

[DESCRIPTION]

[TITLE OF INVENTION]

SIGNAL CONTROL DEVICE, SIGNAL CONTROL SYSTEM, SIGNAL CONTROL
METHOD, AND PROGRAM

5 [Technical Field]

[0001]

The present invention relates to a signal control device, a signal control system,
a signal control method, and a program.

Priority is claimed on Japanese Patent Application No. 2016-146591, filed July
10 26, 2016, the content of which is incorporated herein by reference.

[Background Art]

[0002]

As a system for supporting an emergency vehicle to quickly reach a destination,
there has been proposed a system that transmits the current position of an emergency
15 vehicle to a command center server and controls, in the command center server, traffic
lights not yet passed by the emergency vehicle on a traveling route of the emergency
vehicle, thereby enabling the emergency vehicle to travel quickly (for example, Patent
Document 1).

[Citation List]

20 [Patent Literature]

[0003]

[Patent Literature 1]

Japanese Unexamined Patent Application, First Publication No. 2004-252854

[Summary of Invention]

25 [Technical Problem]

[0004]

However, in the above-described system, control such as changing to a green light, maintaining a green light, or the like is performed uniformly for the traffic lights provided on the traveling route of the emergency vehicle. In such a system, for example, 5 in the case in which congestion or the like is occurring in a certain road section on the traveling route, even when the control such as changing the traffic lights provided in the road section to a green light is performed, there is a likelihood that traffic conditions such as a traffic flow in the road section will not be improved. That is, in such a road section, despite the inability to obtain the effect that the emergency vehicle can travel quickly, 10 there is a likelihood that the control such as changing the traffic lights to a green light will be performed. Then, since the time during which the traffic lights of other road sections not included in the traveling route of the emergency vehicle become red lights increases, traffic flows in the other road sections may be hindered, and rather, there is a likelihood that adverse effects such as congestion will be caused.

15 [0005]

The present invention has been made in view of the above problem and provides a signal control device, a signal control system, a signal control method, and a program capable of improving traffic conditions of a road section on which an emergency vehicle travels and suppressing an influence on traffic conditions of road sections on which the 20 emergency vehicle does not travel.

[Solution to Problem]

[0006]

To solve the above problem, the present invention employs the following means.

According to an aspect of the present invention, a signal control device includes 25 an emergency vehicle information acquisition unit configured to acquire emergency

vehicle information including position information on an emergency vehicle, a traffic condition change amount information acquisition unit configured to acquire traffic condition change amount information indicating, for each road section, an amount of change in traffic conditions according to a lighting state of traffic lights, and a signal control unit configured to perform, on the basis of the emergency vehicle information and the traffic condition change amount information, control of the traffic lights provided in a road section on which the emergency vehicle travels.

In such a way, on the basis of the traffic condition change amount information, the signal control unit only selects, among traffic lights provided in the road section on which the emergency vehicle travels, traffic lights expected to improve traffic conditions on the road section according to the lighting state of each traffic light and controls the selected traffic lights. Consequently, the signal control unit may improve the traffic conditions on the road section on which the emergency vehicle travels so that the emergency vehicle may have priority and travel smoothly.

Also, by controlling the traffic lights so that the emergency vehicle may have priority and travel smoothly, there is a likelihood that an influence such as deterioration of traffic conditions will occur due to restrictions on traffic in the other road sections on which the emergency vehicle does not travel. However, since, for road sections in which it is expected that traffic conditions would not be improved even when the control of traffic lights in the road sections on which the emergency vehicle travels is performed, the signal control unit does not perform the control of the traffic lights, the influences on the traffic conditions of the other road sections may be suppressed.

[0007]

According to an aspect of the present invention, in the signal control device of the above-described aspect, the emergency vehicle information may further include a

scheduled traveling route of the emergency vehicle, the traffic condition change amount information acquisition unit may acquire the traffic condition change amount information on each road section included in the scheduled traveling route, and the signal control unit may perform, on the basis of the emergency vehicle information and the traffic condition change amount information on each road section included in the scheduled traveling route, control of the traffic light provided in each road section before the emergency vehicle reaches each road section.

In such a way, the signal control unit may improve traffic conditions of the road sections included in the scheduled traveling route of the emergency vehicle before the emergency vehicle travels on each road section. As a result, the signal control device can cause the emergency vehicle to travel quickly and smoothly.

[0008]

According to an aspect of the present invention, the signal control device of the above-described aspect may further include a signal switching information acquisition unit configured to acquire signal switching information indicating that the lighting state of the traffic light has been switched, a traffic condition indicator acquisition unit configured to acquire a traffic condition indicator of a road section in which the traffic light is provided, and a traffic condition change amount information generation unit configured to generate, on the basis of the traffic condition indicator at a time point at which the signal switching information is acquired from the traffic light and the traffic condition indicator at a time point at which the previous signal switching information has been acquired from the traffic light, generate traffic condition change amount information on a road section in which the traffic light is provided.

In this manner, by generating traffic condition change amount information every time the lighting state of the traffic light is switched, the traffic condition change amount

information generation unit may generate, even in the case in which actual traffic conditions on a road section are changed due to various factors such as the date and time, climate, and accidents, traffic condition change amount information corresponding to such a change in real time. As a result, the signal control unit can highly accurately select a traffic light having a significant effect on improving traffic conditions according to the actual traffic condition on the road section and control the selected traffic light.

[0009]

According to an aspect of the present invention, the signal control device of the above-described aspect further includes a restriction information transmission unit configured to transmit restriction information on a road section subject to restrictions on which traffic restrictions are performed by the signal control unit performing the control of the traffic light to at least one of an on-board unit mounted in a vehicle located in the road section subject to restrictions and a restriction information notification unit provided in the road section.

In such a way, the restriction information transmission unit can cause a driver of a vehicle to recognize restriction information involving traveling of the emergency vehicle. Consequently, the restriction information transmission unit can cause a driver of an emergency vehicle to recognize the lighting state of the traffic light, the traffic conditions on the road section, and the like in the scheduled traveling route, thereby performing support for the emergency vehicle to travel smoothly. Also, the restriction information transmission unit can cause a driver of a general vehicle to recognize a road section on which the emergency vehicle is scheduled to travel and a road section subject to restrictions, thereby inducing an action such as traveling by avoiding such road sections. As a result, in addition to allowing the emergency vehicle to have priority and travel smoothly, the restriction information transmission unit can cause the likelihood

that traffic conditions will be aggravated on a road section subject to restrictions due to the occurrence of congestion or the like to be reduced.

[0010]

According to an aspect of the present invention, a signal control system includes
5 the signal control device according to any one of the above-described aspects, a probe data collection unit configured to collect probe data including position information on an on-board unit mounted in each of a plurality of vehicles, and a traffic condition indicator generation unit configured to generate a traffic condition indicator for each road section on the basis of the probe data and record the generated traffic condition indicator in a
10 traffic condition database.

In such a way, the traffic condition indicator generation unit can generate, on the basis of probe data sequentially collected by the probe data collection unit, a traffic condition indicator according to actual conditions on a road section. For this reason, the traffic condition indicator generation unit can improve accuracy of the traffic condition
15 indicator.

Also, on the basis of such a highly accurate traffic condition indicator, the signal control device can highly accurately select traffic lights having a significant effect on improving traffic conditions and control the selected traffic lights.

[0011]

20 According to an aspect of the present invention, a signal control method has an emergency vehicle information acquisition step of acquiring emergency vehicle information including position information on an emergency vehicle, a traffic condition change amount information acquisition step of acquiring traffic condition change amount information indicating, for each road section, an amount of change in traffic conditions
25 according to a lighting state of traffic lights, and a signal control step of performing, on

the basis of the emergency vehicle information and the traffic condition change amount information, control of the traffic lights provided in a road section on which the emergency vehicle travels.

[0012]

5 According to an aspect of the present invention, a program causes a computer of a signal control device to function as an emergency vehicle information acquisition unit configured to acquire emergency vehicle information including position information on an emergency vehicle, a traffic condition change amount information acquisition unit configured to acquire traffic condition change amount information indicating, for each
10 road section, an amount of change in traffic conditions according to a lighting state of traffic lights, and a signal control unit configured to perform, on the basis of the emergency vehicle information and the traffic condition change amount information, control of the traffic lights provided in a road section on which the emergency vehicle travels.

15 [Advantageous Effects of Invention]

[0013]

 According to the above-described signal control device, signal control system, signal control method, and program, traffic conditions of a road section on which an emergency vehicle travels can be improved and an influence on traffic conditions of road
20 sections on which the emergency vehicle does not travel can be suppressed.

[Brief Description of Drawings]

[0014]

 Fig. 1 is a view illustrating the overall configuration of a signal control system according to an embodiment of the present invention.

25 Fig. 2 is a view illustrating an example of road sections according to an

embodiment of the present invention.

Fig. 3 is a view illustrating a function of a traffic condition indicator generation unit according to an embodiment of the present invention.

Fig. 4 is a first view illustrating a processing flow of the traffic condition
5 indicator generation unit according to an embodiment of the present invention.

Fig. 5 is a second view illustrating a processing flow of the traffic condition indicator generation unit according to an embodiment of the present invention.

Fig. 6 is a third view illustrating a processing flow of the traffic condition indicator generation unit according to an embodiment of the present invention.

10 Fig. 7 is a view illustrating a functional configuration of a signal control device according to an embodiment of the present invention.

Fig. 8 is a first view for describing a function of the signal control device according to an embodiment of the present invention.

Fig. 9 is a first view illustrating an example of traffic condition change amount
15 information according to an embodiment of the present invention.

Fig. 10 is a second view for describing a function of the signal control device according to an embodiment of the present invention.

Fig. 11 is a second view illustrating an example of the traffic condition change amount information according to an embodiment of the present invention.

20 Fig. 12 is a first view illustrating a processing flow of the signal control device according to an embodiment of the present invention.

Fig. 13 is a second view illustrating a processing flow of the signal control device according to an embodiment of the present invention.

Fig. 14 is a view illustrating an example of a hardware configuration of the
25 signal control device according to an embodiment of the present invention.

[Description of Embodiments]

[0015]

Hereinafter, a signal control system 1 according to an embodiment of the present invention will be described with reference to Figs. 1 to 14.

5 [0016]

(Overall configuration of signal control system)

Fig. 1 is a view illustrating the overall configuration of a signal control system according to an embodiment of the present invention.

As illustrated in Fig. 1, the signal control system 1 of the present embodiment
10 includes a probe data collection unit 10, a traffic condition indicator generation unit 20, a traffic condition database 30, and a signal control device 50 which are communicatively connected via a network NW such as the Internet.

Further, the probe data collection unit 10, the traffic condition indicator
generation unit 20, the traffic condition database 30, and the signal control device 50 may
15 also be communicatively connected via an exclusive line such as a Local Area Network (LAN).

[0017]

The probe data collection unit 10 collects, at predetermined time intervals (for example, every 1 second), probe data (on-board unit probe data) transmitted via the
20 network NW from an on-board unit A mounted in a vehicle. In the present embodiment, unless particularly mentioned otherwise, “on-board unit A” includes an on-board unit A1 mounted in an emergency vehicle and an on-board unit A2 mounted in a general vehicle other than the emergency vehicle. Also, “vehicle” includes an emergency vehicle and a general vehicle.

25 An emergency vehicle is a vehicle, such as an ambulance, a fire engine, and a

police vehicle, that is required to quickly reach a destination for an emergency service and is a vehicle that does not have to stop even at a point where stopping is required according to a lighting state or the like of a traffic light S. Further, for example, the lighting state of the traffic light S indicates which of “red light (passage prohibition
5 signal),” “green light (passage permission signal),” “yellow light (stop signal)” or the like each traffic light is displaying.

Also, a general vehicle is any vehicle other than an emergency vehicle and is a vehicle that has to stop according to the lighting state or the like of the traffic light S.

[0018]

10 The probe data includes “transmission date and time,” “device type,” “device ID,” “position information,” “moving speed” and the like.

The “transmission date and time” is information indicating the date and time when the probe data is transmitted from the on-board unit A1 or the on-board unit A2. The “device type” is information for specifying whether a transmission source of the
15 probe data is the on-board unit A1 (emergency vehicle) or the on-board unit A2 (general vehicle). The “device ID” is information capable of specifying the on-board unit A1 or the on-board unit A2 that is the transmission source of the probe data. Further, in the case in which the on-board unit A1 (emergency vehicle) and the on-board unit A2 (general vehicle) can be identified by the “device ID,” the “device type” may be omitted,
20 and whether the transmission source of the probe data is the on-board unit A1 or the on-board unit A2 may also be specified on the basis of the “device ID.” The “position information” is information indicating a point (latitude, longitude, or the like) where an emergency vehicle in which the on-board unit A1 is mounted or a general vehicle in which the on-board unit A2 is mounted is located at the date and time when the probe
25 data is transmitted. The “moving speed” is information indicating a traveling speed

(m/s) of the emergency vehicle in which the on-board unit A1 is mounted or the general vehicle in which the on-board unit A2 is mounted at the date and time when the probe data is transmitted.

[0019]

5 Fig. 2 is a view illustrating an example of road sections according to an embodiment of the present invention.

The traffic condition indicator generation unit 20 generates, on the basis of the probe data collected by the probe data collection unit 10, a traffic condition indicator for each road section at predetermined time intervals (for example, every 1 second).

10 As illustrated in Fig. 2, the road section indicates an area between two adjacent nodes among nodes set for each of a plurality of traffic nodal points (intersection points or the like) on the road. A “link ID” capable of specifying a road section is attached to each road section. For example, as illustrated in Fig. 2, as areas between two nodes (intersection points), a link ID “B20a” is attached to a road section indicating a lane that
15 heads to one side, and a link ID “B20b” is attached to a road section indicating a lane that heads to the other side. Further, in the case in which a distance between the traffic nodal points is longer than a predetermined distance (for example, 100 m), nodes may be set at further predetermined distances. In the present embodiment, the traffic condition indicator generation unit 20 has included therein, in advance, map data associated with a
20 “link ID,” “road section position information” indicating a position of a road section (for example, the latitude and longitude of the start and end points of the road section), a “road section length,” and “traffic light information” indicating information on a traffic light S provided in the road section (a traffic light ID capable of specifying the traffic light S, an installation position of the traffic light S, and the like).

25 The traffic condition indicator is information indicating a traffic condition of a

vehicle within a road section. In the present embodiment, the traffic condition indicator includes a “traffic volume,” “traffic density,” and “average speed.”

The “traffic volume” indicates the number of vehicles passing per 1 second (number/sec) within a road section. The “traffic density” indicates the number of
 5 vehicles per 1 m (number/m) within a road section. The “average speed” indicates an average moving speed (m/s) of a vehicle that is traveling within a road section.

Also, on the basis of probe data used when computing the traffic condition indicator, the traffic condition indicator generation unit 20 updates data associated with a road section (link ID) and information on the on-board unit A located in the road section
 10 (portion of the probe data) by adding the data to a traffic condition table of a traffic condition database 30. In the traffic condition table, the “transmission date and time” of each piece of probe data, the “device type,” “device ID,” and “position information” of the on-board unit A which is a transmission source of each piece of probe data, and the “link ID” of a road section in which a vehicle in which the on-board unit A is mounted is
 15 located are recorded in association with one another.

[0020]

In the traffic condition database 30, the traffic condition indicator generated by the traffic condition indicator generation unit 20 and the traffic condition table are recorded.

20 [0021]

The signal control device 50 controls a lighting state of each of a plurality of traffic lights S (S1 to Sn) provided in each road section via the network NW.

[0022]

(Function of traffic condition indicator generation unit)

25 Fig. 3 is a view illustrating a functional configuration of a traffic condition

indicator generation unit according to an embodiment of the present invention.

Hereinafter, a function of the traffic condition indicator generation unit 20 of the present embodiment will be described with reference to Fig. 3.

As illustrated in Fig. 3, first, the traffic condition indicator generation unit 20
5 acquires probe data from the probe data collection unit 10. Then, the traffic condition indicator generation unit 20 uses already-known big data distributed processing technology, stream data processing technology, and the like to generate a traffic condition indicator for each road section based on probe data collected from a plurality of on-board units A and a mobile terminal T. When the traffic condition indicator is generated, the
10 traffic condition indicator generation unit 20 records the traffic condition indicator in the traffic condition database 30 for each road section. Consequently, the traffic condition indicator generation unit 20 is able to generate a traffic condition indicator according to an actual condition for each road section in real time.

[0023]

15 Also, on the basis of probe data used when computing the traffic condition indicator, the traffic condition indicator generation unit 20 updates traffic condition data associated with a road section (link ID) and information on an on-board unit A located in the road section (portion of the probe data) by adding the data to the traffic condition table of the traffic condition database 30.

20 [0024]

(Processing flow of traffic condition indicator generation unit)

Fig. 4 is a first view illustrating a processing flow of the traffic condition indicator generation unit according to an embodiment of the present invention.

Hereinafter, a processing flow of the traffic condition indicator generation unit
25 20 of the present invention will be described with reference to Fig. 4.

[0025]

As illustrated in Fig. 4, the traffic condition indicator generation unit 20 acquires probe data collected by the probe data collection unit 10 (step S200).

[0026]

5 Next, on the basis of the probe data, the traffic condition indicator generation unit 20 generates a traffic condition indicator for each road section and updates a traffic condition table (step S201). The process of generating the traffic condition indicator and the process of updating the traffic condition table will be described in detail below.

[0027]

10 Next, every time the traffic condition indicator is computed, the traffic condition indicator generation unit 20 records and accumulates the traffic condition indicator for each road section and the traffic condition table in the traffic condition database 30 (step S202).

In this manner, the traffic condition indicator generation unit 20 repeatedly
15 executes the above process every time the probe data is acquired.

[0028]

Fig. 5 is a second view illustrating a processing flow of the traffic condition indicator generation unit according to an embodiment of the present invention.

Fig. 6 is a third view illustrating a processing flow of the traffic condition
20 indicator generation unit according to an embodiment of the present invention.

Hereinafter, the process of generating a traffic condition indicator and the process of updating a traffic condition table by the traffic condition indicator generation unit 20 will be described with reference to Figs. 5 and 6.

[0029]

25 First, as illustrated in Fig. 5, the traffic condition indicator generation unit 20

performs a process P21 of specifying a road section in which a vehicle in which the on-board unit A, which is a transmission source of each piece of probe data, is mounted is located (hereinafter, road section in which the vehicle is located).

In the process P21, first, the traffic condition indicator generation unit 20 reads
5 “position information” from each piece of probe data (step S210).

[0030]

Next, on the basis of the “position information” on each piece of probe data, the traffic condition indicator generation unit 20 specifies a road section in which each vehicle is located (step S211).

10 Specifically, the traffic condition indicator generation unit 20 specifies a road section having “road section position information” including the “position information” (latitude and longitude) on the probe data by searching for the road section from the map data.

[0031]

15 Next, the traffic condition indicator generation unit 20 adds the “link ID” of the specified road section to each piece of probe data (step S212).

[0032]

Next, the traffic condition indicator generation unit 20 updates data associated with the “transmission data and time,” “device type,” and “device ID” of each piece of
20 probe data and the “link ID” of the road section added in step S212 by adding the data to the traffic condition table recorded in the traffic condition database 30 (step S213).

In this manner, the traffic condition indicator generation unit 20 repeatedly executes the process P21 every time the probe data is acquired.

[0033]

25 Also, as illustrated in Fig. 6, on the basis of the plurality of pieces of probe data

to which the “link ID” has been added by the process P21, the traffic condition indicator generation unit 20 performs a process P22 of computing a traffic condition indicator at each time of each road section.

In the process P22, first, the traffic condition indicator generation unit 20
5 extracts, among the plurality of pieces of probe data, target probe data which is subject to computation (step S220).

In the present embodiment, on the basis of the “transmission date and time” and “link ID” of each piece of probe data, the traffic condition indicator generation unit 20 extracts probe data indicating being present in an arbitrary target road section at an
10 arbitrary target time as the target probe data of the computation process. Specifically, as probe data having “transmission date and time” within a predetermined time (for example, 1 second) from an arbitrary target time, the traffic condition indicator generation unit 20 extracts probe data having a “link ID” identical to the link ID of an arbitrary target road section as the target probe data of the computation process.

15 [0034]

Next, the traffic condition indicator generation unit 20 acquires a “moving speed” of a vehicle in which each on-board unit A is mounted that is included in the target probe data (hereinafter, “moving speed” of the vehicle) (step S221). Specifically, the traffic condition indicator generation unit 20 reads and acquires the “moving speed”
20 of the vehicle included in the probe data.

Further, in the present embodiment, an example in which the “moving speed” of the probe data is recorded in meters per second (m/s) will be described, but, in another embodiment, the “moving speed” may also be recorded in another unit such as kilometers per hour (km/h). In the case in which the “moving speed” is recorded in
25 another unit, the traffic condition indicator generation unit 20 may acquire the “moving

speed” by converting the “moving speed” to meters per second (m/s).

[0035]

Next, on the basis of each piece of probe data included in the target probe data, the traffic condition indicator generation unit 20 calculates the “number of vehicles” indicating the number of vehicles in which the on-board unit A is mounted that are located in the target road section (step S222).

[0036]

Next, by using the “link ID” of the target road section as a search key, the traffic condition indicator generation unit 20 searches for and acquires the “length of the target road section” from the map data (step S223).

[0037]

Next, the traffic condition indicator generation unit 20 calculates a traffic volume at the target time in the target road section (step S224).

Specifically, first, the traffic condition indicator generation unit 20 obtains a traffic volume q (number/sec) using Equation (1) below by setting the “number of vehicles” calculated in step S222 as N , the “moving speed” of each vehicle acquired in step S221 as v_i ($i=1$ to N), and the “length of the target road section” acquired in step S223 as K .

[0038]

20 [Equation 1]

$$q = \sum_{i=1}^N \frac{v_i}{K} \quad \cdot \cdot \cdot (1)$$

[0039]

Next, the traffic condition indicator generation unit 20 calculates a traffic density

at the target time in the target road section (step S225).

Specifically, the traffic condition indicator generation unit 20 obtains a traffic density k (number/m) using Equation (2) below by setting the “number of vehicles” calculated in step S222 as N and the “length of the target road section” acquired in step S223 as K .

[0040]

[Equation 2]

$$k = \frac{N}{K} \quad \cdot \cdot \cdot (2)$$

[0041]

Next, the traffic condition indicator generation unit 20 calculates an average speed at the target time in the target road section (step S226).

Specifically, the traffic condition indicator generation unit 20 obtains an average speed v_s (m/s) using Equation (3) below by setting the “number of vehicles” calculated in step S222 as N and the “moving speed” of each vehicle acquired in step S221 as v_i ($i=1$ to N).

[0042]

[Equation 3]

$$\bar{v}_s = \sum_{i=1}^N \frac{v_i}{N} \quad \cdot \cdot \cdot (3)$$

[0043]

In this manner, every time the probe data is acquired, the traffic condition indicator generation unit 20 repeatedly executes the process P22, thereby computing a traffic condition indicator at each time in each road section.

[0044]

(Functional configuration of signal control device)

Fig. 7 is a view illustrating a functional configuration of a signal control device according to an embodiment of the present invention.

5 As illustrated in Fig. 7, the signal control device 50 includes a signal switching information acquisition unit 510, a traffic condition indicator acquisition unit 520, a traffic condition change amount information generation unit 530, an emergency vehicle information acquisition unit 540, a traffic condition change amount information acquisition unit 550, a signal control unit 560, a restriction information transmission unit
10 570, and a recording medium 580.

[0045]

Every time the lighting state of each traffic light S is switched, the signal switching information acquisition unit 510 acquires, from each traffic light, signal switching information indicating a lighting state to which each traffic light has been
15 switched via the network NW. In the present embodiment, the signal switching information includes “traffic light ID” capable of specifying a traffic light, “lighting state,” and the like.

[0046]

When the signal switching information acquisition unit 510 acquires the signal
20 switching information, the traffic condition indicator acquisition unit 520 acquires, from the traffic condition database 30, a traffic condition indicator of a road section in which the traffic light S, which is the transmission source of the signal switching information, is provided via the network NW. Also, the traffic condition indicator acquisition unit 520 records and accumulates information associated with the signal switching information
25 and the traffic condition indicator in the recording medium 580.

[0047]

Fig. 8 is a first view for describing a function of the signal control device according to an embodiment of the present invention.

Fig. 9 is a first view illustrating an example of traffic condition change amount information according to an embodiment of the present invention.

Fig. 10 is a second view for describing a function of the signal control device according to an embodiment of the present invention.

Fig. 11 is a second view illustrating an example of the traffic condition change amount information according to an embodiment of the present invention.

Fig. 8 illustrates an example of signal switching information of a traffic light S20 and a traffic condition indicator of a road section B20a in a certain time zone during the daytime, and an example in which the traffic volume is high and a change in the traffic condition according to the lighting state of the traffic light S20 is great is illustrated therein. Fig. 10 illustrates an example of signal switching information of the traffic light S20 and a traffic condition indicator of the road section B20a in a certain time zone during the nighttime, and an example in which the traffic volume is low and a change in the traffic condition according to the lighting state of the traffic light S20 is small is illustrated therein.

In Figs. 8 and 10, the horizontal axis indicates time at which signal switching information is acquired, and the vertical axis indicates values of traffic condition indicators (traffic volume, traffic density, and average speed).

As illustrated in Figs. 8 and 10, in the road section B20a, the traffic condition is changing according to the lighting state of the traffic light S20.

When the signal switching information acquisition unit 510 acquires the signal switching information from the traffic light S, the traffic condition change amount

information generation unit 530 detects changes in the traffic condition according to the lighting state of the traffic light S such as those illustrated in Figs. 8 and 10 on the basis of the traffic condition indicators at a time point at which the signal switching information is acquired and the traffic condition indicators at a time point at which the previous signal switching information has been acquired from the traffic light S and generates traffic condition change amount information D30 (Figs. 9 and 11) on a road section in which the traffic light S is provided.

Also, the traffic condition change amount information generation unit 530 records and accumulates the generated traffic condition change amount information D30 in the recording medium 580.

Fig. 9 illustrates an example of the traffic condition change amount information D30 in the same time zone as Fig. 8, and an example in which the traffic volume is high and a change in the traffic condition according to the lighting state of the traffic light S20 is great is illustrated therein. Fig. 11 illustrates an example of the traffic condition change amount information D30 in the same time zone as Fig. 10, and an example in which the traffic volume is low and a change in the traffic condition according to the lighting state of the traffic light S20 is small is illustrated therein

The traffic condition change amount information D30 is information indicating how the traffic conditions (traffic volume, traffic density, and average speed) in the road section in which the traffic light S is provided change according to the lighting state of the traffic light S. Specifically, as illustrated in Figs. 9 and 11, the traffic condition change amount information D30 is information indicating whether the traffic conditions on the road section are “improved,” “aggravated,” or “not changed” according to the lighting state of the traffic light S and indicating whether the degree of “improvement” and “aggravation” is high (“large”) or low (“small”).

For example, the “improvement” of the traffic condition indicates a state in which the traffic volume is increased, the traffic density is decreased, the average speed is increased, or the like. Also, for example, the “aggravation” of the traffic condition indicates a state in which the traffic volume is decreased, the traffic density is increased, the average speed is decreased, or the like. Also, in the case in which change amounts of the traffic volume, traffic density, and average speed are predetermined values or larger, the traffic condition change amount information generation unit 530 determines that the degree of “improvement” or “aggravation” is high. As the predetermined values, different values are set for each of the traffic volume, traffic density, and average speed. Also, as the predetermined values, different values may be set for each road section according to characteristics of a road section such as a road width and the number of lanes.

[0048]

When an emergency vehicle travels for an emergency service, the emergency vehicle information acquisition unit 540 acquires emergency vehicle information from the on-board unit A1 mounted in the emergency vehicle via the network NW.

The emergency vehicle information includes “transmission date and time,” “device ID,” “position information,” “moving speed,” “destination,” “scheduled traveling route,” and the like.

The “transmission date and time” is information indicating the date and time when the emergency vehicle information is transmitted from the on-board unit A1. The “device ID” is information capable of specifying the on-board unit A1, which is the transmission source of the emergency vehicle information and is the same as the “device ID” included in the probe data. The “position information” is information indicating a point (latitude, longitude, or the like) where the emergency vehicle in which the on-board

unit A1 is mounted is located on the date and time when the emergency vehicle information is transmitted. The “moving speed” is information indicating a traveling speed (m/s) of the emergency vehicle in which the on-board unit A1 is mounted on the date and time when the emergency vehicle information is transmitted. The

5 “destination” is information indicating a point (latitude, longitude, or the like) where the emergency vehicle reaches. The “scheduled traveling route” is information in which one or more road sections (link IDs) included in a route to the destination from the point where the emergency vehicle is located are listed in order traveled by the emergency vehicle.

10 Further, the emergency vehicle information acquisition unit 540 may acquire the probe data transmitted from the on-board unit A1 as the emergency vehicle information. In this case, the probe data transmitted from the on-board unit A1 includes each of the above-described pieces of emergency vehicle information.

[0049]

15 The traffic condition change amount information acquisition unit 550 acquires the traffic condition change amount information D30 accumulated in the recording medium 580.

In the present embodiment, when the emergency vehicle information acquisition unit 540 acquires the emergency vehicle information, the traffic condition change amount information acquisition unit 550 acquires the traffic condition change amount

20 information D30 associated with each road section included in the “scheduled traveling route” of the emergency vehicle information from the recording medium 580.

[0050]

On the basis of the emergency vehicle information and the traffic condition

25 change amount information D30 acquired by the traffic condition change amount

information acquisition unit 550, the signal control unit 560 performs control of the traffic light S provided in each road section included in the “scheduled traveling route.”

Specifically, in the case in which each traffic light S has been controlled on the basis of the emergency vehicle information and the traffic condition change amount
5 information D30, the signal control unit 560 determines whether the effect of improving the traffic conditions on the road section in which each traffic light S is provided is significant. Then, when the signal control unit 560 determines that, in the case in which a traffic light S is controlled to reach a certain lighting state (for example, the “green light” state), “the effect of improving the traffic condition is significant” in a road section
10 in which the traffic light S is provided, the signal control unit 560 selects the traffic light S as an object to be controlled. Then, the signal control unit 560 performs control of the traffic light S by transmitting signal control information including a command to switch the lighting state of the traffic light S which is the object to be controlled (switch to the “green light”) or a command to extend the current lighting state of the traffic light S
15 (extend the “green light” state) to the traffic light S.

Meanwhile, when the signal control unit 560 determines that, even when the lighting state of the traffic light S is controlled, “the effect of improving the traffic condition is small” in the road section in which the traffic light S is provided, the signal control unit 560 does not perform the control of the traffic light S. Further, in the
20 present embodiment, “the effect of improving the traffic condition is small” includes a state in which “the traffic condition is improved, but the effect is small,” “the traffic condition does not change,” “the traffic condition is aggravated,” or the like.

[0051]

The restriction information transmission unit 570 transmits restriction
25 information on a road section subject to restrictions on which traffic restrictions such as

prohibiting passage are performed by the signal control unit 560 controlling the traffic light S to at least one of the on-board unit A mounted in the vehicle located in the road section subject to restrictions and a restriction information notification unit G (which will be described below). In this case, the restriction information transmission unit 570

5 looks up the traffic condition table recorded in the traffic condition database 30 and extracts the on-board unit A mounted in the vehicle located in the road section having the same “link ID” as the “link ID” of the road section subject to restrictions.

[0052]

The restriction information includes information (“link ID”) capable of

10 specifying a road section on which traffic restrictions such as prohibiting passage (being switched to the “red light”) are performed by the signal control unit 560 controlling the traffic light S, information on a period (start time and end time) of the traffic restrictions, and the like. Also, the restriction information may include information warning a general vehicle, which is located in a road section, of traveling of an emergency vehicle

15 by estimating the time at which the emergency vehicle will travel on each road section on the basis of the “position information,” “moving speed,” and “scheduled traveling route” of the emergency vehicle information. By transmitting such restriction information, the restriction information transmission unit 570 can cause a driver of the general vehicle to recognize information on a road section subject to restrictions and a road section on

20 which the emergency vehicle travels.

Furthermore, the restriction information may include the lighting state of each traffic light S on the “scheduled traveling route” of the emergency vehicle, traffic conditions on a road section, and the like. By transmitting such restriction information, the restriction information transmission unit 570 can cause a driver of the emergency

25 vehicle to recognize the lighting state of each traffic light on the “scheduled traveling

route” and the traffic conditions on each road section.

The road section subject to restrictions indicates a road section in which an influence of traffic restrictions occurs such as a road section included in the “scheduled traveling route” of the emergency vehicle information and a road section connected to the road section included in the “scheduled traveling route” of the emergency vehicle.

For example, the restriction information notification unit G is a road information sign for displaying traffic information such as traffic congestion and passage prohibition that is provided on a road, a communication device for delivering traffic information to an on-board unit A via radio waves etc., or the like.

Further, the restriction information transmission unit 570 may estimate a time at which the emergency vehicle will reach each road section on the basis of the “position information” and “moving speed” of the emergency vehicle information and transmit the restriction information at a timing that is a predetermined time earlier (for example, 10 seconds earlier) than an estimated time at which the emergency vehicle will reach a reference position. Also, on the basis of the “position information” of the emergency vehicle information, the restriction information transmission unit 570 may transmit the restriction information at a timing at which the emergency vehicle reaches a position that is a predetermined distance ahead (for example, 100 m ahead) of a reference position. In this case, the reference position is a position at which a traffic light S to be controlled is provided, a position of a start point or an end point of a road section in which the traffic light S to be controlled is provided, or the like.

[0053]

In the recording medium 580, information associated with the signal switching information and traffic condition indicators recorded by the traffic condition indicator acquisition unit 520 and the traffic condition change amount information D30 generated

by the traffic condition change amount information generation unit 530 are recorded. Also, in the recording medium 580, map data associated with a road section in which each traffic light S is provided and a road section in which each restriction information notification unit G is provided is recorded in advance.

5 [0054]

(Processing flow of signal control device)

Fig. 12 is a first view illustrating a processing flow of the signal control device according to an embodiment of the present invention.

Fig. 13 is a second view illustrating a processing flow of the signal control
10 device according to an embodiment of the present invention.

Hereinafter, a processing flow of the signal control device 50 of the present embodiment will be described with reference to Figs. 12 and 13.

[0055]

First, as illustrated in Fig. 12, the signal control device 50 performs a process
15 P50 of generating the traffic condition change amount information D30 for each road section.

In the process P50, the signal switching information acquisition unit 510 acquires signal switching information from each traffic light S (step S500).

[0056]

20 Next, when the signal switching information acquisition unit 510 acquires the signal switching information, the traffic condition indicator acquisition unit 520 acquires, from the traffic condition database 30, a traffic condition indicator of a road section in which the traffic light S, which is a transmission source of the signal switching information, is provided (step S501).

25 Also, the traffic condition indicator acquisition unit 520 records and accumulates

information associated with the signal switching information and the traffic condition indicator in the recording medium 580.

[0057]

Next, when the signal switching information acquisition unit 510 acquires the
5 signal switching information from the traffic light S, the traffic condition change amount information generation unit 530 generates, on the basis of a traffic condition indicator at a time point at which the signal switching information is acquired and a traffic condition indicator at a time point at which the previous signal switching information has been acquired from the traffic light S, traffic condition change amount information D30 of a
10 road section in which the traffic light S is provided (step S502). Also, the traffic condition change amount information generation unit 530 records and accumulates the generated traffic condition change amount information D30 in the recording medium 580.

[0058]

15 Here, specific details of the process of the traffic condition change amount information generation unit 530 in step S502 will be described with reference to Figs. 8 to 11.

For example, the traffic condition change amount information generation unit 530 generates, on the basis of a traffic condition indicator of the road section B20a at a
20 time point at which the signal switching information is acquired from the traffic light S20 and a traffic condition indicator at a time point at which the previous signal switching information has been acquired from the traffic light S20, traffic condition change amount information D30 on the road section B20a according to the lighting state of the traffic light S20.

25 For example, as illustrated in Fig. 8, in the case in which, at time “t2,” signal

switching signal indicating that the lighting state has been switched to “green light” is acquired from the traffic light S20, the traffic condition change amount information generation unit 530 generates, on the basis of a traffic condition indicator at the time “t2” and a traffic condition indicator at time “t1” at which the previous signal switching signal has been acquired, traffic condition change amount information D30 of a period from the time “t1” to “t2.” In the example of Fig. 8, because the lighting state of the traffic light S20 included in the previous signal switching signal is “red light,” the traffic condition change amount information generation unit 530 generates traffic condition change amount information D30 when the lighting state of the traffic light S20 is “red light.” In the example of Fig. 8, in the period from the time “t1” to “t2,” the traffic volume decreases by a predetermined value or more, the traffic density increases by a predetermined value or more, and the average speed decreases by a predetermined value or more. For this reason, the traffic condition change amount information generation unit 530 determines “the degree of aggravation is high” as the traffic condition on the road section B20a during the period from the time “t1” to “t2,” that is, when the lighting state of the traffic light S20 is “red light.” For this reason, as illustrated in Fig. 9, the traffic condition change amount information generation unit 530 generates traffic condition change amount information D30 indicating “the degree of aggravation is high” as the traffic condition on the road section B20a when the lighting state of the traffic light S20 is “red light.”

Meanwhile, in the case in which, at time “t3,” a signal switching signal indicating that the lighting state has been switched to “yellow light” is acquired from the traffic light S20, the traffic condition change amount information generation unit 530 generates, on the basis of a traffic condition indicator at the time “t3” and a traffic condition indicator at the time “t2” at which the previous signal switching signal has

been acquired, traffic condition change amount information D30 of a period from the time “t2” to “t3,” that is, when the lighting state of the traffic light S20 is “green light.”

In the example of Fig. 8, in the period from the time “t2” to “t3,” the traffic volume increases by a predetermined value or more, the traffic density decreases by a

5 predetermined value or more, and the average speed increases by a predetermined value or more. For this reason, the traffic condition change amount information generation unit 530 determines “the degree of improvement is high” as the traffic condition on the road section B20a during the period from the time “t2” to “t3,” that is, when the lighting state of the traffic light S20 is “green light.” For this reason, as illustrated in Fig. 9, the
10 traffic condition change amount information generation unit 530 generates traffic condition change amount information D30 indicating “the degree of improvement is high” as the traffic condition on the road section B20a when the lighting state of the traffic light S20 is “green light.”

[0059]

15 Also, as illustrated in Fig. 10, in the case in which, at the time “t2,” signal switching signal indicating that the lighting state has been switched to “green light” is acquired from the traffic light S20, the traffic condition change amount information generation unit 530 generates, on the basis of a traffic condition indicator at the time “t2” and a traffic condition indicator at time “t1” at which the previous signal switching signal
20 has been acquired, traffic condition change amount information D30 of a period from the time “t1” to “t2,” that is, when the lighting state of the traffic light S20 is “red light.” In the example of Fig. 10, in the period from the time “t1” to “t2,” the traffic volume decreases, the traffic density increases, and the average speed decreases, but each change amount is less than a predetermined value. For this reason, the traffic condition change
25 amount information generation unit 530 determines “the degree of aggravation is low” as

the traffic condition on the road section B20a during the period from the time “t1” to “t2,” that is, when the lighting state of the traffic light S20 is “red light.” For this reason, as illustrated in Fig. 11, the traffic condition change amount information generation unit 530 generates traffic condition change amount information D30 indicating “the degree of aggravation is low” as the traffic condition on the road section B20a when the lighting state of the traffic light S20 is “red light.”

Meanwhile, in the case in which, at time “t3,” a signal switching signal indicating that the lighting state has been switched to “yellow light” is acquired from the traffic light S20, the traffic condition change amount information generation unit 530 generates, on the basis of a traffic condition indicator at the time “t3” and a traffic condition indicator at the time “t2” at which the previous signal switching signal has been acquired, traffic condition change amount information D30 of a period from the time “t2” to “t3,” that is, when the lighting state of the traffic light S20 is “green light.”

In the example of Fig. 10, in the period from the time “t2” to “t3,” the traffic volume increases, the traffic density decreases, and the average speed increases, but each change amount is less than a predetermined value. For this reason, the traffic condition change amount information generation unit 530 determines “the degree of improvement is low” as the traffic condition on the road section B20a during the period from the time “t2” to “t3,” that is, when the lighting state of the traffic light S20 is “green light.” For this reason, as illustrated in Fig. 11, the traffic condition change amount information generation unit 530 generates traffic condition change amount information D30 indicating “the degree of improvement is low” as the traffic condition on the road section B20a when the lighting state of the traffic light S20 is “green light.”

Further, in the case in which there is no change in a traffic condition indicator, the traffic condition change amount information generation unit 530 generates traffic

condition change amount information D30 indicating “not changed” as illustrated in Fig.

11. Further, in the case in which an amount of change in traffic condition indicators is within a predetermined range, the traffic condition change amount information generation unit 530 determines that the traffic condition is “not changed.”

5 Every time the signal switching information is acquired from each traffic light S, the signal control device 50 repeatedly executes the process P50, thereby accumulating the traffic condition change amount information D30 in the recording medium 580.
[0060]

 Also, as illustrated in Fig. 13, the signal control device 50 performs a process
10 P51 of controlling a traffic light S.

 In the process P51, when an emergency vehicle travels for an emergency service, the emergency vehicle information acquisition unit 540 acquires the emergency vehicle information from an on-board unit A1 mounted in the emergency vehicle (step S510). In the present embodiment, in a period from the start of the traveling of the emergency
15 vehicle for the emergency service until the service is completed (until the emergency vehicle reaches a destination), the emergency vehicle information acquisition unit 540 acquires the emergency vehicle information every predetermined interval (for example, every 5 seconds).
[0061]

20 Next, the traffic condition change amount information acquisition unit 550 acquires traffic condition change amount information D30 accumulated in the recording medium 580 (Step S511).

 Specifically, when the emergency vehicle information acquisition unit 540 acquires the emergency vehicle information in step S510, the traffic condition change
25 amount information acquisition unit 550 acquires, from the recording medium 580, the

traffic condition change amount information D30 associated with each road section included in the “scheduled traveling route” of the emergency vehicle information.

[0062]

Next, on the basis of the emergency vehicle information and the traffic condition
 5 change amount information D30, the signal control unit 560 selects a traffic light S having a significant effect on improving traffic conditions on a road section as a traffic light to be controlled (step S512).

Specifically, on the basis of the “position information” of the emergency vehicle information and the map data recorded in advance in the recording medium 580, the
 10 signal control unit 560 extracts a traffic light S not reached by the emergency vehicle among traffic lights S provided in each road section included in the “scheduled traveling route.”

For example, it is assumed that the signal control unit 560 extracts the traffic light S20 (see Fig. 2) provided in the road section B20a as one of the traffic lights S not
 15 reached by the emergency vehicle. The signal control unit 560 controls, on the basis of the traffic condition change amount information D30 on the road section B20a, the traffic light S20 to reach a lighting state in which the effect of improving the traffic condition on the road section B20a is significant, thereby determining whether the effect of improving the traffic condition on the road section B20a is significant.

20 In the example of Fig. 9, in the case in which, according to the traffic condition change amount information D30, the lighting state of the traffic light S20 is “green light,” the traffic condition on the road section B20a is expected to be largely improved (“improvement (large)”). For this reason, the signal control unit 560 determines that the effect of improving the traffic condition on the road section B20a is significant by setting
 25 the lighting state of the traffic light S20 to “green light.” In this case, the signal control

unit 560 selects the traffic light S20 as a traffic light to be controlled.

Meanwhile, in the example of Fig. 11, in the case in which, according to the traffic condition change amount information D30, the lighting state of the traffic light S20 is “green light,” the traffic condition on the road section B20a is expected to be improved, but the degree of improvement is expected to be small (“improvement (small)”). For this reason, the signal control unit 560 determines that the effect of improving the traffic condition on the road section B20a is small even in the case in which the lighting state of the traffic light S20 is “green light.” In this case, the signal control unit 560 determines that control of the traffic light S20 is unnecessary and does not select the traffic light S as the traffic light to be controlled.

The signal control unit 560 performs such determination for all traffic lights S not reached by the emergency vehicle to select a traffic light S to be controlled.

[0063]

Next, the signal control unit 560 performs control of the traffic light S to be controlled that has been selected in step S512 (step S513).

In the example of Fig. 9, in the case in which, according to the traffic condition change amount information D30, the lighting state of the traffic light S20 is “green light,” the traffic condition on the road section B20a is expected to be largely improved (“improvement (large)”). For this reason, the signal control unit 560 controls the traffic light S20 so that the lighting state of the traffic light S20 reaches “green light.” Specifically, in the case in which the latest signal switching information on the traffic light S20 acquired by the signal switching information acquisition unit 510 indicates that the lighting state of the traffic light S20 is a lighting state other than “green light,” the signal control unit 560 transmits signal control information including a command to switch to “green light” to the traffic light S20.

Meanwhile, in the case in which the latest signal switching information on the traffic light S20 acquired by the signal switching information acquisition unit 510 indicates that the lighting state of the traffic light S20 is “green light,” the signal control unit 560 transmits signal control information including a command to extend the “green light” lighting state for a predetermined extension time (for example, for 10 seconds) to the traffic light S20.

Further, the signal control unit 560 may estimate, on the basis of the “position information” and “moving speed” included in the emergency vehicle information, time at which the emergency vehicle passes the traffic light S20. Then, the signal control unit 560 may set the extension time so that the “green light” lighting state is continued until time at which the emergency vehicle is predicted to pass the traffic light S20.

Also, the signal control unit 560 may estimate, on the basis of the “position information” and “moving speed” included in the emergency vehicle information, the number of seconds after which the emergency vehicle reaches the road section in which the traffic light S to be controlled is provided and may transmit signal control information a predetermined time before (for example, 10 seconds before) the emergency vehicle reaches the road section. Also, on the basis of the “position information” included in the emergency vehicle information, the signal control unit 560 may transmit signal control information when the emergency vehicle has reached a predetermined distance ahead (for example, 100 meters ahead) of where the emergency vehicle reaches the road section. In this case, according to the lighting state of the traffic light S at the time point at which signal control information is transmitted, the signal control unit 560 determines whether to transmit signal control information including a command to switch the lighting state or to transmit signal control information including a command to extend the lighting state. In such a way, before the emergency vehicle actually travels a

road section in which the traffic light S to be controlled is provided, the signal control unit 560 can improve the traffic condition on the road section.

The signal control device 50 repeatedly executes the process P51 until the emergency vehicle completes the service (reaches the destination). Consequently, even
5 in the case in which the scheduled traveling route of the emergency vehicle is changed, the case in which the traffic condition on the road section is changed due to an accident etc., or the like, every time such cases occur, the signal control device 50 can suitably select the traffic light S to be controlled on the basis of the emergency vehicle information and the traffic condition change amount information D30 and perform
10 control thereof.

[0064]

(Hardware configuration of signal control device)

Fig. 14 is a view illustrating an example of a hardware configuration of the signal control device according to an embodiment of the present invention.

15 Hereinafter, an example of the hardware configuration of the signal control device 50 of the present embodiment will be described with reference to Fig. 14.

[0065]

A computer 900 includes a central processing unit (CPU) 901, a main storage device 902, an auxiliary storage device 903, an input/output interface 904, and a
20 communication interface 905.

The above-described signal control device 50 is mounted in the computer 900. Then, the above-described operation of each processing unit is stored in a program format in the auxiliary storage device 903. The CPU 901 reads a program from the auxiliary storage device 903, develops the program in the main storage device 902, and
25 executes the process according to the program. Also, the CPU 901 secures a memory

area corresponding to a recording medium 460 in the main storage device 902 according to the program. Also, the CPU 901 secures a memory area in which data being processed is stored in the auxiliary storage device 903 according to the program.

Further, the computer 900 may be connected to an external storage device 910 via the

5 input/output interface 904, and a memory area corresponding to the recording medium 580 may be secured in the external storage device 910. Also, the computer 900 may be connected to an external storage device 920 via the communication interface 905, and a memory area corresponding to the recording medium 580 may be secured in the external storage device 920.

10 [0066]

Further, in at least one embodiment, the auxiliary storage device 903 is an example of a non-temporary type medium. Other examples of the non-temporary type medium include a magnetic disk, an optical magnetic disk, a compact disc read-only memory (CD-ROM), a digital versatile disk (DVD)-ROM, a semiconductor memory, and the like connected via the input/output interface 904. Also, in the case in which the

15 the like connected via the input/output interface 904. Also, in the case in which the program is delivered to the computer 900 by a communication line, the computer 900 that has received the program may develop the program in the main storage device 902 and execute the process.

[0067]

20 Also, the program may be for realizing some of the above-described functions.

Further, the program may be a so-called differential file (differential program) which realizes the above-described functions by a combination with another program already stored in the auxiliary storage device 903.

[0068]

25 Also, the signal control device 50 may consist of a single computer 900 or

consist of a plurality of computers which are communicatively connected. For example, each function of the signal control device 50 may be included in the traffic condition indicator generation unit 20.

[0069]

5 (Effects)

[0070]

As described above, the signal control device 50 according to the present embodiment includes the emergency vehicle information acquisition unit 540 configured to acquire emergency vehicle information including position information on an
10 emergency vehicle, the traffic condition change amount information acquisition unit 550 configured to acquire traffic condition change amount information D30 indicating, for each road section, an amount of change in traffic conditions according to a lighting state of traffic lights, and the signal control unit 560 configured to perform, on the basis of the emergency vehicle information and the traffic condition change amount information D30,
15 control of the traffic light S provided in a road section on which the emergency vehicle travels.

In such a way, on the basis of the traffic condition change amount information D30, the signal control unit 560 only selects, among traffic lights S provided in the road section on which the emergency vehicle travels, traffic lights S expected to improve the
20 traffic condition on the road section according to the lighting state of each traffic light S and controls the selected traffic lights. Consequently, the signal control unit 560 may improve the traffic condition on the road section on which the emergency vehicle travels so that the emergency vehicle may have priority and travel smoothly.

Also, by controlling the traffic lights S so that the emergency vehicle may have
25 priority and travel smoothly, there is a likelihood that influences such as deterioration of

traffic conditions will occur due to restrictions on traffic in the other road sections on which the emergency vehicle does not travel. However, since, for road sections in which it is expected that traffic conditions would not be improved even when the control of traffic lights S in the road sections on which the emergency vehicle travels is

5 performed, the signal control unit 560 does not perform the control of the traffic lights S, the influences on the traffic conditions of the other road sections can be suppressed.

[0071]

Also, the emergency vehicle information includes a scheduled traveling route of the emergency vehicle. The traffic condition change amount information acquisition

10 unit 550 acquires the traffic condition change amount information D30 on each road section included in the scheduled traveling route of emergency vehicle information.

Also, the signal control unit 560 performs, on the basis of the emergency vehicle information and the traffic condition change amount information D30 on each road section included in the scheduled traveling route, control of the traffic light S provided in

15 each road section before the emergency vehicle reaches each road section. Specifically, on the basis of the “position information” and “moving speed” included in the emergency vehicle information, the signal control unit 560 performs the control of the traffic light S to be controlled, a predetermined time before the emergency vehicle reaches the road section or a predetermined distance ahead of where the emergency vehicle reaches the

20 road section.

In such a way, the signal control unit 560 can improve traffic conditions of the road sections included in the scheduled traveling route of the emergency vehicle before the emergency vehicle travels on each road section. As a result, the signal control device 50 can cause the emergency vehicle to travel quickly and smoothly.

25 [0072]

Also, the signal control device 50 further includes the signal switching information acquisition unit 510 configured to acquire signal switching information indicating that the lighting state of the traffic light S has been switched, the traffic condition indicator acquisition unit 520 configured to acquire a traffic condition indicator of a road section in which the traffic light S is provided, and the traffic condition change amount information generation unit 530 configured to generate, on the basis of the traffic condition indicator at a time point at which the signal switching information is acquired from the traffic light S and the traffic condition indicator at a time point at which the previous signal switching information has been acquired from the traffic light S, generate traffic condition change amount information D30 on a road section in which the traffic light S is provided.

In this manner, by generating traffic condition change amount information D30 every time the lighting state of the traffic light is switched, the traffic condition change amount information generation unit 530 can generate, even in the case in which actual traffic conditions on a road section are changed due to various factors such as the date and time, climate, and accidents, traffic condition change amount information D30 corresponding to such a change in real time. As a result, the signal control unit 560 can highly accurately select a traffic light S having a significant effect on improving traffic conditions according to the actual traffic condition on the road section and control the selected traffic light.

[0073]

Also, the emergency vehicle information acquisition unit 540 acquires the emergency vehicle information from the emergency vehicle until the emergency vehicle completes a service (reaches the destination). Every time the emergency vehicle information acquisition unit 540 acquires the emergency vehicle information, the traffic

condition change amount information acquisition unit 550 acquires the traffic condition change amount information D30 from the recording medium 580. Then, on the basis of the emergency vehicle information and the traffic condition change amount information D30, the signal control unit 560 repeats the process of selecting the traffic light S having a significant effect on improving traffic conditions on a road section and controlling the selected traffic light.

In such a way, even in the case in which the scheduled traveling route of the emergency vehicle is changed, the case in which the traffic condition on the road section is changed due to an accident etc., or the like, every time such cases occur, the signal control device 50 can highly accurately select, on the basis of the emergency vehicle information and the traffic condition change amount information D30, the traffic light S having a significant effect on improving traffic conditions and control the selected traffic light.

[0074]

Also, the signal control device 50 includes the restriction information transmission unit 570 configured to transmit restriction information on a road section subject to restrictions on which traffic restrictions such as prohibiting passage are performed by the signal control unit 560 controlling the traffic light S to at least one of the on-board unit A2 mounted in a general vehicle located in the road section subject to restrictions and the restriction information notification unit G.

In such a way, the restriction information transmission unit 570 can cause a driver of a vehicle to recognize restriction information involving traveling of the emergency vehicle.

Consequently, the restriction information transmission unit 570 can cause the driver of the emergency vehicle to recognize the lighting state of the traffic light S, the

traffic condition on the road section, and the like in the scheduled traveling route, thereby performing support for the emergency vehicle to travel smoothly.

Also, the restriction information transmission unit 570 can cause the driver of the general vehicle to recognize a road section on which the emergency vehicle is scheduled to travel and a road section subject to restrictions, thereby inducing an action such as traveling by avoiding such road sections. As a result, in addition to allowing the emergency vehicle to have priority and travel smoothly, the restriction information transmission unit 570 can cause the likelihood that a traffic condition will be aggravated in the road section subject to restrictions due to the occurrence of congestion or the like to be reduced.

[0075]

Also, the signal control system 1 includes the signal control device 50, the probe data collection unit 10 configured to collect probe data including position information on an on-board unit A mounted in each of a plurality of vehicles, and the traffic condition indicator generation unit 20 configured to generate a traffic condition indicator for each road section on the basis of the probe data and record the generated traffic condition indicator in the traffic condition database 30.

In such a way, the traffic condition indicator generation unit 20 can generate, on the basis of probe data sequentially collected by the probe data collection unit 10, a traffic condition indicator according to actual conditions on a road section. For this reason, the traffic condition indicator generation unit 20 can improve accuracy of the traffic condition indicator. Also, on the basis of such a highly accurate traffic condition indicator, the signal control device 50 can highly accurately select a traffic light S having a significant effect on improving traffic conditions and control the selected traffic light.

[0076]

The embodiments of the present invention have been described above in detail, but the present invention is not limited thereto, and some design changes and the like are also possible as long as the changes do not deviate from the technical idea of the present invention.

5 For example, in the above-described embodiment, the aspect in which the signal control unit 560 selects the traffic light S having a significant effect on improving traffic conditions on a road section as a traffic light to be controlled and controls the selected traffic light has been described, but the present invention is not limited thereto. For example, in the case in which the traffic condition on the road section is improved by
10 controlling the traffic light S, even in the case in which the improvement effect is small, the signal control unit 560 may select the traffic light S as the traffic light to be controlled and perform control thereof. Also, criteria for selecting a traffic light as a traffic light to be controlled may be changed for each road section according to traffic conditions, location conditions, and the like of the road sections. For example, in a road section in
15 which the traffic volume is a predetermined value or higher, only the traffic light S having a significant improvement effect may be selected and controlled, and in a road section in which the traffic volume is less than the predetermined value, even in the case in which the improvement effect is small, the traffic light S may be selected as a traffic light to be controlled, and control thereof may be performed.

20 [Industrial Applicability]

[0077]

 According to the above-described signal control device, signal control system, signal control method, and program, it is possible to improve traffic conditions of a road section on which an emergency vehicle travels and suppressing an influence on traffic
25 conditions of road sections on which the emergency vehicle does not travel.

[Description of reference numerals]

[0078]

- 1: Signal control system
- 10: Probe data collection unit
- 5 20: Traffic condition indicator generation unit
- 30: Traffic condition database
- 50: Signal control device
- 510: Signal switching information acquisition unit
- 520: Traffic condition indicator acquisition unit
- 10 530: Traffic condition change amount information generation unit
- 540: Emergency vehicle information acquisition unit
- 550: Traffic condition change amount information acquisition unit
- 560: Signal control unit
- 570: Restriction information transmission unit
- 15 580: Recording medium
- 900: Computer
- 901: CPU
- 902: Main storage device
- 903: Auxiliary storage device
- 20 904: Input/output interface
- 905: Communication interface
- 910: External storage device
- 920: External storage device
- A: On-board unit
- 25 A1: On-board unit (emergency vehicle)

A2: On-board unit (general vehicle)

G: Restriction information notification unit

NW: Network

S: Traffic light

[CLAIMS]

1. A signal control device comprising:
 - an emergency vehicle information acquisition unit configured to acquire emergency vehicle information including position information on an emergency vehicle;
 - a traffic condition change amount information acquisition unit configured to acquire traffic condition change amount information indicating, for each road section, an amount of change in traffic conditions according to a lighting state of traffic lights;
 - a signal control unit configured to perform, on the basis of the emergency vehicle information and the traffic condition change amount information, control of the traffic lights provided in a road section on which the emergency vehicle travels;
 - a signal switching information acquisition unit configured to acquire signal switching information indicating that the lighting state of the traffic light has been switched;
 - a traffic condition indicator acquisition unit configured to acquire a traffic condition indicator of a road section in which the traffic light is provided; and
 - a traffic condition change amount information generation unit configured to generate, on the basis of the traffic condition indicator at a time point at which the signal switching information is acquired from the traffic light and the traffic condition indicator at a time point at which the previous signal switching information has been acquired from the traffic light, generate traffic condition change amount information on a road section in which the traffic light is provided.

2. The signal control device according to claim 1, wherein:
 - the emergency vehicle information further includes a scheduled traveling route of the emergency vehicle;
 - the traffic condition change amount information acquisition unit acquires the traffic condition change amount information on each road section included in the scheduled traveling route; and
 - the signal control unit performs, on the basis of the emergency vehicle information and the traffic condition change amount information on each road section included in the scheduled traveling route, control of the traffic light provided in each road section before the emergency vehicle reaches each road section.

3. The signal control device according to claim 1 or 2, further comprising a restriction information transmission unit configured to transmit restriction information on a road section subject to restrictions on which traffic restrictions are performed by the signal control unit performing the control of the traffic light to at least one of an on-board unit mounted in a vehicle located in the road section subject to restrictions and a restriction information notification unit provided in the road section.

4. A signal control system comprising:
 - the signal control device according to any one of claims 1 to 3;
 - a probe data collection unit configured to collect probe data including position information on an on-board unit mounted in each of a plurality of vehicles; and
 - a traffic condition indicator generation unit configured to generate a traffic condition indicator for each road section on the basis of the probe data and record the generated traffic condition indicator in a traffic condition database.

5. A signal control method comprising:
 - an emergency vehicle information acquisition step of acquiring emergency vehicle information including position information on an emergency vehicle;
 - a traffic condition change amount information acquisition step of acquiring traffic condition change amount information indicating, for each road section, an amount of change in traffic conditions according to a lighting state of traffic lights; and
 - a signal control step of performing, on the basis of the emergency vehicle information and the traffic condition change amount information, control of the traffic light provided in a road section on which the emergency vehicle travels;
 - a signal switching information acquisition step of acquiring signal switching information indicating that the lighting state of the traffic light has been switched;
 - a traffic condition indicator acquisition step of acquiring a traffic condition indicator of a road section in which the traffic light is provided; and
 - a traffic condition change amount information generation step of generating, on the basis of the traffic condition indicator at a time point at which the signal switching information is acquired from the traffic light and the traffic condition indicator at a time point at which the previous signal switching information has been acquired from the traffic light, generate traffic condition change amount information on a road section in which the traffic light is provided.

6. A program causing a computer of a signal control device to function as:
 - an emergency vehicle information acquisition unit configured to acquire emergency vehicle information including position information on an emergency vehicle;
 - a traffic condition change amount information acquisition unit configured to acquire traffic condition change amount information indicating, for each road section, an amount of change in traffic conditions according to a lighting state of traffic lights; and
 - a signal control unit configured to perform, on the basis of the emergency vehicle information and the traffic condition change amount information, control of the traffic lights provided in a road section on which the emergency vehicle travels;

a signal switching information acquisition unit configured to acquire signal switching information indicating that the lighting state of the traffic light has been switched;

a traffic condition indicator acquisition unit configured to acquire a traffic condition indicator of a road section in which the traffic light is provided; and

a traffic condition change amount information generation unit configured to generate, on the basis of the traffic condition indicator at a time point at which the signal switching information is acquired from the traffic light and the traffic condition indicator at a time point at which the previous signal switching information has been acquired from the traffic light, generate traffic condition change amount information on a road section in which the traffic light is provided.