication device and the vehicle.

When the period of time of the guard band of the interval elapses, the wireless communication device 1 transmits timing notification information to the vehicle 2 as shown in FIG. 5. The timing notification information is information used to synchronize the in-vehicle device mounted in the vehicle 2 with the wireless communication. Further, the wireless communication device 1 transmits service channel (SCH) designation information and position correction information using the control channel. The service channel designation information is information used to designate necessary in-vehicle device data.

The position correction information is data used to correct the position of the in-vehicle device.

[0046]

Then, upon receiving the timing notification information, the service channel designation information, and the position correction information, the in-vehicle device of the vehicle 2 transmits in-vehicle device information on the service channel after the

guard band of the transmission and reception control period on the service channel elapses. When an acknowledge response (ACK) is not received from the wireless communication device 1 before the transmission and reception control period on the service channel elapses, the in-vehicle device transmits the in-vehicle device information again within the same transmission and reception control period on the service channel.

5 [0047]

Here, when the length of the interval is too short, the ratio of the period of the guard band of the interval (the transmission and reception control period) is increased, and a communication rate (a data transmission/reception amount per unit time) between the wireless communication device 1 and the vehicle 2 is lowered. Thus, it is necessary to set the length of the interval so that transmission and reception of certain information based on wireless communication on the service channel can be completed in the wireless communication region 3 after the in-vehicle device of the vehicle 2 receives the wireless communication on the control channel from the wireless communication device

10 1.

15 [0048]

Further, each of the wireless communication device 1, the transmission control device 10, and the in-vehicle device equipped in the vehicle 2 includes an internal computer system. Further, the above-described processes are stored in a computer readable recording medium in a program form, and are performed as the program is read and executed by a computer. Here, examples of the computer readable recording medium include a magnetic disk, a magneto optical disk, a CD-ROM, a DVD-ROM, and a semiconductor memory. The computer program may be delivered to a computer via a communication line and executed by the computer that received the delivery.

20 [0049]

25 [0049]

Further, the program may implement some of the above-described functions.

In addition, the program may be a so-called differential file (a differential program) that can be implemented in combination with a program having the above-described functions that are already recorded in a computer system.

5 Industrial Applicability

[0050]

According to an aspect of the present invention, it is possible to provide a wireless communication system capable of reducing the occurrence of radio wave interference regions.

10 Reference Signs List

[0051]

1, 1a, 1b, 1c, 1d Wireless communication device

2 Vehicle

10 Transmission control device

15 11 Communication unit

12 Transmission control unit

13 Storage unit

50 Road

60, 60a, 60b, 60c, 60d Lane

CLAIMS

[Claim 1]

A wireless communication system, comprising:

5 a plurality of wireless communication devices each of which performs wireless communication with a vehicle traveling in one of a plurality of lanes formed on a road, each of the plurality of wireless communication devices corresponding to one of the plurality of lanes,

wherein the wireless communication device performs transmission and reception
10 with the vehicle traveling in the corresponding lane such that a timing of a transmission and reception control period in which transmission and reception with the vehicle is performed on a control channel which a first frequency is and a timing of a transmission and reception control period in which transmission and reception with the vehicle is performed through a service channel which is a frequency different from the first
15 frequency are shifted from a timing of another wireless communication device.

[Claim 2]

The wireless communication system according to claim 1,

wherein the wireless communication device performs transmission and reception
with the vehicle traveling in the corresponding lane such that a timing of the transmission
20 and reception control period in which transmission and reception with the vehicle is performed on the control channel and a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on the service channel are shifted from a timing of another adjacent wireless communication device.

[Claim 3]

25 The wireless communication system according to claim 1,

wherein the wireless communication device performs transmission and reception with the vehicle traveling in the corresponding lane such that a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed through the control channel and a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on a service channel which is the same as the service frequency of each of plurality of wireless communication devices are shifted from a timing of another first adjacent wireless communication device adjacent to the wireless communication device and a timing of a second adjacent wireless communication device adjacent to the first adjacent wireless communication device.

[Claim 4]

The wireless communication system according to claim 2 or 3,
wherein the wireless communication device performs transmission and reception with the vehicle on a service channel of a frequency different from a frequency of the service channel used by the another adjacent wireless communication device.

[Claim 5]

A control method of a wireless communication system including a plurality of wireless communication devices each of which performs wireless communication with a vehicle traveling in one of a plurality of lanes formed on a road, each of the plurality of wireless communication devices corresponding to one of the plurality of lanes, the control method comprising:

performing, by the wireless communication device, transmission and reception with the vehicle traveling in the corresponding lane such that a timing of a transmission and reception control period in which transmission and reception with the vehicle is performed through a control channel which a first frequency is and a timing of a

transmission and reception control period in which transmission and reception with the vehicle is performed on a service channel which is a frequency different from the first frequency are shifted from a timing of another wireless communication device.

[Claim 6]

5 The control method according to claim 5,

 wherein the wireless communication device performs transmission and reception with the vehicle traveling in the corresponding lane such that a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on the control channel and a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on the service channel are shifted from a timing of another adjacent wireless communication device.

[Claim 7]

 The control method according to claim 5,

 wherein the wireless communication device performs transmission and reception with the vehicle traveling in the corresponding lane such that a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on the control channel and a timing of the transmission and reception control period in which transmission and reception with the vehicle is performed on a service channel which is the same as the service frequency of each of plurality of wireless communication devices are shifted from a timing of another first adjacent wireless communication device adjacent thereto and a timing of a second adjacent wireless communication device adjacent to the first adjacent wireless communication device.

[Claim 8]

 The control method according to claim 6 or 7,

25 wherein the wireless communication device performs transmission and reception

with the vehicle on a service channel of a frequency different from a frequency of the service channel used by the another adjacent wireless communication device.

[Claim 9]

5 A program causing a computer of each of a plurality of wireless communication devices each of which performs wireless communication with a vehicle traveling in one of a plurality of lanes formed on a road, each of the plurality of wireless communication devices corresponding to one of the plurality of lanes, to function as:

a unit configured to perform transmission and reception with the vehicle traveling in the corresponding lane such that a timing of a transmission and reception control period in which transmission and reception with the vehicle is performed on a control channel which is a first frequency and a timing of a transmission and reception control period in which transmission and reception with the vehicle is performed on a service channel which is a frequency different from the first frequency are shifted from a timing of another wireless communication device.

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