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(54) AUTOMATIC TRAIN PROTECTION SYSTEM AND METHOD

(57) Provided in the present invention are an automatic train protection system and method. The automatic train protection system comprises: an allocation unit, connected to operating trains and regional controller computing nodes, configured to receive movement authorization requests transmitted by the operating trains, the movement authorization requests comprising location information of the operating trains, operating information of the operating trains, and feature identifiers of the operating trains, to select regional controller computing nodes for the movement authorization requests, and to transmit the movement authorization requests to the selected regional controller computing nodes. The area controller computing nodes are configured, when selected, to acquire train sorting map information, movement authorization information of other trains, and interlocking information on the basis of the location information and of the feature identifiers, and to generate target movement authorizations. The allocation unit is further configured to transmit the target movement authorizations to the operating trains. The present solution implements the unified management of the operating trains.

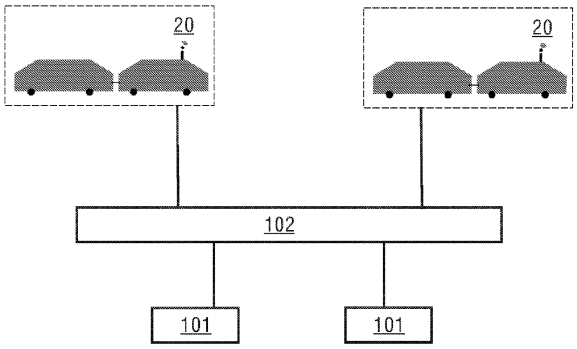

Fig. 2

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of rail traffic control, in particular to an automatic train protection system and method.

BACKGROUND ART

[0002] As one of the indispensable public transportation modes for urban development, urban rail transport can fundamentally improve urban traffic conditions. Increases in the numbers of rail lines and operating trains pose constant challenges to the carrying capacity and operation stability of the ground equipment in a train control system. The existing ground equipment is mainly composed of an Automatic Train Supervision (ATS) system, an Automatic Train Protection (ATP) system, an Automatic Train Operation (ATO) system, a Computer Interlocking (CI) system, and a Data Communication System (DCS); among them, the ATP comprises: a Zone Controller (ZC) and on-board Automatic Train Protection (ATP, on-board ATP); the CI manages routes on the ground to ensure correct interlocking relationships among routes, switches, and signals, so as to ensure the safe operation of the train.

[0003] At present, given the limitation of the processing capacity of the zone controller itself, in order to solve the problems of limited transportation capacity and long rail lines, a rail line is divided into a plurality of sections, and a corresponding zone controller is designated for each section. For this method of allocating zone controllers according to rail sections, a control boundary inevitably exists between the zone controllers corresponding to two adjacent rail sections, wherein, generally, when the locomotive of a train reaches the control boundary or a zone range, the zone controllers corresponding to two adjacent rail sections on both sides of the boundary need to communicate with each other to complete a handover of the train. However, once the communication between the zone controllers corresponding to two adjacent rail sections is delayed or interrupted, the actual operation of the train will become inconsistent with the information obtained by the zone controllers, which affects the smoothness, comfortableness and even safety of train operation.

SUMMARY OF THE INVENTION

[0004] In view of this, the present invention provides an automatic train protection system and method, which implements the unified management of operating trains, eliminates a handover procedure between zone controllers, thereby eliminating control boundaries, and can effectively reduce risks of inconsistency between actual train running conditions and information obtained by zone controllers.

[0005] In a first aspect, an embodiment of the present invention provides an automatic train protection system, comprising:

at least two zone controller computing nodes;
an allocation unit, connected to the at least one operating train and the at least two zone controller computing nodes, configured to receive movement authorization requests transmitted by the target operating trains, the movement authorization requests comprising location information of the target operating trains, operating information of the target operating trains, and feature identifiers of the target operating trains, to select, from the at least two zone controller computing nodes, one zone controller computing node for the movement authorization requests, and to transmit the movement authorization requests to the selected zone controller computing node;
wherein each zone controller computing node is configured to, when selected, acquire train sorting map information, movement authorization information of other trains, and interlocking information on the basis of the location information of the target operating trains and of the feature identifiers of the target operating trains, generate target movement authorizations on the basis of the train sorting map information, the movement authorization information of other trains, the interlocking information and the operating information of the target operating trains, and transmit the target movement authorizations to the allocation unit; the allocation unit is further configured to transmit the target movement authorizations to the target operating trains.

[0006] In a first possible implementation manner, according to the first aspect, the automatic train protection system further comprises:

at least one first registration node, connected to the at least one operating train and the at least two zone controller computing nodes, and configured to generate and store a corresponding train registration list for the operating trains in response to a registration request received from each of the operating trains,

wherein the registration request comprises feature identifiers and operating information of the operating trains, and the train registration list comprises the feature identifiers and the operating information corresponding to the operating trains;

wherein each zone controller computing node is configured to match feature identifiers of the target operating trains from the train registration list after receiving the movement authorization request, and if the matching is successful, update the operating information of the target operating train in the registration list on the basis of feature identifiers of the target operating trains, and acquire train sorting map information related to the target trains, movement authorization information of other trains, and interlocking information; if the matching fails, the target operating trains are transferred to at least one first registration node, so that the target operating trains enter the registration process.

[0007] In a second possible implementation manner, according to the first possible implementation manner, the automatic train protection system further comprises:

at least one second registration node configured to register each zone controller computing node;

an allocation unit, connected to at least one second registration node, and configured to search for at least one registered zone controller computing node from the at least one second registered node, and select one zone controller computing node for the target operating trains from the at least one registered zone controller computing node.

[0008] In a third possible implementation manner, according to the second possible implementation manner,

at least one second registration node is configured to store operating states of each registered zone controller computing node;

an allocation unit is configured to select one zone controller computing node for the target operating trains on the basis of the operating state of each registered zone controller computing node, so that load balancing may be achieved among the registered zone controller computing nodes.

[0009] In a fourth possible implementation manner, in combination with any of the first aspect, the first possible implementation manner, the second possible implementation manner and the third possible implementation manner, the automatic train protection system further comprises:

an operating data management subsystem, connected to the at least two zone controller computing nodes and configured to store the train sorting map information and all train movement authorization information, the train sorting map information comprising real-time locations corresponding to each of the operating trains, the all train movement authorization information comprising real-time and historical movement authorizations corresponding to each of the operating trains, the train sorting map information indicating the location sorting of the operating trains on all the operating lines;

each zone controller computing node is configured to, when selected, transmit location information of the target operating trains and feature identifiers of the target operating trains to the operating data management subsystem;

the operating data management subsystem is further configured to, on the basis of the location information of the target operating trains and the feature identifiers of the target operating trains, provide the zone controller computing nodes with train sorting maps as well as real-time and historical movement authorizations related to the target operating trains; and, on the basis of the location information of the target operating trains and the feature identifiers of the target operating trains, update the train sorting map information related to the target operating trains;

the operating data management subsystem is further configured to update the movement authorization information corresponding to the target operation trains on the basis of the latest movement authorization information of the target operation trains calculated by the zone controller computing nodes.

[0010] In a fifth possible implementation manner, according to the fourth possible implementation manner, the operating data management subsystem comprises: a first screening server, a second screening server, at least one first database, and at least one second database, wherein

each first database is connected to the first screening server, and is configured to store and update some of the train sorting maps;

the first screening server is connected to each zone controller computing node, and is configured to search for train sorting maps related to the target operating trains from at least one first database on the basis of the location information of the target operating trains and the feature identifiers of the target operating trains, and provide the train sorting maps related to the target operating trains to the zone controller computing nodes;

the first screening server is connected to each zone controller computing node and is configured to, on the basis of the location information of the target operating trains and the feature identifiers of the target operating trains, update train sorting information related to the target operating trains in at least one first database;
each second database is connected to the second screening server, and is configured to store and update real-time and historical movement authorizations corresponding to some of the operating trains;
the second screening server is connected to each zone controller computing node, and is configured to find out, from at least one second database, historical and real-time movement authorizations related to the target operating trains on the basis of the location information of the target operating trains and feature identifiers of the target operating trains, and provide historical and real-time movement authorizations related to the target operating trains to the zone controller computing nodes; and, on the basis of the feature identifiers of the target operating trains and the latest movement authorizations of the target operating trains, update the real-time and historical movement authorization information related to the target operating trains in the at least one second database.

[0011] According to actual situations, the first/second screening server and the first/second database may be selected optionally.

[0012] In a sixth possible implementation manner, in combination with any of the first aspect, the first possible implementation manner, the second possible implementation manner and the third possible implementation manner, the automatic train protection system further comprises:

an interlocking information processing subsystem, connected to the at least two zone controller computing nodes and interlocking systems, and configured to store interlocking information, the interlocking information comprising state information of all the interlocking elements of all the connected interlocking systems;
each zone controller computing node is configured to, when selected, transmit an interlocking information acquisition request to the interlocking information processing subsystem, the interlocking information acquisition request comprising the identifiers of the interlocking elements;
the interlocking information processing subsystem is further configured to query the state information of all the interlocking elements in the interlocking systems, control states of some of the interlocking elements, and transmit relevant retrieved interlocking information to the selected zone controller computing nodes.

[0013] In a seventh possible implementation manner, according to the sixth possible implementation manner, the interlocking information processing subsystem comprises: at least two interlocking information cache databases and interlocking information screening servers, wherein

each interlocking information cache database is connected to at least one interlocking system and interlocking information screening server, and is configured to cache the state information of the interlocking elements in the at least one interlocking system connected thereto;
the interlocking information screening server is connected to the at least two zone controller computing nodes, and is configured to receive interlocking information acquisition requests, search for state information of the interlocking elements in the at least two interlocking information cache databases, and transmit the state information of the interlocking elements to the selected zone controller computing nodes.

[0014] In an eighth possible implementation manner, according to the seventh possible implementation manner, the interlocking information processing subsystem further comprises:

at least two interlocking information cache backup databases, in a one-to-one correspondence with at least two interlocking information databases, connected to the interlocking information screening servers, and configured to back up the interlocking element state information cached in the corresponding interlocking information cache database;
the interlocking information screening server is configured to, when its communication with any interlocking information cache database has failed, search for relevant interlocking element state information from the interlocking information cache backup database corresponding to the interlocking information cache database with which the communication has failed.

[0015] In a ninth possible implementation manner, according to the sixth possible implementation manner, the automatic train protection system further comprises:

an interlock processing standby subsystem, connected to the at least two zone controller computing nodes and all the interlocking systems of the rails, and configured to back up interlocking information;

each zone controller computing node is configured to, when selected, transmit an interlocking information acquisition request to the interlock processing standby subsystem after communication with the interlocking information processing subsystem has failed;

the interlock processing standby subsystem is further configured to search for relevant interlocking element information and transmit the relevant interlocking element information to the selected zone controller computing nodes.

[0016] In a second aspect, an embodiment of the present invention further provides an automatic train protection method, comprising:

receiving, with the allocation unit, movement authorization requests transmitted by the target operating trains, the movement authorization requests comprising location information of the target operating trains, operating information of the target operating trains, and feature identifiers of the target operating trains;

selecting, with the allocation unit, one zone controller computing node for the movement authorization requests, and transmitting the movement authorization requests to the selected zone controller computing node;

with the selected zone controller computing node, acquiring train sorting map information, real-time movement authorization information of other trains, and interlocking information on the basis of the location information of the target operating trains and of the feature identifiers of the target operating trains, generating target movement authorizations on the basis of the train sorting map information, the movement authorization information of other trains, the interlocking information and the operating information of the target operating trains, and transmitting the target movement authorizations to the allocation unit;

transmitting, with the allocation unit, the target movement authorizations to the target operating trains.

[0017] In a first possible implementation manner, according to the automatic train protection method provided by the second aspect, the automatic train protection method further comprises: with at least one first registration node, generating and storing a corresponding train registration list for the operating trains in response to a registration request received from each of the operating trains, wherein the registration request comprises feature identifiers and operating information of the operating trains, and the train registration list comprises the feature identifiers and the operating information corresponding to the operating trains;

after the step of transmitting a mobile authorization request to the selected zone controller computing nodes, the method further comprises:

matching, with the selected zone controller computing node, the feature identifiers of the target operating trains from the train registration list, if the matching is successful, acquiring train sorting map information related to the target trains, movement authorization information of other trains, and interlocking information on the basis of the feature identifiers of the target operating trains; and, if the matching fails, transferring the target operating trains to at least one first registration node, so that the target operating trains enter the registration process.

[0018] In a second possible implementation manner, in combination with the first possible implementation manner, the automatic train protection method further comprises: registering each zone controller computing node with at least one second registration node;

the step of selecting a zone controller computing node for the target operating trains comprises: searching for at least one registered zone controller computing node from at least one second registration node, and selecting one zone controller computing node for the target operating trains from the at least one registered zone controller computing node.

[0019] In a third possible implementation manner, in combination with the first possible implementation manner, the automatic train protection method further comprises:

storing the operating state of each registered zone controller computing node with at least one second registration node;

the step of selecting one zone controller computing node for the target operating trains from the at least one registered zone controller computing node comprises: selecting one zone controller computing node for the target operating trains on the basis of the operating state of each registered zone controller computing node, so that load balancing may be achieved among the registered zone controller computing nodes.

[0020] In a fourth possible implementation manner, in combination with the second aspect, the first possible implementation manner, the second possible implementation manner, and the third possible implementation manner, the automatic train protection method further comprises:

storing, with an operating data management subsystem, train sorting map information, and real-time locations corresponding to each of the operating trains, the all train movement authorization information comprising real-time and historical movement authorizations corresponding to each of the operating trains, the train sorting map infor-

mation indicating the location sorting of the operating trains on all the operating lines;
after transmitting the mobile authorization request to the selected zone controller computing nodes, the method further comprises:

transmitting, with the selected zone controller computing node, location information of the target operating trains and feature identifiers of the target operating trains to the operating data management subsystem;
with the operating data management subsystem, on the basis of the location information of the target operating trains and the feature identifiers of the target operating trains, providing the zone controller computing nodes with train sorting maps as well as real-time and historical movement authorizations related to the target operating trains, and, on the basis of the location information of the target operating trains and the feature identifiers of the target operating trains, updating the train sorting map information related to the target operating trains; and updating the movement authorization information corresponding to the target operation trains on the basis of the latest movement authorization information of the target operation trains calculated by the zone controller computing nodes.

[0021] In a fifth possible implementation manner, according to the fourth possible implementation manner, the step of storing train sorting map information through the operating data management subsystem comprises: storing train sorting maps through at least two first databases, and storing real-time and historical movement authorizations corresponding to the operating trains through at least two second databases.

[0022] In a sixth possible implementation manner, in combination with the second aspect, the first possible implementation manner, the second possible implementation manner, and the third possible implementation manner, the automatic train protection method further comprises: storing interlocking information with an interlocking information processing subsystem, the interlocking information comprising state information of all the interlocking elements of all the connected interlocking systems;
the step of acquiring interlocking information comprises:

transmitting, with the selected zone controller computing node, an interlocking information acquisition request to the interlocking information processing subsystem, the interlocking information acquisition request comprising the identifiers of the interlocking elements;
and searching, with the interlocking information processing subsystem, for relevant interlocking element information and transmit the relevant interlocking element information to the selected zone controller computing nodes.

[0023] In a seventh possible implementation manner, according to the sixth possible implementation manner, the step of storing interlocking information with an interlocking information processing subsystem comprises: caching, with at least two interlocking information cache databases, the state information of all the interlocking elements in the at least one interlocking system connected thereto; the step of searching, with the interlocking information processing subsystem, for interlocking information related to the location information of the target operating trains, and transmitting the interlocking information related to the location information of the target operating trains to the selected zone controller computing nodes comprises: receiving the interlocking information acquisition request with an interlocking information screening server; and searching for state information of the interlocking elements in the at least two interlocking information cache databases, and transmitting the state information of the interlocking elements to the selected zone controller computing nodes.

[0024] In an eighth possible implementation manner, according to the seventh possible implementation manner, the automatic train protection method further comprises: backing up, with at least two interlocking information cache backup databases, the state information of the interlocking elements cached in the corresponding interlocking information cache database;
when the communication between the interlocking information screening server with any interlocking information cache database has failed, searching for relevant interlocking element state information from the interlocking information cache backup database corresponding to the interlocking information cache database with which the communication has failed.

[0025] In a ninth possible implementation manner, according to the sixth possible implementation manner, the automatic train protection method further comprises:

backing up the interlocking information with the interlock processing standby subsystem;
transmitting the interlocking information acquisition request to the interlock processing standby subsystem after the communication between the selected zone controller computing node and the interlocking information processing subsystem has failed;
searching for relevant interlocking information with the interlock processing standby subsystem, and transmitting the relevant interlocking information to the selected zone controller computing nodes.

[0026] It is thus clear from the above-described technical solution that the allocation unit, as a communication hub between operating trains and the at least two zone controller computing nodes, after receiving movement authorization requests transmitted by the target operating trains, selects one zone controller computing node for the target operating trains, which means that zone controller computing nodes are selected by the allocation unit, and selected zone controller computing nodes acquire train sorting map information, movement authorization information of other trains, and interlocking information on the basis of the location information of the target operating trains and of the feature identifiers of the target operating trains, generate target movement authorizations on the basis of the train sorting map information, the operating information of the target operating trains, the movement authorization information of other trains, and the interlocking information, and transmit the target movement authorizations to the allocation unit, so that the need for the zone controller computing nodes to control the operating trains by zone is eliminated, and at the same time, the process of information exchange between the zone controller computing nodes is eliminated, thereby implementing the unified management of the operating trains, and the handover procedure between zone controllers is eliminated, so as to eliminate control boundary, thus avoiding the problem of inconsistency between actual train operating situations and information acquired by zone controllers, which is caused by control boundary.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

Fig. 1 is a schematic diagram of the management of operating trains by zone controllers in the prior art;
Fig. 2 is a schematic structural diagram of an automatic train protection system provided by an embodiment of the present invention;
Fig. 3 is a schematic structural diagram of another automatic train protection system provided by an embodiment of the present invention;
Fig. 4 is a schematic structural diagram of an operating data management subsystem provided by an embodiment of the present invention;
Fig. 5 is a schematic structural diagram of data storage by an operating data management subsystem provided by an embodiment of the present invention;
Fig. 6 is a schematic structural diagram of an interlocking information processing subsystem provided by an embodiment of the present invention;
Fig. 7 is a schematic diagram of an operating line for a plurality of operating trains according to an embodiment of the present invention;
Fig. 8 is a schematic diagram related to the movement authorizations of a plurality of operating trains according to an embodiment of the present invention;
Fig. 9 is a partial flow chart of automatic train protection implemented by the interaction among interlocking elements, interlocking information processing subsystems and zone controller computing nodes provided by an embodiment of the present invention;
Fig. 10 is a flow chart of a management method for operating trains provided by an embodiment of the present invention;
Fig. 11 is a partial flow chart of automatic train protection implemented by the interaction among management nodes, load balancing servers, and zone controller computing nodes in a cluster according to an embodiment of the present invention.

List of reference numbers:

101:	Zone controller computing node	102:	Allocation unit	103:	First registration node
104:	Operating data management subsystem	1041:	First screening server	1042:	Second screening server
1043:	First database	1044:	Second database	105:	Interlocking information processing subsystem
1051:	Interlocking information cache atabase	1053:	Interlocking information cache backup database		
1052:	Interlocking information screening server	106:	Interlock processing standby subsystem	107:	Second registration node
108:	Cluster	109:	Management node	110:	Load balancing server

(continued)

20: Operating train 30: Interlocking system

601: The zone controller computing nodes transmit instructions related to control of interlocking elements to the interlocking information processing subsystem

602: The interlocking information processing subsystem stores the instructions related to the control of interlocking elements in cache data blocks

603: The interlocking system triggers the interlocking information processing subsystem, and receives element control instructions transmitted by the interlocking information processing subsystem

604: The interlocking system executes the received element control instructions

605: The interlocking system transmits results of execution of the element control instructions to the interlocking information processing subsystem

606: The interlocking information processing subsystem updates the states of execution of the element control instructions

607: The zone controller computing nodes transmit, in a timed manner, instructions to acquire the states of execution of the element control instructions to the interlocking information processing subsystem

608: The zone controller computing nodes receive the states of execution of the control instructions

609: The interlocking system, in a timed manner, writes element states to the interlocking information processing subsystem

610: The interlocking information processing subsystem updates stored element states

611: The zone controller computing nodes transmit the states of the interlocking elements acquired from the interlocking information processing subsystem

612: The zone controller computing nodes rewrite specific interlocking element states

613: The interlocking information processing subsystem updates the corresponding stored element states, and sends them back to the zone controller computing nodes

614: The interlocking system, in a timed manner, acquires, from the interlocking information processing subsystem, interlocking element states that need to be rewritten

701: The allocation unit receives a movement authorization request

702: The allocation unit selects one zone controller computing node for the movement authorization request

703: The selected zone controller computing node acquires train sorting map information, movement authorization information of other related trains, and interlocking information

704: The selected zone controller computing node calculates and generates a target movement authorization on the basis of the train sorting map information, the movement authorization information of other related trains, and the interlocking information

801: Two operating trains transmit train locations to the allocation unit in real time

802: The allocation unit transmits the train locations of the two operating trains to a management node

803: The management node, on the basis of the train locations of the two operating trains, updates the train locations stored therein

804: The allocation unit receives the movement authorization requests transmitted by the two operating trains

805: The allocation unit selects zone controller computing nodes for the operating trains, and transmits the location information of the operating trains to the zone controller computing nodes

806: The zone controller computing nodes acquire the train sorting maps and historical movement authorizations related to the operating trains

807: The management node splits the train list to obtain a partial list related to the operating trains

808: The management node transmits the partial list related to the operating trains to the zone controller computing nodes

809: The zone controller computing nodes generate movement authorizations and update the historical movement authorizations

810: The zone controller computing nodes transmit the movement authorizations to the allocation unit

811: The allocation unit transmits the movement authorizations related to the operating trains to the operating trains

SPECIFIC EMBODIMENTS

[0028] With methods in the prior art for managing operating trains mainly including rail trains such as subways, light rail trains, trains and high-speed rails, as mentioned above, an operating track is divided into different zones, and zone controllers and interlocking systems, such as signal lights, track detectors and switch equipment, are deployed in each zone, so that every time an operating train passes through a zone, the operating train is controlled by the zone controller

of the zone where the operating train is located, and when the operating train is running from one zone to another, unavoidably, the zone controllers in the two adjacent zones are required to perform an information transfer, which means that there is information transferability between the zone controllers in every two adjacent zones.

[0029] The specific process of controlling operating trains through zone controllers in the prior art may be shown in Fig. 1. Due to the limitations of the control performance, such as the ability to process data, of zone controllers, the rail sections shown in Fig. 1 need to be controlled zonally by two zone controllers ZC 1 and ZC2, wherein the zone controller ZC1 manages section R1 to the left of the dot-and-dash line (that is, the control boundary between ZC1 and ZC2) in the figure, and the zone controller ZC2 manages section R2 to the right thereof. Then, during the operation of the operating train 20 on the rail, the section R1 is managed by the zone controller ZC1, and the section R2 is managed by the zone controller ZC2. In other words, some data related to the section R1, such as the state information of the interlocking element CI1 on the section R1 and train sorting maps of the section R1, are all on the zone controller ZC1, while the interlocking element CI1 on the section R1 communicates with the zone controller ZC1; some data related to the section R2, such as the state information of the interlocking element CI2 on the section R2 and train sorting maps of the section R2, are on the zone controller ZC2, while the interlocking element CI2 on the section R2 communicates with the zone controller ZC2. Thus, the zone controller ZC1 generates a movement authorization MA1 for the operating train 20 when the operating train 20 is operating on the section R1, and the zone controller ZC2 generates a movement authorization MA2 for the operating train 20 when the operating train 20 is operating on the section R2. It may be necessary to generate a plurality of movement authorizations in each section, which will not be described in detail again herein. Here, movement authorization refers to the farthest location currently determined to which the operating train may move.

[0030] Since a zone controller needs to operate on the basis of some operating data of operating trains, such as location information, train operating information, interlocking information, and historical movement authorizations, when a train crosses the dot-and-dash line shown in Fig. 1, the zone controller ZC1 needs to carry out an information transfer with the zone controller ZC2, which means that the zone controller ZC1 transfers some operating information of the operating train 20 to the zone controller ZC2, and, at the same time, the zone controller ZC1 informs the operating train 20 that the train has been taken over by the ZC2. The zone controller ZC1 transfers information to the zone controller ZC2, and the zone controller ZC1's notification of the operating train 20 and the zone controller ZC2's takeover of the operating train 20 is completed only after a plurality of information exchanges. Then, if a problem, for example, a delay, occurs during information transfer or information exchange between the zone controllers ZC1/ZC2 and the operating train 20, it is possible that the zone controller ZC2 has lost control of the operating train 20, wherein, for example, an information delay occurs, causing a delay in the zone controller ZC2's grasping of the location of the operating train 20. In other words, in the process of information transfer between the zone controllers in two adjacent zones, an invisible zone boundary is inevitably created for the operating train, wherein, when the operating train crosses the zone boundary, accurate control of the operating train is likely to be lost in the event of a failure to transfer information in a timely manner. When the zone controller ZC2 acquires an accurate location of the operating train 20, it is possible that the distance between the operating train 20 and the preceding operating train has become smaller than the safe distance between two adjacent operating trains, and thus the emergency brake has to be pulled to stop the operating train 20, which makes the operation of the operating train 20 unstable. Therefore, it is highly probable that a train runs unstably and needs to be stopped by emergency braking at a zone boundary.

[0031] In addition, with the extension of operating rail lines, control is generally achieved by increasing the number of zones, while an increase in the number of zones and an increase in the number of trains operating on operating tracks will lead to an increase in the number of zone controllers, and to more frequent information transfers between adjacent zone controllers. Furthermore, due to the limitations on the processing capacities of zone controllers and on the communication bandwidths between adjacent zone controllers, it is difficult for the number of trains that can run on an operating track to overcome the bottleneck posed by zone boundaries.

[0032] In order to solve the problems that occur when an operating train crosses a zone boundary, the inventor of the present invention proposes the idea of eliminating any zone boundaries, that is, implementing the unified management of the entire operating process of operating trains on a line. Furthermore, considering the limitations of the processing capabilities of existing zone controllers, the present invention proposes that centralizing processing capabilities of a plurality of zone controllers can satisfy the requirement for generating corresponding movement authorizations simultaneously for movement authorization requests transmitted simultaneously by all the operating trains.

[0033] Based on the above-mentioned idea, with an automatic train protection system mentioned in an embodiment of the present invention, zone boundaries between zone controllers are eliminated and, instead, all the movement authorizations are centrally managed by a plurality of zone controllers. Preferably, based on the idea of load balancing, the system selects suitable zone controller computing nodes (equivalent to zone controllers) for movement authorization requests, so that the selected zone controller computing nodes can generate movement authorizations in response to movement authorization requests. In addition, the system can also select idle zone controller computing nodes for movement authorization requests (this method requires a relatively large number of zone controller computing nodes) or directly select one zone controller computing node for movement authorization requests in sequence. Therefore, an

automatic train protection system proposed in an embodiment of the present invention does not involve the process of information transfer between zone controller computing nodes, thereby overcoming the defects that may be caused by boundaries of zone control.

[0034] An automatic train protection system is provided by an embodiment of the present invention, as shown in Fig. 2, the automatic train protection system comprising:

at least two zone controller computing nodes 101;

an allocation unit 102, connected to the at least one operating train 20 and the at least two zone controller computing nodes 101, configured to receive movement authorization requests transmitted by the target operating trains 20, the movement authorization requests comprising location information of the target operating trains 20, operating information of the target operating trains 20, and feature identifiers of the target operating trains 20, to select, from the at least two zone controller computing nodes 101, one zone controller computing node 101 for the movement authorization requests, and to transmit the movement authorization requests to the selected zone controller computing node 101;

each zone controller computing node 101 is configured to, when selected, acquire train sorting map information and interlocking information on the basis of the location information of the target operating trains 20 and of the feature identifiers of the target operating trains 20, generate target movement authorizations on the basis of the train sorting map information, the operating information of the target operating trains 20, and the interlocking information, and transmit the target movement authorizations to the allocation unit 102;

the allocation unit 102 is further configured to transmit the target movement authorizations to the target operating trains 20.

[0035] The target operating trains 20 mentioned in an embodiment of the present invention refer to, among at least one operating train 20, the operating trains 20 that transmit movement authorization requests to the allocation unit 102.

[0036] The connection of the allocation unit 102 to at least one operating train 20 as mentioned in an embodiment of the present invention refers to a communication connection and/or a data connection, which means that data or instructions may be exchanged between the allocation unit and a train.

[0037] In addition, it should be noted that location information of the target operating trains may be reliable location information in the target operating trains, or may be relative locations of the target operating trains on the line. Operating information of the target operating trains may include the speeds of the target operating trains, the operating states of the target operating trains, and the operating directions of the target operating trains.

[0038] It is worth noting that the allocation unit may preferably be a load balancing server, and the load balancing server can select one zone controller computing node for the target operating trains on the basis of the operating states of each of the registered zone controller computing nodes, so that load balancing is achieved among the registered zone controller computing nodes. Thus, the operation load of a plurality of centralized zone controller computing nodes (the zone controller computing nodes may be existing zone controllers) may be adequately balanced, so as to avoid centralized allocation of movement authorization requests to one or several zone controllers. In an embodiment of the present invention, operating states of zone controller computing nodes may be the load/duty of the zone controller computing nodes, wherein the load/duty of the zone controller computing nodes refers to the number of movement authorization requests to be processed by the zone controller computing nodes or the number of target operating trains corresponding to the zone controller computing nodes.

[0039] Therefore, the allocation unit 102 may simultaneously receive movement authorization requests transmitted by a plurality of target operating trains 20, or may receive movement authorization requests transmitted by only one target operating train 20. The allocation unit 102 may select a zone controller computing node 101 with a low current load for movement authorization requests on the basis of the current load (computational load) of each zone controller computing node 101. In addition, the allocation unit 102 can also use the existing load balancing technology to select zone controller computing nodes 101 for movement authorization request. For example, when 10 movement authorization requests are received at the same time, the same zone controller computing node 101 with the lowest load may be selected for 6 of the movement authorization requests, and one zone controller computing node 101 with a slightly higher load may be selected for the remaining 4 movement authorization requests respectively.

[0040] The above-mentioned zone controller computing nodes 101 may be directly implemented by using an existing zone controller configuration, wherein, for example, the existing zone controllers may be directly centralized and connected to the allocation unit, and each zone controller is a zone controller computing node in the embodiment.

[0041] In addition, in the above-described automatic train protection system, there is no need for communication between zone controller computing nodes, and thus, when one or more zone controller computing nodes have failed, the remaining zone controller computing nodes can still serve all the trains, thereby effectively improving the stability of rail line operation. In addition, replacement of a faulty zone controller computing node will not affect the operation of any other normal zone controller computing node, which means that hot replacement, hot expansion and hot upgrade are

supported, providing ease of maintenance and further improving the stability of rail line operation. In addition, in the above-described automatic train protection system, tasks, namely, movement authorization requests, are allocated by the allocation unit to the zone controller computing nodes, so that more train requests may be processed through load balancing and parallel computing without being limited by hardware performance. This allows the operating trains to operate more safely and efficiently.

[0042] The communication between the zone controller computing nodes and the allocation unit and the communication between the allocation unit and the operating trains are completed on the basis of Ethernet.

[0043] In an embodiment of the present invention, train sorting maps/train sorting map information are static information, movement authorization
information/movement authorizations are dynamic information (to be generated in the future), and different train movement authorizations are not allowed to overlap.

[0044] As shown in Fig. 3, in an embodiment of the present invention, the automatic train protection system may further comprise:

at least one first registration node 103, connected to the at least one operating train 20 and the at least two zone controller computing nodes 101, and configured to generate and store a corresponding train registration list for the operating trains 20 in response to a registration request received from each of the operating trains 20, wherein the registration request comprises feature identifiers and
operating information, and the registration list comprises the feature identifiers and the operating information corresponding to the operating trains;
each zone controller computing node 101 is configured to match feature identifiers of the target operating trains 20 from the train registration list corresponding to the target operating trains 20 after receiving the movement authorization request, and if the matching is successful, on the basis of feature identifiers of the target operating trains 20, acquire train sorting map information related to the target trains, movement authorization information of other relevant trains, and interlocking information; and, if the matching fails, transfer the target operating trains 20 to at least one first registration node 103, so that the target operating trains 20 enter the registration process. The process of registering the target operating trains 20 performed by the first registration node 103 may comprise inserting the train feature identifiers and operating information of the target operating trains 20 into a train registration list, and updating relevant train sorting maps as well as real-time and historical movement authorizations.

[0045] The registration of operating trains may be realized through the first registration node, so as to better manage the operating trains, which means that an operating train needs to be registered before it can run on a train rail. Then, after an operating train goes offline, for example, returning to the depot for maintenance, the operating train that has gone offline may be deleted at the first registration node, so as to ensure that the operating trains registered on the first registration node are all drivable. It is worth noting that the above-mentioned feature identifiers refer to unique identity identifiers of the operating trains, such as the unique codes of each of the operating trains.

[0046] In addition, the above-mentioned operating line is generally a line or section in which an operating train is allowed to run, wherein, for example, if operating train A is allowed to run on metro line 10, then the operating line of operating train A is metro line 10; another example is that if operating train B is allowed to go from place A to place B, and there are 5 lines for going from place A to place B, of which line 1 is the line on which the operating train B is allowed to run, then the operating line of operating train B is line 1.

[0047] The above-mentioned train sorting map information indicates the train locations and operating states of the all operating trains; the above-mentioned train movement authorization information indicates the real-time and historical movement authorization information of all the operating trains, wherein, for example, if the operating line of operating train A is metro line 10, then the train sorting map information corresponding to operating train A indicates the locations of all the operating trains carried on metro line 10 and the operating states of all the operating trains carried on metro line 10. The locations of all the trains on the operating line where the operating trains are located may be indicated by marking on a train sorting map. For example, the locations of all the operating trains operating on line 10 are marked with special marks on the line map corresponding to metro line 10, and the special mark may be a feature identifier marked as an operating train, or the like.

[0048] In an embodiment of the present invention, as shown in Fig. 3, the automatic train protection system may further comprise: at least one second registration node 107 configured to store operating states of each registered zone controller computing node 101;
an allocation unit 102 configured to select one zone controller computing node 101 for the target operating trains 20 on the basis of the operating state of each registered zone controller computing node 101, so that load balancing may be achieved among the registered zone controller computing nodes 101. Registration management of the zone controller computing nodes is implemented. The second registration node may be the same node as the first registration node, or may be a different node. In addition, when the zone controller computing nodes are nodes in a cluster, the second

registration node and the first registration node may be management nodes in the cluster.

[0049] In an embodiment of the present invention, as shown in Fig. 3, the automatic train protection system may further comprise:

an operating data management subsystem 104, connected to the at least two zone controller computing nodes 101 and configured to store the train sorting map information and all train movement authorization information, the train sorting map information comprising real-time locations corresponding to each of the operating trains 20, the all train movement authorization information comprising real-time and historical movement authorizations corresponding to each of the operating trains 20, the train sorting map information indicating the location sorting of the operating trains 20 on all the operating lines;

each zone controller computing node 101 is configured to, when selected, transmit location information of the target operating trains 20 and feature identifiers of the target operating trains 20 to the operating data management subsystem 104; the operating data management subsystem 104 is further configured to, on the basis of the location information of the target operating trains 20 and the feature identifiers of the target operating trains 20, provide the zone controller computing nodes 101 with train sorting maps as well as real-time and historical movement authorizations related to the target operating trains 20; and, on the basis of the location information of the target operating trains 20 and the feature identifiers of the target operating trains 20, update the train sorting map information related to the target operating trains 20;

the operating data management subsystem 104 is further configured to update the movement authorization information corresponding to the target operation trains 20 on the basis of the latest movement authorization information of the target operation trains 20 calculated by the zone controller computing nodes 101.

[0050] The above-mentioned operating data management subsystem implements the management of the data of the operating trains and the operating lines, which means that the zone controller computing nodes are separated from the data necessary for generating movement authorizations, such as train sorting maps and historical movement authorizations. In other words, the operating data management subsystem provides all the zone controller computing nodes with the data necessary for generating movement authorizations, and these data necessary for generating movement authorizations are equal for each zone controller computing node, which realizes separation of data storage and zone controller computing nodes, so that the load of the zone controller computing nodes may be effectively reduced. In addition, when one zone controller computing node has failed or developed a communication fault, acquisition of all the required data by other zone controller computing nodes remains unaffected, which reduces risks of a train getting out of control, thereby further ensuring the stability of train operation.

[0051] The train sorting map related to the target operating train may indicate the sequence of the operating trains before and after the section where the target operating train is located. The train ranking map related to the target operating train can also indicate the location sequence of all the operating trains on the line where the target operating train is located.

[0052] Historical movement authorizations related to the target operating trains may indicate movement authorizations that the target operating trains have obtained, and may also indicate historical movement authorizations obtained by the operating trains adjacent to the target operating trains.

[0053] It is worth noting that the above-mentioned registration node and the operating data management subsystem may exist at the same time, or may exist in an alternative manner.

[0054] For the operating data management subsystem 104, as shown in Fig. 4, in an embodiment of the present invention, the operating data management subsystem 104 comprises: a first screening server 1041, a second screening server 1042, at least two first databases 1043, and at least two second databases 1044, wherein each first database 1043 is connected to the first screening server (1041), and is configured to store and update some of the train sorting maps;

the first screening server 1041 is connected to each zone controller computing node 101, and is configured to search for train sorting maps related to the target operating trains 20 from at least one first database 1043 on the basis of the location information of the target operating trains 20 and the feature identifiers of the target operating trains 20, and provide the train sorting maps related to the target operating trains 20 to the zone controller computing nodes 101;

each second database 1044 is connected to the second screening server 1042, and is configured to store and update real-time and historical movement authorization information corresponding to some of the operating trains 20;

the second screening server 1042 is connected to each zone controller computing node 101, and is configured to find out, from at least one second database 1044, historical and real-time movement authorizations related to the target operating trains 20 on the basis of the location information of the target operating trains 20 and feature identifiers of the target operating trains 20, and provide historical and real-time movement authorizations related to the target operating trains 20 to the zone controller computing nodes 101; and, on the basis of the feature identifiers of the target operating trains 20 and the latest movement authorizations of the target operating trains (20), update

the real-time and historical movement authorization information related to the target operating trains 20 in the at least one second database 1044.

[0055] In the above-mentioned first database and second database, when there is a newly registered operating train, the information of the newly registered operating train is added for the newly registered operating train, so as to update the train sorting map information as well as historical and real-time movement authorizations related to the newly registered operating train.

[0056] The first screening server and the second screening server can communicate with the zone controller computing nodes through Ethernet.

[0057] On the basis of embodiments, the operating data management subsystem is deployed in a distributed manner to implement the distributed management of train operation data such as train sorting maps as well as real-time and historical movement authorization information, which can effectively improve the security of these train operation data. In addition, by distributing the train sorting maps as well as real-time and historical movement authorizations in different databases, searching for train sorting maps through the first screening server, and searching for real-time and historical movement authorizations through the second screening server, it is possible to effectively improve the efficiency of the zone controller computing nodes in acquiring the train sorting maps and historical movement authorizations, thereby further improving the efficiency of generating the movement authorizations, so that movement authorizations more accurately match the actual movements of the target trains.

[0058] Generally, the number of the first databases and that of the second databases are each at least two, so that they can store train sorting maps and historical movement authorizations in a distributed manner, respectively. In addition, the stored train sorting maps and historical movement authorizations may be backed up respectively, so as to further improve the security of train operation data such as train sorting maps and historical movement authorizations.

[0059] In order to clearly explain how train sorting maps and historical movement authorizations are stored and backed up in the first databases and the second databases, a description is given by providing an example in which 3 first databases and 3 second databases are used for distributed storage and backup of train sorting maps as well as real-time and historical movement authorizations. As shown in Fig. 5, the train sorting maps are stored in a distributed manner in 3 first databases 1043, wherein a first first database 1043 stores a first part 1 of the train sorting maps, a second first database 1043 stores a second part 2 of the train sorting maps, a third first database 1043 stores a third part 3 of the train sorting maps, meanwhile, the first first database 1043 backs up the second part 2 of the train sorting maps, the second first database 1043 backs up the third part 3 of the train sorting maps, the third first database 1043 backs up the first part 1 of the train sorting maps, and the historical movement authorizations are stored in a distributed manner in 3 second databases 1044, wherein a first second database 1044 stores a first part 4 of the historical movement authorizations, a second second database 1044 stores a second part 5 of the historical movement authorizations, a third second database 1044 stores a third part 6 of the historical movement authorizations, meanwhile, the first second database 1044 backs up the second part 5 of the historical movement authorizations, the second second database 1044 backs up the third part 6 of the historical movement authorizations, and the third second database 1044 backs up the first part 4 of the historical movement authorizations, so that data security is further improved through cross backup. The division among the first part, the second part and the third part shown in Fig. 3 may be arbitrary, and the first part, the second part and the third part are combinable to form all the historical movement authorization data or all the train sorting maps.

[0060] In addition, the above-mentioned first databases, second databases, first screening server and second screening server may exist in the form of a cluster. The number of nodes may be increased for the cluster on the basis of the data volume of the train sorting maps and the data volume of the historical movement authorizations, thereby expanding the first databases and the second databases.

[0061] In particular, the first databases and the first screening server may exist in the form of a cluster. The second databases and the second screening server may exist in the form of another cluster. In other words, the train sorting maps and historical movement authorizations are stored in two clusters, which allows convenient data management. In embodiments, the storage method adopted by the cluster corresponding to the train sorting maps and the storage method adopted by the cluster corresponding to the historical movement authorizations will be described respectively.

[0062] A clustered storage method corresponding to the train sorting maps may be dividing databases for storing the train sorting maps by sections. As shown in Fig. 6, a rail is divided into 7 sections, namely S1, S2, S3, S4, S5, S6 and S7, wherein relevant data corresponding to the sections S1 - S3, such as the occupancy of the sections by trains, are stored in a database DB1, relevant data corresponding to the sections S4 - S6 are stored in a database DB2, relevant data corresponding to the sections S7 - Sn are stored in a database DB3, and so on. The database DB1, the database DB2 and the database DB3 are different first databases 1043.

[0063] On the basis of the occupancy of the rail by the operating trains shown in Fig. 6, in the first databases 1043, the train sorting maps may be recorded in the form of tables, and the table structures related to the train sorting maps are shown in Table 1 and Table 2 below, respectively.

Table 1

Section state table				
Section ID	Occupancy	ID of train occupying section	ID of adjacent train	...
S1	O	T1	...	...
S2	O	T1	...	...
S3	Not O	0	...	...
S4	O	T2	...	...
S5	Not O	0	...	...
S6	O	T4	...	...
S7	O	T4	...	...
...	...	...	...	...

[0064] In the preceding table, O indicates "occupied", and Not O indicates "not occupied".

Table 2

Partial train table			
Train ID	Location information 1	Location information 2	...
T1	...	...	...
T2	...	...	...
T3	...	...	...
T4	...	...	...
...	...	...	...

[0065] In addition, a clustered storage method corresponding to real-time and historical movement authorizations may be dividing databases for storing historical movement authorizations by sections. As shown in Fig. 7, a rail is divided into 7 sections, namely S1, S2, S3, S4, S5, S6 and S7, wherein the movement authorizations corresponding to the sections S1 - S3 are stored in a database DB4, the movement authorizations corresponding to the sections S4 - S6 are stored in a database DB5, the movement authorizations corresponding to the sections S7 and S8 are stored in a database DB6, and so on. The database DB4, the database DB5, and the database DB6 are different second databases 1044.

[0066] On the basis of relevant data of the historical movement authorizations shown in Fig. 7, in the second databases 1044, the historical movement authorizations may be recorded in the form of a table, and the table structure related to historical movement authorizations is shown in Table 3 below.

Table 3

Section information table				
Section ID	Section type	ID of train occupying section	Sequence	Operating train ID
S1	xx1	MA1 lock	1	T1
S2	xxl	MA1 lock	2	T1
S3	xxl	MA1 lock	3	T1
S4	xxl	MA2 lock	1	T2
S5	Signal light	MA2 lock	2	T2
S6	xx2	MA2 lock	3	T2
S7	xxl	MA3 lock	1	T3
...	...	...	...	...

(continued)

Section information table				
Section ID	Section type	ID of train occupying section	Sequence	Operating train ID
Sn	...	Unlock		

[0067] In the preceding table, xx1 indicates an unbranched rail; xx2 indicates a section with a switch; MAn lock indicates that the section is locked by the nth movement authorization pair; Unlock indicates that the section is not locked by any movement authorization pair; a sequence indicates the order in which the section is traversed by an operating train in one movement authorization.

[0068] In addition, there may be other cross-backup methods, such as backing up the historical movement authorizations to the first databases, and backing up the train sorting maps to the second databases, which will not be described in detail again herein.

[0069] In addition, the number of the first databases and that of the second databases may also be increased or decreased according to storage requirements.

[0070] In an embodiment of the present invention, as shown in Fig. 3, the automatic train protection system may further comprise:

an interlocking information processing subsystem 105, connected to the at least two zone controller computing nodes 101 and all the interlocking systems 30 of the rail, and configured to store interlocking information, the interlocking information comprising state information of all the interlocking elements of all the connected interlocking systems 30;

each zone controller computing node 101 is configured to, when selected, transmit an interlocking information acquisition request to the interlocking information processing subsystem 105, the interlocking information acquisition request comprising the identifiers of the interlocking elements;

the interlocking information processing subsystem 105 is further configured to query the state information of all the interlocking elements in the interlocking systems 30, control states of some of the interlocking elements, and transmit relevant retrieved interlocking information to the selected zone controller computing nodes 101.

[0071] The interlocking elements, such as an indicator light for indicating whether the rail is occupied, implement the unified management of interlocking information through the interlocking information processing subsystem.

[0072] It should be noted that the interlocking information processing subsystem 105 and the operating data management subsystem 104 may exist at the same time, or may exist in an alternative manner, in the automatic train protection system. The interlocking information processing subsystem 105 and the registration node 103 may exist at the same time, or may exist in an alternative manner, in the automatic train protection system.

[0073] In addition, the interlocking information processing subsystem 105 may be a database cluster, and the relationship and flow of information interaction between the interlocking information processing subsystem 105 and the zone controller computing nodes as well as the interlocking elements may be as shown in Fig. 8, which may specifically comprise the following steps:

Step 601: The zone controller computing nodes 101 transmit instructions related to control of interlocking elements to the interlocking information processing subsystem 105;

Step 602: The interlocking information processing subsystem 105 stores the instructions related to the control of interlocking elements in cache data blocks;

Step 603: The interlocking system 30 triggers the interlocking information processing subsystem 105, and receives element control instructions transmitted by the interlocking information processing subsystem 105;

the trigger may be a time event trigger, which means that instructions are acquired from the interlocking information processing subsystem 105 in a timed manner.

Step 604: The interlocking system 30 executes the received element control instructions;

Step 605: The interlocking system 30 transmits results of execution of the element control instructions to the interlocking information processing subsystem 105;

Step 606: The interlocking information processing subsystem 105 updates the states of execution of the element control instructions;

the instruction state may be acknowledgment received or no acknowledgment received. Acknowledgment received is further divided into two states: success and failure.

[0074] The above-mentioned instruction may be a heartbeat packet for detecting whether the communication between the interlocking system 30 and the interlocking information processing subsystem 105 is good.

Step 607: The zone controller computing nodes 101 transmit, in a timed manner, instructions to acquire the states of execution of the element control instructions to the interlocking information processing subsystem 105;
the timing may be triggered by a time event set at the front line.
Step 608: The zone controller computing nodes 101 receive the states of execution of the control instructions;
Step 609: The interlocking system 30, in a timed manner, writes element states to the interlocking information processing subsystem 105;
the timing may be triggered by a time event set at the front line.
Step 610: The interlocking information processing subsystem 105 updates stored element states;
Step 611: The zone controller computing nodes 101 transmit the states of the interlocking elements acquired from the interlocking information processing subsystem 105;
Step 612: The zone controller computing nodes 101 rewrite specific interlocking element states, such as a screen door;
Step 613: The interlocking information processing subsystem 105 updates the corresponding stored element states, and sends them back to the zone controller computing nodes 101;
Step 614: The interlocking system 30, in a timed manner, acquires, from the interlocking information processing subsystem 105, interlocking element states that need to be rewritten.

[0075] No strict sequence is followed between step 614 and any of the above-described steps.

[0076] Steps 601 to 608 are the processes and steps for information exchange among the zone controller computing nodes 101, the interlocking information processing subsystem 105 and the interlocking system 30 regarding instructions. Steps 609 to 611 are the processes and steps for information exchange between the zone controller computing nodes 101, the interlocking information processing subsystem 105 and the interlocking system 30 regarding element states. Steps 612 to 614 are the processes and steps for information exchange among the zone controller computing nodes 101, the interlocking information processing subsystem 105 and the interlocking system 30 regarding states of faulty elements.

[0077] In an embodiment of the present invention, as shown in Fig. 9, the interlocking information processing subsystem 105 comprises: at least two interlocking information cache databases 1051 and interlocking information screening servers 1052, wherein

each interlocking information cache database 1051 is connected to at least one interlocking system 30 and the interlocking information screening servers 1052, and is configured to cache the state information of all the interlocking elements in the at least one interlocking system 30 connected thereto;
the interlocking information screening server 1052 is connected to the at least two zone controller computing nodes 101, and is configured to receive interlocking information acquisition requests, search for state information of the interlocking elements in the at least two interlocking information cache databases 1051, and transmit the state information of the interlocking elements to the selected zone controller computing nodes 101.

[0078] An interlocking information acquisition request may comprise the ID of the interlocking element, and the interlocking information screening server 1052 directly searches for the state information of the interlocking element and the occupancy of the rail zone corresponding to the ID of the interlocking element.

[0079] The communication between the interlocking information screening server and the zone controller computing nodes may be carried out through Ethernet.

[0080] In addition, in a preferred embodiment, the number of interlocking information cache databases may be set according to zones, which means that the state information of the interlocking elements in each zone and the occupancy of the rail zone corresponding to the zone are stored in the same interlocking information cache database. This can solve the problem that interfaces of the interlocking systems in different zones are different. For example, if the interlocking system in zone X is provided by supplier H, and the interlocking system in zone Y is provided by supplier Z, then the interface of the interlocking system in zone X may be different from the interface of the interlocking system in zone Y, and corresponding interlocking information cache databases may be deployed for zone X and zone Y, respectively, wherein the interlocking information cache database corresponding to zone X communicates with the interlocking system in zone X, and the interlocking information cache database corresponding to zone Y communicates with interlocking system communication in zone Y. Communication between an interlocking information cache database and an interlocking system may be established through Ethernet. In addition, a corresponding interlocking information cache database is allocated for the interlocking system in each zone, which is implemented on the basis of the existing interlocking systems of each section. In other words, a solution provided by an embodiment of the present invention eliminates the

need to adjust existing interlocking systems, so that an automatic train protection system provided by the embodiment is more practical, while the system construction cost may be reduced significantly.

[0081] A zone mentioned above may be an operating line, for example, metro line 10, or may be a section of an operating line, for example, the Beijing-Zhengzhou section in the Beijing-Kowloon Line.

[0082] In an embodiment of the present invention, as shown in Fig. 9, the interlocking information processing subsystem 105 further comprises:

at least two interlocking information cache backup databases 1053, in a one-to-one correspondence with at least two interlocking information databases 1051, connected to the interlocking information screening servers 1052, and configured to back up the state information and the occupancy of rail zones cached in the corresponding interlocking information cache database 1051;

the interlocking information screening server 1052 is configured to, when its communication with any interlocking information cache database 1051 has failed, search for interlocking element state information related to the target operating trains 20 from the interlocking information cache backup database 1053 corresponding to the interlocking information cache database 1051 with which the communication has failed.

[0083] By setting an interlocking information cache backup database, the data in an interlocking information cache database are backed up to ensure the safety of the interlocking information, thereby further improving the accuracy of controlling the operating trains and the operating stability of the operating trains.

[0084] In an embodiment of the present invention, as shown in Fig. 3, the automatic train protection system further comprises:

an interlock processing standby subsystem 106, connected to the at least two zone controller computing nodes 101 and all the interlocking systems 30 of the rails, and configured to back up interlocking information;

each zone controller computing node 101 is configured to, when selected, transmit the interlocking information acquisition request to the interlock processing standby subsystem 106 after communication with the interlocking information processing subsystem 105 has failed;

the interlock processing standby subsystem 106 is further configured to search for relevant interlocking information and transmit the relevant interlocking information to the selected zone controller computing nodes 101.

[0085] The relevant interlocking information refers to the interlocking information of the interlocking elements on the section where the target operating trains are located.

[0086] This functions as a backup of an interlocking information processing subsystem, whose setting is the same as that of the interlocking information processing subsystem and will not be described in detail again herein.

[0087] Since there are many suppliers of interlocking systems and large amounts of data are involved therein, interlocking information cache backup databases and interlock processing backup subsystems may be combined to effectively guarantee the unity of interlocking information.

[0088] It should be noted that there may be an automatic train protection backup system corresponding to the automatic train protection system. The automatic train protection backup system can temporarily take the place of the automatic train protection system when a problem occurs in the operation of the automatic train protection system.

[0089] In an embodiment of the present invention, the above-mentioned automatic train protection system further comprises: a management node 109 connected to the allocation unit 102 and the zone controller computing nodes 101, the management node 109 being configured to receive location reports of the operating trains 20 transmitted by the allocation unit 102, store the location reports of the operating trains 20, update the location information of the trains in real time, and transmit the location information corresponding to movement authorization requests to the selected zone controller computing nodes 101. In addition, the management node 109 may also register each zone controller computing node 101 to facilitate the management of the zone controller computing nodes 101.

[0090] The allocation unit 102 is connected to the management node 109, and is configured to search for at least one registered zone controller computing node 101 from the management node 109, and from the at least one registered available zone controller computing node 101, select one zone controller computing node 101 for the target operating trains 20. According to this embodiment, the management of zone controller computing nodes may be implemented. The management node 109 can also store the real-time load conditions of the zone controller computing nodes, so that the allocation unit can select zone controller computing nodes for movement authorization requests on the basis of the real-time load conditions of the zone controller computing nodes stored in the management node.

[0091] It is worth noting that the above-mentioned first registration node 103 and second registration node 107 may exist as independent management nodes, or the first registration node 103 and the second registration node 107 may be replaced with the management node 109, so that the registration and management of the operating trains and zone controller computing nodes are completed on the management node.

[0092] It is worth noting that the number of zone controller computing nodes may be increased or decreased according to actual needs, wherein, for example, during a peak passenger flow period, for example, a transport period during the Spring Festival, when the number of operating trains need to be increased, the need of managing the added operating trains may be met by increasing the number of zone controller computing nodes. Another example is that after the peak passenger flow period, the number of operating trains returns to that before the peak passenger flow, the added zone controller computing nodes are no longer needed, and thus the added zone controller computing nodes may be taken offline. Yet another example is that the number of operating trains need to be reduced for line maintenance, in which case some zone controller computing nodes may be idle, and the idle zone controller computing nodes may be removed. To add a zone controller computing node, it is necessary to register, on a management node, the zone controller computing node to be added, so that the allocation unit is informed of the added zone controller computing node. To remove a zone controller computing node, it is necessary to deregister, on the management node, the zone controller computing node to be removed, so that the allocation unit no longer selects the removed zone controller computing node. This makes the operating train management system highly available.

[0093] More preferably, as shown in Fig. 3, at least two zone controller computing nodes 101 and the management node 109 form a cluster 108, wherein the management node 109 is the master node of the cluster 108, and each zone controller computing node 101 among the at least two zone controller computing nodes 101 is a slave node of the cluster 108. In addition, the registration node 103 may also be a slave node in the cluster 108. Thus, the allocation unit 102 is communicatively connected to the management node 109 (master node) in the cluster 108 and each zone controller computing node 101 (slave node) in the cluster, respectively, and the management node 109 (master node) implements overall management of all the zone controller computing nodes, location information of the operating trains, and the train list. Then, the allocation unit 102 transmits the location information of each of the operating trains 20 to the management node 109 (master node), and then the management node 109 (master node) will update the location information of each of the operating trains 20. After the allocation unit 102 receives movement authorization requests transmitted by the target operating trains 20 and selects zone controller computing nodes 101 for the movement authorization requests, the allocation unit 102 transmits the location information of the target operation trains 20 to the selected zone controller computing nodes 101 and returns the selected zone controller computing nodes 101 to the management node 109 (master node), so that the management node 109 (master node) then transmits the list information related to the target operating trains 20 in the train list to the selected zone controller computing nodes 101. In addition, the selected zone controller computing nodes 101 acquire, from the operating data management subsystem 104, train sorting maps and historical movement authorizations related to the target operating trains 20. The selected zone controller computing nodes 101 calculate and generate movement authorizations on the basis of the list information, the train sorting maps as well as the real-time and historical movement authorizations related to the target operating trains 20, and update the movement authorizations stored in the operating data management subsystem 104. At the same time, the selected zone controller computing nodes 101 transmit the movement authorizations to the allocation unit 102, and the allocation unit 102 transmits the movement authorizations to the target operating trains 20.

[0094] Since existing zone controllers may be directly selected as zone nodes in an embodiment, existing interlocking elements may continue to be used, which can ensure the safety of train operation.

[0095] In addition, in an embodiment, a backup automatic train protection system may also be set for the automatic train protection system, so that when the automatic train protection system fails, the backup automatic protection system may be enabled to take the place of the automatic train protection system, thereby providing services to the operating trains.

[0096] In addition, in an embodiment of the present invention, the automatic train protection system may be deployed on a cloud server. For example, the zone controller computing nodes, allocation unit, operating data management subsystems and interlocking information processing subsystems in the automatic train protection system are deployed on a cloud server.

[0097] An automatic train protection method for an automatic train protection system provided by an embodiment of the present invention will be described in detail below with reference to the drawings.

[0098] As shown in Fig. 10, an embodiment of the present invention provides an automatic train protection method for an automatic train protection system, wherein the automatic train protection method may comprise the following steps: Step 701: The allocation unit receives a movement authorization request;

Step 702: The allocation unit selects one zone controller computing node for the movement authorization request;
Step 703: The selected zone controller computing node acquires train sorting map information, movement authorization information of other related trains and interlocking information;
Step 704: The selected zone controller computing node calculates and generates a target movement authorization on the basis of the train sorting map information, the movement authorization information of other related trains, and the interlocking information.

[0099] The calculation and generation of a target movement authorization may be implemented by using an existing calculation method.

[0100] In one embodiment, the automatic train protection method is implemented with the automatic train protection system shown in Fig. 2 or Fig. 3, and a specific implementation of step 701 may be to receive movement authorization requests transmitted by the target operating trains 20 through the allocation unit 102, the movement authorization requests comprising the location information of the target operating trains 20, the operating information of the target operating trains 20, and the feature identifiers of the target operating trains 20.

[0101] In one embodiment, the automatic train protection method is implemented with the automatic train protection system shown in Fig. 2 or Fig. 3, and a specific implementation of step 702 may be to select one zone controller computing node 101 for a movement authorization request through the allocation unit 102, and transmit the movement authorization request to the selected zone controller computing node 101. The allocation unit 102 selects zone controller computing nodes for movement authorization requests according to the principle of load balancing, so as to avoid an excessive difference in the load between the zone controller computing nodes.

[0102] In one embodiment, the automatic train protection method is implemented with the automatic train protection system shown in Fig. 2 or Fig. 3, and a specific implementation of step 703 may be, with the selected zone controller computing node 101, acquiring train sorting map information, movement authorization information of other trains, and interlocking information on the basis of the location information of the target operating trains 20 and of the feature identifiers of the target operating trains 20, generating target movement authorizations on the basis of the train sorting map information, the operating information of the target operating trains 20, the movement authorization information of other trains, and the interlocking information, and transmitting the target movement authorizations to the allocation unit 102.

[0103] In an embodiment, the automatic train protection method is implemented with the automatic train protection system shown in Fig. 2 or Fig. 3, and a specific implementation of step 704 may be transmitting the target movement authorizations to the target operating trains 20 through the allocation unit 102.

[0104] In one embodiment, the train operation management method may further comprise: with at least one registration node 103, generating and storing a corresponding train registration list for the operating trains 20 in response to a registration request received from each of the operating trains 20, wherein the registration request comprises feature identifiers and operating information, and information corresponding to registration and operation of trains comprises feature identifiers and operating information; thus, after the step of transmitting movement authorization requests to the selected zone controller computing nodes 101, the method further comprises: matching, with the selected zone controller computing node 101, the feature identifiers of the target operating trains 20 from the train registration list, if the matching is successful, acquiring train sorting map information related to the target trains 20, relevant movement authorization information, and interlocking information on the basis of the feature identifiers of the target operating trains, and, if the matching fails, transferring the target operating trains 20 to at least one first registration node 103, so that the target operating trains 20 enter the registration process. The registration and deregistration management of the operating trains is implemented with at least one registration node.

[0105] In one embodiment, the automatic train protection method may further comprise: storing the operating state of each registered zone controller computing node with at least one registration node; the step of selecting one zone controller computing node for the target operating trains from at least one registered zone controller computing node comprises: selecting one zone controller computing node for the target operating trains on the basis of the operating state of each registered zone controller computing node, so that load balancing may be achieved among the registered zone controller computing nodes.

[0106] In one embodiment, the train operation management method may further comprise: registering each zone controller computing node 101 with the at least one first registration node 103; thus, the step of selecting one zone controller computing node 101 for the target operating trains 20 comprises: searching for at least one registered zone controller computing node 101 from at least one registration node 103, and selecting one zone controller computing node 101 for the target operating trains 20 from the at least one registered zone controller computing node 101.

[0107] In one embodiment, the automatic train protection method may further comprise: storing, with the operating data management subsystem 104, train sorting map information, the train sorting map information comprising train sorting maps corresponding to operating lines, as well as real-time and historical movement authorizations corresponding to each of the operating trains 20, the train sorting maps indicating the location sorting of the operating trains 20 on the operating lines; after transmitting movement authorization requests to the selected zone controller computing nodes 101, the method further comprises: transmitting, with the selected zone controller computing node 101, location information of the target operating trains 20 and feature identifiers of the target operating trains 20 to the operating data management subsystem 104; and with the operating data management subsystem 104, on the basis of the location information of the target operating trains 20 and the feature identifiers of the target operating trains 20, providing the zone controller computing nodes 101 with train sorting maps and historical movement authorizations related to the target operating trains 20.

[0108] In one embodiment, a specific implementation of storing train sorting map information with the operating data management subsystem 104 may be storing, with at least two first databases 1043, the train sorting maps corresponding to the operating lines, and storing, with at least two second databases 1044, real-time and historical movement authorizations corresponding to the operating trains 20.

[0109] In one embodiment, the train operation management method may further comprise: storing interlocking information with the interlocking information processing subsystem 105, the interlocking information comprising state information of all the interlocking elements of all the connected interlocking systems 30; thus, the step of acquiring interlocking information comprises: transmitting, with the selected zone controller computing node 101, an interlocking information acquisition request to the interlocking information processing subsystem 105, the interlocking information acquisition request comprising location information of the target operating trains 20; and searching, with the interlocking information processing subsystem 105, for interlocking information related to the location information of the target operating trains 20, and transmitting the interlocking information related to the location information of the target operating trains 20 to the selected zone controller computing nodes 101.

[0110] In one embodiment, a specific implementation of storing interlocking information with the interlocking information processing subsystem 105 may comprise: caching, with at least two interlocking information cache databases 1051, the state information of all the interlocking elements in the at least one interlocking system 30 connected thereto; thus, a specific implementation of searching, with the interlocking information processing subsystem 105, for interlocking information related to the location information of the target operating trains 20, and transmitting the interlocking information related to the location information of the target operating trains 20 to the selected zone controller computing nodes 101 may comprise: receiving the interlocking information acquisition request with the interlocking information screening server 1052; and searching for the state information related to the location information of the target operating trains 20 and the occupancy situations of rail zones in at least two interlocking information cache databases 1051, and transmitting the state information related to the location information of the target operating trains 20 and the occupancy situations of rail zones to the selected zone controller computing nodes 101.

[0111] In one embodiment, the train operation management method may further comprise: backing up, with at least two interlocking information cache backup databases 1051, the state information and occupancy situations of rail zones cached in the corresponding interlocking information cache database 1051; and when communication between the interlocking information screening server 1052 and any interlocking information cache database 1051 has failed, searching for state information and occupancy situations of rail zones related to the target operating trains 20 from the interlocking information cache backup database 1053 corresponding to the interlocking information cache database 1051 with which the communication has failed.

[0112] In one embodiment, the train operation management method may further comprise: backing up interlocking information with the interlock processing standby subsystem 106; transmitting the interlocking information acquisition request to the interlock processing standby subsystem 106 after the communication between the selected zone controller computing node 101 and the interlocking information processing subsystem 105 has failed; and searching, with the interlock processing standby subsystem 106, for interlocking information related to the location information of the target operating trains 20, and transmitting the interlocking information related to the location information of the target operating trains 20 to the selected zone controller computing nodes 101.

[0113] In order to clearly explain how the automatic train protection system automatically protects trains, a description will be given by providing an example in which the allocation unit in the system is a load balancing server 800 and the system manages two operating trains. As shown in Fig. 11, the process of managing the operating trains with the automatic train protection system is specifically as follows:

Step 801: The two operating trains 201, 202 transmit movement authorization requests with train locations to the load balancing server 800;

Step 802: The load balancing server 800, on the basis of the load situation of each zone controller computing node 101, selects the corresponding zone controller computing nodes 101 for the movement authorization requests with train locations transmitted by the two operating trains 201, 202, wherein the load balancing server 800 selects a zone controller computing node 1011 for the movement authorization request with a train location from the operating train 201, and selects a zone controller computing node 1012 for the movement authorization request with a train location from the operating train 202;

Step 803: The load balancing server 800 transmits, in a timed manner, the train locations of the two operating trains 201, 202 to the management node 109 in the cluster 108;
the management node 109 and each zone controller computing node 101 exist in the form of the cluster 108. By means of a cluster, it is convenient to manage the management node 109 and each zone controller computing node 101, while the number of zone controller computing nodes 101 may be increased or decreased as required. The

above-described step 803 is a relatively independent step, and no strict sequence of it, step 801, and step 802 is followed.

Step 804: The zone controller computing node 1011 acquires the train sorting map as well as real-time and historical movement authorizations related to the operating train 201, and the zone controller computing node 1012 acquires the train sorting map as well as real-time and historical movement authorizations related to the operating train 202; the train sorting maps as well as real-time and historical movement authorizations may be stored independently of the cluster 108, wherein, for example, the train sorting maps as well as real-time and historical movement authorizations are stored in a plurality of databases in a distributed manner, and in order to facilitate the invocation of databases, a corresponding screening server may be set for databases storing the train sorting maps, and a corresponding screening server may be set for the real-time and historical movement authorizations. In other words, required train sorting maps are searched for, with the screening server corresponding to the train sorting maps, from the database storing train sorting maps, and required real-time and historical movement authorizations are searched for, with the screening server corresponding to the real-time and historical movement authorizations from the database storing real-time and historical movement authorizations. The communication relationship between databases and screening servers is described in detail in the above-mentioned automatic train protection system, and will not be described in detail again herein.

Step 805: The management node 109, on the basis of the train locations of the two operating trains 201, 202, updates the train locations stored by itself; step 804 and step 805 are relatively independent steps, which do not follow a strict sequence, without affecting each other.

Step 806: The management node 109 gives a response to the load balancing server 800 to exchange information with the load balancing server 800;
this step is mainly intended to check that the management node communicates properly and has received information such as the train locations of the operating trains, and update the load balancing server 800 with all the zone controller computing nodes 101 associated with the train calculation and the operating states of these zone controller computing nodes 101, the operating states including, for example, normal, suspended, offline, and faulty.

Step 807: The management node 109 acquires a train list, and splits the train list to acquire a partial list related to the operating train 201 and a partial list related to the operating train 202;
in this step, the management node 109 generates a time-triggered event on the basis of the train locations of the operating trains 201, 202 to determine an operating list of the operating trains.

Step 808: The management node 109 transmits the partial list related to the operating train 201 to the zone controller computing node 1011, and the management node 109 transmits the partial list related to the operating train 202 to the zone controller computing node 1012;

Step 809: The zone controller computing node 1011 generates a movement authorization and updates the historical movement authorizations, and the zone controller computing node 1012 generates a movement authorization and updates the historical movement authorizations;
the specific process of updating the historical movement authorizations in step 809 may be transmitting generated movement authorizations to the database storing historical movement authorizations, for storage, and this process is not shown in Fig. 11.

Step 810: The zone controller computing node 1011 transmits the movement authorization to the load balancing server 800, and the zone controller computing node 1012 transmits the movement authorization to the load balancing server 800;

Step 811: The load balancing server 800 transmits the movement authorization related to the operating train 201 to the operating train 201, and transmits the movement authorization related to the operating train 202 to the operating train 202.

[0114] In an embodiment of the present invention, each subject in the system, for example, a zone controller computing node, an allocation unit/load balancing server, a registration node, an operating data management subsystem, a screening server, and an interlocking information processing subsystem, may be implemented as a stand-alone server, or a virtual machine based on a clustered server. In other words, these subjects may be physical subjects, or may be on a device physically and divided logically.

[0115] In addition, the allocation unit, zone controller computing nodes, registration nodes, operating data management subsystems, and interlocking information processing subsystems in the above-described automatic train protection system may be deployed on a cloud server.

[0116] The present invention further provides a computer-readable medium storing an instruction for combining a load balancing server and the at least two zone controller computing nodes to execute the automatic train protection method as described herein. In addition, it is possible to provide a system or apparatus equipped with a storage medium storing software program code for implementing functions of any of the above-described embodiments, and to cause a computer (or a CPU or an MPU or an MCU) of the system or apparatus to read and execute the program code stored on the storage medium.

[0117] In this case, the program code itself read from the storage medium can fulfill the functions of any of the above-described embodiments and, therefore, program code and the storage medium storing the program code constitute a part of the present invention.

[0118] Examples of a storage medium for providing program code include floppy disk, hard disk, magneto-optical disk, optical disk (for example, CD-ROM, CD-R, CD-RW, DVD-ROM, DVD-RAM, DVD-RW, or DVD+RW), magnetic tape, non-volatile memory card, and ROM. Optionally, program code may be downloaded from a server computer via a communications network.

[0119] In addition, it should be made clear that functions of any of the above-described embodiments may be implemented not only by executing program code read by a computer but also by causing, according to an instruction given by program code, an operating system, etc. running on a computer to complete part or all of actual operations.

[0120] In addition, it is understandable that functions of any one of the above-described embodiments may be implemented by writing program code read from a storage medium to a memory disposed in an expansion board inserted into a computer or to a memory disposed in an expansion module connected to a computer, and then by, according to the instruction of program code, causing a CPU, etc. installed on the expansion board or expansion module to execute part of all of the actual operations.

[0121] It should be noted that not all the steps or modules in the above-described flow and system structural diagrams are required, and certain steps or modules may be omitted as needed. The sequence of performing steps is not fixed and may be adjusted as needed. The system structures described in the above embodiments may be physical structures or logical structures, which means that certain modules may be implemented as the same physical entity, or certain modules may be implemented as a plurality of physical entities separately, or certain modules may be jointly implemented by certain components in a plurality of standalone devices.

[0122] In each of the above embodiments, a hardware module may be implemented mechanically or electrically. For example, a hardware module may comprise a permanently dedicated circuit or logic (for example, a special processor, an FPGA, or an ASIC) for completing corresponding operations. A hardware module may further comprise programmable logic or circuitry (for example, a general-purpose processor or any other programmable processor), which may be temporarily configured by software to perform corresponding operations. Specific implementation manners (mechanical systems, or dedicated permanent circuits, or temporarily configured circuits) may be determined on the basis of cost and time considerations.

[0123] While the present invention has been described and illustrated in detail above with reference to the drawings and preferred embodiments, the present invention is not limited to these disclosed embodiments, and those of ordinary skill in the art, on the basis of the above-mentioned embodiments, may appreciate that more embodiments of the present invention may be obtained by combining the code auditing means in the different embodiments described above and that these embodiments also fall within the scope of protection of the present invention.

Claims

1. An automatic train protection system, **characterized in that** it comprises:

at least two zone controller computing nodes (101);

an allocation unit (102), connected to the at least one operating train (20) and the at least two zone controller computing nodes (101), configured to receive movement authorization requests transmitted by the target operating trains (20), the movement authorization requests comprising location information of the target operating trains (20), operating information of the target operating trains (20), and feature identifiers of the target operating trains (20), to select, from the at least two zone controller computing nodes (101), one zone controller computing node (101) for the movement authorization requests, and to transmit the movement authorization requests to the selected zone controller computing node (101);

wherein each of the zone controller computing nodes (101) is configured to, when selected, acquire train sorting map information, movement authorization information of other trains, and interlocking information on the basis

of the location information of the target operating trains (20) and of the feature identifiers of the target operating trains (20), generate target movement authorizations on the basis of the train sorting map information, the movement authorization information of other trains, the interlocking information and the operating information of the target operating trains (20), and transmit the target movement authorizations to the allocation unit (102); the allocation unit (102) is further configured to transmit the target movement authorizations to the target operating trains (20).

2. The automatic train protection system as claimed in claim 1, **characterized in that** it further comprises:

at least one first registration node (103), connected to the at least one operating train (20) and the at least two zone controller computing nodes (101), and configured to generate and store a corresponding train registration list for the operating trains (20) in response to a registration request received from each of the operating trains (20), wherein the registration request comprises feature identifiers and operating information of the operating trains, and the train registration list comprises the feature identifiers and the operating information corresponding to the operating trains;
wherein each zone controller computing node (101) is configured to match feature identifiers of the target operating trains (20) from the train registration list after receiving the movement authorization request;
if the matching is successful, update the operating information of the target operating train in the registration list on the basis of feature identifiers of the target operating trains (20), and acquire train sorting map information related to the target trains, movement authorization information of other trains, and interlocking information;
if the matching fails, transfer the target operating trains (20) to the at least one first registration node (103), so that the target operating trains (20) enter the registration process.

3. The automatic train protection system as claimed in claim 1, **characterized in that** it further comprises:

at least one second registration node (107) configured to register each of the zone controller computing nodes (101);
the allocation unit (102), connected to at least one second registration node (107), and configured to search for at least one registered zone controller computing node (101) from the at least one second registered node (107), and select one zone controller computing node (101) for the target operating trains (20) from the at least one registered zone controller computing node (101).

4. The automatic train protection system as claimed in claim 3, **characterized in that**

the at least one second registration node (107) is configured to store operating states of each of the registered zone controller computing nodes (101);
the allocation unit (102) is configured to select one zone controller computing node (101) for the target operating trains (20) on the basis of the operating states of each of the registered zone controller computing nodes (101), so that load balancing may be achieved among the registered zone controller computing nodes (101).

5. The automatic train protection system as claimed in any of claims 1 to 4, **characterized in that** it further comprises:

an operating data management subsystem (104), connected to the at least two zone controller computing nodes (101) and configured to store the train sorting map information and all train movement authorization information, the train sorting map information comprising real-time locations corresponding to each of the operating trains (20), the all train movement authorization information comprising real-time and historical movement authorizations corresponding to each of the operating trains (20), the train sorting map information indicating the location sorting of the operating trains (20) on all the operating lines;
each of the zone controller computing nodes (101) is configured to, when selected, transmit location information of the target operating trains (20) and feature identifiers of the target operating trains (20) to the operating data management subsystem (104);
the operating data management subsystem (104) is further configured to, on the basis of the location information of the target operating trains (20) and the feature identifiers of the target operating trains (20), provide the zone controller computing nodes (101) with train sorting maps as well as real-time and historical movement authorizations related to the target operating trains (20); and, on the basis of the location information of the target operating trains (20) and the feature identifiers of the target operating trains (20), update the train sorting map information related to the target operating trains (20);
the operating data management subsystem (104) is further configured to update the movement authorization

information corresponding to the target operation trains (20) on the basis of the latest movement authorization information of the target operation trains (20) calculated by the zone controller computing nodes (101).

6. The automatic train protection system as claimed in claim 5, **characterized in that**

the operating data management subsystem (104) comprises: a first screening server (1041) and at least one first database (1043) connected to the first screening server (1041), wherein each first database (1043) is connected to the first screening server (1041), and is configured to store and update some of the train sorting maps; the first screening server (1041) is connected to each of the zone controller computing nodes (101), and is configured to search for train sorting maps related to the target operating trains (20) from the at least one first database (1043) on the basis of the location information of the target operating trains (20) and the feature identifiers of the target operating trains (20), and provide the train sorting maps related to the target operating trains (20) to the zone controller computing nodes (101); and the first screening server (1041) is configured to, on the basis of the location information of the target operating trains (20) and the feature identifiers of the target operating trains (20), update the train sorting map information related to the target operating trains (20) in the first database (1043); or

the operating data management subsystem (104) comprises: a second screening server (1042) and at least one second database (1044) connected to the second screening server (1042), wherein each second database (1044) is connected to the second screening server (1042), and is configured to store and update real-time and historical movement authorizations corresponding to some of the operating trains (20); the second screening server (1042) is connected to each of the zone controller computing nodes (101), and is configured to search for real-time and historical movement authorizations related to the target operating trains (20) from the at least one second database (1044) on the basis of the location information of the target operating trains (20) and the feature identifiers of the target operating trains (20), and provide the real-time and historical movement authorizations related to the target operating trains (20) to the zone controller computing nodes (101); and, on the basis of the feature identifiers of the target operating trains (20) and the latest movement authorizations of the target operating trains (20), update the real-time and historical movement authorization information related to the target operating trains (20) in the at least one second database (1044).

7. The automatic train protection system as claimed in any of claims 1 to 4, **characterized in that** it further comprises:

an interlocking information processing subsystem (105) connected to the at least two zone controller computing nodes (101), and an interlocking system (30) configured to store interlocking information, wherein the interlocking information comprises state information of all the interlocking elements in all the connected interlocking systems (30);

each of the zone controller computing nodes (101) is configured to, when selected, transmit an interlocking information acquisition request to the interlocking information processing subsystem (105), the interlocking information acquisition request comprising the identifiers of the interlocking elements;

the interlocking information processing subsystem (105) is further configured to query the state information of all the interlocking elements in the interlocking systems (30), control states of some of the interlocking elements, and transmit relevant retrieved interlocking information to the selected zone controller computing nodes (101).

8. The automatic train protection system as claimed in claim 7, **characterized in that** the interlocking information processing subsystem (105) comprises: at least two interlocking information cache databases (1051) and interlocking information screening servers (1052), wherein

each of the interlocking information cache databases (1051) is connected to at least one interlocking system (30) and the interlocking information screening servers (1052), and is configured to cache the state information of the interlocking elements in the at least one interlocking system (30) connected thereto;

the interlocking information screening server (1052) is connected to the at least two zone controller computing nodes (101), and is configured to receive the interlocking information acquisition requests, search for state information of the interlocking elements in the at least two interlocking information cache databases (1051), and transmit the state information of the interlocking elements to the selected zone controller computing nodes (101).

9. The automatic train protection system as claimed in claim 8, **characterized in that** the interlocking information processing subsystem (105) further comprises:

at least two interlocking information cache backup databases (1053), in a one-to-one correspondence with at least two interlocking information databases (1051), connected to the interlocking information screening servers (1052), and configured to back up the interlocking element state information cached in the corresponding interlocking information cache database (1051);
the interlocking information screening server (1052) is configured to, when its communication with any of the interlocking information cache databases (1051) has failed, search for relevant interlocking element state information from the interlocking information cache backup database (1053) corresponding to the interlocking information cache database (1051) with which the communication has failed.

10. The automatic train protection system as claimed in claim 7, **characterized in that** it further comprises:

an interlock processing standby subsystem (106), connected to the at least two zone controller computing nodes (101) and all the interlocking systems (30) of the rails, and configured to back up interlocking information;
each of the zone controller computing nodes (101) is configured to, when selected, transmit the interlocking information acquisition request to the interlock processing standby subsystem (106) after communication with the interlocking information processing subsystem (105) has failed;
the interlock processing standby subsystem (106) is further configured to search for relevant interlocking element information and transmit the relevant interlocking element information to the selected zone controller computing nodes (101).

11. An automatic train protection method, **characterized in that** it comprises:

receiving, with the allocation unit (102), movement authorization requests transmitted by the target operating trains (20), the movement authorization requests comprising location information of the target operating trains (20), operating information of the target operating trains (20), and feature identifiers of the target operating trains (20);
selecting, with the allocation unit (102), one zone controller computing node (101) for the movement authorization requests, and transmitting the movement authorization requests to the selected zone controller computing node (101);
transmitting, with the allocation unit (102), the target movement authorization from the selected zone controller computing node (101) to the target operating trains (20);
wherein the selected zone controller computing node (101) is configured to acquire train sorting map information, real-time movement authorization information of other trains, and interlocking information on the basis of the location information of the target operating trains (20) and of the feature identifiers of the target operating trains (20), generate target movement authorizations on the basis of the train sorting map information, the movement authorization information of other trains, the operating information of the target operating trains (20), and the interlocking information, and transmit the target movement authorizations to the allocation unit (102).

12. The method as claimed in claim 11, **characterized in that** the method further comprises:

with at least one first registration node (103), generating and storing a corresponding train registration list for the operating trains (20) in response to a registration request received from each of the operating trains (20), wherein the registration request comprises feature identifiers and operating information of the operating trains, and the train registration list comprises the feature identifiers and the operating information corresponding to the operating trains;
after the step of transmitting movement authorization requests to the selected zone controller computing node (101), the method further comprises:
matching, with the selected zone controller computing node (101), the feature identifiers of the target operating trains (20) from the train registration list, if the matching is successful, acquiring train sorting map information related to the target trains (20), movement authorization information of other trains, and interlocking information on the basis of the feature identifiers of the target operating trains (20); if the matching fails, transferring the target operating trains (20) to the at least one first registration node (103), so that the target operating trains (20) enter the registration process.

13. The method as claimed in claim 11, **characterized in that** it further comprises:

registering each of the zone controller computing nodes (101) with at least one second registration node (107);
the step of selecting one zone controller computing node (101) for the target operating trains (20) comprises:

searching for at least one registered zone controller computing node (101) from the at least one second registration node (107), and selecting one zone controller computing node (101) for the target operating trains (20) from the at least one registered zone controller computing node (101).

14. The method as claimed in claim 12, **characterized in that**

the method further comprises: storing the operating state of each of the registered zone controller computing nodes (101) with the at least one second registration node (107);
the step of selecting one zone controller computing node (101) for the target operating trains (20) from at least one of the registered zone controller computing nodes (101) comprises:
selecting one zone controller computing node (101) for the target operating trains (20) on the basis of the operating state of each of the registered zone controller computing nodes (101), so that load balancing may be achieved among the registered zone controller computing nodes (101).

15. The method as claimed in any of claims 11 to 14, **characterized in that** the method further comprises:

storing, with the operating data management subsystem (104), the train sorting map information, and real-time locations corresponding to each of the operating trains (20), the all train movement authorization information comprising real-time and historical movement authorizations corresponding to each of the operating trains (20), the train sorting map information indicating the location sorting of the operating trains (20) on all the operating lines;
after the step of transmitting movement authorization requests to the selected zone controller computing node (101), the method further comprises:

transmitting, with the selected zone controller computing node (101), location information of the target operating trains (20) and feature identifiers of the target operating trains (20) to the operating data management subsystem (104);
with the operating data management subsystem (104), on the basis of the location information of the target operating trains (20) and the feature identifiers of the target operating trains (20), providing the zone controller computing nodes (101) with train sorting maps as well as real-time and historical movement authorizations related to the target operating trains (20), and, on the basis of the location information of the target operating trains (20) and the feature identifiers of the target operating trains (20), updating the train sorting map information related to the target operating trains (20); and updating the movement authorization information corresponding to the target operation trains (20) on the basis of the latest movement authorization information of the target operation trains (20) calculated by the zone controller computing nodes (101).

16. The method as claimed in any of claims 11 to 14, **characterized in that** the method further comprises: storing interlocking information with the interlocking information processing subsystem (105), the interlocking information comprising state information of all the interlocking elements of all the connected interlocking systems (30);
the step of acquiring interlocking information comprises:

transmitting, with the selected zone controller computing node (101), an interlocking information acquisition request to the interlocking information processing subsystem (105), the interlocking information acquisition request comprising identifiers of the interlocking elements;
and searching, with the interlocking information processing subsystem (105), for relevant interlocking element information and transmitting the relevant interlocking element information to the selected zone controller computing nodes (101).

17. The method as claimed in claim 16, **characterized in that** the step of storing interlocking information with the interlocking information processing subsystem (105) comprises:

caching, with at least two interlocking information cache databases (1051), the state information of all the interlocking elements in the at least one interlocking system (30) connected thereto;
the step of searching, with the interlocking information processing subsystem (105), for interlocking information related to the location information of the target operating trains (20), and transmitting the interlocking information related to the location information of the target operating trains (20) to the selected zone controller computing nodes (101) comprises:

receiving the interlocking information acquisition request with the interlocking information screening server (1052);
searching for state information of the interlocking elements in the at least two interlocking information cache databases (1051), and transmitting the state information of the interlocking elements to the selected zone controller computing nodes (101).

18. The method as claimed in claim 17, **characterized in that** it further comprises:

backing up, with at least two interlocking information cache backup databases (1051), the state information of the interlocking elements cached in the corresponding interlocking information cache database (1051);
when the communication between the interlocking information screening server (1052) and any of the interlocking information cache databases (1051) has failed, searching for relevant interlocking element state information from the interlocking information cache backup database (1053) corresponding to the interlocking information cache database (1051) with which the communication has failed.

19. The method as claimed in claim 16, **characterized in that** it further comprises:

backing up the interlocking information with the interlock processing standby subsystem (106);
transmitting the interlocking information acquisition request to the interlock processing standby subsystem (106) after the communication between the selected zone controller computing node (101) and the interlocking information processing subsystem (105) has failed;
searching for relevant interlocking information with the interlock processing standby subsystem (106), and transmitting the relevant interlocking information to the selected zone controller computing node (101).

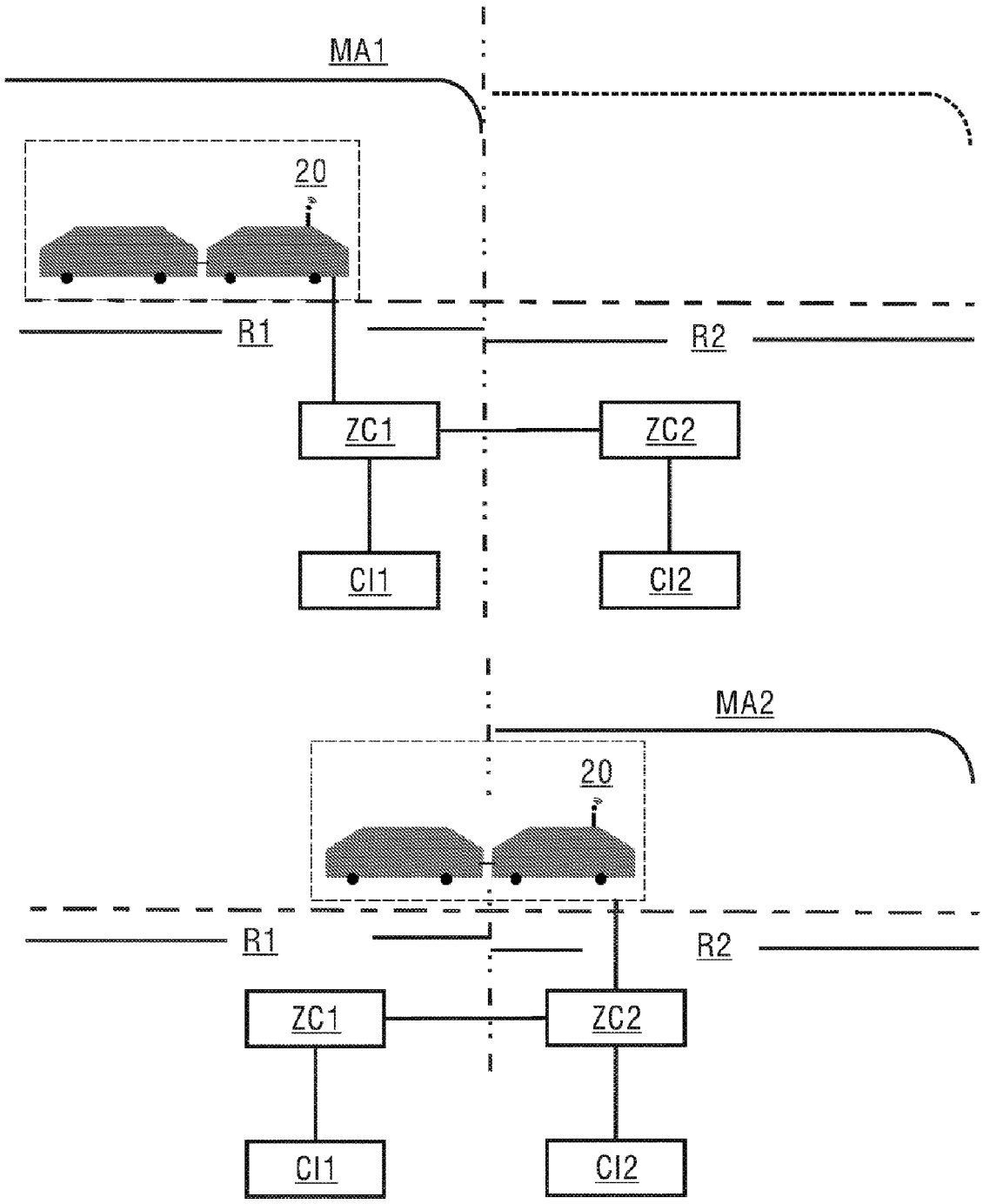

Fig. 1

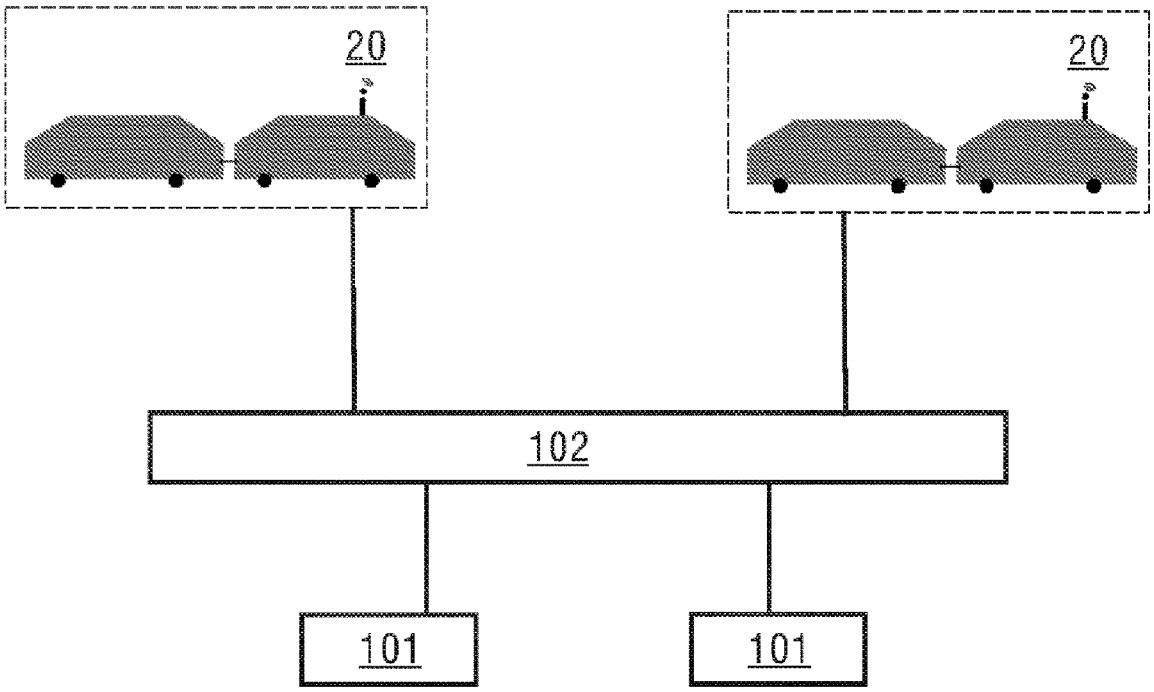

Fig. 2

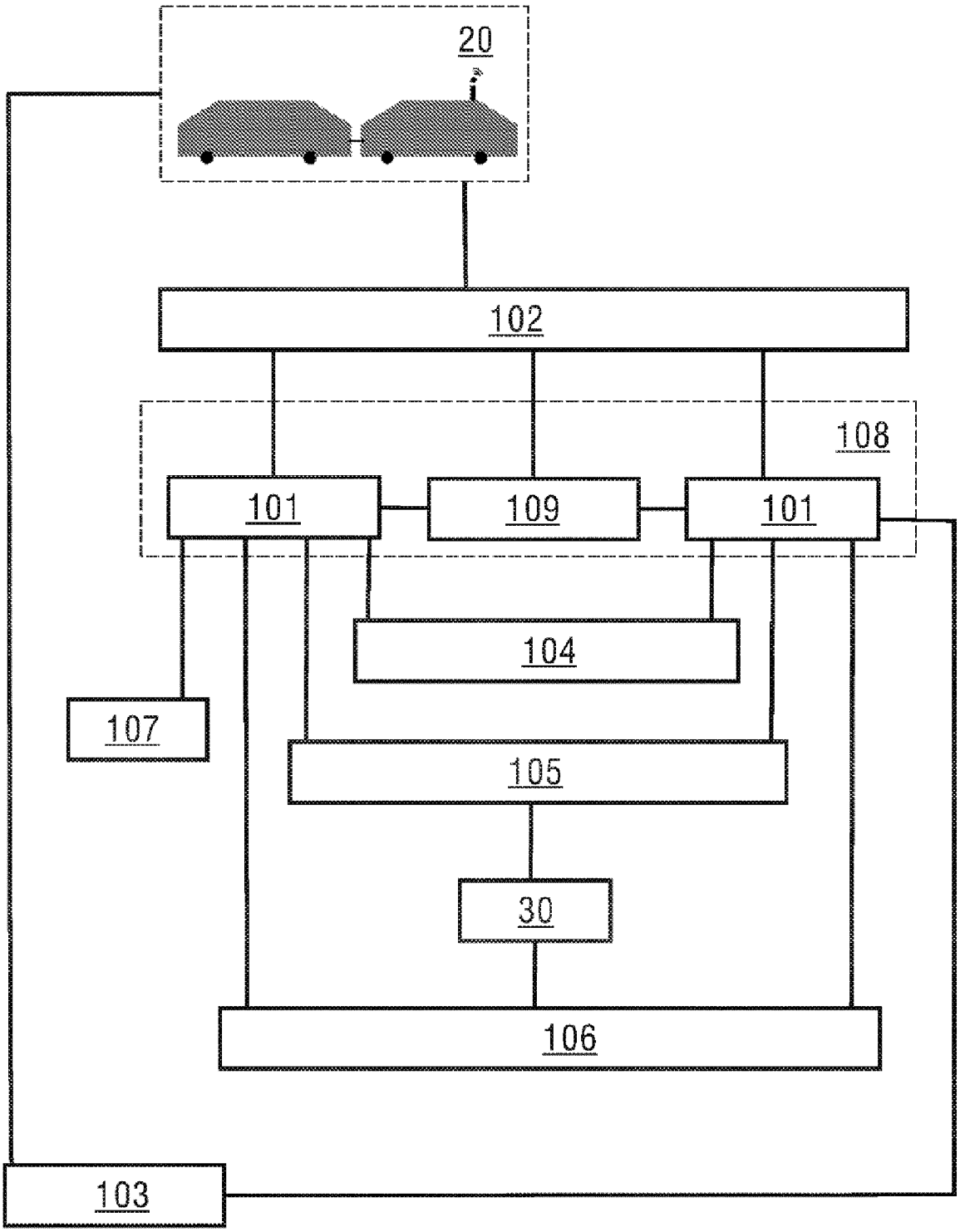

Fig. 3

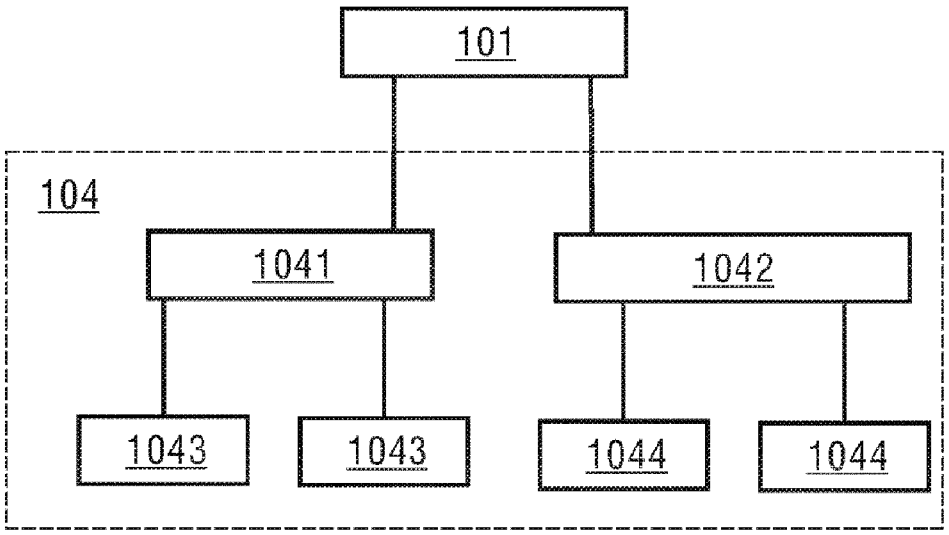
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Fig. 4

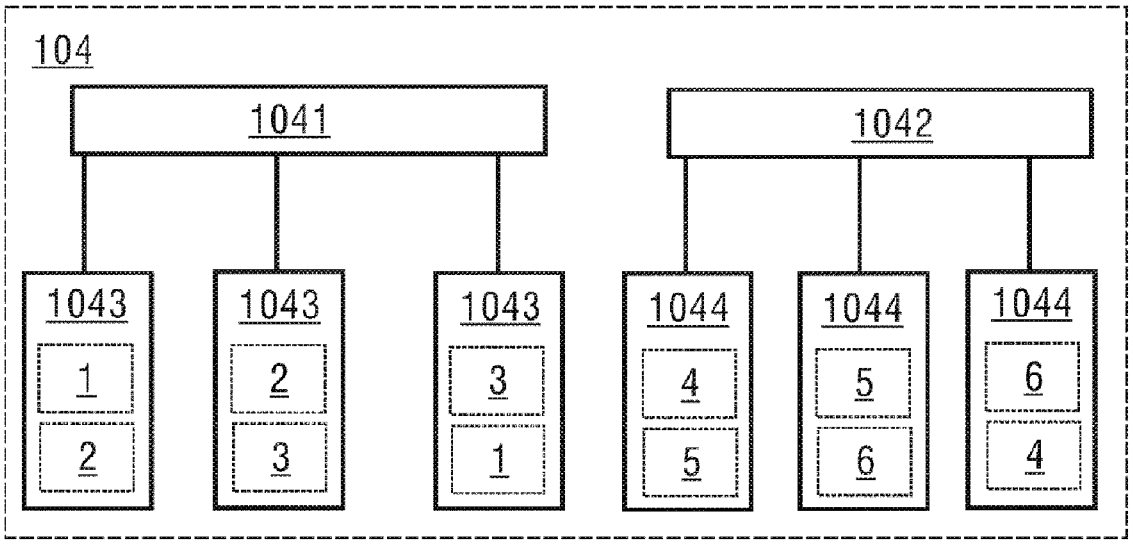
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Fig. 5

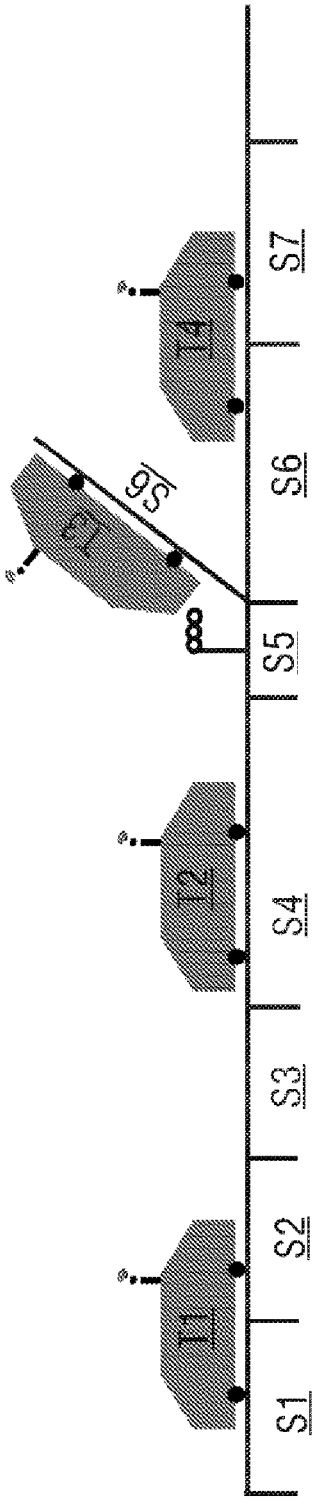

Fig. 6

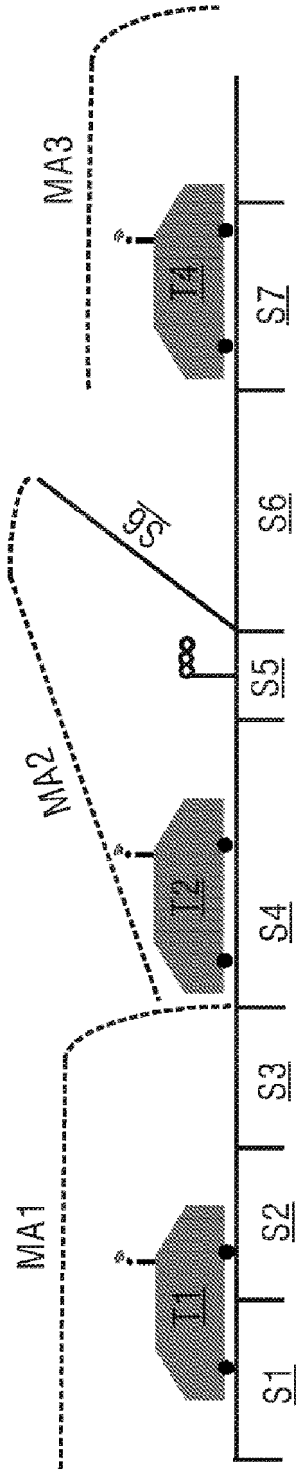

Fig. 7

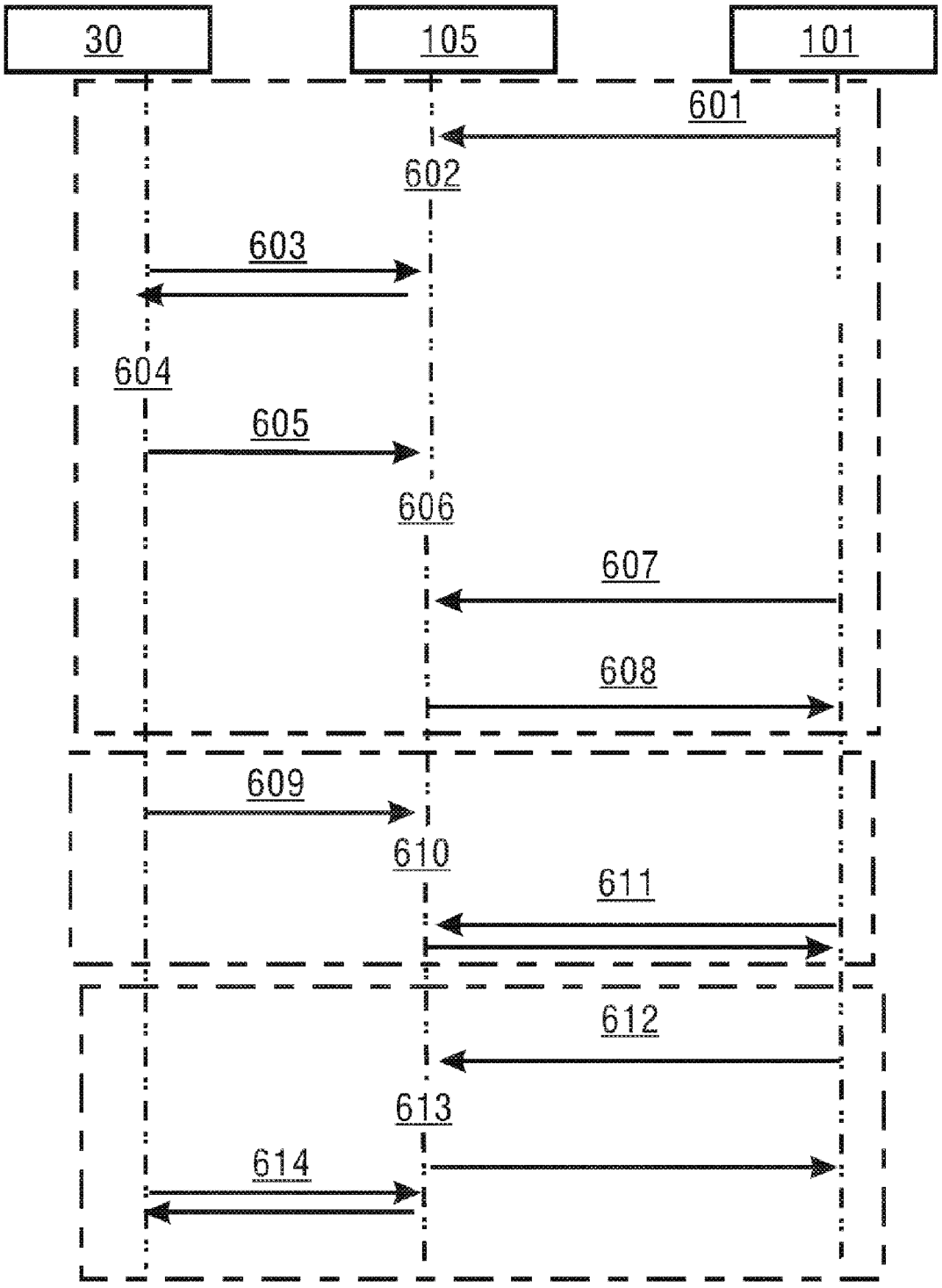
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Fig. 8

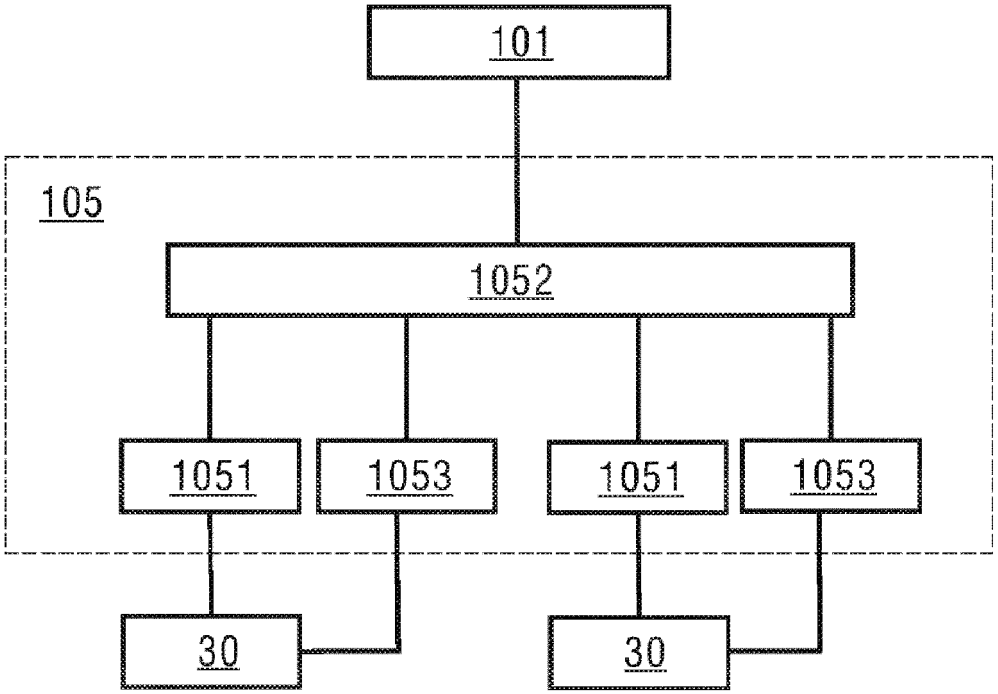

Fig. 9

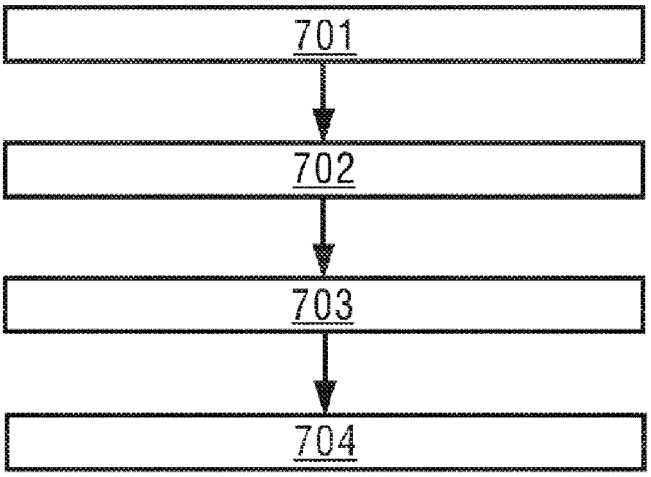

Fig. 10

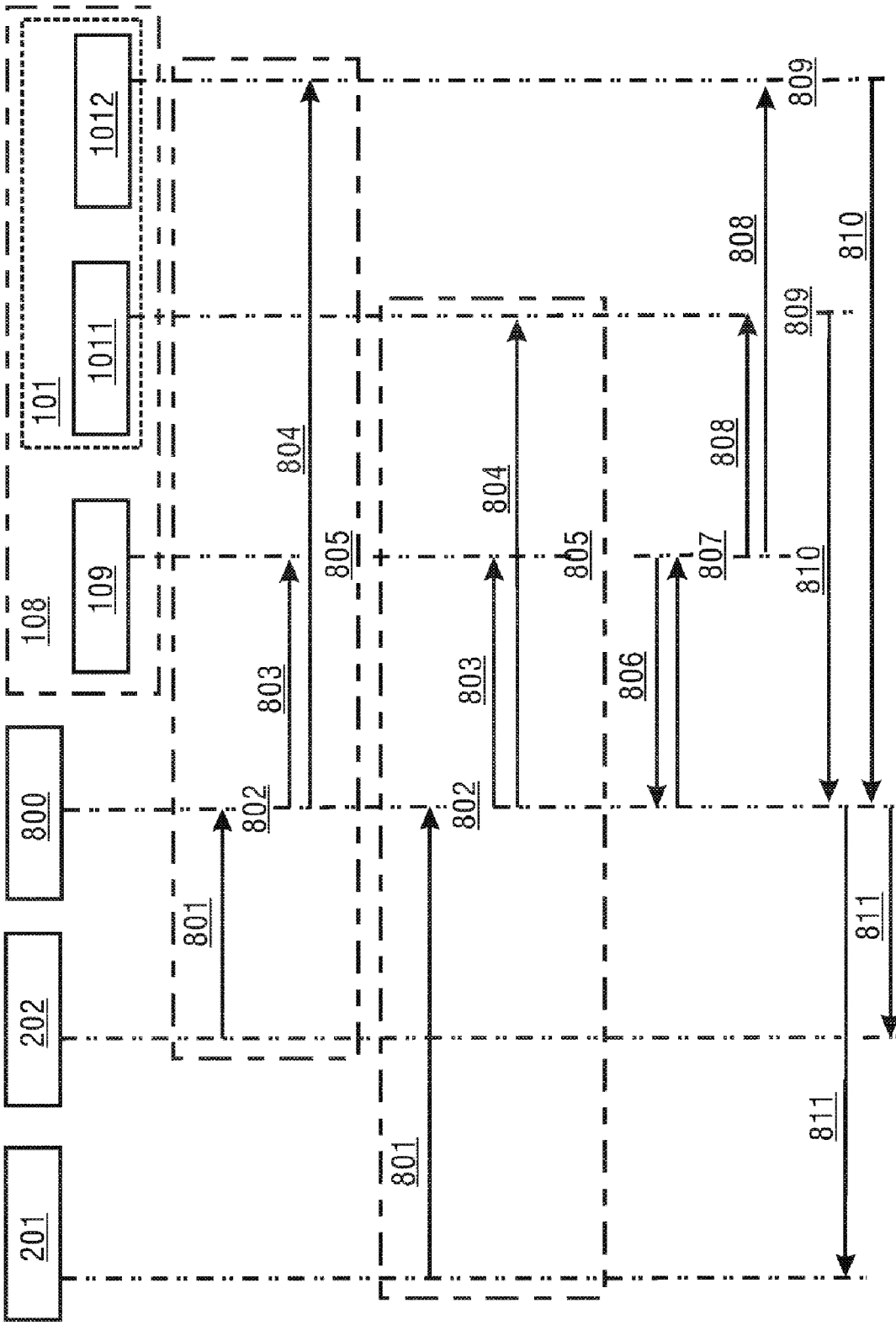
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Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/118547

A. CLASSIFICATION OF SUBJECT MATTER

B61L 23/14(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS; CNTXT; CNKI; 万方; 超星; VEN; USTXT; EPTXT; WOTXT; IEEE: 西门子, 陈典, 区域控制器, 地面设备, 通讯, 列车, 自动系统, 自动保护, 分段, 控制, 多段, 区域, 自动驾驶, 断, 通信, 火车, 高铁, 信息, ATP, ATS, ATO, MA, position, region, control+, interlock+, movement, Authority, domain, train, district, railway

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 101927775 A (BEIJING JIAOTONG UNIVERSITY) 29 December 2010 (2010-12-29) description, paragraphs [0029]-[0038], and figures 1-4	1, 11
Y	CN 109305200 A (BYD COMPANY LTD.) 05 February 2019 (2019-02-05) description, paragraphs [0073]-[0088], and figures 4-6	1, 11
A	US 2010299007 A1 (GHALY NABIL N) 25 November 2010 (2010-11-25) entire document	1-19
A	JP H082416 A (TOSHIBA CORP.) 09 January 1996 (1996-01-09) entire document	1-19
A	CN 103029723 A (BEIJING TRAFFIC CONTROL TECHNOLOGY CO., LTD.) 10 April 2013 (2013-04-10) entire document	1-19

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 November 2020	**31 December 2020**

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Facsimile No. **(86-10)62019451**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/118547

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CN 109305200 A	05 February 2019	WO 2019020020 A1	31 January 2019
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		US 2012018591 A1	26 January 2012
		US 2014100724 A1	10 April 2014
		US 8200380 B2	12 June 2012
		US 9290191 B2	22 March 2016
JP H082416 A	09 January 1996	JP 3210526 B2	17 September 2001
CN 103029723 A	10 April 2013	CN 103029723 B	08 April 2015

Form PCT/ISA/210 (patent family annex) (January 2015)