

## **SIGNALING SYSTEM AND DOOR CONTROL METHOD**

### **Technical Field**

[0001]

The present invention relates to a signaling system and a door control method, and especially, to a signaling system and a door control method, in which a moving vehicle travels on a track.

### **Background Art**

[0002]

A moving vehicle (a train) traveling on a track as in a new transportation system and a railway is known. A signaling system which controls the traveling of such a moving vehicle is known. The conventional signaling system is of a central supervisory control-type. In the central supervisory control-type signaling system, devices for a main safety function (a protection function) are concentrates in a control center and the traveling states of trains in a whole railroad division are grasped and managed, in order to realize a function safety. The devices for the safety function (protection devices) contain an interlocking device, an ATP (Automatic Train Protection) ground device, and a station control device.

[0003]

FIG. 1A and FIG. 1B are block diagrams showing the configuration of a conventional signaling system. The conventional signaling system is divided into a control center, (a group of) trains, stations and railroad tracks. The control center grasps and manages the operation states of trains in the whole railroad division, to realize the function safety. The control center contains an operation control device 230, an ATP ground device 232, a station

control device 234 and an interlocking device 236. The respective devices are mutually connected by an exclusive-use LAN (Local Area Network) 238 to be bi-directionally communicable. The operation control device 230 controls the whole operation. The interlocking device 236 carries out the protection of traveling routes of the trains. The ATP ground device 232 prevents a collision between the trains. The station control device 234 attains the function safety of the opening/closing control of the doors of a platform screen door and a train at a station.

[0004]

Each of the (group of) trains is provided with an on-board device 210. The on-board device 210 controls the operation of the train based on the control of the control center. The on-board device 210 is connected with the ATP ground device 232 by the exclusive-use LAN 250 to be bi-directionally communicable. The station is provided with a remote I/O 220. The remote I/O 220 carries out the opening/closing control of the platform screen door 240 and the control of railroad switches 250 on the railroad track based on the control of the control center. The remote I/O 220 is connected with the station control device 234 and the interlocking device 236 by an exclusive-use LAN 252 to be bi-directionally communicable.

[0005]

The operation of this conventional signaling system (the operation of a train) is as described below, for example, with reference to FIG. 1A.

When a departure time of an optional train comes gets closer based on the train diagram, the operation control device 230 refers to the on-rail state 205 from the ATP ground device 232 to check the on-rail state in the railroad division. When

determining that the on-rail state indicates that the train is possible to depart, the operation control device 230 issues a departure command (or a traveling route request) 206 to the train.

[0006]

When receiving the departure command (or the traveling route request) 206, the interlocking device 236 refers to the on-rail state 205 in the railroad division to be received from the ATP ground device 232 at a constant period and issues a command to the remote I/O 220 such that the railroad switches (branches) 250 in an object section for which the train travels, become coincident with the direction of a traveling route. The remote I/O 220 controls the railroad switches (branches) 250 in the object section for which the train travels, to be switched to the traveling route direction. The interlocking device 236 locks the railroad switches (branches) 250 after the switching. As a result, the traveling route of the train is exclusively established (traveling route control 201). The other train never travels on the traveling route. The interlocking device 236 outputs the state of such a traveling route to the ATP ground device 232 at a constant period as a traveling route state 207.

[0007]

The ATP ground device 232 always monitors a train position by using a latest train position 204 received from detectors arranged on the railroad track and the train. The ATP ground device 232 outputs the on-rail state 205 in the railroad division which is based on the monitoring result, to the interlocking device 236 at a constant period. Also, the ATP ground device 232 refers to the traveling route state 207 received from the interlocking device 236 at a constant period, outputs a traveling permission 202 to

the train for which the traveling route is established, while considering to keep a safety distance from a preceding train. The train generates a speed profile to a traveling permission limit position when receiving the traveling permission 202, and starts to travel under the speed control to be carried out while referring to the profile.

[0008]

The station control device 234 receives a train state 208 (the state in which the operation is perfectly stopped and a brake is working) through the ATP ground device 232, after the train has arrived at a station. At the same time, the station control device 234 checks a door state of a platform screen door 240 through the remote I/O 220. After it is confirmed that it is possible to open doors of the train and the platform screen door 240, the station control device 234 issues a door opening command 203 to (the on-board device 210 of) the train through the ATP ground device 232. At the same time, the station control device 234 issues a door opening command 203 to the platform screen door 240 through the remote I/O 220.

[0009]

In this way, in the conventional signaling system, for example, the traveling route control is carried out by the interlocking device 236 to establish the traveling route of the train, and the train interval protection for issuing the traveling permission of the train is carried out by the ATP ground device 232. In other words, in the conventional signaling system, the traveling route control and the train interval protection are carried out by different systems.

[0010]

This method is a method proved based on

results but having a problem described below. For example, the method has a processing system in which the protection functions are independent from each other, as mentioned above. Therefore, the conventional signaling system has a redundant configuration. Therefore, considering the system configuration while paying attention to the safety of the signaling system, it is not possible to step out from the above configuration and there is a limit in the cost reduction.

[0011]

Also, when the signaling system is introduced, the operation control device 230, the interlocking device 236, the ATP ground device 232, and the station control device 234 become necessary to control the operations of all the trains in the whole railroad division regardless of a railroad division scale and the details of the train operation. These are a minimum configuration when the signaling system is configured, and there is a limit in reduction of an introduction cost.

[0012]

Especially, the operation control device 230, the ATP ground device 232, control device 234 and the interlocking device 236 control the operations of all the trains in the whole railroad division. Therefore, each device is allocated with a very large load. For this reason, each device is extremely large in size and is expensive. Therefore, a technique is demanded in which a space for the device can be reduced, an introduction cost can be reduced, and the handling of equipments is easy.

[0013]

Moreover, the operation (the opening/closing operation of doors) in this conventional signaling system is as described below with reference to FIG.

1B.

When a train has stopped at a station, the on-board device 210 issues a fixed point stop signal 261 to the ATP ground device 232. The ATP ground device 232 transfers the fixed point stop signal 261 to the station control device 234 and the interlocking device 236. Moreover, the on-board device 210 transmits through the ATP ground device 232 to the interlocking device 236, a brake operating/power running off signal 262 indicating that the brake is operated in the train so that the power running is in an off condition (a condition that the train is stopped and does not travel).

[0014]

The interlocking device 236 issues a door open permission signal 263 to the platform screen door 240 of the station based on an AND condition of the above two signals (the fixed point stop signal 261 and the brake operation/power running off signal 262). The platform screen door 240 is set to the state that the lock state of the doors is released to allow them to be opened, in response to the door open permission signal.

[0015]

On the other hand, the station control device 234 enters a timer count mode after receiving the fixed point stop signal 261, and issues a door open command signal 264 to the platform screen door 240 after the timer counts out. The platform screen door 240 opens the doors in response to the door open command signal 264 after receiving the door open permission signal 263.

[0016]

The flow of these signals is based on the view point of the function safety. The system is divided into two different types of processing: the

processing for releasing the lock state of the doors (security system: containing the interlocking device 236) and the processing for opening the doors (non-security system: containing the station control device 234). Moreover, as another phase, the processing is distributed into the interlocking device 236 and the station control device 234 for the load distribution of a series of door open sequences.

[0017]

This system is a control system having good performance but has a problem described below. Because the function has to be realized by making the devices provided in the control center (such as the ATP ground device 232, the station control device 234, and the interlocking device 236) cooperate, the transmission paths for information necessary for the sequences increases so that it takes a long time for the processing to the door open command. Therefore, it takes the long time from a time when a train arrives at a station to a time when the doors are opened, which has an influence on a transportation capacity of the train system. In order to output the door open permission signal and the door open command signal from the different devices to the identical platform screen door 240, the transmission timing of the door open command signal must be adjusted by use of a timer so that the door open permission signal is transmitted earlier than the door open command signal. A technique is demanded that can reduce the processing time for the opening and closing of the doors of the train.

[0018]

As a related art, JP 2012-96704A discloses a radio train control system and a radio train control method. The radio train control system includes a central device, a station control device provided for

each railroad station and connected with the central device to be communicable, an on-board device provided in each train and connected with the station control device to be radio-communicable in a radio communication area of a station and a periphery of the station. In this radio train control system, the on-board device includes transmission means for transmitting position information to the station control device. The station control device includes main operation means for receiving the position information from the on-board device, storing on-rail information showing that the train is on a rail every partitioning section, transmitting the on-rail information to the central device, receiving instruction information from the central device, and controlling devices in the station based on the instruction information. The central device includes main operation means for determining a traveling permission range of each train based on the on-rail information received from the station control device and transmitting instruction information to the station control device. Moreover, the station control device further includes advance data storing means for setting advance data showing that the train advanced into the station, to a inerasable state when cannot be normally communicated with the central device. The central device includes return means for receiving all the advance data from the station control device and returning to a main use operation from a temporary use operation after the partitioning sections where all the trains are present are determined.

[0019]

Also, JP 2012-131324A discloses an operation security method and an operation security system. The operation security method is a method by the operation security system which includes 1) a control device

which manages an occupation state in each closed section, 2) a railroad switch control device which controls a railroad switch, and 3) an on-board device which is loaded into a train and carries out an interlocking control of the configuration of a traveling schedule route based on each closed section and position information of the railroad switch. The method includes a securement request step in which the on-board device transmits a securement request signal to the control device to request the occupation securement of the closed sections of a traveling schedule route; an occupation securing step in which the control device carries out a determination of whether or not all of the closed sections of the traveling schedule route meet a predetermined occupation possible condition, based on the securement request signal, sets all the closed sections to occupation existence when meeting the predetermined occupation possible condition, and transmits a securement signal to the on-board device; a first switching instruction step in which the on-board device transmits a switching instruction signal to a switch control device for a switch on the traveling scheduled route when receiving the securement signal; a switching step in which the switch control device carries out the switch and lock operation to transmits a switching completion signal to the on-board device when receiving the switching instruction signal; a traveling permission step in which the on-board device permits the traveling to the traveling scheduled route when receiving the switching completion signal; a release request step in which the on-board device transmits a release request signal to request the occupation release of the closed section which the train has traveled; and an occupation release step in which the control device releases the occupation of a

target closed section based on the release request signal.

[0020]

Also, JP 62-60308A discloses an automatic train operation control system. The automatic train operation control system stops a train at a fixed position of a platform of a station and carries out the opening/closing control by making the train and the platform screen door cooperate. The automatic train operation control system includes an automatic operation ground unit which is provided on a ground side to transmit a fixed position stop signal of the train through a transmission and reception unit, a station platform screen door, a ground loop line which is provided in a fixed position stop section of the train to transmit the above fixed position stop signal, the transmission and reception unit which is provided on the train to transfer a control signal to the ground-side units, a speed generator which is provided on the train to detect a train speed, and an on-board automatic operation unit which is provided on the train to generate a fixed position stop pattern in response to the fixed position stop signal and to control a brake control unit by receiving the detected speed from the speed generator so that the train speed follows the fixed position stop pattern. In an automatic operation control method, a last loop section of the above ground loop line is provided in a fixed position stop permission range, the last loop section of the ground loop line is used for transmission of a fixed position stop confirmation signal from the automatic operation on-board unit to the automatic operation ground unit and for transmission of an on-board door opening/closing command from the automatic operation ground unit to the automatic operation on-board unit based on the

reception of the fixed position stop confirmation signal.

**Citation list**

[0021]

[Patent literature 1] JP 2012-96704A

[Patent literature 2] JP 2012-131324A

[Patent literature 2] JP 62-60308A

**Summary of the Invention**

[0022]

Therefore, an object of the present invention is to provide a signaling system and a door control method, in which a space for devices and so on can be reduced. Also, another object of the present invention is to provide a signaling system and a door control method, in which an introduction cost can be reduced. Still another object of the present invention is to provide a signaling system and a door control method, in which the treatment of devices becomes easier. Another object of the present invention is to provide a signaling system and a door control method, in which a time taken for a door opening/closing process of a train can be reduced.

[0023]

A signaling system of the present invention includes an on-board device, a station interface device, and a platform screen door. The on-board device is provided in a moving vehicle traveling on a track. The station interface device is provided in a station along the track. The platform screen door is provided in the station and controlled by the station interface device. When the moving vehicle has stopped at the station, the on-board device outputs a door open permission command to instruct release of a lock state. The station interface device releases the lock

state of the platform screen door in response to the door open permission command. After the lock state is released, the on-board device outputs a door open command to instruct the opening of the doors of the platform screen door. The station interface device opens the doors of the platform screen door in response to the door open command. The on-board device opens the doors of the moving vehicle.

[0024]

In the above-mentioned signaling system, the on-board device may release the lock state of the doors of the moving vehicle in response to the opening of the platform screen door. The on-board device opens the doors of the moving vehicle in response to the release of the lock state of the doors of the moving vehicle.

[0025]

In the above-mentioned signaling system, the on-board device may detect that the moving vehicle has stopped at the station. The on-board device may output a power running off command and a brake operation command in response to the detection of the stop. The on-board device may detect a power running turning off and a brake operation.

[0026]

A door control method of the present invention is a door control method using a signaling system. This signaling system includes an on-board device provided for the moving vehicle traveling on a track, a station interface device provided for a station along the track, and a platform screen door provided for the station and controlled by the station interface device. The door control method includes outputting a door open permission command by the on-board device to instruct a release of a lock state of the platform screen door when the moving vehicle has

stopped at the station; releasing the lock state of the platform screen door by the station interface device in response to the door open permission command; outputting a door open command by the on-board device to instruct the opening of the doors of the platform screen door, after the lock state is released; opening the doors of the platform screen door by the station interface device in response to the door open command; and opening doors of the moving vehicle by the on-board device.

[0027]

In the above-mentioned door control method, the opening the doors of the moving vehicle includes releasing the lock state of the doors of the moving vehicle by the on-board device in response to the opening of the platform screen door; and opening the doors of the moving vehicle by the on-board device in response to the releasing the lock state of the doors of the moving vehicle.

[0028]

The above-mentioned door control method includes detecting by the on-board device that the moving vehicle has stopped at the station; outputting a power running off command and a brake operation command by the on-board device in response to the detection of the stop; and detecting the power running turning off and the brake operation in response to the release of the lock state of the doors of the moving vehicle.

[0029]

The present invention can reduce the space for the devices and so on. Also, in the present invention, the introduction cost can be reduced. Moreover, in the present invention, the handling of equipments becomes easy. Moreover, in the present invention, the reduction of the time which the process

of the opening and closing of the doors of the train takes becomes possible.

### **Brief Description of the Drawings**

[0030]

The object and other objects, advantages and features of the present invention could be understood in detail from the description of the following embodiments (examples), with reference to the drawings.

[FIG. 1A]

FIG. 1A is a block diagram showing a configuration of a conventional signaling system.

[FIG. 1B]

FIG. 1B is a block diagram showing a configuration of a conventional signaling system.

[FIG. 2]

FIG. 2 is a block diagram showing a configuration of a signaling system according to a first embodiment.

[FIG. 3]

FIG. 3 is a block diagram showing a configuration example of the signaling system according to the first embodiment.

[FIG. 4A]

FIG. 4A is a block diagram showing a configuration example of a control device of an on-board device in the signaling system according to the first embodiment.

[FIG. 4B]

FIG. 4B is a block diagram showing a configuration example of a control device of a station I/F device in the signaling system according to the first embodiment.

[FIG. 5A]

FIG. 5A is a block diagram showing the

configuration of a storage unit of the on-board device in the signaling system according to the first embodiment.

[FIG. 5B]

FIG. 5B is a block diagram showing the configuration of a storage unit of the station I/F device in the signaling system according to the first embodiment.

[FIG. 5C]

FIG. 5C is a block diagram showing a configuration of a storage unit of an operation control device in the signaling system according to the first embodiment.

[FIG. 6]

FIG. 6 is a diagram schematically showing a configuration example of a railroad line to which the signaling system according to the first embodiment is applied.

[FIG. 7]

FIG. 7 is a diagram schematically showing a scene of a train interval protection in case of inter-station traveling of a train in an intermediate station portion.

[FIG. 8]

FIG. 8 is a flow chart showing an operation when the on-board device of the train communicates with other device.

[FIG. 9A]

FIG. 9A is a flow chart showing an operation of the train interval protection in case of the inter-station traveling of the train in the intermediate station portion.

[FIG. 9B]

FIG. 9B is a flow chart showing an operation when the on-board device of the train carries out branch release of the station I/F device.

[FIG. 10]

FIG. 10 is a block diagram showing a configuration example of a door control section of the control device of the on-board device in the signaling system according to a second embodiment.

[FIG. 11]

FIG. 11 is a block diagram showing a configuration example of the control device of the station I/F device of the signaling system according to the second embodiment.

[FIG. 12]

FIG. 12 is a flow chart showing the control of the opening/closing the doors according to the second embodiment.

#### **Description of the Embodiments**

[0031]

Hereinafter, a signaling system according to embodiments of the present invention will be described with reference to the attached drawings.

In this signaling system, a protection function, which is achieved by a protection device (of an interlocking device, an ATP ground device, and a station control device) in the conventional signaling system, is provided in an on-board device of a moving vehicle (a train) in a different configuration. As a result, the on-board device judges traveling route securement autonomously and determines a traveling route (establishing a traveling route autonomously and permitting the traveling autonomously), and the train interval protection can be autonomously carried out. Thus, the reduction of a device load in a control center, the reduction of a device space, the reduction of an introduction cost, and the easy handling of equipments are realized. Hereinafter, the respective embodiments will be described in detail.

[0032]

[First Embodiment]

#### 1. Configuration

The configuration of a signaling system according to a first embodiment of the present invention will be described. FIG. 2 is a block diagram showing the configuration of the signaling system according to the present embodiment. The signaling system 1 is divided into sections of a control center 4, (a group of) trains 2, stations 3 and railroad tracks 50.

[0033]

The control center 4 grasps an operation state of the trains 2 in the whole of railroad divisions. The control center 4 is provided with an operation control device 30. The operation control device 30 is connected with (on-board devices 10 of) the trains 2 and (station interface devices 20 of) the stations 3 through a general-purpose LAN 60 to be communicable bi-directionally. The operation control device 30 receives data of the trains 2 (e.g. train positions 101) from the trains 2, receives data of platform screen doors, train doors and railroad switches (e.g. door states 106, and railroad switch switching positions 104) from the stations 3, and displays them on a display unit (not shown). Also, the operation control device 30 sets an operation mode 105 and a train diagram of the train 2, and transmits them to the trains 2 and the stations 3. The operation mode 105 is exemplified by a normal mode in which a usual operation is carried out, and a failure mode in which a failure has occurred on a track. Any devices which have functions of the operation control device 230, the ATP ground device 232, the station control device 234, and the interlocking device 236, which are shown in FIG. 1, are not arranged in the

control center 4.

[0034]

There are a plurality of trains 2. Each train 2 grasps an operation state of each of neighbor trains 2, manages its own operation, and realizes a function safety. The train 2 is provided with the on-board device 10. The on-board device 10 is connected with (a station I/F device 20 of) each of the stations 3 through the general-purpose LAN 60 to be communicable bi-directionally. The on-board device 10 checks through the station 3, a railroad switch switching position 104 indicating a switching position of each of railroad switches, and controls the protection of a traveling route of the train 2 by carrying out a switching control 102 to switch the railroad switches according to necessity. Moreover, the on-board device 10 controls the collision prevention with a preceding train or a succeeding train by communicating with the preceding and succeeding trains 2. Moreover, the on-board device 10 carries out a door opening/closing control 103 to open or close the train door and the platform screen door in the station 3, to attain a function safety of the train door and the platform screen door. In this way, the on-board device 10 is provided with the protection function that has been attained by the protection device (of the interlocking device, the ATP ground device, and the station control device) in the conventional signaling system, in a different form. Therefore, the interlocking device, the ATP ground device, and the station control device can be removed from the devices of the control center 4.

[0035]

There are a plurality of stations 3. Each of the stations 3 carries out the opening/closing of the platform screen door 40 and the switching of the

railroad switches 51 on the railroad track 50. The station 3 is provided with the station I/F device (station interface device) 20. The station I/F device 20 controls the opening/closing of the platform screen door 40 based on the control of the on-board device 10. Moreover, the station I/F device 20 controls the switching of the plurality of railroad switches 51 on the railroad track 50 on the inbound side and the outbound side in the neighborhood of the station 3 based on the control of the on-board device 10. Moreover, the station I/F device 20 manages a switching request to the railroad switches 51 from each train 2. When the requests compete, the station I/F device 20 does not accept the later switching request.

[0036]

FIG. 3 is a block diagram showing a configuration example of the signaling system according to the present embodiment. The operation control device 30 of the control center 4 is provided with a center control device 31, a center storage unit 32 and a center communication device 33. The center control device 31 is an information processing device which is exemplified by a computer, and is provided with a CPU (Central Processing Unit), a storage section, an input section, an output section and an interface, which are not shown. The center control device 31 executes information processing for the operation control device 30. The center storage unit 32 is a storage unit which is exemplified by a hard disk drive, RAM (Random Access Memory) and ROM (Read Only Memory), and stores data and a software program which are used in the center control device 31, and data and a software program which are outputted from the center control device 31. The center communication device 33 is a radio LAN transmitting

and receiving unit which carries out a data communication through the general-purpose LAN 60. The center communication device 33 transmits data and the software program which are outputted from the center control device 31, to the on-board device 10 and the station I/F device 20, and receives data and the software program which are transmitted from the on-board device 10 and the station I/F device 20 to output to the center control device 31.

[0037]

The general-purpose LAN 60 is provided with a plurality of base stations 61. The plurality of base stations 61 are arranged in the control center 4 and each station 3 and at a plurality of locations along the railroad track 500. The base station 61 mediates a radio communication among the operation control device 30, the plurality of the on-board devices 10 and the plurality of the station I/F devices 20 to allow data to be sent and received among them. Note that in the present embodiment, an example using the radio LAN as the communication means is shown. However, different communication means may be used if it is possible to send and receive data among them.

[0038]

The on-board device 10 of the train 2 is provided with a control device 11, a storage unit 12 and a communication device 13. The control device 11 is an information processing device which is exemplified by a computer, and is provided with a CPU, a storage section, an input section, an output section and an interface, which are not shown. The control device 11 executes information processing for the on-board device 10. The storage unit 12 is a storage which is exemplified by a hard disk drive, RAM and ROM, and stores data and a software program which are used in the control device 11, and data and a software

program which are outputted from the control device 11. The communication device 13 is a radio LAN transmitting and receiving unit which carries out a data communication through the general-purpose LAN 60. The communication device 13 transmits the data and the software program which are outputted from the control device 11, to the on-board device 10 of the operation control device 30, and another train 2, the station I/F device 20, and receives the data and the software program which are transmitted from the on-board device 10 of the operation control device 30, the other train 2 and the station I/F device 20 to output to the control device 11.

[0039]

Moreover, the train 2 is provided with a rotation count sensor 18 and a receiver 19. The rotation count sensor 18 detects the number of rotations of a wheel and a time change of them to output to the control device 11. The control device 11 calculates a position and speed of the train 2 based on the number of rotations and the time change of it. However, because the calculation of the position is carried out by integrating the number of rotations of the wheel, there is a possibility that an error comes out to an extent in case of a long-range integration due to the influences such as slip and tire abrasion. Therefore, a track antenna beacon (a transponder) 52 is installed in the railroad track 50 at a predetermined interval and the position is corrected every time the data of the track antenna beacon 52 is received, to prevent the accumulation of the error.

[0040]

The station I/F device 20 of the station 3 is provided with a station control device 21, a station storage unit 22 and a station communication device 23.

The station control device 21 is an information processing unit which is exemplified by a computer, and is provided with a CPU, a storage section, an input section, an output section and an interface, which are not shown. The station I/F device 20 executes information processing for the station I/F device 20. The station storage unit 22 is a storage unit which is exemplified by a hard disk drive, RAM and ROM, and stores data and a software program which are used in the station control device 21, and data and a software program which are outputted from the station control device 21. The station communication device 23 is a radio LAN transmitting and receiving unit which carries out a data communication through the general-purpose LAN 60, transmits the data and the software program which are outputted from the station control device 21, to the operation control device 30, the on-board device 10 and the station I/F device 20 of the other station 3, and receives the data and the software program, which are transmitted from the operation control device 30, the on-board device 10 and the station I/F device 20 of the other station 3, to output to the station control device 21.

[0041]

Moreover, the station 3 is provided with the platform screen door 40. The station control device 21 detects a state of the platform screen door 40 and controls the opening/closing of the platform screen door 40. Moreover, the station control device 21 is connected with the plurality of railroad switches 51 (a plurality of branches) on the railroad track 50, which are arranged in the neighborhood of the station 3. The railroad switch 51 is a branch of the railroad track 53. The station control device 21 detects the state of each of the plurality of railroad switches 51 and controls the switching of each of the plurality of

railroad switches 51.

[0042]

Next, the control device of the on-board device 10 will be more described. FIG. 4A is a block diagram showing a configuration example of the control device of the signaling system according to the present embodiment. In the control device, for example, the CPU develops a computer program installed in the hard disk drive through an interface from a recording medium, in RAM (Random Access Memory). Then, the CPU executes the developed computer program, and realizes information processing of the computer program while controlling a hardware configuration such as the storage section, the input section, the output section, the interface, the storage unit 12 and the communication device 13 according to necessity. The storage section and the storage unit 12 record the computer program and record the data used by the CPU and the generated data. The input section outputs the data generated through operation by the user and another device to the CPU and the storage section. The output section outputs the data generated by the CPU and the data stored in the storage section to the user and the other apparatus to be recognizable.

[0043]

The control device 11 grasps the operation states of neighbor trains 2, manages its own operation and carries out a control for realizing a function safety. The control device 11 is provided with a traveling route securement determining section 70, a traveling determining section 80, a train traveling control section 90 and a door control section 120. The traveling route securement determining section 70, the traveling determining section 80, the train traveling control section 90 and the door control section 120 are realized by the computer program, or

by cooperation between the computer program and the hardware configuration.

[0044]

The traveling route securement determining section 70 carries out a control for the protection of a traveling route of the train 2 itself. That is, the traveling route securement determining section 70 checks the securement of the traveling route based on station related data (to be described later) and different train related data (to be described later). Specifically, the traveling route securement determining section 70 checks the railroad switch switching position showing the switching position of the railroad switch 51 through the station 3, and carries out the switching control to switch the railroad switch 51 according to necessity. The traveling route securement determining section 70 is provided with an operation mode checking section 71, a different train state checking section 72, a station state checking section 73 and a traveling route establishing section 74. The operation mode checking section 71 checks the operation mode. The different train state checking section 72 acquires the different train related data and checks the state of a different train 2. The station state checking section 73 acquires the station related data and checks the state of the station (e.g. the switching position of the railroad switch 51 (a branch state)). The traveling route establishing section 74 switches the switching position of the railroad switch 51 according to necessity and establishes (secures) the traveling route for the train 2.

[0045]

The traveling determining section 80 carries out a control for the collision prevention among the trains 2. That is, the traveling determining section

80 determines the traveling of the moving vehicle on the traveling route which was secured based on the different moving vehicle related data. Specifically, the traveling determining section 80 communicates with the neighbor train 2 and grasps a range where the train 2 itself is permitted to pass or travel, and permits the passage of the train 2 in the range (determines the traveling of the train 2 itself). The traveling determining section 80 is provided with a traveling permission limit position checking section 81. The traveling permission limit position checking section 81 checks a traveling permission limit position of the train 2. Here, the traveling permission limit position shows a limit position where the traveling (moving) is permitted to the targeted train 2 (e.g. distance from a reference point, or distance to a preceding train).

[0046]

The train traveling control section 90 carries out a control for the train 2 to move (travel) based on a train diagram of the train 2, a position of the train 2, and the traveling permission limitation position. The train traveling control section 90 is provided with a traveling section 91, a speed profile generating section 94 and a train diagram checking section 95. The traveling section 91 drives the train 2 to travel. The train diagram checking section 95 checks the train diagram of the train 2 and issues a departure command at a departure time. The speed profile generating section 94 generates a speed limit profile showing an upper limit value of speed when traveling from a current station at which the train 2 is in a stop state to a next stop station, based on a distance from the targeted train 2 to the traveling permission limitation position.

[0047]

The door control section 120 carries out a control for the function safety of the doors of the train 2 and the platform screen door by controlling the opening/closing of the doors of the train 2 and the platform screen door 40 in the station 3.

[0048]

Next, the station control device 21 of the station I/F device 20 will be more described. FIG. 4B is a block diagram showing a configuration example of the station control device 21 of the signaling system according to the present embodiment. In the station control device 21, for example, the CPU develops the computer program installed in the hard disk drive through an interface from a storage medium, in the RAM. Then, the CPU execute the developed computer program, and realizes information processing of the computer program while controlling a hardware configuration such as a storage section, an input section, an output section, an interface, the station storage unit 22, and the station communication device 23 according to necessity. The storage section and the storage unit 12 record the computer program and record data used by the CPU and the generated data. The input section outputs the data generated through the operation by the user and the other device to the CPU and the storage section. The output section outputs the data generated by the CPU and the data of the storage section to the user and the other devices to be recognizable.

[0049]

The station control device 21 controls the opening/closing of the platform screen door 40 and the switching of the railroad switch 51 of the railroad track 50. The station control device 21 is provided with a railroad switch operating section 25. The railroad switch operating section 25 is realized by

the computer program or the cooperation between the computer program and the hardware configuration.

[0050]

The railroad switch operating section 25 outputs the railroad switch switching position data showing a switching position of the railroad switch 51 in response to an inquiry of the station related data from the train 2. Also, the railroad switch operating section 25 determines whether the switching of the railroad switch 51 is possible or not, based on a railroad switch switching command from the train. When the railroad switch 51 has been locked in response to the railroad switch switching command from a different train 2, the railroad switch operating section 25 refuses the switching of the railroad switch 51. When the railroad switch 51 has not been locked, the railroad switch operating section 25 carries out the switching of the railroad switch 51 and retains the railroad switch switching command as a part of the railroad switch switching position data (stores in the station storage unit 22). While the railroad switch switching command is retained, the switching state of the railroad switch 51 is maintained (locked). In this case, the railroad switch operating section 25 erases the railroad switch switching command based on a railroad switch release command from a source side train 2. Thus, the lock state of the railroad switch 51 is released. The station control device 21 of the station I/F device 20 grasps whether or not there is a failure on the traveling route to the other station 3 which is neighbor to the station 3, based on an input from a user and a notice from the station I/F device 20 of the other station 3.

[0051]

Next, the main data which are stored in the

storage unit 12, the station storage unit 22 and the center storage unit 32 will be described.

[0052]

FIG. 5A is a block diagram showing the configuration of the storage unit 12 of the on-board device 10 of the signaling system according to the present embodiment. The storage unit 12 contains operation mode data 130, train diagram data 131, station related data 132, train related data 133 and basic data 134 at least.

[0053]

The operation mode data 130 contains data showing in what mode the train 2 travels. The operation mode data 130 is exemplified by the normal mode showing a usual operation and the failure mode showing a case where a failure has occurred on the track (it is the same as the operation mode 105 of FIG. 2). The operation mode data 130 is supplied from the operation control device 30 and is same for all the trains 2 on a railroad line.

[0054]

The train diagram data 131 contains data showing the train diagram of the train 2. The train diagram data 131 is supplied from the operation control device 30 and is different for every train 2. However, the train diagram data 131 may contain only the train diagram of the train 2 and the neighbor train 2. Or, the train diagram data may be data of an operation interval.

[0055]

When the train 2 is in a stop state, the station related data 132 contains data related to a current station (hereinafter, to be referred to as the station 3A) at which the train 2 is in the stop state, data related to the next station as the station 3 (hereinafter, to be referred to as the station 3B) for

the train to be stopped next, data related to a previous station as the station 3 (hereinafter, to be referred to as the station 3C) for the train to have been stopped last time. When the train 2 is traveling, the station related data 132 contains data related to the previous station as the station 3 for the train 2 to have departed and data related to the next station as the station 3. The station related data 132 is updated appropriately (e.g. regularly) and is different for every train 2. The station related data 132 contains the railroad switch switching position data and the inter-station section related data. The railroad switch switching position data shows a switching position of each of the plurality of railroad switches 51 which belongs to the targeted stations 3A, 3B and 3C (the previous station, the current station, the next station), and contains the railroad switch command data (to be described later) of each railroad switch 51. Moreover, the railroad switch switching position data may contain the locked state or the unlocked state of the railroad switch 51. The inter-station section related data shows whether or not there is a failure in an inter-station section (e.g. between the station 3A and the station 3B, between the station 3A and the station 3C) among the targeted stations 3A, 3B and 3C, and whether or not a different train is not in the on-rail state between the stations (the on-rail clearance between the stations).

[0056]

The train related data 133 contains data showing the moving (traveling) of the train 2 (hereinafter, to be referred to as the train 2A) and a different train 2 (hereinafter, to be referred to as the train 2B) around the train 2A and related to the traveling. The train related data 133 is updated

appropriately (e.g. regularly) and is different for every train 2. The train related data 133 contains train position data, traveling permission limit position data, arrival scheduled platform data, traveling direction data, traveling route data and traveling line data. The train position data shows a position (e.g. a distance from a reference point) of each of targeted trains 2 (the train 2A and the train 2B). The reference point is exemplified by a stop position in a starting station and a position of a track antenna beacon provided on the railroad track. The traveling permission limit position data shows a limit position for the targeted train 2 to be permitted to travel (move) (e.g. a distance from the reference point, a distance to a preceding train). The arrival scheduled platform data shows an arrival scheduled platform of the next station for the targeted train 2. The traveling direction data shows a traveling direction of the targeted train 2 (e.g. an inbound direction, an outbound direction, a branch direction). The traveling route data shows a traveling route of the targeted train 2. The traveling line data shows the traveling line (inbound line, outbound line) of the targeted train 2. Note that the arrival scheduled platform data, the traveling direction data, the traveling route data and the traveling line data can be called travel schedule data showing a schedule of travel of the train 2. Moreover, the train related data 133 may further contain the operation mode data and traveling route request time data. The operation mode data shows the operation mode of the targeted train 2. The traveling route request time data shows a time at which the targeted train 2 issues a traveling route request (switching request of the railroad switch 51) to the station I/F device 20.

[0057]

The basic data 134 contains data of a basic configuration of the trains 2, the railroad tracks 50 and so on. The train 2 on the railroad line retains common basic data 134. Here, because the vehicle characteristic is sometimes different for every vehicle, each train 2 retains vehicle characteristic data showing the vehicle characteristic of its own vehicle. The basic data 134 contains linear structure data, station stop position data, limit position data in case of a failure (for branch), and vehicle characteristic data. The linear structure data shows the structure of the railroad track 50, and is exemplified by a position, shape and distance of a curved railroad track, a position and distance of a linear railroad track, a grade of the railroad track, a position of a station, a branch position, existence or non-existence of double track, a position of the rail yard and so on. The station stop position data shows a stop position at every station. The branch limit position data shows a traveling limit position on a branch railroad track of the railroad track 50. The vehicle characteristic data shows structure characteristic and operation characteristic of the vehicle.

[0058]

FIG. 5B is a block diagram showing the configuration of the station I/F device 20 of the signaling system according to the present embodiment. The station storage unit 22 contains station in-station related data 142 at least.

[0059]

The station in-station related data 142 contains data related to the station 3. The station in-station related data 142 is different for every station 3. The station in-station related data 142

contains railroad switch switching position data and inter-station section related data. The railroad switch switching position data shows a switching position of each of a plurality of railroad switches 51 which belong to the station 3, and contains railroad switch command data of each railroad switch 51. The railroad switch command data shows the railroad switch switching command from the train 2 to each of the plurality of railroad switches 51 which belong to the station 3. The railroad switch switching command is a command which instructs the switching of the railroad switch 51, and is related with data of a command source side train 2 and is stored. While the railroad switch switching command is retained, the railroad switch 51 maintains (locks) the switching state. When the railroad switch switching command is erased in response to a railroad switch release command from the command source side train 2, the lock state of the railroad switch 51 is released. The inter-station section related data shows whether or not there is a failure between the station 3 and a neighbor station 3. The railroad switch command data and the inter-station section related data are transmitted to the on-board device 10 and the operation control device 30, and are stored as the station related data 132 and the center station related data 152.

[0060]

FIG. 5C is a block diagram showing the configuration of the center (CTR.) storage unit 32 of the operation control device 30 of the signaling system according to the present embodiment. The center storage unit 32 contains center (CTR.) operation mode data 150, center (CTR.) train diagram data 151, center (CTR.) station related data 152, center (CTR.) train related data 153 and center (CTR.)

basic data 154 at least.

[0061]

The center operation mode data 150 is the same as the operation mode data 130.

[0062]

The center train diagram data 151 contains data showing a train diagram of a railroad line and contains the train diagrams for all the trains 2. The train diagram data may be data of the operation interval.

[0063]

The center station related data 152 contains data related to all stations 3. The center station related data 152 contains the railroad switch switching position data and inter-station section related data of the station in-station related data 142 acquired from all the stations 3. The center station related data 152 are appropriately acquired from the station I/F devices 20 of all the stations 3.

[0064]

The center train related data 153 contains data related to the moving (traveling) of all the trains 2. The center train related data 153 contains the train position data, the traveling permission limit position data, the arrival scheduled platform data, traveling direction data, the traveling route data and the traveling line data of the train related data 133 acquired from all the trains 2. The center train related data 153 are appropriately acquired from the on-board devices 10 of all the trains 2.

[0065]

The center basic data 154 contains data of basic structures of the train 2, the railroad track 50 and so on. The center basic data 154 is the same as the basic data 134.

[0066]

## 2. Operation

Next, the operation of the signaling system according to the present embodiment will be described. In this case, as the operation of the signaling system, a train interval protection in case of traveling of the train 2 between the stations in the usual operation (the normal mode) will be described. [0067]

A configuration example of a railroad line to which the signaling system is applied will be described before the explanation of a specific operation.

FIG. 6 is a schematic diagram showing a configuration example of the railroad line to which the signaling system to according the present embodiment is applied. This railroad line is provided with a railroad track 50 and stations 3. The railroad track 50 is provided with a railroad track 53D, a railroad track 53U and crossovers 53M. The railroad track 53D is a railroad track of an outbound line provided between line ends 161. The railroad track 53U is a railroad track of an inbound line provided between tracks ends 161. The crossover 53M is a railroad track provided in the neighborhood of the station 3 to join the railroad track 53D and the railroad track 53U. A plurality of stations 3 are provided between the railroad track 53D and the railroad track 53U to have intervals. In this railroad line, an area of the station 3 which contains the tracks ends 161 is referred to as an end station portion 160 and an area of the station other than the end station portions 160 is referred to as an intermediate state portion 170. In the signaling system, in the intermediate station portion 170 of this traveling route, the traveling directions of the trains 2 in the inbound line 53U and the outbound line

53D are regarded to be fixed in the usual operation. Below, the operation of the signaling system in such a railroad line will be described.

[0068]

Next, a scene of the train interval protection in the configuration example of the railroad line of FIG. 6 will be described.

FIG. 7 is a diagram schematically showing the scene of the train interval protection in an inter-station traveling of the train in the intermediate station portion 170. In FIG. 7, the attention should be paid to the train 2A which travels between the stations in the intermediate station portion 170. It is supposed that the train 2A travels on the railroad track 53D of the outbound line. The station 3 at which the train 2A has been currently stopped is supposed to be a current station 3A, the station at which the train 2 stops next is supposed to be a next station 3B, the train 2 preceding to the train 2A is supposed to be a train 2B. The railroad switches 51 provided at the current station 3A are supposed to be the railroad switches 51A1 and 51A2 on the side of the railroad track 53D from the side near the station 3A, and are supposed to be the railroad switches 51A3 and 51A4 on the side of the railroad track 53U. The railroad switches 51 provided at the next station 3B are supposed to be the railroad switches 51B1 and 51B2 on the side of the railroad track 53D from the side near the station 3B and are supposed to be the railroad switches 51B3 and 51B4 on the side of the railroad track 53U.

[0069]

As mentioned above, in case of the usual operation, the traveling directions of the trains 2 in the inbound line 53U and the outbound line 53D are fixed in the intermediate station portion 170. That

is, the station I/F device 20 of each station 3 maintains the traveling route between the stations 3 to constant directions, and maintains the railroad switch switching positions of the railroad switches 51 in predetermined directions. The direction of the traveling route is expressed as the operation mode. In this case, it is the normal mode. The operation control device 30 notifies the operation mode to each train 2 through each station I/F device 20. The operation mode is never changed in principle if there is not the occurrence of a predetermined situation such as a failure. That is, it is presupposed that the train 2 travels on a single line (the railroad track 53D or the railroad track 53U) in the intermediate station portion 170 in the normal mode and does not cross on the railroad tracks 53 to the opposite side by using the crossover 53M. In other words, the inbound line (the railroad track 53U) and the outbound line (the railroad track 53D) are independent from each other. Therefore, in case of the normal mode, it is enough to consider only the train interval protection to the preceding train 2 on the single line in the intermediate station portion 170, for the train interval protection of the train 2. Here, the train 2 checks the passage direction of the railroad switch 51 and the inter-station section state, before traveling between the stations.

[0070]

Note that when it is necessary to cross to another railroad track as in the end station portion 160 (e.g. the time of folding or switching the mode), the traveling route control becomes necessary. That is, a different data communication route is necessary in addition to the intervals to the preceding train 2 and the succeeding train 2. Such a case will be described in a second embodiment.

[0071]

Next, a method of exchanging data between the on-board device 10 of the train 2 and a different device will be described.

FIG. 8 is a flow chart showing the operation when the on-board device of the train and the different device exchange data. The on-board device 10 of the train 2 exchange data with the different device (a plurality of different on-board devices 10, a plurality of station I/F devices 20, and the operation control device 30) according to necessity, or regularly. In this case, the attention should be paid to the on-board device 10 of the train 2A in FIG. 7.

[0072]

The operation control device 30 transmits the operation mode (the normal mode) and the train diagram to the on-board device 10 of the train 2A at, for example, the departure time of the train 2A (Step S1). In this case, these data may be transmitted to the on-board device 10 of the train 2A through the station I/F device 20 (Steps S1-01/S1-02). The on-board device 10 of the train 2A stores these data in the storage unit 12 (Step S2).

[0073]

The on-board device 10 (the different train state checking section 72) of the train 2A inquires the train related data to the on-board device 10 of the different train 2B (Step S3). The on-board device 10 of the train 2B transmits the train related data of the train 2B to the on-board device 10 of the train 2A in response to the inquiry (Step S4). The on-board device 10 (the different train state checking section 72) of the train 2A stores the data in the storage unit 12 (Step S5). The train related data contains the traveling permission limit position data, the

arrival scheduled platform data, the traveling direction data, the traveling route data, the traveling line data, and the operation mode data (the traveling route request time data, and the train position data). The different train 2 having received the inquiry is the preceding train 2B related to the train interval protection in this case. Here, in the operation mode in which entering of the train from the crossover 53M is predicted, the inquiry is issued to the trains 2 in a neighbor field (within a predetermined distance) containing the train on an opposite line in addition to the preceding train. [0074]

The on-board device 10 (the station state checking section 73) of the train 2A inquires the station related data to the station I/F devices 20 of the station 3A and the station 3B (Step S6-1/S6-2). The station I/F device 20 of the station 3A inquires the railroad switch switching positions to the railroad switches 51A1 to 51A4 in response to the inquiry (Step S7). The railroad switches 51A1 to 51A4 reply the railroad switch switching positions to the station I/F device 20 of the station 3A (Step S9). In the same way, the station I/F device 20 of the station 3B inquires the switching positions to the railroad switches 51B1 to 51B4 in response to the inquiry (Step S8). The railroad switches 51B1 to 51B4 reply the railroad switch switching positions to the station I/F device 20 of the station 3B (Step S10). The station I/F devices 20 of the station 3A and the station 3B transmit the station related data of the station 3A and the station 3B to the on-board device 10 of the train 2A (Steps S11/S12). The on-board device 10 (the station state checking section 73) of the train 2A stores the data in the storage unit 12 (Step S13). The station related data contains the railroad switch

switching position data, and the inter-station section state data. The stations 3 as an inquiry destination are the current station 3A and the next station 3B related to the train interval protection in this case. Note that when the station I/F device 20 always grasps the railroad switch switching position data, the steps S7 to S10 can be omitted.

[0075]

In this way, the train 2A inquires necessary data to the other devices (a plurality of different on-board devices 10, a plurality of station I/F devices 20, and an operation control device 30) regularly or according to necessity and acquires the data.

[0076]

Next, the train interval protection in case of inter-station traveling of the train in the intermediate station section will be described specifically.

FIG. 9A is a flow chart showing the operation of the train interval protection in case of inter-station traveling of the train in the intermediate station section. The on-board device 10 of the train 2 carries out the traveling route securement and the traveling permission by the train 2 itself based on the exchange of data with the above-mentioned different device. In this case, the attention should be paid to the on-board device 10 of the train 2A in FIG. 7.

[0077]

The on-board device 10 (the train diagram checking section 95) of the train 2A reads the train diagram from the storage unit 12 and checks the departure time (Step S21). Then, when the departure time comes, the on-board device 10 issues a departure command (Step S22).

[0078]

Next, the on-board device 10 (the operation mode checking section 71) of the train 2A reads the operation mode from the storage unit 12 and confirms that the operation mode is the normal mode (Step S23). Thus, it is checked and confirmed that any failure has not occurred on the railroad track 50 and that the traveling route of the train 2A on the railroad track 53D of the outbound line is a traveling route which destines for the next station 3B on the railroad track 53D.

[0079]

Next, the on-board device 10 (the different train state checking section 72) of the train 2A checks the state of a different train 2 (the train 2B) (Step S24). For example, this step can be executed like the steps S3 to S5 in FIG. 8. Thus, the on-board device 10 acquires the train related data P1 of the train 2B (the traveling permission limit position data, the arrival scheduled platform data, the traveling direction data, the traveling route data, the traveling line data, and the operation mode data). It is possible to check whether or not the train 2B is in the normal mode based on the operation mode data. The next destination of the train 2B (the station 3) can be checked based on the arrival scheduled platform data, the traveling direction data, the traveling route data, and the traveling line data. By the traveling permission limit position data, the distance 181 (position 180) to which the train 2A can travel can be confirmed. The train related data P1 can be acquired without passing through the control center 4.

[0080]

Next, the on-board device 10 of the train 2A (the station state checking section 73) checks the states of the stations 3 (the station 3A and the

station 3B) (Step S25). For example, this step can be executed like the steps S6-1/S6-2 to S13 in FIG. 8. Thus, the station related data P2 and P3 (the railroad switch switching position data, and the inter-station section state data) are acquired. Whether there is a failure in the inter-station section and whether the on-rail train clearance between the stations has been achieved can be checked based on the inter-station section state data. Based on the railroad switch switching position data, it can be checked whether the switching positions of the railroad switches 51A1, 51A2, 51B2, 51B1 which are on the traveling route of the train 2A is secured. These station related data P2 and P3 can be acquired without passing through the control center 4.

[0081]

Next, the on-board device 10 of the train 2A (the traveling route establishing section 74) checks the on-rail clearance between the stations and determines whether or not the traveling route of the train 2A has been secured, based on the railroad switch switching position data of the station related data P2 and P3 (Step S26). That is, it is determined whether the switching positions of the railroad switches 51A1, 51A2, 51B2, and 51B1 cause any problem in the traveling of the train 2A from the station 3A to the next station 3B. Specifically, whether or not the railroad switches 51 are secured and be locked is determined in response to the railroad switch switching command from the train 2A. When the traveling route has not been secured (Step S26: No), the traveling route establishing section 74 outputs the railroad switch switching command to the station I/F device 20 of the station 3 (the station 3A, the station 3B) to which the railroad switches 51 to be switched (51A1, 51A2, 51B2, and 51B1) belong (Steps

S27-1/S27-2).

[0082]

The station I/F device 20 (the railroad switch operating section 25) relates the railroad switch switching command with the train 2A and stores them in the station storage unit 22 (Steps S28/S29). Then, the railroad switch switching signal is outputted to the targeted railroad switches 51 (51A1, 51A2, 51B2, 51B1) (Steps S30/S31) in response to the railroad switch switching command. The targeted railroad switches 51 (51A1, 51A2, 51B2, and 51B1) are switched in response to the railroad switch switching signal (Steps S32/S33), and outputs a switching confirmation signal to the station I/F device 20 (Steps S34/S35). The station I/F device 20 (the railroad switch operating section 25) outputs the railroad switch switching positions to the on-board device 10 of the train 2A in response to the switching confirmation signal (Steps S36/S37). At this time, the railroad switch switching command is stored in the station storage unit 22 so that the railroad switches 51 are locked by the station I/F device 20 (the railroad switch operating section 25). For example, the railroad switch switching signal from the station I/F device 20 (the railroad switch operating section 25) is set to the high level, and the signal is continuously outputted. The locking state is continued until the train 2A passes away, the station I/F device 20 receives the railroad switch release command from the on-board device 10 of the train 2A and the station I/F device 20 erases the railroad switch switching signal. In this case, even if the railroad switch switching signal is erased, the switching position of the railroad switch 51 may be held without being moved just as it is, until the railroad switch switching command is received from the

succeeding train to the train 2A.

[0083]

The traveling route establishing section 74 of the on-board device 10 determines whether or not the traveling route of the train 2A has been secured in response to the railroad switch switching position (Step S26). When the traveling route has been secured (Step S26: Yes), the traveling route establishing section 74 advances toward step S38. Thus, the traveling route securement for the train 2A completes.

[0084]

Note that the determination for the first time may be made as NO at step S26 so that the steps from S27 to S36 are executed, regardless of whether the traveling route has been secured (whether or not the switching positions of the railroad switches 51A1, 51A2, 51B2, 51B1 have any problem as for the traveling of the train 2A to the next station 3B). That is, the command (the railroad switch switching command) of the switching and the maintenance (locking) may be outputted to (the station I/F device 20 for) the railroad switch 51 on the traveling route at least once. Thus, the traveling route can be more surely secured.

[0085]

Next, the on-board device 10 of the train 2A (the traveling permission limit position checking section 81) checks the traveling permission limit position. That is, a distance 181 (position 180) by which the train 2A can travel is checked (Step S38). In a range to the traveling permission limit position, the on-board device 10 of the train 2A issues the traveling permission. Regarding the permission of traveling, a permission range is set in the range between the train 2A and the train 2B (e.g. the distance to the traveling permission limit position).

Therefore, it is not necessary to provide a conventional closed section and so on and the facilities can be simplified.

[0086]

Next, the on-board device 10 (the speed profile generating section 94) of the train 2A, i.e. the speed profile generating section 94 generates a speed limit profile indicating an upper limit value of the speed when traveling from the current station 3A to the next station 3B, based on the traveling permission limit position, i.e. based on the distance from the targeted train 2 to the traveling permission limitation position (Step S39). After that, the on-board device 10 (the traveling section 91) of the train 2A starts traveling of the train 2A based on the basic data 134 (the linear structure, the vehicle characteristic and so on) stored in the storage unit 12, while referring to the speed limit profile, so that the train 2A travels to the next station 3B according to the train diagram (Step S40).

[0087]

As mentioned above, the train interval protection in the inter-station travel of the train in the intermediate station section is carried out.

[0088]

Here, the release of the locking state of a branch (the railroad switch 51) will be described.

FIG. 9B is a flow chart showing an operation when the on-board device of the train instructs the station I/F device to release the branch. The train 2A travels on the traveling route secured for the train 2A itself, and passes through the railroad switch 51. The on-board device 10 (the train traveling control section 90) of the train 2A checks its own position (S221). Then, the on-board device 10 determines whether or not the train 2A has passed

through the railroad switch 51 (Step S222). When having passed (Step S222: Yes), the on-board device 10 (the train traveling control section 90) issues a railroad switch release command (Step S223) to the station I/F device 20 (Steps S224-1/S224-2). When receiving the railroad switch release command, the station I/F device 20 (the railroad switch operating section 25) outputs a railroad switch release signal to the railroad switch 51 or sets the railroad switch switching command signal to a low level (Steps S225/S226). As a result, the locked state of the railroad switch 51 is released (Steps S227/S228). The railroad switch 51 outputs a release signal indicating the release of the lock state, to the station I/F device 20 (Steps S229/S230). The station I/F device 20 (the railroad switch operating section 25) erases (Steps S231/S232) the stored railroad switch switching command and outputs an erasure confirmation data to the on-board device 10 of the train 2A (Steps S233/S234).

[0089]

In the present embodiment, the on-board device 10 of the train 2 can carry out the train interval protection in the normal mode by receiving the train related data from the different train 2, by receiving the station related data from the station I/F device 20 of the station 3, and by communicating with the station I/F device 20 according to necessity. That is, in the on-board device 10, mainly, the traveling route securement determining section 70 secures a traveling route (the traveling route protection) and the traveling determining section 80 can permit a passage (the crash protection). As a result, by providing the function of the train interval protection to the on-board device 10, it becomes unnecessary to provide the ATP ground device

232, the station control device 234 and the interlocking device 236 to the control center, unlike the configuration of FIG. 1. Thus, a space for the ATP ground device 232, the station control device 234 and the interlocking device 236 can be reduced and, also, the reduction of the introduction cost becomes possible. Moreover, the maintainability of the equipment can be improved. Moreover, because the train interval protection is carried out by the on-board device as a main device, so that the work of a command issuing member of the control center is changed from the conventional monitoring and controlling operations to the monitoring operation, the work load of the command issuing member and the skill required to the member can be made lower.

[0090]

Also, the branch control in the present embodiment can be regarded as, mainly, steps S23 to S39 in the above train interval protection. In this case, in the branch control of the present embodiment, a series of sequences of the departure and arrival control and the controls from the traveling route establishment to the traveling permission can be realized by the cooperation of the on-board device 10 with the station I/F device 20. Thus, the time until the train 2 starts to travel from the station 3 can be reduced. In this way, the function of the branch control can be accomplished by the on-board device 10 and the station I/F device 20. Thus, the reduction of the space for the devices in the control center and the cost reduction can be accomplished. Moreover, because the on-board device 10 and the station I/F device 20 narrow a sequence range, a process time to the railroad switch switching can be shortened. That is, because the time taken until the train 2 departs the station 3 can be reduced, the transportation

capacity can be reinforced.

[0091]

[Second Embodiment]

The signaling system according to a second embodiment of the present invention will be described. In the present embodiment, the control of opening/closing doors will be described in the signaling system which has the configuration having been described in the first embodiment. Below, a difference point from the first embodiment will be mainly described.

[0092]

#### 1. Configuration

The control device 11 of the on-board device 10 will be described.

FIG. 10 is a block diagram showing a configuration example of a door control section 120 of the control device 11 of the signaling system according to the present embodiment. The door control section 120 is provided with a train door section 121 and a platform screen door section 122. The train door section 121 is provided with a train door lock function section 125 which controls the lock state of the train doors, and a train door open/close function section 126 which controls the opening/closing of the train doors. The platform screen door section 122 is provided with a platform screen door lock function section 127 which controls the lock state of the platform screen door, and a platform screen door open/close function section 128 which controls the opening/closing of the doors of the platform screen door.

[0093]

Next, the station control device 21 of the station I/F device 20 will be described.

FIG. 11 is a block diagram showing a

configuration example of the station control device 21 in the signaling system according to the present embodiment. The station control device 21 of the station I/F device 20 is provided with an in-station platform screen door section 420 in addition to a railroad switch operating section 25. The railroad switch operating section 25 operates the railroad switch 51. The in-station platform screen door section 420 operates the platform screen door 40. The in-station platform screen door section 420 is provided with an in-station platform screen door lock function section 421 which turns ON/OFF the lock state, and an in-station platform screen door open/close function section 422 which opens/closes the platform screen door.

[0094]

## 2. Operation

Next, the operation of the signaling system according to the present embodiment will be described. In this case, as the operation of the signaling system, the control of the opening/closing of the doors will be described.

FIG. 12 is a flow chart showing the operation of the door opening/closing control. In this case, the attention should be paid to the on-board device 10 of the train 2A in case of FIG. 7. The on-board device 10 of the train 2A carries out the opening/closing control of the doors of the platform screen door 40 of the station 3A where the train 2A has stopped, and the train doors of the train 2A based on the exchange of the data with the station I/F device 20. In other words, the signaling system realizes the sequences of opening the doors of the platform screen door and the train doors of the train through the cooperation of the on-board device 10 and the station I/F device 20. Thus, a transmission

sequence is simplified and the time can be reduced from a time when the train 2A stops at the station 3A to a time when the doors of the platform screen door and the train doors are opened. Hereinafter, it is specifically described.

[0095]

The on-board device 10 (traveling section 91) of the train 2A detects that the train 2A arrived at a station and has stopped (zero speed detection: Step S91, and fixed point detection step S92). The on-board device 10 (the traveling section 91) of the train 2A outputs a power running off command to turn off the power running (Step S93), and outputs a brake command to operate a brake (Step S94). As a result, the train 2A is set to a rolling prevention state.

[0096]

When detecting the power running off and the brake operation (Step S95), the on-board device 10 (the platform door lock function section 127 in the platform screen door section 122) of the train 2A generates a door open permission command (Step S96), and sends it to the station I/F device 20 (Step S97). The station I/F device 20 (the in-station platform screen door lock function section 421 in the in-station platform screen door section 420) outputs a door open permission signal to the platform screen door 40 in response to the door open permission command (Step S98). The platform screen door 40 releases (turns off) the lock state in response to the door open permission signal (Step S99), and outputs a lock release signal to the station I/F device 20 (Step S100). The station I/F device 20 (the in-station platform screen door lock function section 421 of the in-station platform screen door section 420) outputs lock release data to the on-board device 10 in response to the lock release signal (Step S101).

[0097]

The on-board device 10 (the platform screen door open/close function section 128 of the platform screen door section 122) of the train 2A generates (step S102) and sends a door open command to the station I/F device 20 in response to the lock release data (Step S103). The station I/F device 20 (the in-station platform screen door open/close function section 422 of the in-station platform screen door section 420) outputs a door open signal to the platform screen door 40 in response to the door open command (Step S104). The platform screen door 40 opens the doors of the platform screen door in response to the door open signal (Step S105), and outputs a door opened signal to the station I/F device 20 (Step S106). The station I/F device 20 (the in-station platform screen door open/close function section 422 of the in-station platform screen door section 420) outputs door opened data to the on-board device 10 in response to the door opened signal (Step S107). In the platform screen door 40, the open state is locked automatically through the opening operation of the doors.

[0098]

After that, the on-board device 10 of the train 2A (the train door lock function section 125 of the train door section 121) releases (turns off) the lock state of the train doors (Step S109) in response to the door opened data (step S108). Then, the on-board device 10 of the train 2A (the train door open/close function section 126 of the train door section 121) opens the train doors in response to the release of the lock state (Step S110). In the train doors, the open state is locked automatically through the opening operation of the doors.

[0099]

As mentioned above, the door opening control is carried out.

[0100]

Note that the door closing control can be realized by executing the door closing operation as in the step S96' to the step S110', like the step S96 to the step S110. For example, they are the following steps.

[0101]

When detecting the movement of no person in the doors of the train and the platform screen door by a sensor and so on (Step S95'), the on-board device 10 of the train 2A (the platform screen door lock function section 127 of the platform screen door section 122) generates a door close permission command (Step S96'), and sends it to the station I/F device 20 (Step S97'). The station I/F device 20 (the in-station platform screen door lock function section 421 of the in-station platform screen door section 420) outputs a door close permission signal to the platform screen door 40 in response to the door close permission command (Step S98'). The platform screen door 40 releases (turns off) the locked doors in response to a door close permission signal (Step S99'), and outputs a lock release signal to the station I/F device 20 (Step S100'). The station I/F device 20 (the in-station platform screen door lock function section 421 of the in-station platform screen door section 420) outputs lock release data to the on-board device 10 in response to the lock release signal (Step S101').

[0102]

The on-board device 10 of the train 2A (the platform screen door open/close function section 128 of the platform screen door section 122) generates a door close command in response to the lock release

data (Step S102'), and sends it to the station I/F device 20 (Step S103'). The station I/F device 20 (the in-station platform screen door open/close function section 422 of the in-station platform screen door section 420) outputs a door close signal to the platform screen door 40 in response to the door close command (Step S104'). The platform screen door 40 closes the doors of the platform screen door in response to the door close signal (Step S105'), and outputs a door closed signal to the station I/F device 20 (Step S106'). The station I/F device 20 (the in-station platform screen door open/close function section 422 of the in-station platform screen door section 420) outputs door closed data to the on-board device 10 in response to the door closed signal (Step S107').

[0103]

After that, the on-board device 10 of the train 2A (the train door lock function section 125 of the train door section 121) releases (turns off) the lock state of the train doors (Step S109') in response to the door closed data (step S108'). Then, the on-board device 10 of the train 2A (the train door open/close function section 126 of the train door section 121) closes the train doors in response to the release of the lock state (Step S110).

Note that the order of the opening/closing of the train doors and the opening/closing of the doors of the platform screen door may be opposite.

[0104]

In the present embodiment, the signal transmission system to the platform screen door 40 is one system between the on-board device 10 and the station I/F device 20. Therefore, a transfer time for transmission and reception of data and signals can be reduced. Therefore, the processing time taken from

arrival of the train 2A at the station 3A to the opening of the platform screen door 40 can be reduced, and the processing time for the opening/closing of the doors can be excluded from the influence factors on the transportation capacity. Moreover, because the on-board device 10 can execute the processing steps sequentially from the door open permission command to the door open command, the timing adjustment can be made simple.

[0105]

Also, in the control which opens the doors of the train 2A, too, the signal transmission system is one system only by the on-board device 10. Therefore, the processing time from the arrival of the train 2A at the station 3 to the opening of the doors of the platform screen door 40 and the train 2 can be more reduced. The processing time of the opening/closing of the doors can be excluded from the influence factors on the transportation capacity.

[0106]

Also, in the control of confirming the condition that the train has been stopped safely at the station 3, too, the signal transmission system is one system only by the on-board device 10. Therefore, the processing time from the arrival of the train 2A at the station 3 to the opening of the doors of the platform screen door 40 and train 2 can be more reduced. The processing time for the opening/closing of the doors can be excluded from the influence factors on the transportation capacity.

[0107]

Also, because the door control function can be realized by the on-board device 10 and the station I/F device 20 without passing through the control center, the processing is made efficient and the devices of the control center (such as the ATP ground

device, the station control device, and the interlocking device) can be made unnecessary. Thus, the space for the devices and so on can be reduced, the facility cost can be reduced and the handling of equipments becomes easy.

[0108]

The program and the data configuration of the present invention may be recorded in a computer-readable storage medium, and may be read into the information processing apparatus from the storage medium.

[0109]

The present invention is not limited to the above embodiments. It would be apparent to a person in the art that each of the embodiments may be modified or changed appropriately in a range of the technical thought of the present invention.

[0110]

The present invention has been described along some embodiments. It would be apparent to the person in the art that these embodiments are merely provided to explain the present invention. These must not be used to interpret the attached claims so as to limit the meanings of the claims.

[0111]

Part or all of the above-mentioned embodiments and the examples can be described as in the following supplemental note, but are not limited below.

[0112]

A signaling system of the present invention includes an on-board device, a station interface device, and a platform screen door. The on-board device is provided in a moving vehicle traveling on a track. The station interface device is provided in a station along the track. The platform screen

door is provided in the station and controlled by the station interface device. When the moving vehicle has stopped at the station, the on-board device outputs a door open permission command to instruct release of a lock state. The station interface device releases the lock state of the platform screen door in response to the door open permission command. After the lock state is released, the on-board device outputs a door open command to instruct the opening of the platform screen door. The station interface device opens the platform screen door in response to the door open command. The on-board device opens doors of the moving vehicle.

In the signaling system of the present invention which has such a configuration, the platform screen door can be opened by the on-board device and the station interface device cooperating and controlling accurately. In this case, the signal transmission system to the platform screen door is one system between the on-board device and the station interface device. Therefore, the processing time from time when the moving vehicle arrives at the station to the time when the platform screen door is opened can be reduced. The processing time of the opening/closing of the doors can be excluded from influence factors on the transportation capacity. Moreover, because it is possible for the on-board device to carry out the sequential processing from the door open permission command to the door open command, the timing adjustment can be made simple. Also, because the function of the door control can be realized by the on-board device and the station I/F device without passing through the control center, the processing is made efficient and the devices of the control center (the ATP ground device, the station control device, and the interlocking device) can be

made unnecessary. Thus, the space for the devices and so on can be reduced, facility cost can be reduced and the handling of equipments becomes easy.

[0113]

In the above-mentioned signaling system, the on-board device may release the lock state of the doors of the moving vehicle in response to the opening of the platform screen door. The on-board device opens the doors of the moving vehicle in response to the release of the lock state of the doors of the moving vehicle.

In the signaling system of the present invention which has such a configuration, the on-board device controls the lock and release of the doors of the moving vehicle and the opening/closing the door. In this case, the signal transmission system of the moving vehicle is concentrated to only the on-board device. Therefore, the processing time to the opening of the doors of the platform screen door and the moving vehicle after the moving vehicle arrives at the station can be more reduced. The processing time for the opening/closing of the doors can be excluded from the influence factor on the transportation capacity.

[0114]

In the above-mentioned signaling system, the on-board device may detect that the moving vehicle has stopped at the station. The on-board device may output a power running off command and a brake operation command in response to the detection of the stop. The on-board device may detect a power running turning off and a brake operation.

In the signaling system of the present invention which has such a configuration, the on-board device checks the safe stop of the moving vehicle and then starts the opening control of the platform screen door. In this case, the signal transmission system of

the moving vehicle is concentrated into only the on-board device. Therefore, the processing time to the opening of the platform screen door after the moving vehicle arrives at the station can be more reduced. The processing time of the opening/closing of the doors can be excluded from the influence factor on the transportation capacity.

[0115]

A door control method of the present invention is a door control method using a signaling system. This signaling system includes an on-board device provided in the moving vehicle traveling on a track, a station interface device provided in a station along the track, and a platform screen door provided in the station and controlled by the station interface device. The door control method includes outputting a door open permission command by the on-board device to instruct a release of a lock state when the moving vehicle has stopped at the station; releasing the lock state of the platform screen door by the station interface device in response to the door open permission command; outputting a door open command by the on-board device to instruct the opening of the platform screen door, after the lock state is released; opening the platform screen door by the station interface device in response to the door open command; and opening doors of the moving vehicle by the on-board device.

In the signaling system of the present invention which has such a configuration, the platform screen door can be opened by the on-board device and the station interface device cooperating and controlling accurately. In this case, the signal transmission system to the platform screen door is concentrated into one system between the on-board device and the station interface device. Therefore,

the processing time from time when the moving vehicle arrives at the station to the time when the platform screen door is opened can be reduced. The processing time of the opening/closing of the doors can be excluded from influence factors on the transportation capacity. Moreover, because it is possible for the on-board device to carry out the sequential processing from the door open permission command to the door open command, the timing adjustment can be made simple. Also, because the function of the door control can be realized by the on-board device and the station I/F device without passing through the control center, the processing is made efficient and the devices of the control center (the ATP ground device, the station control device, and the interlocking device) can be made unnecessary. Thus, the space for the devices and so on can be reduced, facility cost can be reduced and the handling of equipments becomes easy.

[0116]

In the above-mentioned door control method, the opening the doors of the moving vehicle includes releasing the lock state of the doors of the moving vehicle by the on-board device in response to the opening of the platform screen door; and opening the doors of the moving vehicle by the on-board device in response to the releasing the lock state of the doors of the moving vehicle.

In the door control method of the present invention which has such a configuration, the on-board device controls the lock and release of the doors of the moving vehicle and the opening/closing the door. In this case, the signal transmission system of the moving vehicle is concentrated to only the on-board device. Therefore, the processing time to the opening of the doors of the platform screen door and the moving vehicle after the moving vehicle arrives at the

station can be more reduced. The processing time for the opening/closing of the doors can be excluded from the influence factor on the transportation capacity. [0117]

The above-mentioned door control method may include detecting by the on-board device that the moving vehicle has stopped at the station; outputting a power running off command and a brake operation command by the on-board device in response to the detection of the stop; and detecting the power running turning off and the brake operation in response to the release of the lock state of the doors of the moving vehicle.

In the signaling system of the present invention which has such a configuration, the on-board device checks the safe stop of the moving vehicle and then starts the opening control of the platform screen door. In this case, the signal transmission system of the moving vehicle is concentrated into only the on-board device. Therefore, the processing time to the opening of the platform screen door after the moving vehicle arrives at the station can be more reduced. The processing time of the opening/closing of the doors can be excluded from the influence factor on the transportation capacity.

### CLAIMS

1.           A signaling system comprising:  
              an on-board device provided in a moving  
vehicle traveling on a track;  
              a station interface device provided in a  
station along the track;  
              a platform screen door provided in the  
station and controlled by the station interface  
device,  
              wherein when the moving vehicle has stopped  
at the station, the on-board device outputs a door  
open permission command to instruct release of a lock  
state,  
              wherein the station interface device releases  
the lock state of the platform screen door in response  
to the door open permission command,  
              wherein after the lock state is released, the  
on-board device outputs a door open command to  
instruct the opening of the platform screen door,  
              wherein the station interface device opens  
the platform screen door in response to the door open  
command, and  
              wherein the on-board device opens doors of  
the moving vehicle.
2.           The signaling system according to claim 1,  
wherein the on-board device releases the lock state of  
the doors of the moving vehicle in response to the  
opening of the platform screen door, and opens the  
doors of the moving vehicle in response to the release  
of the lock state of the doors of the moving vehicle.
3.           The signaling system according to claim 1 or  
2, wherein the on-board device detects that the moving  
vehicle has stopped at the station, outputs a power  
running off command and a brake operation command in

response to the detection of the stop, and detects the power running off and the brake operation.

4. A door control method using a signaling system, which comprises:

- an on-board device provided for a moving vehicle traveling on a track;

- a station interface device provided for a station along the track;

- a platform screen door provided for the station and controlled by the station interface device,

  - wherein the door control method comprises:

  - outputting a door open permission command by the on-board device to instruct a release of a lock state when the moving vehicle has stopped at the station;

  - releasing the lock state of the platform screen door by the station interface device in response to the door open permission command;

  - outputting a door open command by the on-board device to instruct the opening of the platform screen door, after the lock state is released;

  - opening the platform screen door by the station interface device in response to the door open command; and

  - opening doors of the moving vehicle by the on-board device.

5. The door control method according claim 4, wherein the opening the doors of the moving vehicle comprises:

- releasing the lock state of the doors of the moving vehicle by the on-board device in response to the opening of platform screen door; and

- opening the doors of the moving vehicle by

the on-board device in response to the release of the lock state of the doors of the moving vehicle.

6. The door control method according to claim 4 or 5, further comprising:

detecting by the on-board device that the moving vehicle has stopped at the station;

outputting a power running off command and a brake operation command by the on-board device in response to the detection of the stop of the moving vehicle; and

detecting the power running off and the brake operation by the on-board device.