

TITLE OF THE INVENTION

VEHICLE RUNNING MANAGEMENT METHOD AND SYSTEM, AND
VEHICLE RUNNING ASSISTING APPARATUS

5 BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to vehicle running management method and system and a vehicle running assisting apparatus, and in particular to vehicle running management
10 method and system and a vehicle running assisting apparatus for managing running states of vehicles on a road having single-track parts.

2. Description of the Related Art

Conventionally, as disclosed in Japanese Laid-Open
15 Patent Application No. 61-285168, a vehicle running management system for managing running states of vehicles is known. In this system, a lane on which vehicles run comprises single-track parts and double-track parts.

In order to assure safety of vehicles running in
20 opposite directions, the lane is desired to be entirely double-tracked. However, if the lane is entirely double-tracked, a large-scale infrastructure is required as compared to a case where the lane is partly single-tracked. According to the above-mentioned conventional system, since the lane
25 comprises single-track parts and double-track parts as mentioned above, the scale of the required infrastructure can be reduced.

In the above-mentioned conventional system, a vehicle departs from a station when the vehicle receives a
30 departure-permitting signal. After running on a single-track part, the vehicle reaches a double-track part, where the vehicle stops and waits for an oncoming vehicle to come. When the oncoming vehicle reaches the double-track part, a departure

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permitting signal is transmitted to these two vehicles, and the vehicles start to run on the respective single-track parts.

In this way, two vehicles running in opposite directions can pass each other on the double-track part. Thus, according to the above-mentioned conventional system, it is possible to assure that vehicles can safely run on the lane without collisions while avoiding a necessity of a large-scale infrastructure.

However, in the above-mentioned conventional system, a vehicle which has reached a double-track part earlier than an oncoming vehicle must stop and wait for the oncoming vehicle to reach the double-track part. Thus, vehicles may frequently stop and start on double-track parts, resulting in ride discomfort for passengers of the vehicles.

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SUMMARY OF THE INVENTION

It is a first object of the present invention to provide vehicle running management method and system by which vehicles running in opposite directions can smoothly pass each other without frequently stopping.

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It is a second object of the present invention to provide a vehicle running assisting apparatus by which vehicles running in opposite directions can smoothly pass each other without frequently stopping.

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The first object of the present invention can be achieved by a vehicle running management method for managing running states of vehicles running on a road having single-track parts and double-track parts, comprising:

a step (a) for detecting positions of first and second vehicles which are approaching each other;

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a step (b) for determining whether or not the first and second vehicles are the closest vehicles to each other within a predetermined range ahead of each other based on the detected

positions;

a step (c) for setting a target position to be a double-track part which is situated between the first and second vehicles when it is determined that the first and second vehicles
5 are the closest vehicles to each other within the predetermined range ahead of each other; and

a step (d) for controlling speeds of the first and/or second vehicles so that the first and second vehicles reach the target position substantially at the same time.

10 In this invention, when the first vehicle and the second vehicle are the closest vehicles to each other within a predetermined range ahead of each other, a double-track part situated between the first and second vehicles is selected as a target position. Speeds of the first and/or second vehicles
15 are controlled so that the first and second vehicles reach the target position substantially at the same time. Therefore, the first and second vehicles can pass each other on the double-track part without stopping. Thus, according to this invention, vehicles can smoothly run on the road having the single-track
20 parts without a necessity of stopping to pass oncoming vehicles on the double-track parts.

In this case, the step (d) may comprise:

a step (e) for calculating times required by the first and second vehicles to reach the target position;

25 a step (f) for calculating a time at which one of the first and second vehicles which one requires a longer time to reach the target position than the other vehicle reaches the target position; and

a step (g) for controlling a speed of the other
30 vehicle so that the other vehicle reaches the target position substantially at the time calculated in the step (f).

In this invention, the step (f) calculates a time at which one of the first and second vehicles requiring a longer

time to reach the target position than the other vehicle reaches the target position. In the step (g), the other vehicle, that is, the vehicle requiring a shorter time to reach the target position, is speed-controlled so as to reach the target position
5 substantially at the calculated time. Specifically, the other vehicle is decelerated. In this case, the first and second vehicles reach the double-track part substantially at the same time so that these two vehicles can pass each other without stopping. Thus, according to this invention, vehicles can
10 smoothly run on the road having the single-track parts without a necessity of stopping to pass oncoming vehicles on the double-track parts.

Additionally, the vehicle running management method may further comprise:

15 a step (h) for detecting a position of a third vehicle which runs ahead of the first vehicle in the same direction as the first vehicle;

a step (i) for determining whether or not the third vehicle is the closest vehicle to the first vehicle within the
20 predetermined range ahead of the first vehicle;

a step (j) for, when it is determined that the third vehicle is the closest vehicle to the first vehicle within the predetermined range ahead of the first vehicle, setting a target position to be a first double-track part which is situated
25 backward from a second double-track part which the third vehicle will subsequently reach, at least one double-track part existing between the first and second double-track parts;

a step (k) for calculating a time at which the third vehicle will reach the second double-track part; and

30 a step (L) for controlling a speed of the first vehicle so that the first vehicle reaches the target position substantially at the time calculated in the step (k).

In this invention, if the third vehicle is the closest

vehicle to the first vehicle within a predetermined range ahead of the first vehicle, the target position is set to be the first double-track part which is situated backward of a second double-track part which the third vehicle subsequently will reach. The first double-track part is selected so that at least one double-track part exists between the first and second double-track parts. The speeds of the first and/or third vehicles are controlled so that the first vehicle and the third vehicle reach the first and second double-track parts, respectively, substantially at the same time. Therefore, the first vehicle can pass an oncoming vehicle on the double-track part situated between the first and second double-track parts after the third vehicle has reached the second double-track part. Thus, according to this invention, vehicles can smoothly run on the road having the single-track parts while passing oncoming vehicles on the double-track parts without a necessity of stopping, in a case where a preceding vehicle is running ahead.

The second object of the present invention can be achieved by a vehicle running assisting apparatus provided in a vehicle running on a road having single-track parts and double-track parts, comprising

a transmitter which transmits vehicle information;
a receiver which receives information including a specific double-track part situated ahead of the vehicle and a target time at which the vehicle should reach the specific double-track part; and

a running controller which controls a running state of the vehicle so that the vehicle reaches the specific double-track part at the target time.

In this invention, the vehicle can reach the specific double-track parts situated ahead of the vehicle at the time indicated by the information transmitted by a communication device provided in the infrastructure. Thus, according to this

invention, the vehicle can smoothly run on the road having single-track parts without a necessity of stopping to pass an oncoming vehicle on the double-track part. It should be noted that the vehicle information may include an ID, a position, a velocity, and a running direction of the vehicle.

Other objects and further features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a schematic diagram of an infrastructure facility in which a vehicle running management method of an embodiment according to the present invention is applied;

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FIG.2 is a block diagram of a system which achieves the vehicle running management method of the present embodiment;

FIG.3 is a diagram for illustrating a principle of a running rule which is used when an oncoming vehicle exists;

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FIG.4 is a diagram for illustrating a principle of a running rule which is used when a preceding vehicle exists;

FIG.5 is a flowchart of an example of a routine performed by a management ECU in the embodiment;

FIGS.6A to 6D are diagrams for illustrating a running rule used in the embodiment;

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FIGS.7A to 7C are diagrams showing results of processes performed by the management ECU in the situations shown in FIGS.6A to 6C, respectively;

FIG.8 is a diagram showing a running state of vehicles achieved in the present embodiment; and

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FIGS.9A and 9B are diagrams showing a running state of vehicles when a maximum number of vehicles are running on the road shown in FIG.1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG.1 is a schematic diagram of an infrastructure facility in which an embodiment of a vehicle running management method according to the present invention is applied. As shown
5 in FIG.1, the infrastructure facility includes a first station 10 and a second station 11. A road 12 is provided between the first station 10 and the second station 11. Vehicles run on the road 12 to transport passengers between the first station 10 and the second station 11.

10 The road 12 comprises single-track parts 14₁ to 14₇ on which a vehicle can run only in one direction and double-track parts 16₁ to 16₆ on which two vehicles running in opposite directions can pass each other. The single-track parts 14₁ to 14₇ and the double-track parts 16₁ to 16₆ are alternately
15 provided at predetermined intervals. Each of the double-track parts 16₁ to 16₆ has a length which is greater than a full length of the vehicles.

A vehicle which has departed from the first station 10 runs to the right in FIG.1 on the single-track parts 14-
20 1 to 14₇ and the double-track parts 16₁ to 16₆, and reaches the second station 11. Similarly, a vehicle which has departed from the second station 11 runs to the left in FIG.1 on the single-track parts 14₇ to 14₁ and the double-track parts 16₆ to 16₁, and reaches the first station 10.

25 The infrastructure facility also includes a management center 18. The management center 18 monitors positions of the vehicles running on the road 12 between the first station 10 and the second station 11, and gives control signals to each vehicle so that collisions of the vehicles are
30 prevented.

Now, a description will be given, with a reference to FIG.2, of a system for achieving the vehicle running management method of the present embodiment. FIG.2 shows a

block diagram of the system of the present embodiment.

As shown in FIG.2, the management center 18 includes a management ECU 20. A communication device 22 is connected to the management ECU 20. The communication device 22 performs
5 radio communications between the management center 18 and each of the vehicles. The management ECU 20 detects IDs, positions, velocities, and running directions of the vehicles based on information supplied from the communication device 22. Additionally, the management ECU 20 controls the communication
10 device 22 so as to transmit information including a target position and a target time, which will be discussed later, to each of the vehicles in accordance with a control scheme mentioned below.

Each of the vehicles comprises a vehicle ECU 28 and
15 is controlled by the vehicle ECU 28. The vehicle ECU 28 contains a vehicle ID stored therein. The vehicle ID identifies the vehicle on which the vehicle ECU 28 is mounted. Additionally, the vehicle ECU 28 contains a clock generator. The vehicle ECU 28 detects a current time based on a clock signal generated by
20 the clock generator.

A vehicle speed sensor 30 is connected to the vehicle ECU 28. The vehicle speed sensor 30 outputs a pulse signal having a period corresponding to a vehicle speed. The vehicle ECU 28 detects the vehicle speed based on the output signal of
25 the vehicle speed sensor 30.

The vehicle ECU 28 also contains map information stored therein. The map information includes information on the road 12 such as a distance between the first station 10 and the second station 11 and lengths of the single-track parts 14₁
30 to 14₇, and double-track parts 16₁ to 16₆. The vehicle ECU 28 detects a current position of each vehicle based on the map information and the output signal of the vehicle speed sensor 30.

A communication device 32 is connected to the vehicle ECU 28. The communication device 32 performs radio communications between the management center 18 and the vehicle. The vehicle ECU 28 controls the communication device 32 so as to transmit information such as the vehicle ID, a vehicle position, a vehicle speed, and a running direction of the vehicle. Additionally, the vehicle ECU 28 detects the target position and the target time based on information supplied from the communication device 32.

10 An accelerator actuator 34 and a brake actuator 36 are also connected to the vehicle ECU 28. The vehicle ECU 28 supplies operating signals to the accelerator actuator 34 and the brake actuator 36 based on the target position and the target time. The accelerator actuator 34 controls an accelerator opening of the vehicle in accordance with the operating signal supplied from the vehicle ECU 28, and the brake actuator 36 generates a braking force in accordance with the operating signal supplied from the vehicle ECU 28.

20 In the system of the present embodiment, a speed of each vehicle is controlled so that the vehicles can pass oncoming vehicles on the double-track parts 16 without a necessity of stopping, on the basis of the running directions and positions of vehicles running within a predetermined range ahead of each vehicle.

25 FIG.3 is a diagram for illustrating a principle of a running rule which is used in the present embodiment when an oncoming vehicle exists. FIG.3 shows a situation in which a vehicle 50 is running on the double-track part 16₂ and an oncoming vehicle 52 is running on the single-track part 14₅.

30 In the present embodiment, the management ECU 20 detects positions of the vehicles 50, 52, as mentioned above. If the vehicles 50, 52 are the closest oncoming vehicles to each other and the number of single-track parts 14 situated between

the vehicles 50 and 52 is less than or equal to three, the management ECU 28 calculates a position at which the vehicles 50, 52 should pass each other as a target position of the vehicles 50, 52.

5 In the situation shown in FIG.3, a position at which the vehicles 50, 52 can pass each other is limited to any one of the double-track parts 16₂, 16₃, 16₄. In the present embodiment, the target position is set to be the double-track part 16₃ which is closest to the middle position between the
10 vehicles 50 and 52, based on the information on the vehicle positions.

 In this case, the vehicles 50, 52 can continue to run on the single-track parts 14₃, 14₄, respectively, before they reach the target position. Thus, it is possible to achieve
15 effective running states of the vehicles 50, 52 by setting the target position to be the double-track part 16₃, as compared to a case where the target position is set to be the double-track part 16₂ or 16₄.

 However, if the target position is set as mentioned
20 above, a time lag may occur between times at which the vehicles 50, 52 reach the target position. In this case, one of the vehicles 50, 52 must wait for the other to reach the target position.

 In the present embodiment, the management ECU 20
25 calculates times required by the vehicles 50, 52 to reach the target position, based on the information on positions and speeds of the vehicles 50, 52. The management ECU 20 then calculates a time at which one of the vehicles 50, 52 requiring a longer time than the other reaches the target position. This
30 calculated time is set as a target time. The management ECU 20 transmits a control signal indicating the target position and the target time to the other vehicle, that is, the vehicle 50 or 52 requiring a shorter time to reach the target position.

The vehicle 50 or 52, having received this signal, controls (specifically, decreases) the speed thereof so as to reach the target position at the target time. Thus, according to the present embodiment, the vehicles 50, 52 can pass each other on
5 the double-track parts 16 without stopping.

In the present embodiment, the above-mentioned running rule is applied to all of the vehicles running on the road 12. Thus, according to the present embodiment, all of the vehicles can pass oncoming vehicles on the double-track parts
10 16 without a necessity of stopping.

FIG.4 is a diagram illustrating a basic running rule which is used in the present embodiment when the vehicle 50 is following a preceding vehicle 54. In the situation shown in FIG.4, the vehicle 50 is running on the single-track part 14₂
15 and the preceding vehicle 54 is running on the single-track part 14₄.

In such a situation, if the vehicle 54 is the closest preceding vehicle to the vehicle 50 and the number of single-track parts 14 situated between the vehicles 50, 54 is equal to or less than three, the management ECU 20 determines that the vehicle 50 should subsequently reach the double-track part 16₂ situated two parts backward from the double-track part 16₄ which the preceding vehicle 54 will subsequently reach. That is, the double-track part 16₂ is selected as a target
20 position of the vehicle 50.
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Suppose a situation where the vehicle 50 has passed the double-track part 16₂ when the preceding vehicle 54 reaches the double-track part 16₄. In this situation, if a vehicle approaching the vehicle 50 appears, that is, if the preceding vehicle 54 passes an oncoming vehicle on the double-track part 16₄, after the vehicle 50 has reached the double-track part 16₃,
30 the vehicle 50 must wait for the oncoming vehicle on the double-track part 16₃ or the oncoming vehicle must wait for the

vehicle 50 on the double-track part 16₄. According to the present embodiment, since the target position of the vehicle 50 is set to be the double-track part 16₂ as mentioned above, the vehicle 50 and the oncoming vehicle can pass each other on
5 the double-track part 16₃ without stopping.

However, if the target position of the vehicle 50 is set to be the double-track part 16₃ as mentioned above, a time-lag may occur between times at which the vehicles 50, 54 reach the double-track parts 16₄, 16₂, respectively. In this
10 case, if the vehicle 50 reaches the target position (double-track part 16₂) earlier than a time at which the preceding vehicle 54 reaches the double-track part 16₄, the vehicle 50 must stop at the target position and wait for the preceding vehicle 54 to reach the double-track part 16₄.

15 In the present embodiment, if it is determined that the vehicle 50 will reach the target position earlier than a time at which the preceding vehicle 54 reaches the double-track part 16₄, the management ECU 20 calculates the time at which the preceding vehicle 54 reaches the double-track part 16₄.
20 This calculated time is selected as a target time of the vehicle 50. The management ECU 20 transmits a control signal indicating the target position and the target time to the vehicle 50. The vehicle 50, having received this control signal, controls the speed thereof so as to reach the target position at the target
25 time. Thus, according to the present embodiment, the vehicle 50 can reach the target position simultaneously with the preceding vehicle 54 reaching the subsequent double-track part 16₄, so that the vehicle 50 can follow the preceding vehicle 54 without stopping.

30 In the present embodiment, the above-mentioned running rule is applied to all of vehicles. Thus, according to the present embodiment, all of the vehicles running on the road 12 can appropriately follow the respective preceding

vehicles without a necessity of stopping on the double-track parts 16.

FIG.5 shows a flowchart of an example of a routine performed by the management ECU 20 so as to achieve the
5 above-mentioned function. The routine shown in FIG.5 is repeatedly started at a predetermined interval. When the routine shown in FIG.5 is started, the process of step 100 is performed first.

10 In step 100, information on IDs, positions, speeds and running directions of all of the vehicles running on the road 12 is received.

In step 101, one of the vehicles is selected. Hereinafter, the vehicle selected in this step is referred to as a process-objective vehicle.

15 In step 102, it is determined whether or not a vehicle is running within N blocks ahead of the process-objective vehicle. The "block" is a unit of the number of pairs of a single tracked part 14 and a double-track part 16. In the present embodiment, N is a predetermined value which is equal to or
20 greater than 3. If it is affirmatively determined in step 102, then the process of step 103 is performed.

In step 103, a vehicle which is closest to the process-objective vehicle among the vehicles running within N blocks ahead is selected as a control-objective vehicle of the
25 process-objective vehicle.

In step 104, it is determined whether or not the running direction of the control-objective vehicle is the same as that of the process-objective vehicle based the information received in step 100. If it is determined that the running
30 direction of the control-objective vehicle is the same as that of the process-objective vehicle, then the process of step 106 is performed.

In step 106, a double-track part 16 which the

control-objective vehicle will subsequently reach is determined based on the position information of the control-objective vehicle and the map information.

5 In step 108, the target position is set to be a double-track part 16 which is situated two blocks backward from the double-track part 16 calculated in step 106.

In step 110, a time at which the control-objective vehicle will reach the target position is calculated.

10 In step 112, the target time is set to be the time calculated in step 110.

In step 114, a control signal indicating the target position and the target time is transmitted to the process-objective vehicle. Having received this control signal, the process-objective vehicle controls the speed thereof so as to reach the target position at the target time. When the process of step 114 is finished, then the process of step 122 is performed.

20 On the other hand, if it is determined that the running direction of the control-objective vehicle is opposite to that of the process-objective vehicle in step 104, it can be judged that the control-objective vehicle is approaching the process-objective vehicle. In this case, the process of step 116 is performed.

25 In step 116, a middle position between the process-objective vehicle and the control-objective vehicle is calculated based on the position information of these vehicles.

In step 118, the target position is set to be a double-track part 16 which is closest to the middle position calculated in step 116.

30 In step 119, a time α required by the process-objective vehicle to reach the target position and a time β required by the control-objective vehicle to reach the target position are calculated based on the position and speed

information of these vehicles.

In step 120, it is determined whether or not the time α is smaller than the time β . If it is determined that α is smaller than β , it can be judged that the process-objective vehicle will reach the target position earlier than the control-objective vehicle. In this case, it is determined that the speed of the process-objective vehicle should be decreased so that the process-objective vehicle and the control-objective vehicle can simultaneously reach the target position, and then the process of the above-mentioned step 110 is performed.

If it is negatively determined in step 120, it can be judged that the process-objective vehicle will reach the target position later than the control-objective vehicle. In this case, it is determined that the speed of the process-objective vehicle need not be changed, and then the process of the above-mentioned step 122 is performed.

If it is negatively determined in the above-mentioned step 102, it can be judged that no operation is necessary for the current process-objective vehicle. In this case, the process of step 122 is performed.

In step 122, it is determined whether or not the processes of the above-mentioned steps 102 to 122 have been performed with all of the vehicles running on the road 12 being the process-objective vehicle. If it is positively determined, then the present routine is ended. On the other hand, if it is negatively determined in step 122, a next vehicle is selected as the process-objective vehicle in step 124, and then the process of step 102 is performed again.

According to the above-mentioned process, if the control-objective vehicle is an oncoming vehicle with respect to the process-objective vehicle, the target position is set to be a double-track part 16 which is closest to the middle position between the process-objective vehicle and the oncoming

control-objective vehicle. In this case, a time at which the control-objective vehicle will reach the subsequent double-track part 16 is calculated as the target time.

On the other hand, if the control-objective vehicle
5 is a preceding vehicle with respect to the process-objective vehicle, the target position is set to be a double-track part 16 which is situated two blocks backward from a double-track part 16 which the preceding control-objective vehicle will subsequently reach. In this case, a time at which the
10 control-objective vehicle will reach the target position is calculated as the target time of the process-objective vehicle.

In either case, a control signal indicating the target position and the target time is transmitted to the process-objective vehicle, and the process-objective vehicle
15 controls the speed thereof so as to reach the target position at the target time. This process is performed for all of the vehicles running on the road 12. Thus, according to the routine shown in FIG.5, it is possible to appropriately control running states of all of the vehicles running on the road 12.

20 FIGS.6A to 6D are diagrams for illustrating the running rule used in the present embodiment. FIGS.7A to 7C are diagrams showing results of calculations performed by the management ECU 20 according to the routine shown in FIG.5 in situations shown in FIG.6A to 6C, respectively.

25 FIG.6A shows a situation in which the vehicle 50 is running on the single-track part 14₂, the preceding vehicle 54 is running on the single-track part 14₄, and the oncoming vehicle 52 is running on the single-track part 14₇. FIG.6B shows a situation in which the vehicle 50 is running on the double-track part 16₂, the preceding vehicle 54 is running on the
30 double-track part 16₄, and the oncoming vehicle 52 is running on the double-track part 16₆. FIG.6C shows a situation in which the vehicle 50 is running on the double-track part 16₃, and the

preceding vehicle 54 and the oncoming vehicle 52 are passing each other on the double-track part 16₃. FIG.6D shows a situation in which the vehicle 50 and the oncoming vehicle 52 are passing each other on the double-track part 16₄, and the preceding vehicle 54 is running on the double-track part 16₆.

As shown in FIG.6A, the vehicle 54 is the closest vehicle to the vehicle 50 running within three blocks ahead of the vehicle 50. Additionally, the vehicles 54 and 52 are the closest vehicles to each other running within three blocks ahead of each other. Thus, the vehicle 54 is selected as a control-objective vehicle of the vehicle 50, and the vehicles 54 and 52 are selected as control-objective vehicles of each other.

As mentioned above, the management ECU 20 calculates the target position and the target time of each vehicle based on the detected ID, position, running direction and speed of each vehicle. Specifically, in the situation shown in FIG.6A, the management ECU 20 sets the target position of the vehicles 54 and 52 to be the double-track part 16₅, which is closest to the middle position between these vehicles, as shown in FIG.7A. Then, the management ECU 20 calculates times required by the vehicles 54, 52 to reach the target position, and determines which vehicle will reach the target position later than the other. The calculated time of the vehicle 54 or 52 which reaches the target position later than the other is set as a target time T_{1a} , and a control signal indicating the target position and the target time T_{1a} is transmitted to the other vehicle so that this vehicle reach the target position at the target time T_{1a} .

Additionally, in the situation shown in FIG.6A, the management ECU 20 sets the target position of the vehicle 50 to be the double-track part 16₂, two blocks backward from the double-track part 16₄, which the preceding vehicle 54 will subsequently reach, and calculates a time at which the preceding

vehicle 54 will reach the subsequent double-track part 16₄ as a target time T_{2a} , as shown FIG.7A. Then, a control signal indicating the target position and the target time T_{2a} is transmitted to the vehicle 50 so that the vehicle 50 reaches
5 the target position at the target time T_{2a} . Thus, the vehicles 50 and 54 reach the double-track parts 16₂ and 16₄, respectively, at the same time, as shown in FIG.6B.

In the situation shown in FIG.6B, the vehicle 54 is selected as the control-objective vehicle of the vehicle 50 and
10 the vehicles 54 and 52 are selected as the control-objective vehicles of each other, as in the case of FIG.6A. In such a situation, the management ECU 20 sets the target position of the vehicles 54 and 52 to be the double tracked part 16₅ and sets the target position of the vehicle 50 to be the double-track
15 part 16₃, which is two blocks backward from the double-track part 16₅ which the preceding vehicle 54 will subsequently reach, as shown in FIG.7B.

Similar to the situation shown in FIG.6A, the management ECU 20 calculates times required by the vehicles 54,
20 52 to reach their target position, and determines which vehicle will reach the target position later than the other. The calculated time of the vehicle which will reach the target position later than the other is set as a target time T_{1b} , and a control signal indicating the target position and the target
25 time T_{1b} is transmitted to the other vehicle so that this vehicle reaches the target position at the target time T_{1b} .

Additionally, the management ECU 20 set the target position of the vehicle 50 to be the double-track part 16₃, situated two blocks backward from the double-track part 16₅,
30 which the preceding vehicle 54 will subsequently reach. Then, a control signal indicating the target position and the target time T_{1b} is transmitted to the vehicle 50 so that the vehicle 50 reaches the target position at the target time T_{1b} .

Thus, as shown in FIG.6C, the vehicle 50 reaches the double-track part 16₃ at the time when the preceding vehicle 54 and the oncoming vehicle 52 reach the double-track part 16₅.

After the preceding vehicle 54 and the oncoming
5 vehicle 52 pass each other on the double-track part 16₅ as shown in FIG.6C, the vehicle 52 is the closest vehicle to the vehicle 50 situated within three blocks ahead of the vehicle 50. Thus, the control-objective vehicle of the vehicle 50 is changed from the preceding vehicle 54 to the oncoming vehicle 52.

10 In this situation, the management ECU 20 sets the target position of the vehicles 50 and 52 to be the double-track part 16₄ which is closest to the middle position between these vehicles, as shown in FIG.7C. Then, the management ECU 20 calculates times required by the vehicles 50, 52 to reach
15 the target position, and determines which vehicle will reach the target position later than the other. The calculated time of the vehicle which reaches the target position later than the other is set as a target time T3, and a control signal indicating the target position and the target time T3 is transmitted to
20 the other vehicle so that this vehicle reaches the target position at the target time T3. Thus, as shown in FIG.6D, the vehicles 50 and 52 reach the double-track part 16₄ at the same time.

As mentioned above, two vehicles approaching each
25 other can always reach the same double-track part 16 at the same time. Thus, according to the present embodiment, all of the vehicles on the road 12 can pass oncoming vehicles at double-track parts 16 without a necessity of stopping.

FIG.8 shows a running state of vehicles achieved in
30 the present embodiment in which the distance between the first station 10 and the second station 11 is 30 km and the single-track parts 14₁ to 14₇, and the double-track parts 16₁ to 16₆ are alternately provided at arbitrary intervals. In FIG.8, the

double-track parts 16 are indicated by hatching.

As shown in FIG.8, the preceding vehicle 54 departs from the first station 10 at a time "1". Thereafter, the vehicle 50 departs from the first station 10 around a time "401", and then a vehicle 56 succeeding the vehicle 50 departs from the first station 10 around a time "551". On the other hand, the oncoming vehicle 52 departs from the second station 11 around a time "501", and a second oncoming vehicle 58 departs from the second station 11 around a time "1101".

Each of the vehicles 50, 52, 54, 56, 58 runs on the road 12 in accordance with the above-mentioned running rule. Thus, each vehicle passes an oncoming vehicle at one of the double-track parts 16, as shown in FIG.8. Additionally, when a preceding vehicle has reached one of the double-track parts 16, a vehicle succeeding the preceding vehicle runs on or before a double-track part 16 situated two blocks backward from the double-track part 16 which the preceding vehicle has reached. Thus, according to the above-mentioned running rule, the vehicles can effectively and smoothly run on the road 12 having the single-track parts 14 without a necessity of stopping on the double-track parts 16.

FIGS.9A and 9B show a situation in which a maximum number of vehicles are running on the road 12. In the situation shown in FIGS.9A and 9B, vehicles 80 to 88 are running on the road 12 connecting the first station 10 and the second station 11. In this situation, each of the vehicles 80 to 88 passes an oncoming vehicle at one of the double-track parts 16, and thereafter passes a vehicle succeeding the oncoming vehicle at the subsequent double-track part 16.

Specifically, after the vehicles 80 and 86 have passed each other on the double-track part 16, as shown in FIG.9A, the vehicle 87 stopping at the second station 11 is selected as a control-objective vehicle of the vehicle 80 and the vehicle

80 is selected as a control-objective vehicle of the vehicle 87. Similarly, after the vehicles 81 and 85 have passed each other on the double-track part 16₃, the vehicle 86 is selected as a control-objective vehicle of the vehicle 81 and the vehicle 81 is selected as a control-objective vehicle of the vehicle 86. Further, after the vehicles 82 and 84 have passed each other on the double-track part 16₁, the vehicle 85 is selected as a control-objective vehicle of the vehicle 82 and the vehicle 82 is selected as a control-objective vehicle of the vehicle 85.

Thus, as shown in FIG.9B, the vehicles 80 and 87 pass each other on the double-track part 16₆, the vehicles 81 and 86 pass each other on the double-track part 16₄, and the vehicles 82 and 85 pass each other on the double-track part 16₂. After the situation shown in FIG.9B, each of the vehicles 80 to 88 passes an oncoming vehicle at one of the double-track parts 16, with the oncoming vehicle being selected as a control-objective vehicle in a similar manner as described above.

As mentioned above, each of the vehicles 80 to 88 can run between the first station 10 and the second station 11 without stopping. When a vehicle has reached the first station 10 or the second station 11, this vehicle stops while other vehicles run over two blocks. While the vehicle is stopping at the station, passengers can get on or off the vehicle. Thus, according to the present embodiment, the vehicles can run on the road 12 having the single-track parts 14 without a necessity of stopping between the stations to pass oncoming vehicles on the double-track parts 16.

In the present embodiment, a running state of each vehicle running between the first station 10 and the second station 11 is controlled based on a predetermined program so that the vehicles are decelerated when they approach the first station 10 or the second station 11. Additionally, the vehicles are decelerated in response to the control signals transmitted

from the management center 18. Thus, according to the present embodiment, it is unnecessary to provide signal lamps on the road 12 for controlling the running states of the vehicles. Thus, according to the present embodiment, it is possible to simplify
5 the running control system of vehicles.

In the present embodiment, in a situation where the vehicle 50 reaches the target position earlier than the oncoming vehicle 52, the vehicle 50 is decelerated so that the vehicle 50 and 52 simultaneously reach the target position, as mentioned
10 above. However, it is also possible that the oncoming vehicle 52 is accelerated or the vehicles 50, 52 are decelerated and accelerated respectively, so that the vehicles 50, 52 simultaneously reach the target position in the above-mentioned situation.

15 Additionally, in the present embodiment, the vehicle 50 is decelerated when the vehicle 50 is close to the preceding vehicle 54 so that the vehicle 50 reaches the target position at the time when the preceding vehicle 54 subsequently reaches a double-track part 16. However, it is also possible that the
20 preceding vehicle 54 is accelerated.

The present invention is not limited to these embodiments, but variations and modifications may be made without departing from the scope of the present invention.



WHAT IS CLAIMED IS

5

1. A vehicle running management method for managing running states of vehicles running on a road having single-track parts and double-track parts, comprising:

10 a step (a) for detecting positions of first and second vehicles which are approaching each other;

a step (b) for determining whether or not said first and second vehicles are the closest vehicles to each other within a predetermined range ahead of each other based on said detected positions;

15 a step (c) for setting a target position to be a double-track part which is situated between said first and second vehicles when it is determined that said first and second vehicles are the closest vehicles to each other within the predetermined range ahead of each other; and

20 a step (d) for controlling speeds of said first and/or second vehicles so that said first and second vehicles reach said target position substantially at the same time.

25

2. The vehicle running management method as claimed in claim 1, wherein said step (c) sets said target position to be a double-track part which is closest to a middle position
30 between said first and second vehicles.

3. The vehicle running management method as claimed in claim 1, wherein said step (d) comprises:



a step (e) for calculating times required by said first and second vehicles to reach said target position;

a step (f) for calculating a time at which one of said first and second vehicles which one requires a longer time
5 to reach said target position than the other vehicle reaches said target position; and

a step (g) for controlling a speed of said other vehicle so that said other vehicle reaches said target position substantially at the time calculated in said step (f).
10

4. The vehicle running management method as claimed
15 in any one of claims 1 to 3, further comprising:

a step (h) for detecting a position of a third vehicle which runs ahead of said first vehicle in the same direction as said first vehicle;

a step (i) for determining whether or not said third
20 vehicle is the closest vehicle to said first vehicle within said predetermined range ahead of said first vehicle based on said detected positions of said first and third vehicles;

a step (j) for, when it is determined that said third vehicle is the closest vehicle to said first vehicle within said
25 predetermined range ahead of said first vehicle, setting a target position to be a first double-track part which is situated backward from a second double-track part which said third vehicle will subsequently reach, at least one double-track part existing between said first and second double-track parts;

a step (k) for calculating a time at which said third
30 vehicle will reach said second double-track part; and

a step (L) for controlling a speed of said first vehicle so that said first vehicle reaches said target position



at the time calculated in said step (k).

5

5. A vehicle running assisting apparatus provided in a vehicle running on a road having single-track parts and double-track parts, comprising

10 a transmitter which transmits vehicle information;
a receiver which receives information including a specific double-track part situated ahead of the vehicle and a target time at which said vehicle should reach said specific double-track part; and

15 a running controller which controls a running state of the vehicle so that the vehicle reaches said specific double-track part at said target time.

20

6. A vehicle running management system for managing running states of vehicles running on a road having single-track parts and double-track parts, comprising:

25 a management center which transmits a signal indicating a target time and a target position of each vehicle;
a receiver provided in each vehicle which receives said signal; and

30 a running controller provided in each vehicle which controls a speed of the vehicle so that the vehicle reaches said target position substantially at the target time.



7. The vehicle running management system as claimed in claim 6, wherein said management center comprises:

5 a position detector which detects positions of first and second vehicles which are approaching each other;

a determining part which determines whether or not said first and second vehicles are the closest vehicles to each other within a predetermined range ahead of each other based on said detected positions;

10 a target position setting part which sets said target position to be a double-track part which is situated between said first and second vehicles when it is determined that said first and second vehicles are the closest vehicles to each other within the predetermined range ahead of each other; and

15 a target time setting part which sets said target time of said first and second vehicles to be the substantially same time.

20

8. The vehicle running management system as claimed in claim 7, wherein said target time setting part sets said target time of said first and second vehicles to be a time at
25 which one of said first and second vehicles requiring a longer time to reach said target position than the other reaches said target position.

30

9. The vehicle running management system as claimed in claim 7 or 8, further comprising:



a second position detector which detects a position of a third vehicle which runs ahead of said first vehicle in the same direction as said first vehicle;

5 a second determining part which determines whether or not said third vehicle is the closest vehicle to said first vehicle within said predetermined range ahead of said first vehicle based on said detected positions of said first and third vehicles;

10 a second target position setting part which sets said target position of said first vehicle to be a first double-track part which is situated backward from a second double-track part which said third vehicle will subsequently reach, at least one double-track part existing between said first and second double-track parts, when it is determined that said third
15 vehicle is the closest vehicle to said first vehicle within said predetermined range ahead of said first vehicle; and

a second target time setting part which sets said target time of said first vehicle to be a time at which said third vehicle will reach said first double-track part.