# DESCRIPTION

Title of Invention

## COMMUNICATION METHOD AND COMMUNICATION SYSTEM

Technical Field

[0001]

The present invention relates to a communication method and a communication system in which data is transmitted from a base station to a plurality of mobile stations, and data is transmitted from the mobile stations to the base station.

Priority is claimed on Japanese Patent Application No. 2012-025002, filed February 8, 2012, the content of which is incorporated herein by reference.

Background Art

[0002]

An example of a communication system is described in PTL 1. The communication system of PTL1 includes a wireless base station including a plurality of wireless communication units that perform wireless communication via different communication channels, and a wireless communication unit having a variable communication channel. Further, the communication system of PTL 1 includes a wireless terminal that performs wireless communication with the wireless base station using the wireless communication unit to be provided with a service via the wireless base station.

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Application, First Publication No. 2010-226271

Summary of Invention

Technical Problem

[0004]

In the field of ITSs (Intelligent Transport Systems), a vehicle-mounted device based on a WAVE (Wireless Access in Vehicular Environments) communication standard intended to be commonly used for various traffic-related services including road charging includes a communication system that performs communication between a road and a vehicle or between vehicles.

[0005]

Such a communication system 100 performs road charging in such a manner that a charging device 103 installed above a road 101 receives information transmitted from a vehicle 102 running on the road 101, as illustrated in FIG. 6.

[0006]

As an application example of communication between vehicles, the communication system 100 notifies the vehicle 102 running on the road 101 of a report 104 "An emergency vehicle is approaching from the rear," when an emergency vehicle approaches or of a report 105 "Be careful of the vehicle in front," when an emergency vehicle approaches, as illustrated in FIG. 7.

[0007]

In such a communication system 100, a used communication frequency band is divided into a plurality of communication channels 110 through time division to realize different types of services according to purposes, as illustrated in FIG. 8. The communication channel 110 is divided into a control channel CC and a service channel SC. The control channel CC is shared among all communication terminals 1, 2 and 3, in which a next service channel SC is instructed and communication is established. On the other hand, in the service channel SC, transmission and reception of information is

performed, and different information services are realized in parallel through time division through alternate repetition of the control channel CC and the service channel SC.

[0008]

Here, it is necessary to synchronize timings of a period, an interval and start between a transmission side and a reception side in the communication channel 110. Any of the following schemes are normally used as a method of synchronizing the communication channel 110. A first synchronization method is to use UTC (Universal Time, Coordinated) absolute time included in a signal of the GPS (Global Positioning System). A second synchronization method is to set a start timing of a communication message from a base station to positive and perform matching with the same.

[0009]

However, in the GPS communication system 100, in a place in which GPS electric waves cannot be stably received, such as between buildings or in a tunnel, an interval of exact time correction based on the GPS is generated when such a state continues for a long time, as illustrated in FIG. 9. Accordingly, since time is maintained with a built-in clock in the meantime, an error is accumulated. Therefore, in communication among vehicles 120, 130 and 140, it is necessary to match a starting time among the vehicles. Accordingly, when the accumulated error exceeds a guard interval, collision or failure of the communication occurs.

[0010]

On the other hand, in PTL 1, even when data for a plurality of services is received in parallel, data for each service can be completely received, and can be flexibly received in parallel in response to a request of a user. However, in PTL 1, in a communication system in which it is necessary to synchronize timings of timeslots of the

communication, time is synchronized through matching with an absolute time included in a signal of the GPS or a communication message from a base station. Therefore, in PTL 1, a GPS function or a base station is indispensable. Also, when an interval of exact time correction based on the GPS is generated, time is maintained with a built-in clock in the meantime. Accordingly, an error may be accumulated and an amount of the accumulated error may exceed a guard interval. Therefore, in PTL 1, collision and failure of communication may occur.

[0011]

The present invention is made to solve the above problems, and an object of the present invention is to provide a communication method and a communication system which are capable of maintaining an exact timing of communication when GPS cannot be stably received for a long time.

Solution to Problem

[0012]

In order to solve the above problems, according to a first aspect of the present invention, a communication method in which data is transmitted from a base station to a plurality of mobile stations via a downlink channel and data is transmitted from the mobile station selectively selected among the plurality of mobile stations to the base station via an uplink channel includes receiving, by the mobile station, GPS electric waves, determining quality of the received GPS electric waves, setting, in the mobile station, time obtained from the GPS electric waves when the quality of the GPS electric waves is equal to or more than a predetermined threshold, determining whether the mobile station is in a precision degradation position with reference to a GPS time precision degradation place database based on a present position of the mobile station and applying the time of the mobile station when the quality of the GPS electric waves is

less than or equal to the predetermined threshold or when the mobile station is in the precision degradation position in the GPS time precision degradation place database.

[0013]

The communication method may further include applying time of a wireless LAN when the quality of the GPS electric waves is less than or equal to the predetermined threshold and the mobile station is in the precision degradation position.

[0014]

According to a second aspect of the present invention, a communication system includes a WAVE communication functional unit which communicates in synchronization with a road-side facility or another vehicle through WAVE communication, a GPS time output functional unit which produces absolute time based on GPS electric waves received from the GPS, outputs the absolute time as GPS time used for a reference of a synchronization signal for WAVE communication, and outputs the quality of the GPS electric waves, a mobile-phone time output functional unit which produces absolute time based on electric waves received from a base station, outputs the absolute time as mobile-phone time used for the reference of a synchronization signal for WAVE communication, and outputs quality of mobile-phone electric waves, a position estimation functional unit which obtains positional information from the GPS, corrects the positional information into a position on a road based on road map data to estimate the own position, and outputs the positional information as the own position with a degree of reliability of the positional information indicating how much reliable a result of the estimate is, a synchronization signal output functional unit which corrects a built-in clock using the mobile-phone time, the GPS time, the positional information and the degree of reliability, and outputs the synchronization signal necessary for WAVE communication based on time of the built-in clock, a road map database which includes

road information used by the position estimation functional unit, and a GPS time precision degradation place database which includes places in which the GPS time precision degradation is highly likely to occur.

[0015]

The communication system may further include: a wireless LAN time output functional unit which produces absolute time based on electric waves received from a wireless LAN access point, outputs the absolute time as the synchronization signal for WAVE communication, and outputs quality of the electric waves received from the wireless LAN access point; and a synchronization signal output functional unit which switches any one of the mobile-phone time, the GPS time, the wireless LAN time, and the built-in clock and outputs the synchronization signal necessary for WAVE communication.

Advantageous Effects of Invention

[0016]

With the communication system according to the present invention, an effect of being able to maintain an exact timing of communication when GPS electric waves cannot be stably received for a long time is achieved.

Brief Description of Drawings

[0017]

FIG. 1 is a functional block diagram of a communication system of a first embodiment according to the present invention.

FIG. 2 is a flowchart illustrating a control operation of the communication system of the first embodiment according to the present invention.

FIG. 3 is a functional block diagram of a communication system of a second embodiment according to the present invention.

FIG. 4 is a diagram illustrating an area of the communication system of the second embodiment according to the present invention.

FIG. 5 is a flowchart illustrating a control operation of the communication system of the second embodiment according to the present invention.

FIG. 6 is a schematic view of a related communication system.

FIG. 7 is a schematic diagram of an application example of communication between vehicles in the related communication system.

FIG. 8 is a diagram illustrating of an overview of a time channel in the related communication system.

FIG. 9 is a diagram illustrating an error in the related communication system.

Description of Embodiments

[0018]

Hereinafter, communication systems of a plurality of embodiments according to the present invention will be described with reference to the drawings.

A communication system 10 of a first embodiment according to the present invention is mounted on a vehicle-mounted device 11, and includes a WAVE communication functional unit 12, a GPS time output functional unit 13, a mobile-phone time output functional unit 14, and a position estimation functional unit 15, as illustrated in FIG. 1. The communication system 10 further includes a synchronization signal output functional unit 16, a road map database 17, and a GPS time precision degradation place database 18.

[0019]

The WAVE communication functional unit 12 performs communication in synchronization with a road-side facility (or another vehicle) 19 through WAVE communication. The GPS time output functional unit 13 produces an absolute time

based on GPS electric waves 20 received from the GPS, outputs the absolute time as GPS time used for a reference of a synchronization signal for WAVE communication, and outputs GPS electric-wave reception quality. The mobile-phone time output functional unit 14 produces absolute time based on electric waves received from the mobile-phone base station 22, outputs the absolute time as mobile-phone time used for a reference of the synchronization signal for WAVE communication, and outputs mobile-phone electric-wave reception quality.

[0020]

The position estimation functional unit 15 obtains positional information from the GPS electric waves 20, corrects the positional information into a position on the road based on road map data to estimate its own position, and outputs the position as own positional information with a degree of reliability indicating how reliable an estimation result is. The synchronization signal output functional unit 16 corrects a built-in clock using the mobile-phone time, the GPS time, the positional information and the degree of reliability, and outputs a synchronization signal necessary for WAVE communication based on built-in clock time. The road map database 17 stores road information used by the position estimation functional unit 15. The GPS time precision degradation place database 18 includes precision measured in advance, and stores places in which the GPS time precision degradation is highly likely to occur, which are compiled into a database.

[0021]

Next, a control operation of the communication system 10 will be described. Here, an overview of a process in which the synchronization signal output functional unit 16 corrects the built-in clock using the mobile-phone time, the GPS time, the positional information, and the degree of reliability is shown. As illustrated in FIG. 2, when control starts, latest information of the GPS electric-wave reception quality and the GPS

time is received by the GPS time output functional unit 13 (S101). Latest information of the positional information and the degree of reliability is then received by the position estimation functional unit 15 (S102).

[0022]

When it is then determined that the received GPS electric-wave reception quality is equal to or more than a predetermined threshold, a current position is referred to in the GPS time precision degradation place database 18 (S103 → S104). Also, when it is determined that the degree of reliability is equal to or more than a predetermined threshold and the mobile station is in a place included in the GPS time precision degradation place database 18 using the positional information and the degree of reliability of the position estimation functional unit 15, it is determined that no GPS time is usable and the process proceeds to a correction determination based on the mobile-phone time (S105 → S106).

[0023]

In this case, when it is determined that the degree of reliability is less than the predetermined threshold or that the mobile station is not in a place included in the GPS time precision degradation place database 18, the built-in clock is corrected with the GPS time (S105 → S107). Also, the synchronization signal is output to the WAVE communication functional unit 12 based on built-in clock time (S110). In this case, when it is determined according to the GPS electric-wave reception quality that the GPS electric waves 20 cannot be stably received, latest information of the mobile-phone electric-wave reception quality and the mobile-phone time is received in the mobile-phone time output functional unit 14 (S106).

[0024]

Also, when it is determined that the reception quality of the electric waves of

the mobile-phone is equal to or more than a predetermined threshold, the built-in clock is corrected with the mobile-phone time (S108 → S109). In this case, when the reception quality of the mobile-phone electric waves is less than the predetermined threshold, the synchronization signal is output using the built-in clock and the WAVE communication is performed without correcting the built-in clock with the mobile-phone time (S108 → S110). Also, the synchronization signal is output to the WAVE communication functional unit 12 based on the built-in clock time (S110).

[0025]

As described above, according to the communication system 10 of the first embodiment of the present invention, when the GPS electric waves 20 cannot be stably received for a long time, it is possible to maintain an exact timing of communication based on the mobile-phone time.

[0026]

Further, according to the communication system 10, it is possible to prevent an unstable operation due to frequent reference switching of the GPS time and the mobile-phone time, by applying the mobile-phone time in the precision degradation place recognized in advance even when the GPS electric waves 20 are able to be stably received.

[0027]

Next, a communication system of a second embodiment according to the present invention will be described. Further, in the second embodiment below, the same components and components that are the same in function as those in the first embodiment described above are denoted with the same reference signs or corresponding reference signs, and a description thereof is simplified or omitted.

[0028]

A communication system 30 of the second embodiment according to the present invention is mounted on a vehicle-mounted device 31, and includes a WAVE communication functional unit 32, a GPS time output functional unit 33, a mobile-phone time output functional unit 34, and a position estimation functional unit 35, as illustrated in FIG. 3. The communication system 30 further includes a synchronization signal output functional unit 36, a road map database 37, a GPS time precision degradation place database 38, and a wireless LAN time output functional unit 39.

[0029]

The WAVE communication functional unit 32 performs communication in synchronization with a road-side facility (or another vehicle) 19 through WAVE communication. The GPS time output functional unit 33 produces absolute time based on GPS electric waves 20 received from the GPS, outputs the absolute time as GPS time used for a reference of a synchronization signal for WAVE communication, and outputs GPS electric-wave reception quality. The mobile-phone time output functional unit 34 produces absolute time based on electric waves received from the mobile-phone base station 22, outputs the absolute time as mobile-phone time used for the reference of the synchronization signal for WAVE communication, and outputs mobile-phone electric-wave reception quality.

[0030]

The position estimation functional unit 35 obtains positional information from the GPS electric waves 20, corrects the positional information into a position on the road based on the road map data to estimate the own position, and outputs the position as the own positional information with a degree of reliability indicating how reliable an estimation result is. The synchronization signal output functional unit 36 switches any one of mobile-phone time, GPS time, wireless LAN time, and a built-in clock to output

the synchronization signal necessary for WAVE communication. The road map database 37 stores road information used by the position estimation functional unit 35. The GPS time precision degradation place database 38 includes precision measured in advance, and stores places in which the GPS time precision degradation is highly likely to occur, which are compiled into a database. Also, the wireless LAN time output functional unit 39 produces absolute time based on electric waves received from a wireless LAN access point, and outputs the absolute time as the synchronization signal for WAVE communication. Further, the wireless LAN time output functional unit 39 outputs reception quality of the electric waves of the wireless LAN access point.

[0031]

The communication system 30 performs correction of the built-in clock using beacon signals periodically transmitted by the wireless LANs from a plurality of wireless LAN access points 40 installed in advance in places in which neither the GPS nor the mobile-phone base station 22 is available, as illustrated in FIG. 4.

[0032]

Next, a control operation of the communication system 30 will be described. When control starts, the latest information of the GPS electric-wave reception quality and the GPS time is received by the GPS time output functional unit 33, as illustrated in FIG. 5 (S201). Latest information of the positional information and the degree of reliability is then received by the position estimation functional unit 35 (S202).

[0033]

When it is then determined that the received GPS electric-wave reception quality is equal to or more than a predetermined threshold, a current position is referred to in the GPS time precision degradation place database 38 (S203 → S204). Also, when it is determined that the degree of reliability is equal to or more than a predetermined

threshold and the mobile station is in a place included in the GPS time precision degradation place database 38 using the positional information and the degree of reliability of the position estimation functional unit 35, it is determined that no GPS time is usable, and the process proceeds to a correction determination based on the mobile-phone time (S205 → S206).

[0034]

In this case, when it is determined that the degree of reliability is less than the predetermined threshold or the mobile station is not in a place included in the GPS time precision degradation place database 38, the built-in clock is corrected with the GPS time (S205 → S207). When it is determined according to the GPS electric-wave reception quality that the GPS electric waves cannot be stably received, latest information of the mobile-phone electric-wave reception quality and the mobile-phone time is received in the mobile-phone time output functional unit 34 (S206).

[0035]

Also, when it is determined that the reception quality of the mobile-phone electric waves is less than the predetermined threshold, the wireless LAN access point electric-wave reception quality and the wireless LAN time are received by the wireless LAN time output functional unit 39 (S208 → S209). In this case, when it is determined that the reception quality of the mobile-phone electric waves is equal to or more than the predetermined threshold, the built-in clock is corrected with the mobile-phone time (S208 → S210).

[0036]

When it is determined that the wireless LAN access point electric-wave reception quality of the received wireless LAN access point electric-wave reception quality and the wireless LAN time is equal to or more than a predetermined threshold,

the built-in clock time is corrected with the wireless LAN access-point time (S211 → S212). When it is determined that the wireless LAN access point electric-wave reception quality of the received wireless LAN access point electric-wave reception quality and the wireless LAN time is less than the predetermined threshold, a synchronization signal is output to the WAVE communication functional unit 32 based on the built-in clock time (S213).

[0037]

According to the communication system 30 of the second embodiment, when the GPS electric waves 20 cannot to be stably received for a long time and the mobile-phone electric-wave reception quality cannot be stably received, it is possible to reliably acquire a timing of communication based on the wireless LAN time information.

[0038]

Further, according to the communication system 30, the built-in clock can be corrected using beacon signals periodically transmitted by wireless LANs of the plurality of wireless LAN access points 40 in a place in which neither the GPS nor the mobile-phone base station 22 is available.

[0039]

Further, the communication system of the present invention is not limited to the embodiments described above, and appropriate variations or improvements can be made.

[0040]

As described above, according to the communication system of the present invention, it is possible to maintain an exact timing of the communication when the GPS electric waves 20 cannot be stably received for a long time. As a result of the above, stabilization of a product and improvement of quality are achieved, and industrial applicability of the present invention is high.

Industrial Applicability

[0041]

According to the aspect of the present invention, it is possible to provide the communication system capable of maintaining an exact timing of the communication when GPS electric waves cannot be stably received for a long time.

Reference Signs List

[0042]

10, 30 communication system

11, 31 vehicle-mounted device

12, 32 WAVE communication functional unit

13, 33 GPS time output functional unit

14, 34 mobile-phone time output functional unit

15, 35 position estimation functional unit

16, 36 synchronization signal output functional unit

17, 37 road map database

18, 38 GPS time precision degradation place database

22 mobile-phone base station

39 wireless LAN time output functional unit

# CLAIMS

[Claim 1]

A communication method in which data is transmitted from a base station to a plurality of mobile stations via a downlink channel and data is transmitted from the mobile station selectively selected among the plurality of mobile stations to the base station via an uplink channel, the communication method comprising:

receiving, by the mobile station, GPS electric waves;

determining quality of the received GPS electric waves;

setting, in the mobile station, time obtained from the GPS electric waves when the quality of the GPS electric waves is equal to or more than a predetermined threshold;

determining whether the mobile station is in a precision degradation position with reference to a GPS time precision degradation place database based on a present position of the mobile station; and

applying the time of the mobile station when the quality of the GPS electric waves is less than or equal to the predetermined threshold or when the mobile station is in the precision degradation position in the GPS time precision degradation place database.

[Claim 2]

The communication method according to claim 1, further comprising:

applying time of a wireless LAN when the quality of the GPS electric waves is less than or equal to the predetermined threshold and the mobile station is in the precision degradation position.

[Claim 3]

A communication system comprising:

a WAVE communication functional unit in which communicates in synchronization with a road-side facility or another vehicle through WAVE communication;

a GPS time output functional unit in which produces absolute time based on GPS electric waves received from the GPS, outputs the absolute time as GPS time used for a reference of a synchronization signal for WAVE communication, and outputs the quality of the GPS electric waves;

a mobile-phone time output functional unit in which produces absolute time based on electric waves received from a base station, outputs the absolute time as mobile-phone time used for the reference of a synchronization signal for WAVE communication, and outputs quality of mobile-phone electric waves;

a position estimation functional unit in which obtains positional information from the GPS, corrects the positional information into a position on a road based on road map data to estimate the own position, and outputs the positional information as the own position with a degree of reliability of the positional information indicating how much reliable a result of the estimate is;

a synchronization signal output functional unit which corrects a built-in clock using the mobile-phone time, the GPS time, the positional information and the degree of reliability, and outputs the synchronization signal necessary for WAVE communication based on time of the built-in clock;

a road map database which includes road information used by the position estimation functional unit; and

a GPS time precision degradation place database which includes places in which the GPS time precision degradation is highly likely to occur.

[Claim 4]

The communication system according to claim 3, further comprising:

a wireless LAN time output functional unit which produces absolute time based on electric waves received from a wireless LAN access point, outputs the absolute time as the synchronization signal for WAVE communication, and outputs quality of the electric waves received from the wireless LAN access point; and

a synchronization signal output functional unit which switches any one of the mobile-phone time, the GPS time, the wireless LAN time, and the built-in clock and outputs the synchronization signal necessary for WAVE communication.